Australian Government
Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY REPORT
Aviation Research and Analysis Report – AR-2007-043 (1)
Final

Amateur-built and experimental aircraft

Part 1: A survey of owners and builders of VH- registered non-factory aircraft

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A survey of owners and builders of VH- registered non-factory aircraft

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Amateur-built and experimental aircraft. Part 1: A survey of owners and builders of VH- registered non-factory aircraft

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Mr Rod Carter, Civil Aviation Safety Authority
Figure 6: Grumman F9F Panther replica aircraft courtesy of Robert Frola
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Abstract

Non-factory amateur-built and experimental (ABE) aircraft are a popular alternative to general aviation aircraft. In Australia, there is little comprehensive data on these aircraft and what people do when building or buying them second-hand. Key players in this part of aviation were consulted in developing a survey to better understand these aircraft builders and owners. The survey was distributed electronically and in hard copy to owners of VH-registered ABE aircraft, and about 50 per cent of active ABE aircraft owners answered the survey. It focussed on choice of aircraft, construction and modifications, test flights, transition training, and maintenance. It provides a valuable reference point for aircraft operators, those considering ABE aircraft, aviation regulators, and aircraft associations. In developing a more comprehensive understanding of this sector of aviation, relevant parties are in a better position to plan, build and operate ABE aircraft in the future.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

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

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

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

Purpose of safety investigations

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

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

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

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

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

EXECUTIVE SUMMARY

In the last three decades, both in Australia and overseas, there has been significant growth in the number of amateur-built and experimental (ABE) aircraft. In general, ABE aircraft refer to aircraft that are built for personal use from an original design, established plans or kit, and which are not built in a factory. There are a wide variety of ABE aircraft from single to twin-engine, piston to jet-powered, and single-seat up to six-seat aircraft.

While these aircraft continue to increase in popularity, there has been little formal study of them in Australia and worldwide. Operational and demographic data on ABE aircraft are largely incomplete in comparison to data held for other types of aircraft.

This report examines non-factory amateur-built and experimental aircraft in Australia. It looks at the ABE community, including pilots and their aircraft, regulatory changes, and growth and development of aircraft associations over time. Data for this report was gathered using a survey sent to owners and builders of flying VH-registered ABE aircraft.

This survey focused on the choice of aircraft, construction, and modifications, test flights, transition training, and maintenance. The intent of the survey was to gain a picture of ABE aircraft activities in Australia, and in doing so increase awareness of issues affecting the purchase, construction, and continued safe operation of these aircraft among builders, owners and pilots, manufacturers and government.

Key results from this survey are:

- ABE owners were primarily of retirement age, and private pilots;
- on average, thirty per cent of their total flying hours were flown in ABE aircraft;
- on average, ABE aircraft accumulated forty-two airframe hours in the previous year;
- build challenge, personal satisfaction, aircraft performance, price, operational costs, and ability to perform maintenance were important reasons for purchasing an ABE aircraft. Ability to customise was less important as a reason for purchase;
- thirty-three percent of builders made major modifications during the build process;
- seventy per cent of ABE owners undertook transition training, and this was more likely among private pilots, and those with fewer total hours;
- for eighty-five percent of respondents, one person performed all maintenance on the aircraft; and,
- automotive engines and avionics were associated with the greatest build challenge.

This report has presented an interesting picture of VH- registered ABE aviation in Australia. While many of these facts have been known anecdotally, this report places greater specificity on different aspects of ABE aircraft building and operation. It provides a valuable reference point for aircraft operators, those considering ABE aircraft, aviation regulators, and aircraft associations. In developing a better understanding of this sector of aviation, relevant parties are in a better position to plan, build, and operate ABE aircraft into the future.

ABBREVIATIONS

AB	Amateur-built aircraft
AC	Advisory circular
ABAA	Amateur Built Aircraft Approval
ABE	Non factory-built amateur-built or experimental aircraft
AME	Aircraft maintenance engineer
ANO	Air navigation order
ANR	Air navigation regulation
ANA	*Air Navigation Act 1920*
AP	Authorised person
ATSB	Australian Transport Safety Bureau
BASI	Bureau of Safety Investigation
BITRE	Bureau of Infrastructure, Transport and Regional Economics
CAA	Civil Aviation Authority
CAFE	Comparative Aircraft Flight Efficiency Foundation
CAO	Civil aviation order
CAR	Civil Aviation Regulation
CAS	Calibrated airspeed
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulations
CI	Confidence interval
CPL	Commercial pilot licence
CSU	Constant speed unit
C of A	Certificate of airworthiness
DCA	Department of Civil Aviation
DOT	Department of Transport
EAA	Experimental Aircraft Association (United States)
FAA	Federal Aviation Administration
FADEC	Full authority digital electronic control
FAR	Federal Aviation Regulation
GAMA	General Aviation Manufacturers Association
GA	General aviation

GAS	General Aviation Survey
GAAS	General Aviation Activity Survey
GFA	Gliding Federation of Australia
HORSCOTS	House of Representatives Standing Committee on Transport Safety
IAS	Indicated airspeed
IFR	Instrument flight rules
KG/M^2	Kilograms per metre-squared
KTS	Knots
LAME	Licensed aircraft maintenance engineer
MTOW	Maximum permissible take-off weight
MPP	Manual pitch propeller
NA	Not applicable
NTSB	National Transport Safety Bureau
NVFR	Night visual flight rules
PDF	Portable document file
PFA	Popular Flying Association (United Kingdom)
POH	Pilot operating handbook
PPL	Private pilot licence
RPM	Revolutions per minute
RU	Retractable undercarriage
SAOG	Sport Aircraft Operations Group
SAAA	Sport Aircraft Association of Australia
STOL	Short take-off and landing
ULAAA	Ultra Light Aircraft Association of Australia
URL	Uniform resource locator
US	United States of America
VFR	Visual flight rules
VMC	Visual meteorological conditions
VPP	Variable propeller pitch control

1 INTRODUCTION

In the last three decades, both in Australia and overseas, there has been significant growth in the number of amateur-built and experimental (ABE) aircraft. The nature of amateur-built aircraft has changed significantly since 1955, when the Ultra Light Aircraft Association of Australia (ULAAA) was formed. By modern standards, most early aircraft would be classified as ultralights[1] (Rogers, 1978), a term that embodied amateur-built aircraft until 1998. Today, ABE aircraft may include twin engine, jet-powered, high performance aircraft, and carry up to six people. This moves beyond the traditional scope of ultralights.

Amateur-built and experimental aircraft continue to become more popular and cement their role as an integral part of general aviation (GA) in Australia and overseas, but there has been little formal study of ABE aircraft and their owners worldwide, and no formal study of amateur-built aircraft owners in Australia. Operational and demographic data on ABE aircraft is largely incomplete in comparison to data held for other types of aircraft.

This report is Part 1 of a two-part series that examines non-factory amateur-built and experimental aircraft in Australia. It looks at the ABE aircraft community, including pilots and their aircraft, regulatory changes, and growth and development of aircraft associations over time. Data for this report was gathered using a survey sent to owners and builders of flying VH-registered ABE aircraft.

This report will allow aviation regulators and ABE associations to better understand the needs and activities of ABE aircraft designers, builders, operators and maintainers. This, in turn, will help to foster a safe, highly-skilled, and well-represented amateur-built aircraft community. The demand for new low-cost aircraft in GA may be partially met by ABE aircraft. Better information on the decision processes used by ABE aircraft owners when selecting, buying, building, testing, transitioning to, operating, and maintaining their aircraft, will help to inform people thinking about becoming involved in this progressive area of aviation. The results of this report will also be used to provide context for the study of ABE safety trends and issues in Part 2 of this series.

1.1 Background

1.1.1 What are amateur-built and experimental aircraft?

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

- built from an original design, established plans or kit
- for personal use
- not built in a factory or on a production line (i.e. built solely for the builder’s own education or recreation).

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[1] An ultralight is a small single engine, single seat aircraft, with a low stall speed and limited engine horsepower.

Collectively, these aircraft are called 'amateur-built and experimental' or ABE aircraft in this report. In Australia, the term amateur-built was generally used until Civil Aviation Safety Regulation (CASR) Part 21 was introduced in 1998. Amateur-built experimental aircraft are built and currently operate under these regulations.

Australia has two systems for building ABE aircraft. The term amateur-built is associated with aircraft-built under the Amateur Built Aircraft Approval (ABAA) legislation, while the term 'amateur-built experimental' refers to aircraft-built under the current United States-style Experimental Certificate legislation. Legislation covering construction and sale of these aircraft is explored separately in Section 1.3.

Amateur-built experimental aircraft are not to be confused with factory-built experimental aircraft. Factory-built experimental aircraft are certified aircraft with after-market modifications. The focus of this report is on amateur-built and amateur-built experimental aircraft, which are non-factory built.

Presently, the Civil Aviation Safety Authority (CASA) defines an ABE aircraft as

> ... an aircraft of which the major portion[2] has been fabricated and assembled by a person or persons who undertook the construction project solely for their own education or recreation. (CASA, 2000)

Today, ABE aircraft embody a wide range of aircraft sizes, designs, construction methods and performance capabilities. They include relatively simple high-wing designs such as the Clancy Skybaby or Rans S7 (Figure 1), and single-engine low-wing designs such as the Corby Starlet and Van's RV-6 (Figure 2), through to large, high-performance four-seat touring aircraft such as the Lancair IV and Jabiru J430 (Figure 3). In Australia, these aircraft also include amphibious aircraft (Figure 4), warbird replicas, twin-engine aircraft, composite canard designs[3] such as the Rutan Long-EZ (Figure 5) and Quickie, and replicas of modern jet fighter aircraft such as the Grumman F9F Panther (Figure 6).

Some ABE aircraft are designed as 'one-offs', whereas other designs are built from plans, or assembled from pre-fabricated kits. They are constructed from wood, metal, tube and fabric, and composite materials, and often use a certified aircraft engine. Automotive engines are sometimes used instead of aircraft engines; these engines come from a range of manufacturers including Volkswagen, Subaru, Mazda (Rotary), and Chevrolet.

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2 The majority means that at least 51 per cent of the aircraft was built by an amateur.

3 A canard aircraft has the horizontal stabiliser forward of the wing.

Figure 1: A Rans S7 aircraft

Figure 2: A Van's RV-6

Figure 3: A Jabiru J430 aircraft

Figure 4: A SeaRey amphibious aircraft

Figure 5: A Rutan Long-EZ aircraft

Figure 6: A Grumman F9F Panther replica aircraft

Courtesy of Robert Frola

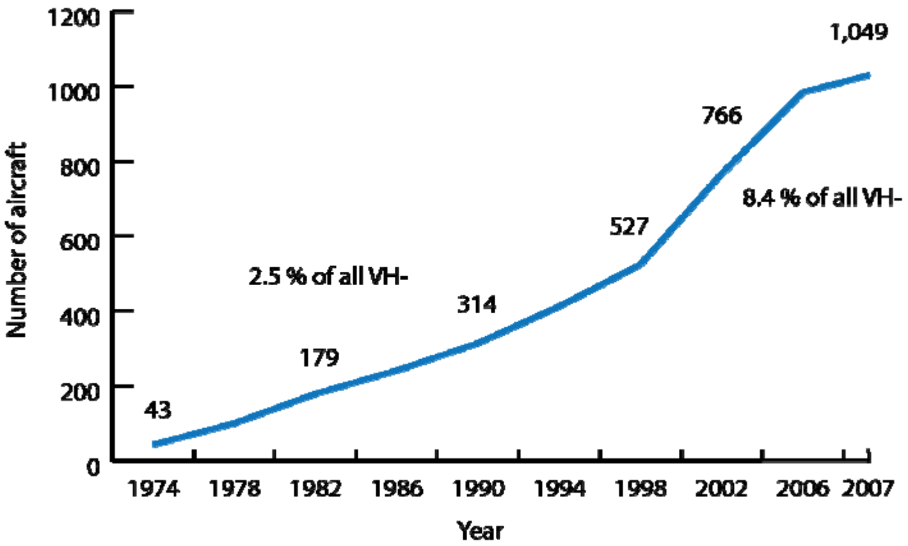
It is important to note that some people are sensitive about the terms experimental and amateur-built (Patillo, 1998). They express the view that the term amateur is demeaning and implies that people building aircraft of this nature are not skilled or knowledgeable. What is clear is that aircraft engineers, draftsmen, designers, and licensed aircraft maintenance engineers (LAME) have been active members of the organised amateur-built aircraft community since it started in 1955. Rogers (1978) points out members of the ULAAA designed and built the Millicer Airtourer, which later became the iconic Victa Airtourer.

1.1.2 Shifts in the ABE aviation industry

Growth of the ABE sector

Figure 7 shows evidence that ABE aircraft are becoming more popular in Australia. Increasing interest by pilots and prospective pilots in ABE aircraft raises questions about why they are a popular choice over more traditional GA aircraft.

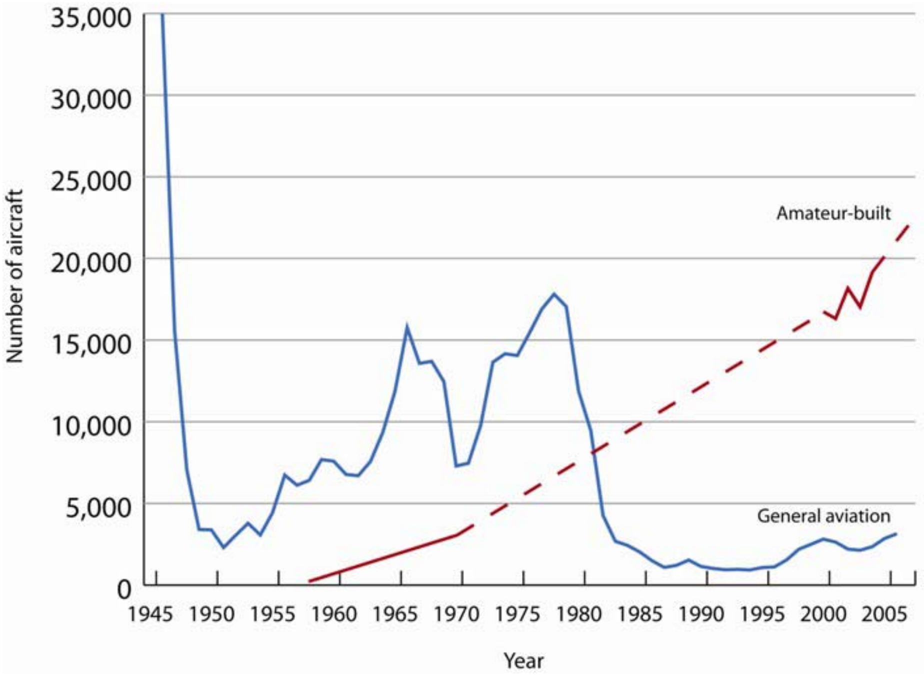
Figure 7: Growth of VH- registered ABE aircraft



Source: Bureau of Infrastructure, Transport and Regional Economics, General Aviation Activity Survey, 2009; Australian Airsport, 1974.

Most certified GA aircraft have been made, and currently are manufactured, in the United States (US). Examining what has happened in the US provides some insight into the Australian experience. One factor that has influenced the popularity of ABE aircraft has been their role in filling the GA market void created by the collapse of certified production aircraft manufacturing in the 1980s (see Figure 8). The downturn in certified production aircraft manufacture at this time was due to a number of factors, including market saturation and product liability. Despite the resumption of certified GA aircraft manufacture by companies such as Cessna and Piper in the late 1990s, production levels have not recovered to those seen in the 1970s and early 1980s, and purchase costs for new aircraft remain high in comparison to ABE aircraft.[4] For example, the 2009 list price for a four-seat Cessna 172SP Skyhawk aircraft is US$297,000, compared with US$110,000for a comparably equipped Van's RV-10 (a four-seat amateur-built kit aircraft) (Cessna, 2009; Van's, 2009).

Figure 8: Number of new GA aircraft produced versus number of amateur-built aircraft constructed and approved in the United States.



Source: GAMA, 2006; Whittier, 1958; Best-Devereux, 1970; NTSB, 2000; NTSB 2001; NTSB, 2002; NTSB 2003; NTSB, 2004.

Individual nature of building

The number of people building aircraft has experienced a significant increase in numbers since the 1950s. A corresponding jump in the membership of amateur-built associations has also been observed. In Australia, this growth in ABE aircraft building and association membership is evident particularly from about 1980.

The individual nature of building ABE aircraft is a common theme; in talking about membership of the ULAAA, Walmsley (1975) says 'our activity attracts more individualists than most.' When the ULAAA was considering a name change, the role of the individual came up on many occasions.

Administration and supervision

As ABE aircraft have grown in popularity, a significant shift in responsibility for administration from government to association has been observed.

From a government perspective, this has been accompanied by at least two major shifts in aviation regulation. The first has been a concerted whole of government

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4 In their 1996 *Blueprint for Growth* report, the General Aviation Manufacturers Association identified a need to close the perceived gap in price and performance between new production certified GA aircraft and ABE aircraft.

effort to reduce costs and increase efficiency. This drive has been present in aviation since its early days but in terms of amateur-built aircraft, it has been most noticeable since the formation of the Department of Transport in 1973.[5] The second has been a greater focus on the safety of regular public transport operations by both aviation regulators and safety investigators.

From an ABE aircraft association perspective, the shouldering of responsibility for administration and regulation has created a need to build and maintain robust systems and structures to deal with finances, articles of association, quality systems, airworthiness directives, and organisational scope and function. It has been important to ensure that ABE aircraft are built, operated, and maintained in a safe and efficient manner (see Section 1.3 for a detailed discussion).

Accidents and incidents

A number of accidents and incidents have occurred in Australia and overseas involving ABE aircraft. Relatively few amateur-built aircraft accidents were reported in Australia between 1920 and 1970, but in the past 35 years an increase has been observed.[6] The number of accidents reported is affected by a number of variables that are independent of the level of ABE safety and the operation of ABE aircraft. Such variables include increases in aircraft movements, and changing attitudes towards reporting accidents and incidents. Part 2 of this series will explore accidents and incidents in detail.

1.1.3 Previous research

A wide variety of people and organisations have published articles and books dealing with ABE aircraft. These include aircraft associations, business journals, aircraft regulators, accident investigators, test pilots, builders of aircraft, and even the *Christian Science Monitor*[7]. The type of coverage given to ABE aircraft tends to be anecdotal; titles such as *Come Fly with Me, Bring Superglue*[8], *On a Wing and a Prayer*[9], and *Backyard Blitz*[10] illustrate the journalistic flavour.

At least one previous in-depth survey of amateur builders has been performed, but this was in the US in about 1958 (Whittier, 1958). The Commonwealth Department of Transport performed surveys on the number and type of aircraft being built in the period between 1973 and 1982, but these efforts did not construct a complete

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5 The Minister for Aviation in the Whitlam Government started an 80 per cent cost recovery procedure. This meant air navigation charges for operators of amateur-built aircraft rose by about 130 per cent. Most operators of amateur-built aircraft did not use government aerodromes, but were charged for their use. A user-pays fuel tax was recommended in place of air navigation charges (ANC) by the ULAAA (Rogers, 1974).

6 The exact number is not known. Accident records held by the Australian Transport Safety Bureau from 1969 onwards are recorded electronically. Incomplete records of accidents are held between 1960 and 1969. Prior to that there were relatively few amateur-built aircraft operating in Australia.

7 Holmstrom (1995)

8 Farnham (1993)

9 Calonius (1998)

10 Jones (2004)

picture of why people built aircraft, how they built them, and the types of modifications made. Such matters were seen as an operational responsibility, and not as a separate subject of study.

Between 1966 and 1979, the National Transportation Safety Board (NTSB) published a series of reports called *Briefs of accidents involving amateur homebuilt aircraft in the United States*. More in-depth study has been made of ABE aircraft in recent years (Wattanja, 2004, 2006a, 2006b, 2008; NTSB, 2003; Hasselquist & Baker, 1995), but there is a distinct lack of population or sample data on general characteristics of ABE aircraft owners, their aircraft, and related material. This is in spite of the fact that many accident records involving ABE aircraft exist worldwide. Many different opinions are expressed on a range of ABE topics, but it is difficult to gauge how representative of the general ABE community these opinions are. Furthermore, analyses of trends and accidents are difficult in this context.

1.2 Objectives

The purpose of this study is to describe the nature and safety of amateur-built experimental aircraft in Australia.

This study is divided into two parts, published as two separate reports:

- Part 1 (this report) explores issues that affect ABE aircraft owners when selecting, building, purchasing, testing, designing, operating, and maintaining these aircraft. This involved distributing a survey to owners and builders of VH-registered ABE aircraft.
- Part 2 of this study will examine the safety of VH- registered ABE aircraft through analysis of accident data held by the ATSB.

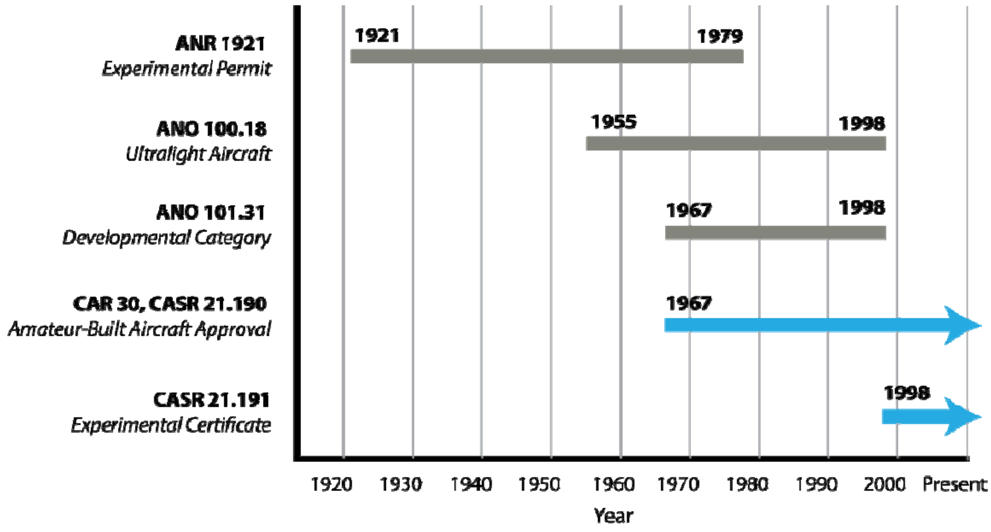
The survey results presented in this report will inform the analysis of ABE aircraft safety trends and issues in Part 2 of this study.

1.3 Legislation for ABE aircraft

Amateur-built experimental aircraft operating in Australia have been built in accordance with five different pieces of legislation, with two being current as at mid-2009 (Figure 9):

- The experimental category under Section 6 of the Air Navigation Regulations 1921
- Air Navigation Order (ANO) 100.18, Ultra Light Aircraft
- Air Navigation Order 101.31, Developmental Category
- CAR 30, Special Certificate, CASR 21.190, Amateur Built Aircraft Approval, Air Navigation Order and Civil Aviation Order 101.28
- Special Certificate, CASR 21.191 Amateur-built Experimental.

Figure 9: ABE aircraft legislation in Australia for G-AU[11] or VH- registered aircraft, 1921 to 2009[12]



The early years

Prior to the *Air Navigation Act 1920* and Air Navigation Regulations 1921, a number of aircraft were built in Australia. At this time, flying was managed by the Commandant of the local Military District, and where necessary, either a member of the police or Army Flying Corps (predecessor to the Royal Australian Air Force) would be called upon to inspect the soundness of the aircraft (K. Meggs, personal communication, 3 September 2008).

Experimental aircraft - Air Navigation Regulations 1921

From 1921 onwards, Regulation 6 of the Air Navigation Regulations 1921, provided the legal basis for experimental aircraft. [13] There were about 70 types of aircraft built by individuals between 1920 and 1939, including the Clancy Skybaby, Heath Parasol and Flying Flea (K. Meggs, personal communication, 3 September 2008).

The experimental system was managed through the Department of Defence. Aircraft could be flown within 3 miles of an aerodrome under a Permit to Fly and did not need to be registered. This provided an opportunity for people to develop, test, and improve aircraft without the need for extensive regulatory oversight. This category was intended as a transition step to certification, however, in many instances these aircraft were flown for long periods of time without ever being registered. This practice continued until 1979 when the Department of Transport introduced Airworthiness Instruction 3-5, requiring ABE aircraft to be entered onto

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11 Australia did not have its own civil aircraft register until 1928, and Commonwealth aircraft were given G- registrations followed by a prefix to designate the country. Australian aircraft registrations started with G-AU. For example, Blanch's ABE aircraft built between 1923 and 1928 was registered as G-AUES.

12 Note this does not include legislation covering aircraft registered with Recreational Aviation Australia (RA-Aus). Operation of these aircraft is governed by the Civil Aviation Order 95.

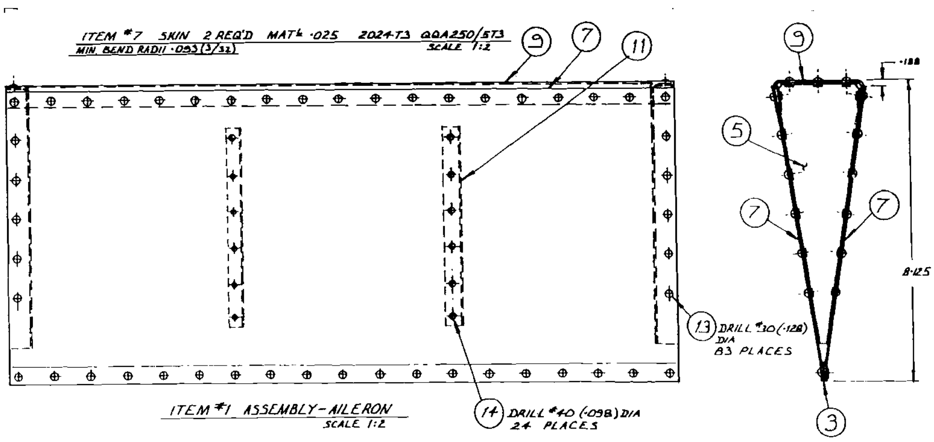
13 Established in Statutory Rule No 33 of 1921.

the Australian civil aircraft register (VH-). The concern driving this policy change was that aircraft not entered onto the register were operating outside the normal system of airworthiness control, and this was perceived to be a risk to aviation safety (National Archives of Australia: Department of Transport, K95).

Ultralight Aircraft - ANO 100.18

First introduced in 1955, ANO 100.18 was a government response to post-war interest in aviation. Air Navigation Order 100.18 set out the requirements for building amateur-built aircraft, including the submission of test pieces to the regulator (Figure 10), welding and flight evaluation specifications, permit to fly, and maintenance. Maintenance was to be carried out according to ANO 100.5, and this required a licensed aircraft maintenance engineer (LAME) or person with a Maintenance Authority to conduct maintenance. The Civil Aviation Branch of the Department of Defence was replaced by the Department of Civil Aviation (DCA) in 1939. The DCA had previous experience with sub-standard workmanship of some amateur builders (National Archives of Australia, 1928), and this may have convinced them of the need to sample the workmanship of prospective builders when formulating ANO 100.18. This ANO operated for about 40 years before being repealed when the present experimental category was introduced in 1998.

Figure 10: Example of a regulator test piece (mock aileron)



Developmental Category - ANO 101.31

Introduced on 1 July 1967, the Developmental Category ANO 101.31 gave amateur aircraft builders the opportunity to build and test a prototype aircraft or significantly alter an existing aircraft. This was a transition category to either production aircraft or design approval under the Amateur Built Aircraft Approval (ABAA) ANO 101.28 scheme (see below). The Corby Starlet, Hughes Lightwing, and Clancy Skybaby are the only designs approved for amateur construction using this process (Mitchell, 1994). Another aircraft constructed by amateur builders, called the Paleto Maverick, operated under the Developmental Category, but was eventually entered into the experimental category (see below).

Aircraft developed under ANO 101.31 required substantial input from a Civil Aviation Regulations (CAR) Part 35 delegate, particularly where design changes were necessary, or adaptations and improvements were made on the original design. Stage inspections were performed at crucial points by the DCA, Department of

Transport, or Department of Aviation airworthiness officers. A flight test schedule was devised and agreed to by the relevant authorities, and the aircraft were test flown. The Developmental Category offered the opportunity for the builder to conduct maintenance so that a cycle of change and modification, necessary while building a prototype aircraft, could be achieved efficiently.

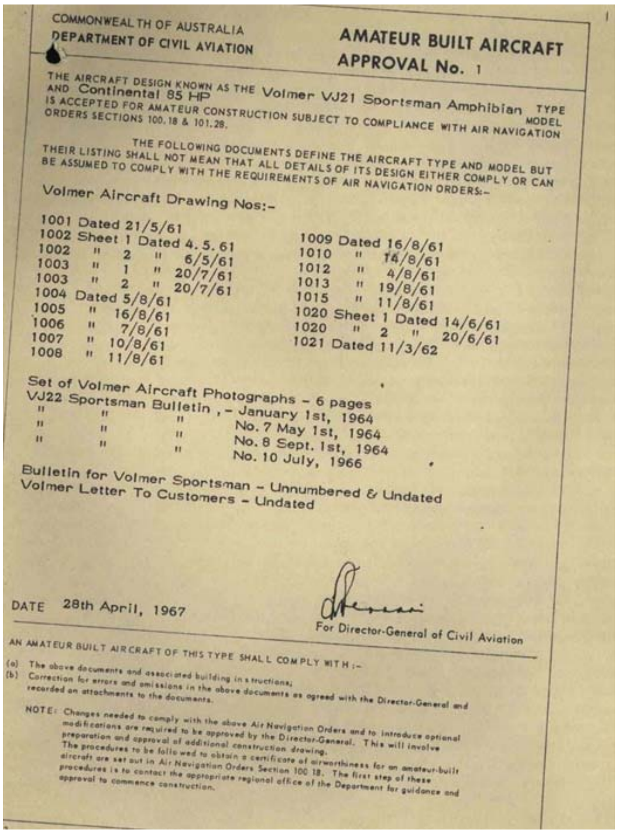
Different interpretations of ANO 101.31 meant this area was plagued with difficulty in terms of regulatory compliance (Mitchell, 1994). This ANO was targeted by sport aviation representatives during the House of Representatives Standing Committee on Transport Safety (HORSCOTS) in 1987. It was cited as an example of the restrictive aviation regulations in Australia that hampered Australian aircraft manufacturing business interests. While the ANO worked for builders who were aeronautical engineers, it did not work very well for most amateur builders. Air Navigation Order 101.31 was repealed when the experimental category was introduced in 1998, having operated for about 30 years.

Amateur Built Aircraft Approval CASR 21.190 (ANO 101.28)

The Amateur Built Aircraft Approval (ABAA) system was introduced in 1967 at the same time as ANO 101.31. This was promulgated under Regulation 30 of the Civil Aviation Regulations. Under ABAA, design plans or specific aircraft kits were approved and certified by the regulator using a system to evaluate basic airworthiness. It seems that in part, ABAA consolidated building experience and lessons learnt from previous ABE aircraft building, as well as controlling changes to aircraft designs through approved modifications. Regulators initially wanted to limit the number of aircraft in order to better manage this sector of aviation.

The first ABAA was given to an amphibious aircraft called the Volmer Sportsman in April 1967. Subsequently, many other aircraft were added, including the popular Jodel aircraft. Frank Rogers modified the plans for the Jodel, originally in French, to meet Australian regulations.

Figure 11: Amateur Built Aircraft Approval Number 1 - Volmer VJ-21 Sportsman Amphibian, 28 April 1967



COMMONWEALTH OF AUSTRALIA
DEPARTMENT OF CIVIL AVIATION

AMATEUR BUILT AIRCRAFT
APPROVAL No. 1

THE AIRCRAFT DESIGN KNOWN AS THE Volmer VJ21 Sportsman Amphibian TYPE AND Continental 85 HP MODEL IS ACCEPTED FOR AMATEUR CONSTRUCTION SUBJECT TO COMPLIANCE WITH AIR NAVIGATION ORDERS SECTIONS 100.18 & 101.28.

THE FOLLOWING DOCUMENTS DEFINE THE AIRCRAFT TYPE AND MODEL BUT THEIR LISTING SHALL NOT MEAN THAT ALL DETAILS OF ITS DESIGN EITHER COMPLY OR CAN BE ASSUMED TO COMPLY WITH THE REQUIREMENTS OF AIR NAVIGATION ORDERS:-

Volmer Aircraft Drawing Nos:-

1001 Dated 21/5/61
1002 Sheet 1 Dated 4.5.61
1002 " 2 " 6/5/61
1003 " 1 " 20/7/61
1003 " 2 " 20/7/61
1004 Dated 5/8/61
1005 " 16/8/61
1006 " 7/8/61
1007 " 10/8/61
1008 " 11/8/61

1009 Dated 16/8/61
1010 " 14/8/61
1012 " 4/8/61
1013 " 19/8/61
1015 " 11/8/61
1020 Sheet 1 Dated 14/6/61
1020 " 2 " 20/6/61
1021 Dated 11/3/62

Set of Volmer Aircraft Photographs - 6 pages
VJ22 Sportsman Bulletin, - January 1st, 1964
" " " No. 7 May 1st, 1964
" " " No. 8 Sept. 1st, 1964
" " " No. 10 July, 1966

Bulletin for Volmer Sportsman - Unnumbered & Undated
Volmer Letter To Customers - Undated

DATE 28th April, 1967

For Director-General of Civil Aviation

AN AMATEUR BUILT AIRCRAFT OF THIS TYPE SHALL COMPLY WITH:-
(a) The above documents and associated building instructions;
(b) Correction for errors and omissions in the above documents as agreed with the Director-General and recorded on attachments to the documents.

NOTE: Changes needed to comply with the above Air Navigation Orders and to introduce optional modifications are required to be approved by the Director-General. This will involve preparation and approval of additional construction drawing. The procedures to be followed to obtain a certificate of airworthiness for an amateur-built aircraft are set out in Air Navigation Orders Section 100.18. The first step of these procedures is to contact the appropriate regional office of the Department for guidance and approval to commence construction.

Source: National Archives of Australia

Although ABAA aircraft can still be built under CASR 21.190, no new aircraft can be added to the approval list, which stands at 138 aircraft: 115 aircraft with full approval, 16 aircraft with provisional approval, and 7 aircraft in draft approval. When plans were being made to introduce CASR part 21.191, CASA envisaged that the ABAA system would cease. Public pressure was mounted from interested parties who wished to retain ABAA. Part 21.190 was introduced to allow ABAA to continue. Under this system, a CAR 35 delegate makes stage inspections, a LAME gives the aircraft a maintenance release, and the CAR 35 delegate gives a permit to fly.

A great deal of effort was expended by the regulator evaluating designs where only a small number of aircraft of that type appear to have ever been built. Furthermore, builders demanded to build other aircraft they saw in magazines such as *Popular Mechanics* that were not on the ABAA list (National Archives of Australia, PP526/1).

ABAA Case study: Lancair 320

Probably one of the most significant, yet least acknowledged safety events in Australian ABE aviation was the ABAA for the Lancair 320. This aircraft had been sold by the US manufacturer in kit form since 1990 (Janes, 1993). At the time of evaluation by the Civil Aviation Authority (CAA), 57 kits had been sold in Australia, and eight had been given permits to fly (Carmen, 1992). The aircraft demonstrated poor longitudinal static stability and this was considered unacceptable by the CAA. The CAA test pilots also found the aircraft was prone to pilot induced oscillations, especially on takeoff. The following recommendations were made by the regulator:

> The aircraft requires an increase in tail volume and an increase in dihedral effect. If the stall warning remains unchanged after modification to improve the longitudinal handling characteristics, an artificial stall warning device should be installed. Further investigation of the longitudinal dynamic stability, Dutch roll and longitudinal manoeuvre stability is required.

Four test flights were conducted by test pilots who had graduated from the Empire Test Pilots' School, with the last flight being conducted by both builder and owner. The CAA said that the 49 Lancair aircraft which had not yet flown would not be issued a permit to fly until a retrofit fix was developed and fitted to the aircraft to improve the design's stability characteristics; the retrofit cost about $2,000. Lancair representatives were incredulous, arguing that more than 300 Lancairs in 11 countries had accumulated 40,000 hours of flying, and that the US Federal Aviation Administration (FAA) had not raised any concerns about the safety of the Lancair 320 design. In the June 1992 edition of *Aircraft Magazine*, the Australian Lancair representative Avtex said that the CAA was 'mixing apples and oranges' by using the US Federal Aviation Regulation (FAR) 23 pitch stability standard for certified aircraft, which they stated was never intended to apply to amateur-built aircraft (Carmen, 1992).

Figure 12: A Lancair 320 aircraft

In a July 1992 letter to the editor of *Aircraft Magazine*, the CAA Chief Test Pilot responded by saying the 'Lancair fail[ed] to comply with some very fundamental stability requirements,' including positive stability. Further, he indicated the following:

> In most countries amateur built aircraft attract no formal airworthiness requirements and can be assembled and flown without any assess of the type of the national authority. This is the case in the US. Despite this, both the FAA and the Experimental Aircraft Association make the strongest possible recommendations regarding the importance of adequate stability, but without any compulsion to comply.

Most importantly, the CAA Chief Test Pilot indicated that the poor longitudinal static stability of the Lancair was easily amenable to rectification (Engelsman, 1992). Subsequently, two design modifications were approved by the CAA (ABAA Number 88) and features of these designs were subsequently incorporated into its certified aircraft. Part of the modification increased the volume of the horizontal stabiliser.

One of the great sticking points for amateur builders using the ABAA system, was the need to engage a CAR 35 delegate where the aircraft was modified from the plans or kit design. During the era of cost recovery in aviation (from about 1970 to 1988), amateur aircraft builders viewed this as a particularly significant imposition as many CAR 35 delegates worked for the aviation regulator. Another challenge was that CAR 35 delegates were based in regions, and it was difficult to build a central database of approved modifications (Zapletal, 1973). This system became onerous to administer, and the regulator turned to other methods in order to evaluate both modifications and new designs. This newer method of appraising ABAA aircraft was based on a history of safe operation, which more often than not was based on an assessment of the operational experience of the type in the United States.

Although some people have criticised the restrictions of the ABAA system Australia is the only country to have implemented a rudimentary airworthiness system based on the evaluation of flight handling characteristics. It was Australia's rudimentary amateur-built aircraft airworthiness requirements that made ABE aircraft designs safer. With the change to the experimental category in 1998 (see below), there is no regulator airworthiness evaluation.

Experimental Certificate CASR 21.191

The Experimental Certificate system, introduced in 1998, is based on an experimental certification process for amateur-built aircraft used in the United States. The US experimental system relies upon a functional demonstration of basic safety and airworthiness after the aircraft is built. The advantage of the experimental system used in the US is that it is less prescriptive, allowing the builder freedom to build as they please.

In Australia, an authorised person (AP)[14] can issue experimental certificates under CASR 21.195A to allow operation of amateur-built and kit built aircraft. Civil Aviation Safety Authority (CASA) Advisory Circular AC-21.4(2) Amateur-built Experimental Aircraft – Certification, provides guidance and information to those applying for an experimental certificate.

Under the Experimental Certificate, ABE aircraft are inspected only once by a CASA or Sport Aircraft Association of Australia (SAAA)[15] authorised person prior to the initial test flight. Advisory Circular AC-21.4(2) describes the purpose of the inspection is to:

> allow the inspector to make a subjective assessment of the workshop methods, techniques and practices used in the construction of the aircraft solely for the purpose of prescribing appropriate conditions and operating limitations necessary to protect other airspace users and persons on the ground or water, i.e. to protect persons and property not involved in the activity.[16]

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[14] An authorised person is a delegate of the SAAA or CASA, who is usually a LAME with extensive experience. The authorised person inspects the aircraft to assess it conforms to applicable CASA administrative requirements (ATSB, 2007).

[15] The SAAA encourages members to have voluntary stage inspections during the build process.

[16] The SAOG reported to the ATSB that there are builders in the experimental category that are prepared to comply with most of the extra requirements of the ABAA system.

If an experimental aircraft has an accident, the regulator has no liability under the provisions of CASR 201.3. This transfer of liability from the regulator to the aircraft owner is what allows ABE aircraft builders, operators, and maintainers to have a high level of control over the airworthiness and design of their aircraft. They are aware of, and accept, that they build and operate experimental aircraft entirely at their own risk.

An Experimental Certificate is not a certificate of airworthiness. Experimental aircraft in Australia do not have to comply with any recognised airworthiness standards, including crashworthiness standards, although some builders use US Federal Aviation Regulation Part 23 as a guide.

A crucial part of the experimental category approval process is demonstrating that an aircraft is capable of safe flight in a limited area for a specified number of hours. A well-designed test flight regime evaluates the soundness of their aircraft's design and construction, and also ensures that the intended flight performance can be achieved. This survey focuses on who conducts test flights, and anything builders would do differently for this process.

Commercial assistance

The CASA regulations specify that the major portion (51 per cent) of ABAA and experimental aircraft must be fabricated and assembled by the builder. The CASA advisory circular AC 21.29(0) states that commercial assistance is 'assistance in the building of an amateur-built aircraft in exchange for compensation. This does not include one builder helping another.' Compensation is defined as 'payment by the amateur-builder applicant in cash, services, or other tender, to any person who provides assistance on a commercial basis in the building of an aircraft.'

Certain types of commercial assistance are allowed during construction of ABE aircraft, including instructional assistance, painting, and installation of interior upholstery or avionics. In addition, an amateur builder is not expected to fabricate aircraft parts such as engines, propellers, wheels and brake assemblies, and standard aircraft hardware. These are generally provided by the kit or engine manufacturers, or other specialised equipment suppliers.

Amateur builders can pay for instruction in fabrication and assembly of parts. For example, another person might build the first few wing ribs, showing the amateur builder what to do, with the remainder being completed by the amateur builder. The amateur builder is expected to be present during all instruction, and undertake fabrication and assembly of parts. The checklist provided in AC 21.29(0) is intended for use by an authorised person in determining whether the aircraft meets the major portion rule. There is circumstantial evidence from this survey that some people in Australia either want to seek, or have sought commercial assistance in building an aircraft in excess of that allowed under the regulations; in other words, obtain assistance above and beyond the major portion rule. This is commonly called 'chequebook building'. In Australia, it is likely that if this practice takes place, commercial assistance comes from either a LAME or someone who has experience in building aircraft.

In the US, a number of kit manufacturers have FAA-approved builder assistance programs, where the builder completes a quick build aircraft under supervision in a factory in as little as two weeks (Cody, 2009). This practice, along with chequebook building, has concerned the FAA Amateur-Built Aircraft Aviation Rulemaking

Committee (the Committee); committee members include representatives from kit manufacturers, the Small Aircraft Manufacturers Association, and the Experimental Aircraft Association. The Committee has recommended a number of possible revisions to the commercial assistance Advisory Circular, including more information on a structured process to evaluate amateur-built, and possibly a more in-depth interview process at the time of aircraft certification.

Summary of Australian legislation

Historically, the focus of Australian aircraft regulators has moved from a largely process-based system to an outcome-based system, focussing on ongoing aircraft safety. The process-based aspect of ABE aircraft appraisal relates to producing drawings, calculations, and structural tests for regulators to review. The outcome-based system starts with the use of a history of safe operation to justify an aircraft design, particularly with the ABAA legislation. When the experimental legislation in CASR Part 21.191 was introduced, it placed less emphasis on drawings and calculations, and greater emphasis on demonstrating that an aircraft is capable of safe operation. A concomitant move for regulators has been to place legal liability for accidents on the builder of the aircraft; noting that experimental aircraft are not given a Certificate of Airworthiness, but a Special Certificate, which demonstrates that due process has been followed in building an aircraft.

Furthermore, some important aspects of constructing and operating an ABE aircraft are not covered by ABE legislation. One such area is transition training[17], which helps to ensure that an aircraft owner can confidently and safely operate his or her aircraft. The General Aviation Manufacturers Association (1989) argues that transition training is especially important when pilots are moving to an aircraft type that has one or more of the following:

- higher performance capabilities
- different type of engine
- different cockpit and instrument layouts
- different undercarriage configuration.

One of the areas explored in the survey was whether owners underwent transition training, its availability and usefulness, and specifically if aircraft performance capabilities or pilot experience played a role in the choice to perform transition training.

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[17] The ATSB investigation of a fatal amateur-built Lancair 360 aircraft accident at Bankstown Airport, NSW in April 2006 identified that 'there was a lack of formal guidance regarding how a pilot can comply with the CAO 40.1.0 subsection 4.4 (a) requirements to be familiar with the normal emergency flight manoeuvres and aircraft performance of the aeroplane to be flown' (ATSB, 2007).

1.4 Aircraft associations

Prior to World War II, building of amateur-built aircraft was largely an individual activity. After World War II, it took some years for amateur aircraft builders to develop enough momentum to warrant an association. Initially, amateur-built aircraft associations were a technical group with an engineering focus. There were only a small number of amateur-built aircraft in existence at the time, and these were not complex or high performance in comparison with modern ABE aircraft. As time developed, the association became much more closely involved with the preparation of design submissions to the DCA.

In Australia, ABE organisations started with the Ultra Light Aircraft Association of Australia (ULAAA) in 1955. Under ABAA, ULAAA members helped to prepare documents and make submissions to the regulator. In 1977, the ULAAA became the Sport Aircraft Association of Australia (SAAA). This was, in part, to reflect a change in focus, but also to distinguish sport aircraft from very light aircraft such as microlights (i.e. those aircraft with a maximum takeoff weight below 450 kg).

Significant debate surrounded amateur-built aircraft and the administration of this sector in the 1970s. Reforms to the nature of government involvement in aviation activities led to a greater focus by the DCA and Department of Transport on its core business of maintaining and improving the safety of industry sectors involved with passenger transport. This policy continues through to the present day, with passenger transport operations being the highest priority for CASAs safety resources.

In the non-passenger carrying sectors of the Australian aviation industry (such as private flying), CASA will generally limit its activities to controlling the people and organisations that enter that sector, providing education about the risks of that sector and removing people or organisations from the industry that endanger lives or engage in other unsafe practices. The Civil Aviation Safety Authority does not generally conduct direct routine surveillance of these non-passenger carrying operations (CASA, 2009).

One of the key reforms to affect ABE aviation in Australia in the 1970s and 1980s was the devolution of oversight for approval and building of experimental aircraft to associations. This policy change by the regulator acknowledged that experimental aircraft are driven by innovation in aircraft design and construction, and that participants accept a higher level of safety risk in comparison with more traditional certified aircraft.

The SAAA was formed with the prospect of becoming an approved organisation under the Department of Transport changes (Heaton, 1977). In January of 1977, Canning (1977) mapped out some of the areas where responsibilities previously carried out by Department of Transport might be devolved to the SAAA. These included approval of aircraft types, workshops, inspections during construction, and preparation of pre-flight documentation. Since the late 1980s, the SAAA has been a CAA/CASA delegate approving ABE aircraft.

Recreational Aviation Australia (RA-Aus) was formed in 1983 as the Australian Ultralight Federation (AUF). The AUF was formed as an off-shoot organisation of the SAAA after some internal tension about the scope and purpose of the SAAA. As a regulator approved organisation, the AUF became responsible for administration of amateur-built recreational aircraft, weight shifting devices, tricycles, microlights, and other lighter aircraft that were originally VH- registered.

The variety of aircraft administered by the AUF, as well the growth in non-traditional ultralight aircraft such as light sport aircraft and amateur-built aircraft, led to a change in name to RA-Aus in 2004.

The RA-Aus register of recreational aircraft is independent of the CASA-maintained VH- register. It began in 1986 with the registration of factory built training aircraft under CAO 95.25. Recreational Aviation Australia-registered aircraft can be identified by a six-digit registration (e.g. 24-1901), compared with the three-letter VH- registration of certified aircraft (e.g. VH-AUS). Since the mid 1980s, at least 150 ABE aircraft have transferred from the VH- to the RA-Aus register. As of April 2008, there were 2,992 aircraft registered on the RA-Aus register with about 1,445 ABE aircraft. This compares to approximately 12,600 aircraft of all types on the VH- register in mid-2008, including about 1,165 ABE aircraft.

Responsibilities of RA-Aus also extend to the investigation of some accidents and incidents involving RA-Aus-registered recreational aircraft. These investigations are carried out with the sole intention of reducing the likelihood of a future similar accident. The investigation and subsequent report is not a means to apportion blame, but rather to improve safety education material and training, as well as to issue airworthiness notices for specific aircraft types where appropriate (RA-Aus, 2007).

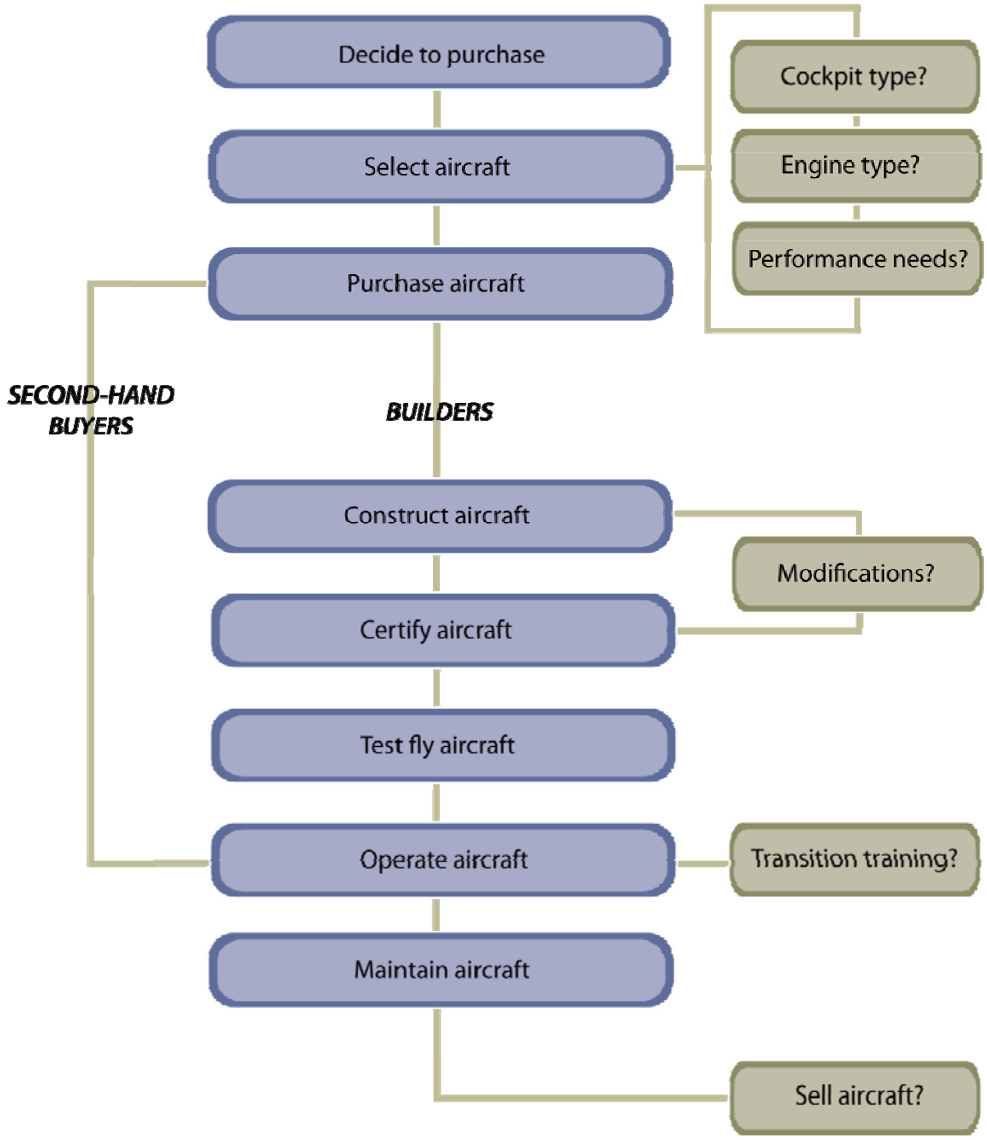
1.5 Phases of ABE aircraft ownership

The decision to purchase and build an ABE aircraft is not just a matter of going out and buying an aircraft that is ready to fly. The prospective purchaser or builder will go through a series of decisions and activities that ensure they can build and/or operate their aircraft safely.

Figure 13 identifies the major decisions and activities that an ABE aircraft purchaser or builder typically encounters in the construction and operation of their aircraft. The blue boxes on the left represent the main decision process, while the brown boxes on the right represent additional things that the builder or purchaser may also consider.

There is very little information available on the decisions and processes people have undertaken for these phases of ownership of an ABE aircraft. This survey was designed to provide insight into these phases for existing owners and builders of ABE aircraft.

Figure 13: Typical phases in the purchase and construction of an ABE aircraft



1.6 Aims

The aims of this report (Part 1) are to:

- identify the demographic makeup of ABE owners and builders;
- characterise the different types of aircraft selected by ABE aircraft owners;
- examine why people chose ABE aircraft;
- explore what ABE aircraft owners do when they construct, prepare to fly, operate, and maintain their aircraft, and particularly:
  - how they modify their aircraft;
  - how they test fly their aircraft;
  - whether they undertake formal transition training; and
  - how they maintain their aircraft;
- examine the resources used to construct, test fly, and buy second-hand ABE aircraft.

1.7 Scope

This report focuses on powered amateur-built and experimental aircraft present on the Australian civil aircraft (VH-) register in 2007-2008.

Non VH- registered ABE aircraft registered with RA-Aus were not studied in this report. However, the findings of this report may be applicable to non-VH-registered ABE aircraft and their owners.

2 METHODOLOGY

There is a paucity of information about non-factory amateur-built and experimental (ABE) activities in Australia. This relates to an understanding of which aircraft are being built, the type of people who take up this challenge, and why they do it. To date, these questions have not been comprehensively answered or researched by governments, manufacturers, or aircraft associations in Australia. In order to better understand this part of aviation, a survey was used to collect data on owners and builders of flying VH-registered ABE aircraft in Australia.

2.1 Survey distribution and response

The survey was conducted between 1 October 2007 and 31 December 2007. A convenience sample method was used to administer the survey.[18] Three different mediums were available to complete the survey – electronic web survey, electronic portable document file (PDF),[19] and paper. In order to generate the highest possible response rate, amateur-built experimental (ABE) aircraft owners were targeted in three main ways. The paper version of the survey was included as a supplement to the October 2007 issue of the *Airsport* magazine, the magazine of the Sport Aircraft Association of Australia (SAAA), with a covering letter requesting that readers complete the survey and bring it to the attention of other ABE aircraft owners. At the same time, a letter was sent to owners of ABE aircraft on the Civil Aviation Safety Authority (CASA) aircraft register encouraging them to complete the survey either electronically or by paper. The letter provided the web address of the electronic web survey and PDF. Finally, the ATSB promoted the survey at the 2007 SAAA Fly-in at Cowra, NSW. Some people would have received an invitation to complete the survey by letter based on CASA register records and the *Airsport* supplement. Paper surveys were returned to the ATSB via reply-paid mail.

In order to encourage honest and frank reporting and to maintain a confidential response, the survey did not ask for details that might identify the owner of the aircraft, such as name, address, or the aircraft's VH-registration.

There were 436 surveys returned, of which 353 were analysed in this report. About 60 surveys were not analysed as more than 80 per cent of all questions were missing. A handful of surveys were received from people who had not yet completed their aircraft, and these were excluded from the analyses.

2.1.1 Survey response rate

During 2008, the total number of ABE aircraft on the VH- and RA-Aus registers in Australia was about 2,610. The VH-register had about 1,165 ABE aircraft, some of which were gliders which were not targeted in this survey.[20]

A number aircraft on both the VH- and RA-Aus registers are inactive. The Bureau of Infrastructure, Transport and Regional Economics (BITRE) estimates that about

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18 Convenience sample means that this report used data from people who were willing to complete a survey, rather than being randomly selected.

19 This could be printed and sent to the Australian Transport Safety Bureau (ATSB) as a hard copy.

20 Administered by the Gliding Federation of Australia.

18 per cent of aircraft did not fly during the 2007 calendar year. Based on responses to the *General Aviation Activity* Survey (BITRE, 2007) a higher proportion of ABE aircraft on the VH- register are not active compared with other aircraft on the register. It is likely that there were about 707 operational VH- registered ABE aircraft in 2007 when the survey was completed.

This represents a 50 per cent (353 of 707) of the survey response rate.

2.2 Survey design

2.2.1 Structure

The survey instrument used was a self-administered questionnaire, consisting of 49 questions, divided into areas covering key aspects of ABE aircraft ownership:

- type and choice of aircraft
- construction issues
- design modifications made
- flight test regimes
- transition training arrangements
- aircraft maintenance.

Where the respondent had completed more than one aircraft, the survey requested they provide details of other aircraft they had built.

Most questions required closed-type responses, but some were partially closed, meaning a standard set of options was provided but an opportunity to record a different response was given. Such questions included aircraft model, reason for purchase, purchase documents and assistance, system challenges, and usefulness of build and test resources. Two questions in the survey were open-ended; these related to test flight and a general comments section. Where respondents were asked to rate items, five point Likert scales were used with a neutral mid-point and/or a not applicable (NA) option. A not applicable (NA) option was provided for questions with multiple parts, with the aim of eliminating non-response bias. Potentially sensitive questions about costs, money, and maintenance were positioned at the end of the survey in order to maximise responses to core survey questions.

2.2.2 Questions

The basic conceptual model demonstrating some of the links between different facets of ABE aircraft selection, construction, and ownership/operation is shown in Figure 13 (on page 19). These facets are explored in the following sections. A full copy of the survey is also provided at Appendix B.

Aircraft questions

Questions 1 to 8 centred on the type of aircraft and engine selected, aircraft complexity, type of instrumentation, and number of hours logged, while questions 9 to 11 asked about any documents and resources used when purchasing a second-hand aircraft. Questions relating to aircraft features (Q4), purchase documents (Q10), and help or assistance (Q11), were designed as multiple-response questions.

Build and construction questions

Questions 12 to 21 covered the build process. This section included the number of amateur-built or experimental aircraft the respondent had built (Q13), build method (Q14), whether the aircraft purchased was partially built (Q15), build time (Q16), how challenging different aircraft systems were to build or install (Q17), modifications (Q18), and access to information needed to construct the aircraft and its usefulness (Q20 and Q21).

Test flight questions

Six questions addressed different aspects of test flight. These included access to test flight information (Q22), available resources (Q23), who made the maiden test flight (Q24) and subsequent test flights (Q25), personal preparedness for the test flight (Q27), and an open-ended question asking if the respondent would do anything differently in preparing for test flight if they built another ABE aircraft in the future (Q27).

Aircraft and pilot characteristics

Four questions addressed aircraft performance and other details, such as expected performance (Q28), time owned (Q30), type of aircraft certificate in the categories of Amateur Built Aircraft Approval (ABAA) or Experimental (Q31 and Q32). As part of Questions 31 and 32, the respondent was also asked whether a type certificate was issued prior to 1998 and when the Experimental category used in the US was introduced into Australia (if applicable). The purpose of this last question was to distinguish between ABAA aircraft built after the introduction of the Experimental system.

Ten questions covered pilot-related characteristics, including the amount of flying performed while building (Q29) and in the 3 months leading up to test flight (Q41), the type of licence held (Q34 and Q35), and the number of hours logged both in the last 12 months and in total (Q36 and Q37). An additional question asked where the pilot had accrued the majority of their flying hours (Q38), and another asked what type of flying the person performed or intended to perform in their ABE aircraft (Q40). Finally, Question 39 was used to identify the reasons why the respondent had purchased an ABE aircraft. This was a partially-closed question to allow respondents a selection of choices or the option to provide their own reasons via an ‘other’ response.

Transition training

Transition training was examined in four questions. Question 43 asked about the type of aircraft used for transition training, while Question 44 enquired into any difficulties that respondents faced in organising transition training. Finally, the usefulness of transition training was rated in Question 45.

Maintenance, cost, age and comments

Question 46 asked who was responsible for performing maintenance on the ABE aircraft, while question 47 related to the cost of the aircraft. In order to construct a demographic picture of those building and operating ABE aircraft, question 48 asked the age of the respondent. Question 49 gave an opportunity for the respondent to make a statement about ABE aircraft in general or to provide additional comments on topics that were not addressed in the survey questions. Finally, question 50 recorded the time taken for the respondent to complete the survey.

2.3 Survey user testing

A number of organisations were consulted during the development of the ABE survey to ensure that it was easy to understand, unbiased, and provided a fair representation of ABE aircraft owners, builders and operators. Key organisations consulted were CASA, Recreational Aviation Australia (RA-Aus), and the Sport Aircraft Association of Australia (SAAA). A set of potential questions was provided to each of these organisations, as well as to individuals within the ATSB, for testing purposes. When the design of the survey was finalised, a draft was sent to the SAAA and distributed to SAAA Councillors in order to test the survey submission systems. This included a full test of the entire infrastructure used to support the survey, such as e-mail, reply paid postage, and the web-based survey tool.

2.4 Survey analysis

2.4.1 General method

Data were analysed from the survey and ATSB databases using the SAS, Microsoft Access, and SPSS software packages. Frequency distributions were created for all variables. Where data were found to be outside an empirically possible range, (e.g. 70,000 flying hours in total), or were blank, the record was flagged but retained for analysis of other variables (with the variable excluded). The number of variables included in each table or model is recorded as an N value.

2.4.2 Aircraft analysis methods

Type of aircraft structure

Most powered ABE aircraft consist of a primary structure (scaffold), which is covered with different materials to make it capable of flight. Amateur-built and experimental aircraft structures are made from any one or combination of four materials: wood, metal, fabric, and fibre composite (Wanttaja, 2008). Many amateur-built aircraft combine two or more materials - for example, the Adventurer 333 aircraft has an airframe structure fabricated from welded steel covered with glass fibre, with the exception of the wing main spar which is glass fibre. Aft of the main spar, the wing is covered with fabric rather than fibreglass. In order to avoid confusion, amateur-built aircraft are categorised by the materials used in the primary structures (fuselage and wings). In Australia, this system has been traditionally used to describe amateur-built aircraft (Airsport, 1991; Rogers, 1997).

Aircraft specifications and performance

Data on wing area, maximum takeoff weight (MTOW), landing gear configuration, and stall speeds were not requested as part of the survey. Data for these parameters were generated by the ATSB based on aircraft manufacturer, design and model.

It is worth noting that aircraft specifications and performance figures vary by 'engine installation, equipment carried and standard of finish….' (Moon, 1974). These data are indicative of the performance of an aircraft type and do not necessarily reflect every aircraft of that type. Aircraft performance varies with atmospheric conditions, the type and combination of engine and propeller fitted, and any modifications made by the builder (Barnett, 1979). Other unique design aspects of some aircraft will often affect their performance; the Europa has different types of wings for different types of operations (Seeley & Stephens, 1999b). Furthermore, Australia has historically faced a problem where aircraft are heavier than the MTOW stated by the designer (Watkins, 1973). As a result, Australian-built aircraft performance data may not always be directly comparable with aircraft built in the US or Europe.

All data for aircraft MTOW were gathered from the CASA register. In some cases, the MTOW as recorded by CASA, was less than or greater than the manufacturer or designer-quoted MTOW. For fixed-wing aircraft, data on stall speeds were collected from Comparative Aircraft Flight Efficiency (CAFE) Foundation flight test data, Jane's All The World's Aircraft (different editions), and manufacturer or designer documentation. In a small number of cases, these sources did not record this data; in this instance, data from a Pilot Operating Handbook (POH) or the test flight of an aircraft with a similar MTOW were used.

The stall speed of fixed-wing amateur-built aircraft can be measured in different ways: indicated airspeed (IAS) or calibrated airspeed (CAS). In some documents, the type of airspeed measurement being used is not clear. Indicated airspeed and CAS can be measured in miles per hour, kilometres per hour, or knots (nautical miles per hour). Flight test data where CAS is used do not always record the same stall speeds as the manufacturer, designer, or POH as documented in Table 1.

Table 1: Variations between the stall speed (kts) quoted by the aircraft designer or POH, and the actual stall speed as tested by the CAFE Foundation

Aircraft	Lancair IVP		Glasair III		Express		Falco	
Stall configuration	*Clean*	*Dirty*	*Clean*	*Dirty*	*Clean*	*Dirty*	*Clean*	*Dirty*
CAFE Foundation	78	66	71	67	67	58	61	59
Designer or POH	73	60	68	64	58	55	56	50

Source: Sealey & Stephens (1999a); Sealey & Stephens (1997); Sealey & Stephens (1996); Sealey & Stephens, (n.d.)

It is not always clear if stall speed is in a dirty[21] or clean aircraft configuration. This is a problem for aircraft with a retractable undercarriage or flaps, but not for aircraft that have a fixed aerodynamic profile, as those aircraft permanently have only one stall speed. Stall speeds shown in this report are tabled by configuration: if the aircraft has the ability to change its aerodynamic profile (i.e. has flaps or a retractable undercarriage), then a dirty stall speed is tabled. If the aircraft has a fixed configuration, the clean stall speed is tabled.

Aircraft age

Aircraft age was recorded as the year in which the prototype of the design first flew. If subsequent model updates occurred, then the age was taken from the year of the model update. For example, the Evans VP-1 Volksplane had a larger horsepower engine installed and was subsequently named the VP-1A Volksplane.

Manufacturer, designer and model names

The analysis of aircraft by name and model is a complex exercise for both certified and ABE aircraft. The same basic aircraft design is often recorded a number of different ways on the CASA register, in SAAA documentation, and in responses to this survey. This comes about for a few different reasons:

- aircraft builders are sometimes more familiar with the designer than with the licensed manufacturer of kit aircraft;
- designers may license kit manufacturers both within and outside of the country of origin and with different names and models;
- amateur-built aircraft designers and manufacturers have frequently experienced financial difficulties or reorganisations, resulting in company name changes, or transfer of the intellectual property rights for the design to another company;
- regulators are keen to store details as they are recorded on the aircraft data plate; and
- legacy electronic databases often have field width limitations (for example, a manufacturer 'Aero Designs' could be recorded in such a database as 'Aerodes'). Whilst field width limitations are less of a problem in modern database systems, historical data sourced from legacy databases may still be subjected to these limitations.

The CH-601HDS aircraft is a prime example of the array of different aircraft names that can be associated with the one designer. Chris Heintz designed the aircraft as the CH-601 HDS, however, subsequent changes in manufacturer and holding companies has led to the same aircraft design being recorded in the CASA register as Zenair CH601 HDS, Zodiac CH601HDS, and Heintz CH601 HDS. Furthermore, the issue of manufacturer licences for these aircraft to foreign companies and the subsequent variation in overseas models has led to further confusion. For example, Jane's (2008) states the Zenith CH-701 is called the Kappa-1 in the Czech Republic, the MXP-740 in the Slovak Republic, the ICP Savannah in Italy, and the Aerotrophy TT 2000 in France. The CASA register records this design as both ICP Savannah and CH-701 Zenith, which on face value appear to be totally unrelated

[21] A dirty configuration is anything that may change the airflow over the wing – components such as landing gear and flaps are two such examples.

aircraft even though they are the same design. This problem of identifying aircraft models is not unique to Heintz aircraft.

Confidentiality

This survey requested details on the make (or design) and model of ABE aircraft, and in some circumstances there were only one or two aircraft of that design on the CASA civil (VH-) aircraft register. In order to maintain respondent confidentiality, make and model details are not tabled in this report for aircraft types where less than five separate aircraft of that type are recorded on the register. This method of de-identification has the potential to strip tables of important information, but for comparison, aircraft are categorised according to their type of structure and configuration, as well as their performance characteristics.

Replica aircraft and first flight

A number of replica aircraft now appear on the VH- register, with the Supermarine Spitfire being a common example. The original Spitfire design, first flown in 1936, is significantly older than the modern replica aircraft manufactured by Supermarine Aircraft Pty Ltd of Queensland, which first flew in 1995 (Jane's, 2008). For the sake of consistency, if a replica aircraft was built to approximately the same type of specification as the original, the first flight recorded is the date when the original design first flew. If a scale version of the aircraft has been built and the aircraft specifications were significantly different from the original MTOW, wing loading, structure, or other design and performance parameters, then the date when the scale prototype first flew is recorded.

Pilot hours and licences

Amateur-built experimental aircraft pilots are compared to *Aviation Safety Survey – Safety Climate Factors* pilot data in this report.

Pilots' hours in total and recent hours are compared using a dataset that removes helicopter, flight engineer, student, airship, and glider pilots. These categories are excluded because they largely involve different flying to the ABE flying recorded in this survey.

Only a small number of people in this report were student pilots and these records were excluded from pilot hours comparisons.

2.4.3 Statistics

This study presents frequency distributions for continuous variables (like airframe time). All continuous variable distributions in this survey were skewed, meaning they did not correspond to a normal distribution[22]. They have a tail to one side and the bulk of the responses on the other side of the distribution. Because of this

[22] A normal frequency distribution is bell-shaped and has the same mean (average) and median (middle value). All parametric statistics assume that the frequency distribution is bell-shaped. If the distribution is not bell-shaped, non-parametric statistics must be used, and the median will differ from the mean.

phenomenon, means are reported along with the median value[23] and the range. Non-parametric statistics were used to analyse associations between variables for these distributions. Continuous and ordinal associations were tested using Kruskal-Wallis one way analysis of variance. This report uses the Chi square distribution (χ^2) to test associations between ordinal variables (like type of flying and transition training). Finally, it uses odds ratios and confidence intervals to illustrate the magnitude or strength of associations.

People often misinterpret statistics. This often comes about because they view statistics as clear cut and causal, focussing on the result rather than the study design, or other possible explanations for an association (bias and confounding). In addition, statistically significant results are not meaningful unless there is a clear reason why an association exists (Hennekens & Buring, 1987). To minimise this possibility, the following section outlines what statistical significance is, how to interpret a confidence interval, and what an odds ratios is.

Statistical significance

In general, research examines how objects, events or behaviours (called variables) relate to each other (called associations). The proof of how variables relate to each other is measured using a term called the probability or *p* value. In short, as the *p* value increases, the likelihood of chance increases.[24] Associations between variables are called statistically significant when the role of chance is small; for example, the chance of being wrong is five times in 100. This report is largely exploratory in nature; therefore, an inclusive approach to statistical significance is used, setting the role of chance at 10 times in 100.[25]

Confidence intervals

Probability or *p* values can be difficult to interpret because they are a composite measure of sample size and the size of the difference between study groups. This means that for a given difference between two groups, a smaller sample may not be statistically significant but a larger sample would be. A better measure of statistical significance is the confidence interval. The confidence interval presents a range where the true magnitude of an effect lies. The width of the confidence interval shows the effect of sample size on the result. Wide confidence intervals show greater variability in a sample, which can be as a result of small samples. The narrower the confidence interval, the greater the likelihood a result is due to the effect, and not sample size. The confidence intervals (CI) reported in these data are 90 per cent upper and lower limits. So nine times out of 10, the result will lie in the range presented.

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23 The median value cuts the distribution in half and is independent of the skewness of the distribution.

24 All studies that use numbers assume there is no relationship between variables unless an effect can be proved. Sometimes, a variable appears to cause an effect, but in reality it does not cause the effect; instead, another characteristic of the numbers causes the effect; this other characteristic of numbers is called chance.

25 The technical term for this event is a type 1 error and it is written as α=0.10. A type one error comes about when a sample (some ABE aircraft owners) drawn from a population of people (all ABE aircraft owners) does not represent the true situation in the population.

Odds ratios

An odds ratio presents the proportion of people with a variable of interest present to those where the variable is absent. This study uses crude odds ratios to calculate the magnitude of association.[26] For example, the proportion of people who do transition training by those who do not do transition training for high performance aircraft. Using the transition training and aircraft performance example, if the proportion of people who perform transition and own a high performance aircraft is greater among those owning lower performance aircraft, the odds ratio is greater than one. A 50 per cent increase in the odds of performing transition training is represented as one-point-five (1.5) and a 100 per cent increase is represented as two (2). If the proportion of people who do transition training is equal, then the odds are one (1), but if people who have high performance aircraft are less likely to perform transition training, the odds are less than 1, such as zero-point-five (0.5) (Table 2).

If several categories are compared, the odds of an event can be calculated for each category. This is usually performed by choosing a reference category, and then comparing each category to the reference category. The choice of category in this report is based on experience, or type of licence, given that there is a linear relationship or a series of steps that precede the next category.

Table 2: How to interpret odds ratios

Odds ratio	Interpretation	Likelihood
Equal to 1	Odds are no different	Same
Greater than 1	Odds are increased	More likely
Less than 1	Odds are decreased	Less likely

26 This is a simple proportion. An odds ratio can also be calculated using a regression equation, but these are not used in this report.

3 RESULTS AND DISCUSSION

This chapter of the report is organised in the following way:

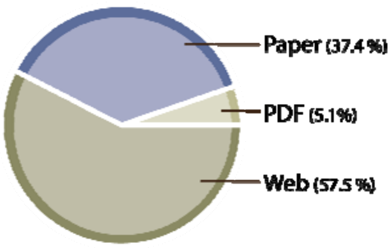
- details of the surveys received
- respondents, their pilot experience, and general characteristics
- type of aircraft and certificate
- reason for purchase
- build process and modifications
- test flights
- second-hand and cost
- maintenance.

3.1 Survey details

Number of responses by source

The number of valid surveys received by the Australian Transport Safety Bureau (ATSB) is shown in Figure 14. Over half of all surveys were web-based (203 of 353, or 57.5 per cent), 132 of 353 (37.4 per cent) were ATSB paper surveys returned by mail, and 18 of 353 (5.1 per cent) were printed Portable Document Files (PDF) surveys sent the ATSB by mail.

Figure 14: Survey by source



Time to complete

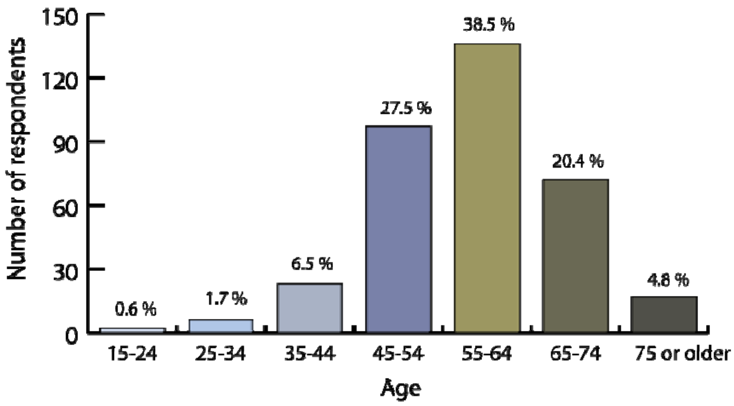
The time taken to complete the survey was recorded for 341 of 353 responses. The mean time to complete was 18 minutes, and median was 15 minutes. Most people completed the survey within 30 minutes, but a small number of people took over 1 hour. The survey took longer to complete than the time suggested in the introductory letter attached to the survey; this was 10 minutes.

3.2 Respondents

3.2.1 Age

The ABE aircraft owner age is recorded in Figure 15. This shows that age was skewed to the left with the tail of respondents in the younger age bracket, and the majority of people in the older age brackets on the right of the distribution[27]. By comparison with a survey of amateur builders in 1958 in the US (Whittier, 1958), the majority of people were much older.

Figure 15: Age of ABE aircraft owners[28]



3.2.2 Type of pilot licence

Pilot licence data were collected on the highest and current licence held by the respondent (Figure 16 and Figure 17). Three-hundred and fifty-two respondents answered these questions[29], and the majority held a private pilot licence (PPL). In relation to the highest pilot licence, a greater proportion of pilots held commercial (CPL) or air transport (ATPL) licences in the past (Figure 16), but they no longer exercise those privileges (Figure 17). For ATPL holders, this represents a drop from 31 to 13 respondents (8.8 per cent to 3.7 per cent), and for CPL, a drop from 46 to 19 respondents (13.1 per cent to 5.4 per cent). These trends mirror normal transitions that take place in the pilot population.

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27 Data were collected in categories rather than as a ratio measurement, therefore, it is not possible to report mean and median ages.

28 Percentages used in this report may not add up to 100 per cent exactly because of rounding.

29 One respondent did not answer this question, and it is unclear if the person held a pilot’s licence.

Figure 16: Highest pilot licence ever obtained

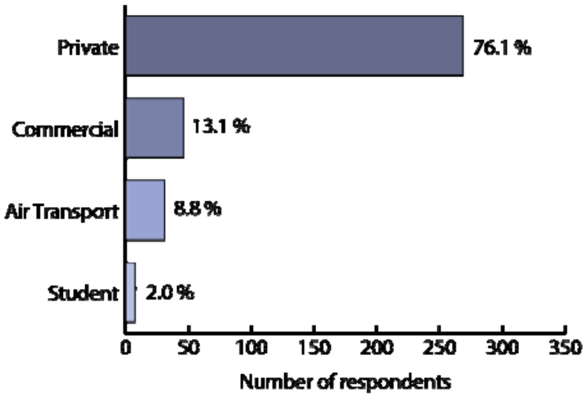
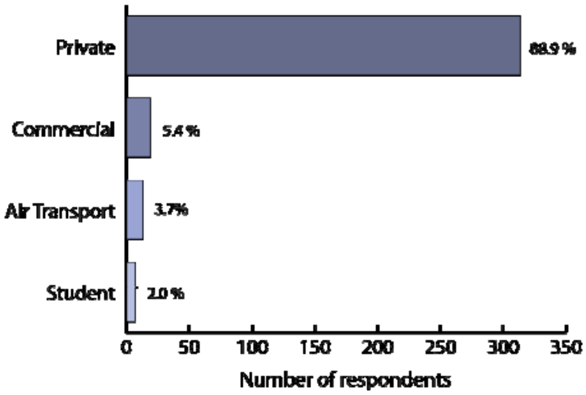


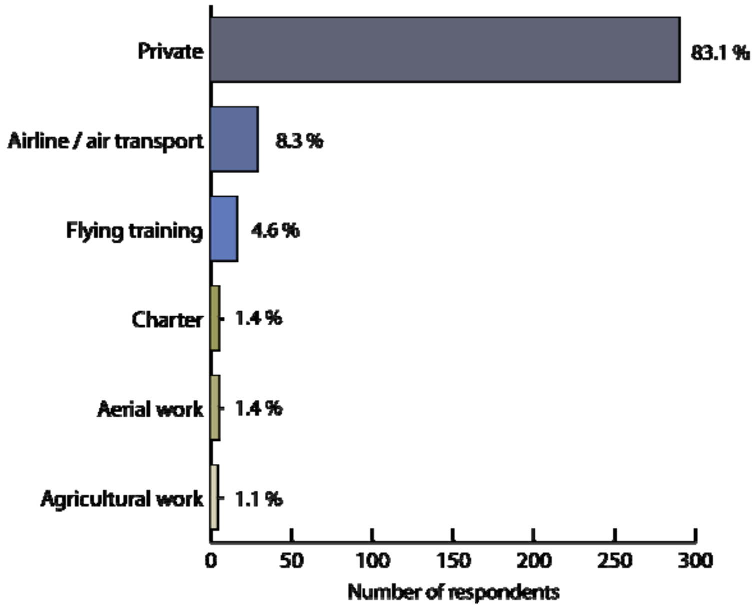
Figure 17: Current pilot licence



3.2.3 Flying background

The type of flying where ABE pilots accumulated the majority of their flying hours is recorded in Figure 18 for 349 of 353 respondents. As expected, this shows that most respondents accumulated their hours in private flying (290 of 349, 83 per cent). Of note, although the numbers of respondents in other categories of flying were small, they covered a wide range of flying activities.

Figure 18: Type of flying performed



3.2.4 Total pilot hours

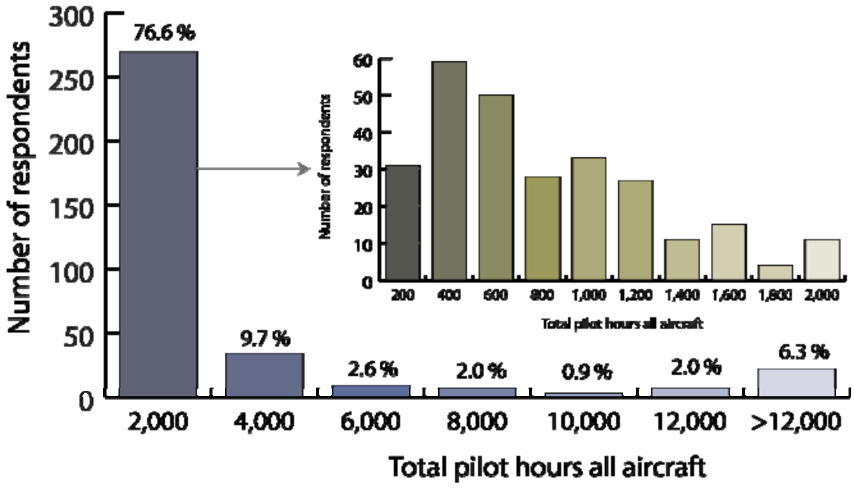
The Civil Aviation Safety Authority (CASA) requires pilots to be recent by performing three takeoffs and landings in a given 90-day period. While total flying hours provides one picture of experience, it does not necessarily show a person is 'up-to-date', so pilot hours in the last year were collected. Both sets of data are presented in the following sections. It is also useful to understand whether ABE pilots are similar or different to other pilots with the same type of licence or operating sector. For comparison, ABE pilot hours were compared to data from other ATSB pilot surveys.

Total pilot hours in all aircraft

Three-hundred and fifty-one of 353 pilots recorded total hours in all types of aircraft (Figure 19). Respondents who flew ABE aircraft had a mean of 2,547 hours flying experience on all aircraft and a median of 865 hours, with a range of 27,998 hours. The pilot hours frequency distribution was very skewed to the right (has a tail to the right of the graph). That is, about 75 per cent of respondents had 2,000 hours or less total flying experience, and a few had very high hours, such as ATPL pilots. In relation to total pilot hours, pilots buying second-hand ABE aircraft were no different to those who built them.[30]

[30] Kuskal-Wallis $\chi^2 = 1.33$, $p = 0.24$

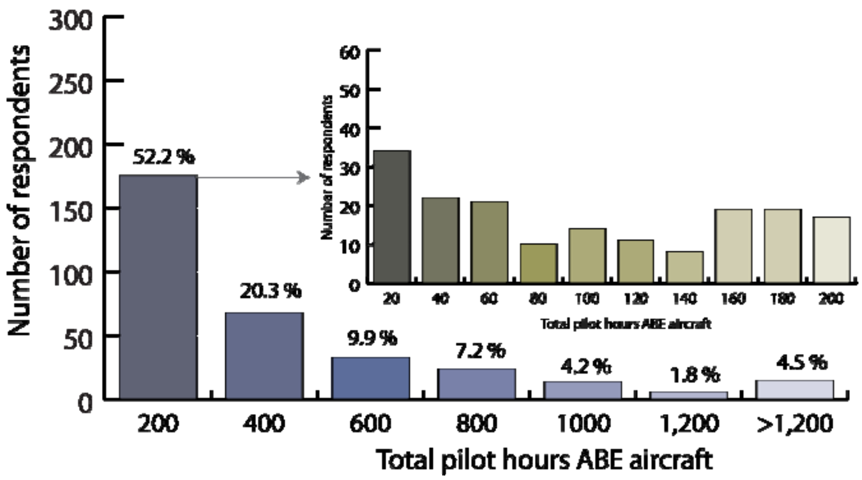
Figure 19: Total pilot hours in all types of aircraft



Total pilot hours in ABE aircraft

The total number of pilot hours in ABE aircraft is recorded in Figure 20. Three-hundred and thirty-five respondents recorded total ABE hours. Figure 20 shows that the 90 per cent of respondents had less than or equal to 850 hours, while all respondents had a mean of 350 hours, a median of 200 hours, and a range of 4,883 hours. The shape of the distribution for ABE pilot hours is similar to that for hours on all types of aircraft.

Figure 20: Total pilot hours in ABE aircraft



Six respondents had flown only ABE aircraft[31]. The total flying hours of these six respondents ranged from 150 to 1,400 hours. Among respondents who had flown other aircraft, about 34 per cent of total flying hours were performed in ABE aircraft, with the range being 1 per cent to 99 per cent. This observation is consistent with the fact that pilots building ABE aircraft come from the general aviation industry.

[31] There was no further information in the survey to explain why these respondents had only flown ABE aircraft. The most likely reason was that those respondents either built or owned an aircraft with fully functioning dual controls or that they had permission from CASA to learn to fly in their own aircraft.

Three survey respondents reported flying zero hours in total on ABE aircraft, even though the aircraft airframe recorded some hours over the previous year. The reasons for this observation are different. One respondent bought the aircraft second-hand, and this suggests that another pilot flew the aircraft. This situation may arise where maintenance is performed on the aircraft after purchase, or alternatively, the aircraft is bought to support the functions of a business such as a cattle station, where the aircraft might be used to check fences on property boundaries; however, the respondent in question did not provide further information on why this was the case. Another respondent with zero ABE pilot hours arranged to have another pilot perform flight testing. The aircraft was still in initial flight testing when the survey was completed, and the builder would not have flown the aircraft.

3.2.5 Pilot hours in the last year

Pilot hours in all aircraft over the last year

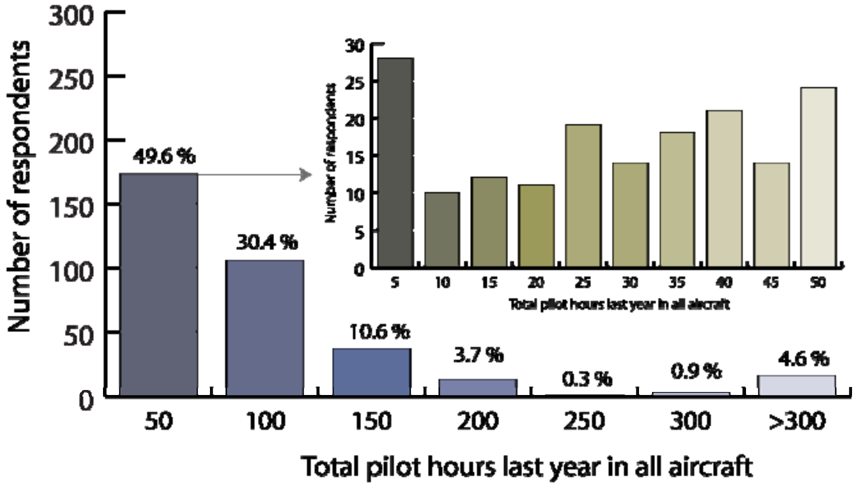
Data on pilot hours in all aircraft over the last year is recorded in Figure 21. The mean number of hours flown in all aircraft by respondents who owned ABE aircraft was 84, the median 51 and the range 840. Ninety per cent of people flew 147 hours or less in the previous year. These statistics include hours from pilots with various licences and they represent a combined picture of ABE pilot aviation.

In 2003, the ATSB studied CPL and ATPL pilot hours in the previous 12 months as part of the *Aviation Safety Survey – Safety Climate Factors* (ATSB, 2003). These pilots were employed in GA and RPT operations. Eight-hundred and eighty-nine pilots answered the 2003 survey. This showed that pilots reported flying a mean of 464 hours, median of 500 hours, with a range of 995 hours. About 60 per cent of pilots in the survey were mostly from GA (N=543), excluding private pilots which were analysed separately, and the remainder were from RPT. ABE aircraft owners in this survey flew substantially less hours than these pilots. If RPT pilots are removed from the survey, the figures drop to a mean of 359 hours, a median of 350 hours, and a range of 995.

Three-hundred private pilots answered the 2003 survey and their number of hours flown in the previous 12 months was lower than those from ABE survey. The mean number of hours flown in the last year by the 2003 survey respondents was 68 hours, with a median of 37 hours and a range of 1,999. Ninety per cent of pilots flew 125 hours or less in the last year. If air transport pilots were removed from the ABE survey data, the mean number of hours in the last year is 65, with a median of 50 and a range of 700.

Flying hours in the last year provides some evidence that ABE pilots, in general, are more like other private pilots, than RPT and GA pilots engaged in charter, aerial work and agricultural work. They do, however, fly about 15 hours more per year than private pilots as evidenced in the 2003 ATSB survey data, using the median value for comparison. Air transport pilots influence the general distribution of ABE aircraft pilot hours.

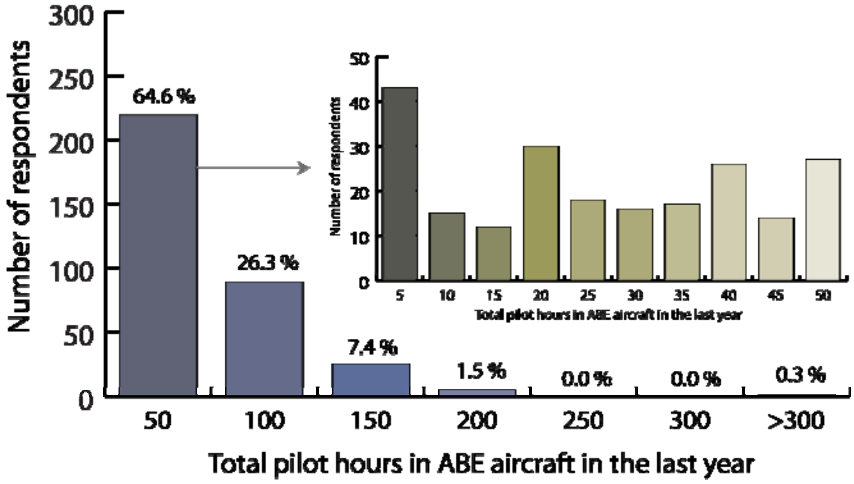
Figure 21: Total pilot hours in all aircraft in the last year



Pilot hours in ABE aircraft over the last year

Data on pilot hours in ABE aircraft over the last year is recorded in Figure 22. This follows a similar frequency distribution to total pilot hours; however, more people flew fewer hours in ABE aircraft. This is expected as not everyone is flying ABE aircraft during the year. The mean number of hours flown in an ABE aircraft in the last year was 47, the median 40 and the range 315. Ninety per cent of respondents flew 100 hours or less per year in ABE aircraft. Comparing all aircraft hours and ABE hours in the last year, the lower median value for ABE aircraft suggests that CPL and ATPL pilots owning ABE aircraft distort the total aircraft hours data.

Figure 22: Total pilot hours in ABE aircraft in the last year

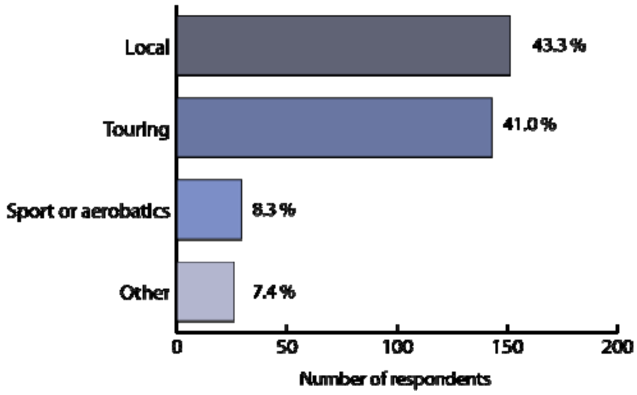


Twenty-one respondents reported flying zero hours over the last year on ABE aircraft. A number of possible scenarios account for this observation. Respondents may have been busy or unwell and unable to fly, or the aircraft may not have been serviceable. Remarks made by aircraft owners when completing the General Aviation Activity Survey support this notion (Bureau of Infrastructure, Transport and Regional Economics, 2007).

3.2.6 Type of flying performed in ABE aircraft

The type of flying the pilot performed in ABE aircraft is recorded in Figure 23. The majority of ABE pilots either flew locally or performed touring (about 40 per cent each). Close to 10 per cent performed sports or aerobatics, and about seven per cent performed other types of flying. The *other* category included combinations of local, touring, aerobatics, or business (such as aircraft flying to bush medical clinics), and commuting.

Figure 23: Type of flying performed in ABE aircraft



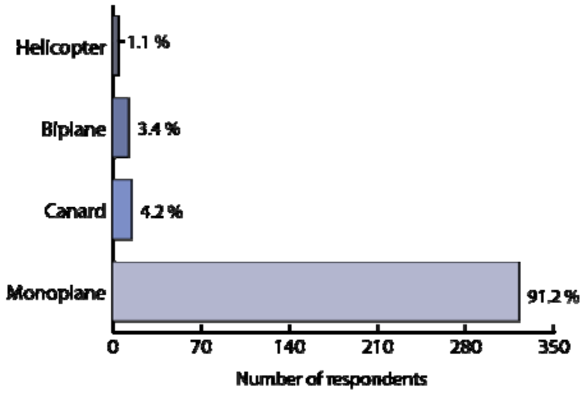
3.3 Aircraft

3.3.1 Aircraft types and models

Aircraft type

As can be seen in Figure 24, the vast majority of aircraft referred to in this survey were fixed-wing monoplanes (91 per cent). A small number of aircraft were canard designs, with Rutan, Quickie and Viking aircraft being examples of this category of aircraft on the VH- register. With a canard aircraft, the tailplane is ahead of the main wing. Only one per cent of respondents owned helicopters.

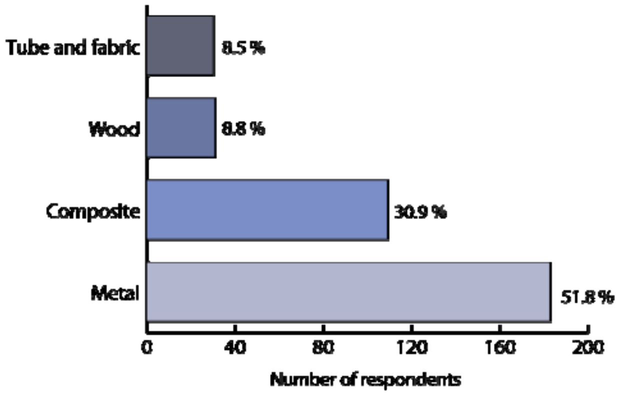
Figure 24: Type of aircraft



Type of aircraft structure

The type of aircraft structure is found in Figure 25. This shows that metal and composite structures are the most popular, with tube and fabric and wood being less popular. Originally, all aircraft were made from wood, with a few metal components. As time has progressed, steel tubing replaced wood, and from the 1930s onwards, all-metal aircraft began to replace wood, tube and fabric aircraft. Amateur builders started by building wooden aircraft, and in the case of the Millicer Airtourer, this was converted to a metal design and put into production. Composite amateur-built aircraft began appearing in the late 1970s. People who build wooden aircraft have encountered challenges finding licensed aircraft maintenance engineers (LAME) with the correct skills to perform work on their aircraft. One person in this survey said it is 'hard to find anyone with wood and fabric aircraft licences....'

Figure 25: Type of aircraft structure



Aircraft model

Respondents to this survey built aircraft from 63 different manufacturers or designers, and 109 different models. The aircraft have been chosen from designs originating mainly in the United States (US), but also in France, Great Britain, Italy, and a number of other countries, including Australia. A wide variety of aircraft are represented in these data, including aircraft with limited numbers on the VH-register. They represent designs that range from pre World War II through to the current period. As per the discussion in Section 2.4.2, aircraft are tabled where there are sufficient numbers on the register to maintain the confidentiality of the respondent.

Table 3 records aircraft where five or more people with the same aircraft responded to the survey. The aircraft in this table account for about 65 per cent of all respondents to the survey (228 of 353). Note that this table represents the most recently completed aircraft for builders of multiple aircraft.

Owners of Van Grunsven (Van's) aircraft (an example of which can be seen in Figure 26) completed the most surveys, followed by Jabiru (Figure 27) and Glasair (Figure 28) aircraft owners. Corby and Supermarine aircraft are of Australian origin, while the rest of the aircraft are from the US. On a smaller scale, this table roughly corresponds to the count of these aircraft on the CASA register. It is worth noting that Table 3 represents a 2007 snapshot of aircraft by model; a snapshot from the 1980s would have shown more Corby Starlets and Jodel aircraft, many of which have transitioned to the RA-Aus register.

Table 3: Aircraft by model where at least five people responded

Aircraft	Model	Total
Bushby	Mustang series	8
Corby	CJ-1 Starlet	8
Glasair	GlaStar	6
Glasair	Glasair II	13
Jabiru	Jabiru J-400	12
Jabiru	Jabiru J-430	10
Jodel	Jodel 100 series	5
Lancair	Lancair 320	5
Lancair	Lancair 360	5
Progressive Aerodyne	SeaRey	6
Rand	KR-2 Robinson	8
Supermarine	Spitfire	5
Thorp	T-18 Tiger series	13
Van's	Van's RV-4	19
Van's	Van's RV-6	38
Van's	Van's RV-6A	28
Van's	Van's RV-7	10
Van's	Van's RV-7A	18
Van's	Van's RV-8	6
Van's	Van's RV-9 series	5
Total		**228**

Figure 26: A Van's RV-7 aircraft

Figure 27: A Jabiru J430 aircraft

Source: Phil Vabre

Figure 28: A Glasair IIS-RG aircraft

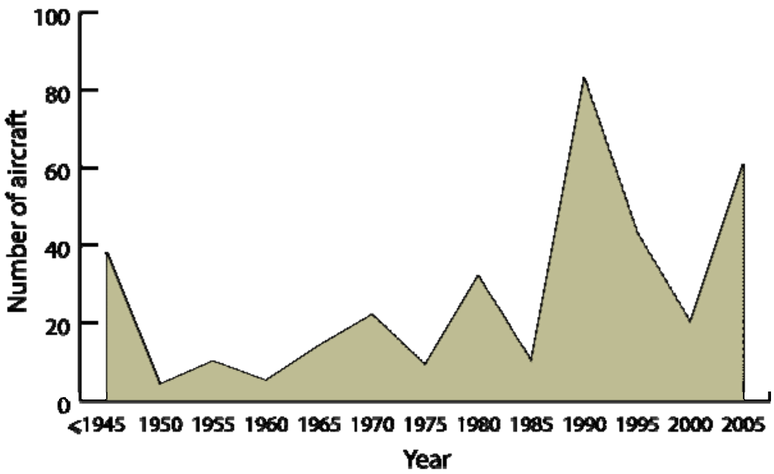
Source: Neville Murphy

These aircraft are tricycle retractable, tail wheel, and fixed tricycle undercarriage varieties, along with amphibious and replica aircraft. The aircraft also represent a wide performance range. People choose a variety of different features when building or buying their aircraft, and it is to these matters that this report now turns.

Year of design

The year of design, as derived from the model name, is recorded in Figure 29. This shows that a large number of ABE aircraft designs owned by respondents were older than 40 years. Designs have been introduced in certain years, and the exact reason for this remains unclear. It may reflect periods of economic growth, or opening of a gap in the ABE aircraft market for a new design. Pattillo (1998) suggests that an entrepreneurial spirit and war drives changes in GA aircraft rather than the market in general.

Figure 29: Year of aircraft design

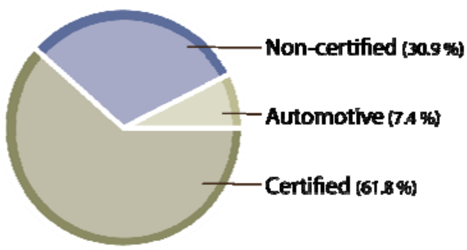


3.3.2 Aircraft components

Type of engine

Respondents chose three different types of engines when purchasing an ABE aircraft; these were certified aircraft engines, non-certified aircraft engines, and automotive engines. The type of engine in this survey is recorded in Figure 30. This shows that the majority of aircraft had certified aircraft engines. Details about the engine were not requested, and it is not known if the engine installed into the aircraft was second-hand.

Figure 30: Type of aircraft engine



A certified aircraft engine is one that meets the requirements of the Federal Aviation Regulations (FAR) Part 33, or their equivalent. The engine is purchased as a complete product and installed into the aircraft. Historically, the major manufacturers for certified engines were Textron-Lycoming and Teledyne-Continental, with more recent entrants into this arena including Bombardier-Rotax and Jabiru.

A non-certified engine is one that is made by the builder, manufacturer, or a third party from new or used certified engine parts but, as a whole, the engine does not meet FAR Part 33 or equivalent certification requirements. For example, Superior Aircraft Engines use new Federal Aviation Administration (FAA)-certified parts to build entire engines. It is worth noting that Textron-Lycoming, Teledyne-Continental, and Bombardier-Rotax also produce non-certified aircraft engines. Another type of company that has emerged in the non-certified aircraft engine space is the parts supplier such as ECi (ECi.aero, 2009). They provide parts that can be assembled by the amateur-builder, or alternatively by a third party. Traditionally, these engines are significantly cheaper than certified aircraft engines.

The final alternative is to convert an automotive engine for use with an ABE aircraft. This involves using a reduction drive (usually 2:1) to match the engine horsepower curve with the efficiency curve of the propeller (Wanttaja, 2006c). Common examples used in Australian ABE aircraft are the four-cylinder Volkswagen and Subaru engines, six cylinder Isuzu engines, and eight cylinder Chevrolet and Ford engines. Less common Australian aircraft engines include those made by Mazda, Leyland, Honda, and Nissan (CASA, 2008). Generally, automotive engines are heavier than aircraft engines as measured by the horsepower generated per kilogram of engine weight. This is generally due to the weight of the crankshaft in automotive engines (Yager, 1974). Additionally, because automotive engines are generally water cooled, builders face some challenges keeping them cool (Farnham, 2005).

The CASA VH- register shows a range of aircraft engines for ABE aircraft, from the Simonini engine in the Stipa Caproni (shown in Figure 31) through to a jet-powered Grumman Panther replica. Of the 1,007 Australian built aircraft that could be identified as amateur-built fixed-wing or rotary-wing powered aircraft on the VH- register in October of 2008, 523 were from Textron-Lycoming, 102 were from Jabiru, 82 Teledyne-Continental, 73 Bombardier-Rotax, and 52 from Rotorway International. Altogether, these engine manufacturers made up around 83 per cent of all ABE aircraft engines on the VH- register. The VH- register does not distinguish between certified and non-certified aircraft engines, but does differentiate automotive engines from aircraft engines. If the majority of engines by Textron-Lycoming and Teledyne-Continental are certified engines, then the proportions in this survey and those on the VH- register are similar.

Figure 31: Stipa Caproni

Source: Falco Builders Newsletter December 2001

The technology in ABE aircraft engines largely reflects engineering principles from the pre World War II era. They tend to be favoured by ABE aircraft owners and builders because they are a known and tested quantity, not necessarily because they are as efficient as modern engines (Wanttaja, 2006c).

Some people in the survey commented on their experiences with engines. One person said:

> I fitted an auto conversion and this was not successful. I am replacing the engine with a Lycoming. The moral is aircraft should have aircraft engines.

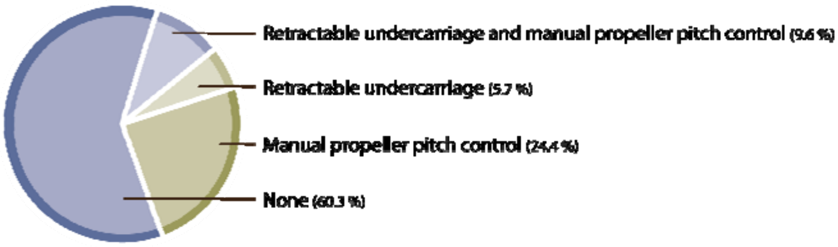
In order to get a better climb rate, one respondent changed to a radial engine, while another respondent talked about getting assistance with automotive conversion.

Advanced aircraft features

Aircraft with a manual propeller pitch control (MPP)[32] or retractable undercarriage are considered more complex aircraft, and they require licence endorsements. This question was a multiple response question; 387 responses were received. The proportion of respondents who reported their aircraft had one or more advanced features is shown in Figure 32. This shows that the majority, about 60 per cent of aircraft in the survey, did not have complex features.

Of the 40 per cent that were complex aircraft, the manual propeller pitch control was the most frequently cited characteristic (34 per cent), while about 15 per cent had a retractable undercarriage. Nearly 10 per cent had both a manual propeller pitch control and retractable undercarriage.

Figure 32: Complex aircraft by aircraft characteristic



A retractable undercarriage can be a challenge to build because of multiple linkages and hydraulics, but it offers better aircraft performance and less drag in the air when compared with a fixed tricycle undercarriage. One challenge associated with retractable undercarriages is when the pilot receives a warning that the undercarriage has not properly extended or only partially retracted. In this circumstance a pilot must manually lower or retract the landing gear, seek confirmation from a person on the ground as to whether the gear is down, or possibly land with the gear in the up position. A manual propeller pitch control allows the pilot flexibility to maintain an optimal angle of attack on the propeller as aircraft speed varies (Kumar, 2005). Under CAO 40.1.0, special design feature

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32 A manual propeller pitch control refers to a controllable pitch propeller as opposed to a fixed pitch propeller. They are also referred to as variable pitch propellers (VPP) or constant speed unit (CSU). The survey used the term 'manual propeller pitch control'.

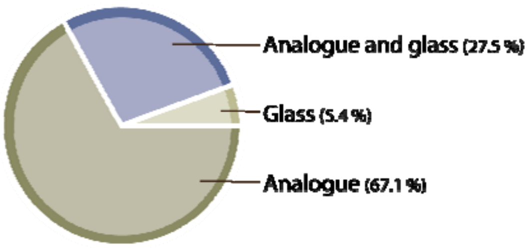
endorsements are required for manual propeller pitch control and retractable undercarriage.

This survey did not ask if ABE aircraft were single or twin-engine. Twin and turboprop aircraft are considered complex aircraft under CAO 40.1.0, and they require special endorsements. Several amateur-built aircraft require individual endorsements; these are the Cri-Cri Criquet (twin-engine), Rutan Defiant (twin-engine), Leza Air-Cam (twin-engine) and Lancair (turboprop).

Type of cockpit instruments

Figure 33 records the type of instruments used in ABE aircraft. The majority of aircraft in this survey used analogue instruments (237 of 353). About a quarter of aircraft combined analogue and glass instruments (97 of 353), while a small number (about 5 per cent) were glass instruments only (19 of 353).

Figure 33: Type of instrumentation



Psychologists have extensively studied the relationship between humans and aircraft instruments. Patterns for scanning instruments are taught to pilots during training. Glass cockpits offer some advantages in terms of minimising eye movement while scanning instruments. If power is lost, analogue instruments will work independently of the power source. It is interesting to note that although builders of and owners of ABE can take advantage of newer technology, only some from this survey chose to do so.

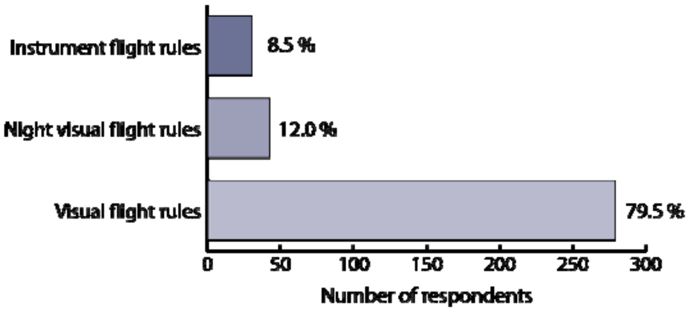
Aircraft built and operated under Amateur Built Aircraft Approval were more likely to be equipped with analogue instruments than experimental aircraft (Odds ratio 2.78, CI 1.57 to 4.91, $\chi^2 = 9.2$, $p < 0.01$). Sixteen per cent of respondents had an aircraft that was built under ABAA and moved to the experimental category. These respondents did not seem to update aircraft instruments when they shifted between categories ($\chi^2 = 0.01$, $p = 0.92$). Combination glass and analogue cockpits were more likely among aircraft built and operated in the experimental category ($\chi^2 = 3.8$, $p = 0.05$).

Older aircraft were more likely to have analogue instruments (Kruskal-Wallis $\chi^2 = 11.6$, $p < 0.01$). This is understandable given that glass instruments may not have been available when the aircraft was made.

Flight rules

The different flight rules that the respondents ABE aircraft were equipped to operate under are recorded in Figure 34. This shows that the majority of ABE aircraft were only equipped to operate under visual flight rules (VFR).

Figure 34: Aircraft flight rules



Civil Aviation Order 20.18 sets out the instrument requirements for the three different types of aircraft flight rules. Visual flight rules (VFR) operations require an airspeed indicator, an altimeter, a magnetic compass, and an accurate timepiece. For night VFR flight rules, a turn and slip coordinator is also required, in addition to the requirements for VFR.

Figure 35: Instrument flight panel of a Van's RV-8 under construction

Aircraft operated under IFR must be equipped with all the VFR and night VFR requirements plus a number of additional instruments including:

- an attitude indicator (artificial horizon)
- a heading indicator (directional gyroscope)
- an outside air temperature indicator
- a way of determining that power is being supplied to the gyro instruments
- instrument lighting
- some sort of anti-icing/condensation system for the airspeed indicator.

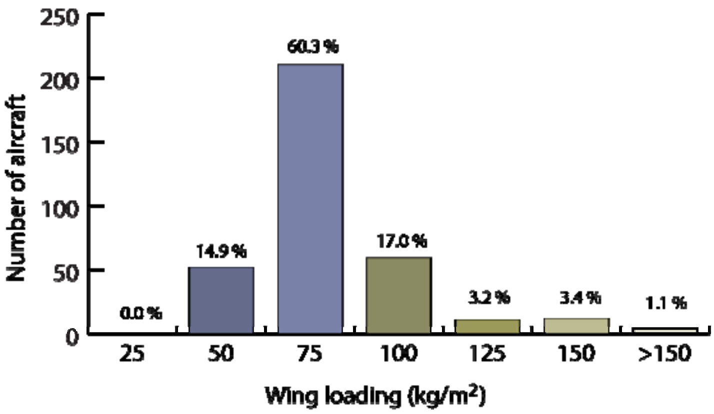
All the instruments require dual power supplies, unless the turn and slip must coordinator has a power supply independent of the other gyro instruments.

Wing loading and stall speed

Wing loading is an important measure of aircraft performance. As aircraft weight increases for a given wing area, wing loading and stall speed increase. A lower wing loading corresponds to a lower minimum velocity at which level flight is possible. Wing loading is the maximum weight of the aircraft divided by the area of the wing measured in kilograms per metres squared (kg/m^2) or pounds per square feet (lb/sq ft).

Figure 36 records wing loading values, derived from the manufacturer and model data, for 348 of 353 ABE aircraft surveyed. Wing loading is continuous data, graphically represented in categories; for example the number 50 represents all values between 26 and 50. This shows a minimum wing loading of 30 kg/m^2 and a maximum of 159 kg/m^2. Ninety per cent of aircraft in this survey had a wing loading of less than 92 kg/m^2, with the mean value being 72 kg/m^2, and the median value 71 kg/m^2. The distribution of values in Figure 36 is skewed to the right (having less values in the higher wing loading range). Aircraft with a low wing loading generally have short take-off and landing (STOL) characteristics.

Figure 36: Wing loading



Although there were some aircraft with high wing loadings, the majority of ABE aircraft had a similar wing loading to certified production aircraft. For example, a standard Cessna 172 Skyhawk has a wing loading of 64 kg/m^2, while a Piper PA-28 Cherokee has a wing loading of 70 kg/m^2. Of the top 10 certified aircraft on the CASA register with a similar type of aircraft configuration, Cirrus SR20 model aircraft have one of the highest wing loadings at 104 kg/m^2 and the Cessna 210 Centurion has a wing loading of 105 kg/m^2.

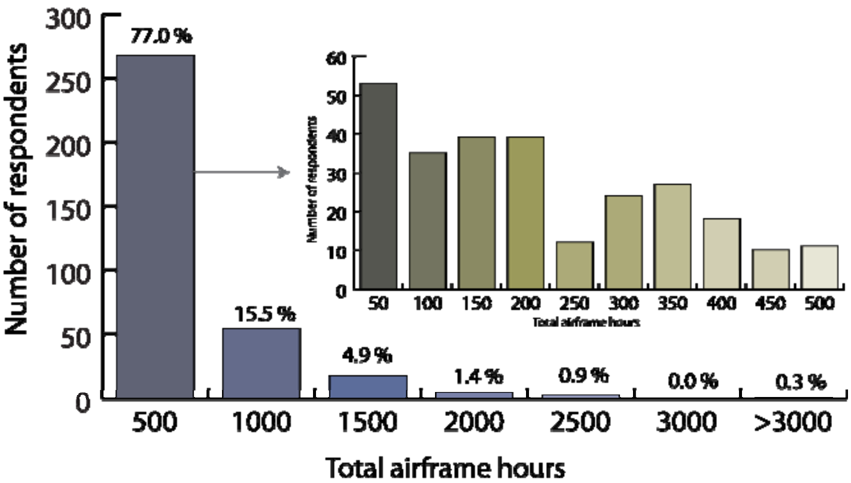
There are two different standards for wing loading in Australian ABE aircraft. In the Experimental Category (CASR 21.191), wing loading requirements are not specified, but the aircraft must be capable of flight. Amateur Built Aircraft Approval aircraft are required to conform to one of two different design standards where there is no acceptable data on stall speed; one standard for aircraft with a certified aircraft engine (61 kts), and another for non-certified engines (55 kts).

Examples of STOL ABE aircraft on the VH- register are the Zenith CH-701, ICP Savannah and Hornet Ag. A Van's RV-6, the most common ABE aircraft on the VH- register, has a wing loading of 71 kg/m^2. Aircraft with higher wing loadings are different models of Glasair, Lancair, and some canard aircraft. Historically, wing loading in Australian ABE aircraft has increased, with the desire to place larger horsepower engines in aircraft; this in turn increases the weight and therefore the wing loading. In this instance, an increase in wing loading is a trade-off for aircraft performance.

Airframe hours in total

Total airframe hours are a useful exposure measure that can be used by researchers, aircraft builders and owners, manufacturers, and regulators to inform analyses of life of type, failures, and accidents. Aircraft hours in the last year are recorded separately from pilot hours because someone other than the owner may fly the aircraft, or it may be owned by more than one person. Three-hundred and forty-eight respondents reported total airframe time. The mean of total airframe hours was 362 and the median was 236, with a range of 3,537 hours. About 12 per cent of respondents (43 of 348) recorded total airframe time of 40 hours or less. This indicates they were operating in the test flight phase, or had just completed the test flight phase.[33] To evaluate total airframe time outside the test flight phase, the investigation team selected aircraft with more than 40 hours. The mean of total airframe hours for aircraft with greater than 40 hours was 410 and the median was 294 with a range of 3,496 hours. Ninety-five per cent of aircraft with more than 40 hours total airframe time had airframe times of 1,200 hours or less.

Figure 37: Airframe hours in total



The type of flying influenced airframe times and this was statistically significant ($\chi^2 = 6.44$, $p = 0.09$). Touring and sports or aerobatic activities recorded the highest median airframe hours. Aircraft cycles in a given time period is beyond the scope of this report.

33 In the experimental category, at least 25 hours are required for a certified aircraft engine, and 40 hours for a non-certified engine. The test flight period can be longer, and depends on other changes made during construction.

Table 4: Type of flying and total airframe hours

Type of flying	N	Mean	Median	Range
Local	148	305	197	2,175
Touring	142	398	297	3,536
Sports or aerobatics	29	424	285	2,179
Other[34]	25	429	200	1,597
Total all types of flying	344	364	243	3,537

Statistically significant Kruskal-Wallis $\chi^2 = 6.44$, $p < 0.10$.

Certified total airframe hours are not readily available to compare with ABE data. Some ATSB[35] incident and accident investigations recorded airframe hours, but this data does not present a complete picture of the population of aircraft operating, only the characteristics of those having accidents. Nonetheless, it provides a useful comparison measure.

In the ATSB electronic occurrence records between 1978 and 2006, there are 42 occurrences (mainly accidents) that recorded total airframe hours for ABE aircraft. These show total airframe times that are lower than records in this report with a mean of 267 hours, a median of 156, and a range is 1,597 hours. Ninety-five per cent of records had less than 847 hours.

A similar set of records for single engine certified aircraft between 1978 and 2006 shows there are 148 VH- registered occurrences (mostly accidents) recording total airframe hours in the private operational group. By comparison with ABE records, they show much larger airframe times with a mean of 3,592, a median of 2,980, and a range of 15,786 hours. Ninety-five per cent of occurrence aircraft had total airframe hours of less than or equal to 8,520. More importantly, only 10 per cent had total airframe times of 286 hours or less. For the purposes of comparison, some of the larger regular public transport aircraft in the ATSB occurrence data between 1993 and 2006 had total airframe times of up to 53,400 hours, while the Boeing 767 aircraft in the Ansett investigation (ATSB, 2002) had between 48,241 and 58,894 total airframe hours.

Airframe hours in the last year

The survey requested airframe hours in the last year and total airframe hours in order to develop a picture of recent ABE activity. Three-hundred and forty-nine respondents recorded airframe hours in the last year (Figure 38).

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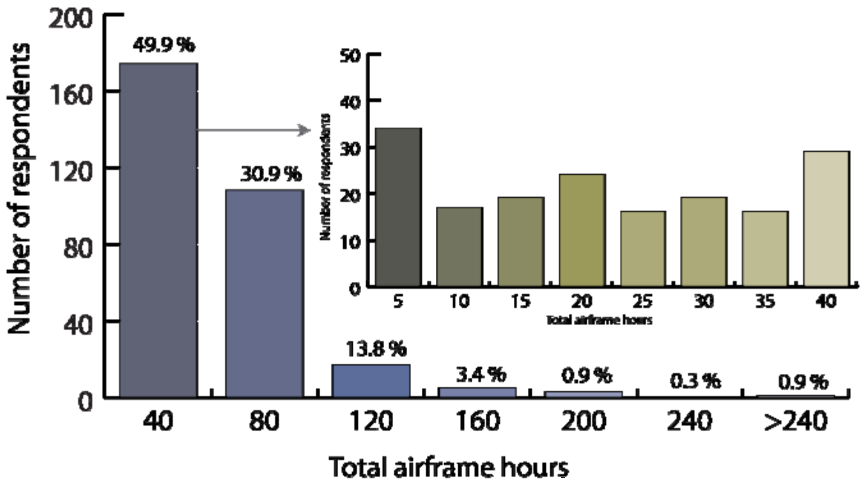
34 This is a category combining people who perform all three types of flying - local, touring, and sport or aerobatics.

35 Some of these investigations were conducted by the then Bureau of Air Safety Investigation, which became part of the multi-model transport investigation agency, the ATSB, in 1999.

Figure 38: Aircraft airframe hours in the last year



The mean value for hours in the last year was 53 and the median was 42. The highest value recorded was 1,078 hours, and the lowest value was zero. The median value of 42 is the better measure of central tendency for these data because of the outlier data value of 1,078. Seventeen aircraft recorded zero hours[36] for the last year, but all had accumulated more than zero hours over the life of the aircraft in total. Twenty-five aircraft recorded more than zero hours but less than 10 hours, and some of these were in the test flight period.

The respondent recording 1,078 airframe hours in the last year was initially considered spurious, but total pilot hours and pilot hours flown in the last year, along with total aircraft airframe hours make this record possible. These are a substantial number of hours to fly in a year, equating to a little less than three hours a day, or a little over four hours, five days a week. It is usually air transport pilots who perform hours of this magnitude each year. [37] In terms of hours per year, the nearest aircraft recorded 256 hours; this is about a quarter of the 1,078 hours.

This raises a number of questions about the type of flying the respondent with 1,078 hours was performing; the survey records the type of flying as touring. It is possible that this aircraft is performing unapproved charter. From the General Aviation Activity Survey (GAAS) between 1998 and 2004, aircraft performing hours in this range are all certified aircraft engaged in aerial work, charter, flying training or business flying (BITRE, 2009). Larger commercial jets do not generally accumulate more than 3,500 hours in a given year (ATSB, 2002). One possibility is that the aircraft is owned by a group of people, who fly it separately. The type of aircraft cannot be identified for reasons relating to confidentiality, but this data value is an outlier.

In this report, airframe hours in the last year do not correlate with 1970s Australian ABE data. Lalor (1974) suggests that the average number of hours operated per year 'could be as much as 700 hours'. If this is the case, then aircraft are now operating much less hours per year than in the past. These data are, however, consistent with the General Aviation Study (GAS) in 1980; this found amateur-built aircraft rarely exceeded 40 hours per year (Australian Airsport, 1980). It is unlikely

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[36] Initially, the ATSB considered removing these records, but they fit the inclusion criteria and were retained in the dataset.

[37] Air transport pilots are limited to 900 hours per year as per CAO 48.1.

that these figures would drop dramatically over a period of 6 years. The GAS presents hours data in the context of rising air navigation charges, advocating a user-pays system.

In 1974, when the figure of up to 700 hours was cited, amateur-built aircraft in Australia were generally flown locally, with a few notable exceptions[38], and it was not until 1980 that area restrictions were lifted by the Department of Transport (Airsport, 1980). It seems likely that the 40 hours per year figure was closer to aircraft hours operated in 1974. In this survey, there were 150 respondents who recorded they performed local flying, and the mean hours per year was 39, while the median was 33 hours per year. Those respondents who undertook touring (N=142) performed more flying in their aircraft with a mean of 68 hours per year and median of 54. Statistically significant differences in airframe hours travelled in the last year are found in Table 5.

Table 5: Type of flying and aircraft hours per year

Type of flying	N	Mean	Median	Range
Local	150	39	33	250
Touring	142	68	54	1078
Sports or aerobatics	29	52	40	256
Other[39]	25	55	60	167
Total	346	53	42	1078

Statistically significant Kruskal-Wallis $\chi^2 = 27.04$, $p < 0.01$

In summary, significant differences are observed between ABE aircraft total airframe times in this report and accident reports for ATSB records relating to ABE aircraft and single-engine certified aircraft operating in the private category. This report does not analyse these data further, as many records do not record airframe hours.

3.3.3 Operating certificate

Respondents were asked to record the certificate used to build and operate their aircraft. About 65 per cent were from the experimental category, 20 per cent from the ABAA category, and 16 per cent had shifted from ABAA to experimental.

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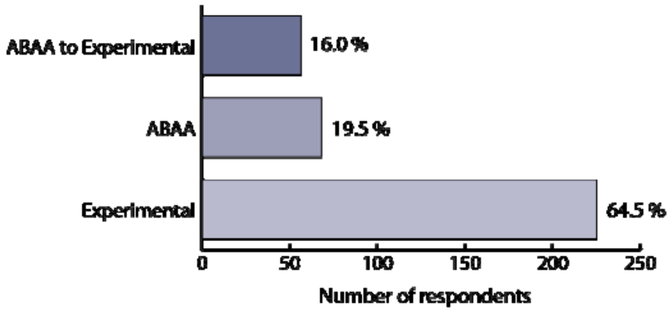
38 Clive Canning flew to England and back in 1976 in a Thorp T-18, narrowly avoiding being shot down by MIG fighters over Syrian airspace (Canning, 1978).

39 This is a category combining people who perform all three types of flying - local, touring, and sport or aerobatics.

Figure 39: Build and operating certificates



3.3.4 Aircraft age and owned time

Survey respondents were asked to record how long they have owned their aircraft. Builders were asked to record the period from the time the aircraft flew, and second hand owners were asked to record the time from purchase. These data are presented as a combined sample and separately. The mean owned time for all respondents was 5.8 years, with a median of 3.9, and a range of 33.9 years (N=351). Overall, 90 per cent of all respondents had owned their aircraft for 13.25 years or less. The mean owned time in years for those who built and flew an ABE aircraft was 6.1 (N=276), with a median of 4.2 years and a range of 32.9. For builders, 90 per cent had owned their aircraft for 13.7 years or less. For second-hand owners, the mean owned time was 4.7 years, with a median of 2.8 and a range of 27.9 (N=79). Ninety per cent of second-hand owners had owned their aircraft for less than or equal to 11 years. Note that some people built and sold an aircraft, then purchased a second-hand aircraft. The owned time data suggests a wide range of builders completed this survey including people who built and flew their aircraft under ABAA shortly after it was promulgated.

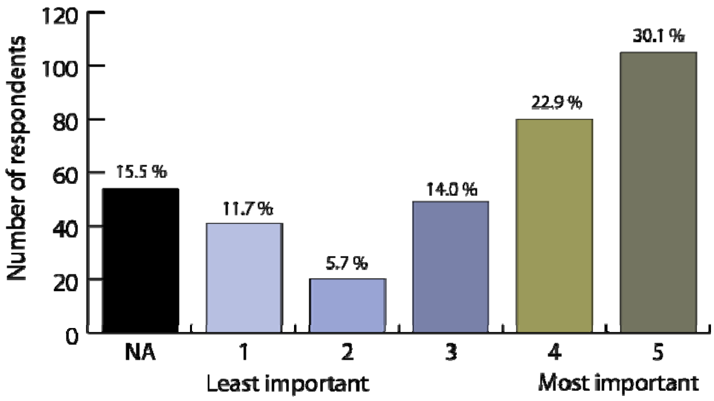
3.4 Reason for purchase

Survey respondents were asked to rate the importance of eight items when purchasing their aircraft, from least important (1) to most important (5). Data are presented both as counts and as a percentage of total responses.

Build challenge

Figure 40 records how important build challenge was to those who purchased an ABE aircraft (N=349). About 66 per cent of respondents rated build challenge as moderately important, very important, or most important. Survey respondents rated build challenge as less important or least important in about 17 per cent of all cases and not applicable in about 15 per cent of all cases. Four of 354 respondents did not answer this question. Combined, about one-third of respondents thought build challenge was either not applicable or not very important. This group of people may be building an ABE aircraft to meet the objective of flying, rather than meeting a need to take on a challenge.

Figure 40: Rating of build challenge



The concept of challenge relates to testing one's own capacity; challenge potentially helps to delineate learning needs, and in turn, develop individual capacity (Neill, 2009). The process of building an aircraft can develop knowledge and skills in a wide range of areas, which include engineering, research, document development, and data collection, interpretation, and evaluation. This process is closely tied to self-education. In some circumstances, people such as engineers, bring skills and knowledge that assist in building an aircraft, whereas in other circumstances, these may need to be developed. Growth in knowledge can occur where build challenge is important to a person, and that challenge is supported with appropriate expertise. This expertise can be sought by the builder, including professional engineers where the relevant knowledge and experience does not cover all aspects of aircraft building. One person responded:

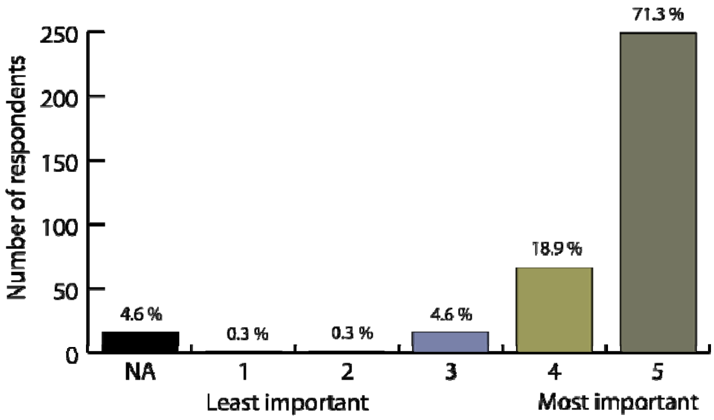
> I am a professional engineer and capable of designing the items required to improve the basic kit (which was of a good standard) to make it more robust and conform to the true look of the [aircraft name]. I sought and got help on things beyond my skill, [such as] automotive engine adaption, avionics and electrical, shaping aluminium cowls and painting. It has been a great education with a very satisfying result.

In this instance, challenges that required assistance led to a process of education. Although this question was directed at build challenge, challenge extends beyond the build process, into flying and aircraft maintenance. One area closely related to build challenge is personal satisfaction, and this is explored in the next section.

Personal satisfaction

Figure 41 records the rating of personal satisfaction as a reason for purchase of an ABE aircraft. This shows personal satisfaction to be very important to most people. Personal satisfaction may come from at least three sources; the ability to fly, a tangible output (for the labour of building), and a social group to share the building and flying experiences. People who rated personal satisfaction as not applicable (NA) tended to rate price, and operating costs as more important. One person who selected NA for personal satisfaction wrote that the aircraft met an amphibious operational need.

Figure 41: Rating of personal satisfaction



In relation to ABE aircraft being a path to social groups, one respondent stated:

> I have been flying amateur-built (ABAA and Experimental) aircraft since [year], and have found them to be economical to operate, easy to maintain and very enjoyable to fly. In addition, I have made many new friends, and now that I have semi-retired, my aircraft is the major means by which I get to explore this great country of ours.

A further comment on how satisfaction with ABE aircraft can occur stated:

> ABE aircraft have given me and continue to give me a great deal of satisfaction both from a building and flying perspective. I find ABE/ABAA aircraft much nicer to fly (granted they are not required to meet the same stability requirements as factory certified aircraft). I work on GA aircraft as a LAME and still feel more passionate toward ABE/ABAA aircraft….

Clearly there are many ways people experience personal satisfaction associated with ABE aircraft, but most rate it as very important in their reason for purchase.

Aircraft performance

The rating of aircraft performance as a reason for purchase is recorded in Figure 42. This shows that aircraft performance is very important to most respondents. Aircraft performance in this context was interpreted as meaning the ability of an aircraft to perform required functions and manoeuvres, along with its stall speed, cruising speed, rate of climb, altitude flight limits, and payloads or flight range (Gunston, 2004; Wanttaja, 2006c). It may also involve the fuel efficiency of the engine. Higher performance aircraft have higher stall speeds and are more challenging to fly, but not all builders want to fly high performance aircraft, and the choice of aircraft may change with time. One person commented on the implications of choosing a high performance aircraft, and the need to develop flying practices that reflect the nature of high performance aircraft by stating:

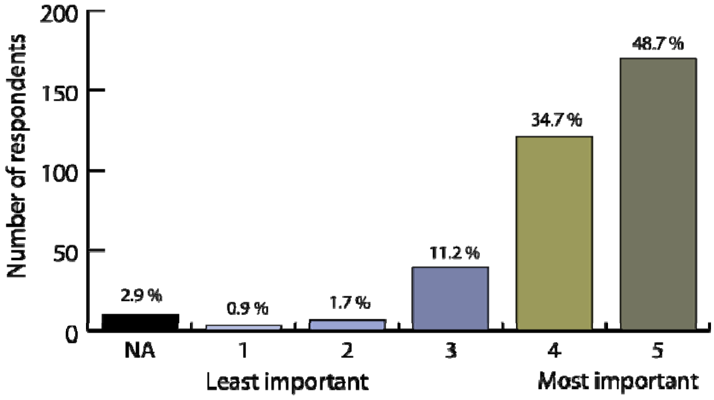
> As my aircraft is a heavily customised complex high performance machine, I was fortunate to have input from [a] LAME, builders, designers, and enthusiasts. The significant lesson I learnt from the successful and safe process is that people who make the most noise don't always have the best information; opinion is a far cry from knowledge. Accepted certified flying practices are not necessarily appropriate for high performance composite aircraft, and just because you haven't hurt yourself yet doesn't mean you are safe.

Another respondent who built a high performance aircraft, but has not flown the aircraft for some years said:

> In retirement, I no longer have need of a fast aircraft and have opted for one of more simple construction with not so high maintenance, for example fixed pitch versus constant prop, fixed versus retractable undercarriage.

Some ABE builders choose aircraft with a wide performance envelope. They perform aerobatics, local flying, touring, or all three flying activities (see Figure 23). Some respondents indicated that having an efficient aircraft has allowed them to see Australia in a way they would not have been able to by other means of transport.

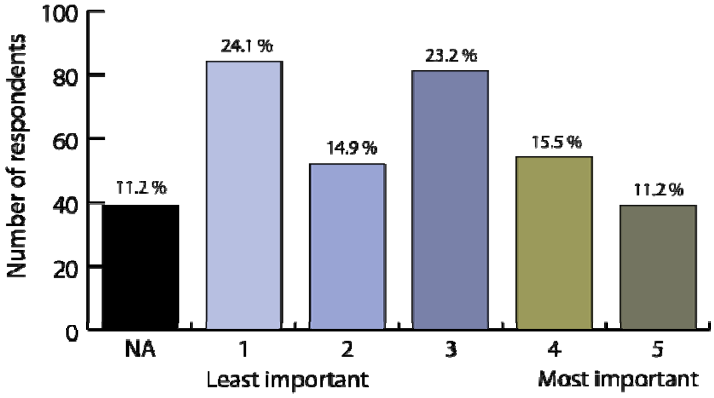
Figure 42: Rating of aircraft performance



Ability to customise

Figure 43 records the rating of ability to customise an aircraft as a reason for purchase. This shows a mixed result by comparison with build challenge, satisfaction, and aircraft performance. About 40 per cent of respondents thought the ability to customise an aircraft was less important or least important, and about 11 per cent thought the question was not applicable. Altogether, this group accounts for about 50 per cent of responses.

Figure 43: Rating of the ability to customise the aircraft



In relation to ability to customise, respondents appear polarised; there are those who want a standard design with no customisation, and those who want to make modifications, with a few people not wanting to make many customisations, but wanting some flexibility. One person who thought customisation was less important said:

> Keep it simple and close (or the same) as [the] kit supplied…Don't add more and more [to] the aircraft, try to stick to the original plan and ideas.

Customisations are generally made for reasons relating to safety, performance, and/or cost. A lot of the inspiration for current ABE aircraft designs came from what was perceived as a customisation to improve an existing design. For example, one person talking about safety and redundancy in aircraft systems said:

> Safety was a major factor in choice of type of aircraft to build…I modified [the] design to incorporate [a] fuel injected engine - less icing risk - constant speed certified prop not fixed pitch wood; too many of those depart the aircraft! All modifications [were] CAR 35 approved including engine, prop, autopilot, IFR electrical and instruments, solid wire throttle cable vs original soft bowden type cable reliant on return spring for throttle opening. Dual battery installation (plus vac pump) and autopilot can fly aircraft without vacuum pump in both horizontal and vertical axes. Safety far exceeds any available certified single engine aircraft.

Another person commenting on the importance of customisation wrote:

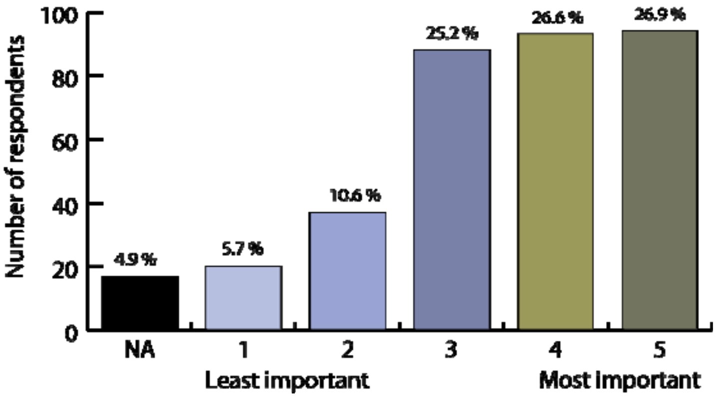
> ABE gives me freedom to sensibly use the latest developments in engines, avionics, and modifications that I am unable to access for my certified aircraft.

The most common types of major modifications performed by people in this survey are found on page 64.

Purchase price

Purchase price is a commonly cited reason for purchasing ABE aircraft. Figure 44 records how important purchase price is for people purchasing ABE aircraft. The survey responses show that purchase price was moderately important, very important or most important in about 80 per cent of cases. About 16 per cent of respondents rated purchase price as less important or least important, while approximately five per cent rated the question not applicable. Four of 354 respondents did not answer this question.

Figure 44: Rating of purchase price



Purchase price seems less important to people who are looking for aircraft with specific performance characteristics or special features. Most people do not have unlimited resources to achieve their aims in ABE aircraft. Historically in the US, plans-built projects are the least expensive (Larsen, 2005), followed by slow-build and then quick-build aircraft. There is essentially a trade-off between time and money (Fuentes, 2005). Data on purchase price by type of build project for this paper is found in section 3.7.

Operating cost

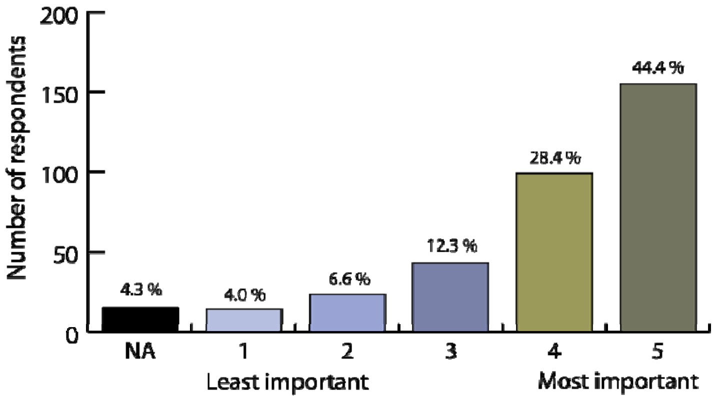
Figure 45 records how important operating cost is for people who purchase an ABE aircraft indicating that operating cost is important to the majority of people in this survey. Quite a few people commented on operating cost saying:

> ABE aircraft present a great opportunity to fly economically and ensure regular maintenance.
>
> [My] aircraft is fast and economical (175 knots @ 32 litres per hour at 9,000 feet).

A number of people commented on operating costs in the context of ageing certified factory-built aircraft[40], versus new ABE aircraft saying:

> With the cost of commercially built aircraft being too high operating and maintaining, ABE is more attractive for recreational flying e.g. a new aircraft at a fraction of the cost to operate and maintain.
>
> Once mastered the Jabiru J-430 is a remarkable little aircraft. [It is] faster and cheaper than the Cessna 172 to purchase and run – 120 knots at $25 per hour.

Figure 45: Rating of operating cost



Ability to perform maintenance

Figure 46 records how important the ability to perform maintenance is for people purchasing ABE aircraft (N=349). About 80 per cent of respondents rated the ability to perform maintenance as moderately important, very important or most important. The ability to perform maintenance was less important or least important in around 14 per cent of cases. About five per cent of respondents thought the question was not applicable. Four of 354 respondents did not answer the question.

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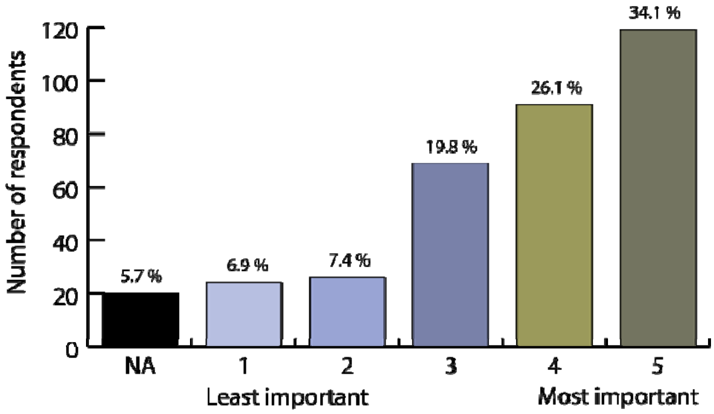
40 Aging certified aircraft was examined in an earlier ATSB report: ATSB (2007). *How Old is Too Old? The impact of ageing aircraft on aviation safety*. (Aviation Research and Analysis Report B20050205). Canberra: ATSB.

Figure 46: Rating of the ability to perform maintenance



Until recently, aircraft built under the ABAA legislation (CAO 100.18 and CAO 101.28) or the Developmental Category (CAO 101.31) had to be maintained by a LAME in accordance with CAO 100.5. Some non-LAME amateur builders were given maintenance authorities in the 1980s and earlier, along with the ability to issue maintenance releases; this was usually because of their substantial aviation experience, but this area was plagued with ambiguities, particularly in the Developmental Category. This changed in 2008, after the Sport Aircraft Operations Group (SAOG) lobbied CASA for change. A new legislative instrument, CASA 451/07, allows amateur-aircraft builders the ability to maintain their aircraft and issue maintenance releases. This process involves classroom training, a hangar field trip, and an assignment. The experimental category (AC 21.4), introduced in 1998, allows the builder of an aircraft to maintain it; if it is subsequently sold, then the original builder or a LAME can maintain the aircraft.

It seems logical that changes to maintenance legislation introduced with the experimental category might influence perceptions about the ability to conduct maintenance, however, a statistically significant association between these variables does not exist, based on the category the aircraft was built in (OR 1.33, 90 per cent CI 0.84 to 2.10, p=0.29), and operates in (OR 1.32, 90 per cent CI 0.84 to 2.09, p=0.30). Other factors must influence how people view the ability to perform maintenance when purchasing an aircraft.

Second-hand aircraft status was a more important predictor of how important maintenance is to respondents. When compared with aircraft builders, second-hand aircraft owners were more likely to see maintenance as not applying, or being least or less important to their ABE purchase decision (OR 2.12, 90 per cent CI 1.31 to 3.44, $\chi^2 = 6.78$, $p \leq 0.01$). This makes sense because maintenance by a LAME on a second-hand aircraft is required by law, and therefore a given, unless the original builder lives locally and is willing to continue to service the aircraft.

Other reasons for purchase

People made a number of other comments which either clarified or added to reasons for purchase. There were 33 people who provided additional comments about reasons for purchase. These included:

- appearance and longevity
- best metal kit available, and reputable kit manufacturer
- no commercial equivalent

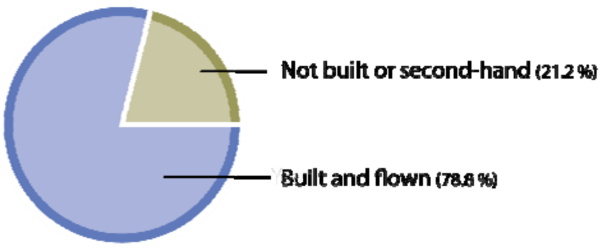
- build time
- special features such amphibious, canard, classic, or replica aircraft
- features such as folding wings, or ability to push and pull the aircraft on the ground
- less regulation
- education.

3.5 Building

3.5.1 Built and flown ABE

Figure 47 indicates that about 80 per cent of respondents had built and flown their own ABE aircraft. Seven people indicated that their aircraft was second-hand, but that they had built and flown an ABE aircraft. The most likely scenario in these cases is that these respondents had built an ABE aircraft prior to purchasing another second-hand ABE aircraft. There were three respondents (making up less than one per cent) who indicated the aircraft was not second-hand, and that they had not built and flown the aircraft. The most likely scenario in these cases is that the respondents were given the aircraft by a relative or friend.

Figure 47: Built and flown an ABE aircraft



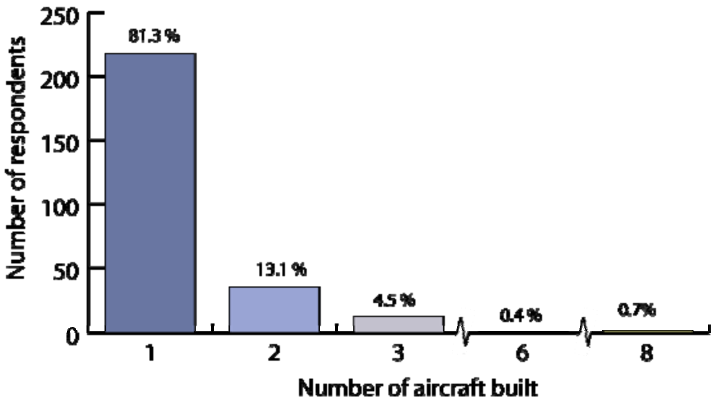
Number of aircraft build

Most respondents (80 per cent) in this survey built one aircraft (N=268). About 15 per cent built two or three aircraft, and a couple of respondents built six and eight aircraft. Aircraft builders who construct more than one aircraft appear to fall into four general categories. There are those who favour building:

- the same aircraft, or an aircraft from the same manufacturer, sometimes a later model
- high performance aircraft
- aircraft of the same construction, for example all wooden aircraft
- aircraft for a specific purpose, such as amphibious operation.

These observations are qualitative because only a small number built more than one aircraft.

Figure 48: Number of aircraft built

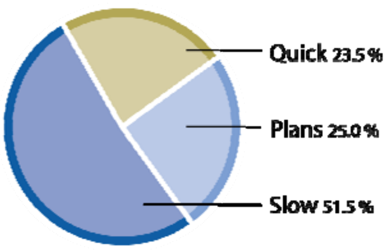


3.5.2 Type of build process

Plans-built, slow-build, fast-build kit

Figure 49 records the method used to build the ABE aircraft where the respondent had both built and flown an ABE aircraft (N=268). About 50 per cent of respondents constructed slow-build kit aircraft, while plans-built and quick-build aircraft accounted for about 25 per cent each of the remaining proportions. Data on construction method was not collected for second-hand aircraft. Of the 278 respondents who reported that they had both built and flown an ABE aircraft, 10 did not respond to this question.

Figure 49: Method of construction used



The decision to construct a plans-built aircraft is often made on the basis of cost and available resources (Cook, 2005). Although kit-build aircraft were offered for sale in the US in the 1920s and 1930s, it has been in the last 30 years that they have been used more extensively in Australia. Pre-fabricated parts in kit aircraft save time, but are more expensive. Because of the need to fabricate parts from scratch, a plans-built aircraft represent a significant challenge, starting with nothing but sheets of paper.

Build time for different types of aircraft

Aircraft can be built in three ways using plans, slow-build kits, and quick-build kit options. With a plans-build option, the builder usually fabricates all parts, except the engine. Kit aircraft are available as slow or quick-build options. Both slow and quick-build options have the same parts; the difference is that the wings and fuselage are largely complete with a quick-build option (Figure 50). Some respondents choose a combination of slow-build wings and quick-build fuselage.

There is generally a trade-off between time and cost associated with building an aircraft. A greater degree of skill is required to fabricate parts from scratch, and the skills reflect the type of aircraft structure.

Although kit aircraft such as the Ace Baby Ace, and the Flying Flea were offered in the 1920s and 1930s, the majority of aircraft built in Australia between 1955 and 1970 were plans-build options. After this point in time, aircraft kits began to appear such as the Glasair and Van’s. A number of kit manufacturers have used sales of kit aircraft to finance production aircraft certificates (Higdon, 1998).

Figure 50: Quick build Van’s RV-7 kit

Source: Van’s aircraft, 2009

Figure 51: Slow build Van’s RV-7 kit

Source: Van’s aircraft, 2009

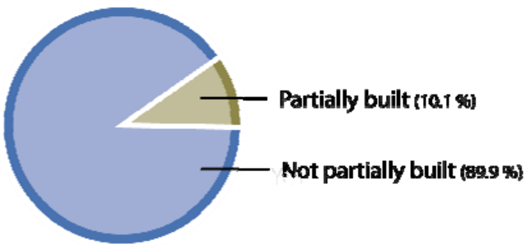
According to build hours data for all aircraft in this report, the mean build time was 2,521, the median 2,200 and the range was 11,680. Statistically significant differences in hours to build are observed by the build method (Kruskal-Wallis χ^2=40.39, p<0.01). Plans-build aircraft have the longest build time with a mean time of 3,137 hours to complete, a median of 3,000 hours, and a range of 6,816. Slow-build kit aircraft have a mean time of 2,646 hours to complete, a median time of 2,450 hours, and a range of 11,680. Quick-build aircraft have a mean time of 1,723 hours to complete, a median of 1,235 hours, and a range of 8,650 hours (Figure 52).

Figure 52: Median (green) and mean (purple) build times for quick build kit aircraft (left), slow build kit aircraft (middle), and plans-built aircraft (right)

Quick build, N=62 Slow build, N=131 Plans build, N=54

One of the comments from a respondent to this survey stated that aircraft manufacturers under-estimate the time taken to build an aircraft, and over-estimate performance. A range of build hours responses were received; a simple unmodified aircraft built (out-of-the-box) might take as little as 350 hours. At the other end of the spectrum, one aircraft took just over 11,000 hours to build. Build time is related to the skill of the person, the support and resources they have to solve specific problems and the complexity of the aircraft. It also relates to the design, and materials used. One option to reduce the amount of work required is to purchase a partially built aircraft. This is permitted under the regulations, as long as the aircraft is at least 51 per cent amateur-built. A small proportion of people purchase a partially built aircraft as recorded in Figure 53.

Figure 53: Purchase of partially-built aircraft



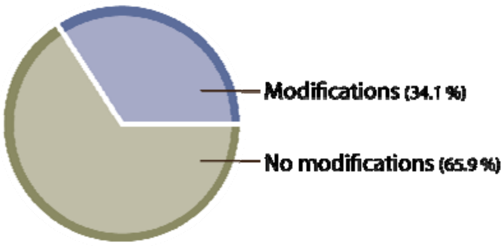
3.5.3 Build modifications

Based on comments from people in this survey, people often chose ABE aircraft because they can make modifications in order to improve performance, safety, and ergonomics. Under ABAA, major modifications or deviations from plans require

CAR 35 approval, but under the experimental certificate system, this is no longer required (however, people may still choose to engage a CAR 35 delegate). Many people are interested in building an off-the-shelf product, with no modifications, while a small number of people make major modifications. The main modifications made to ABE aircraft are an increase in weight and complexity (Mitchell, 1993).

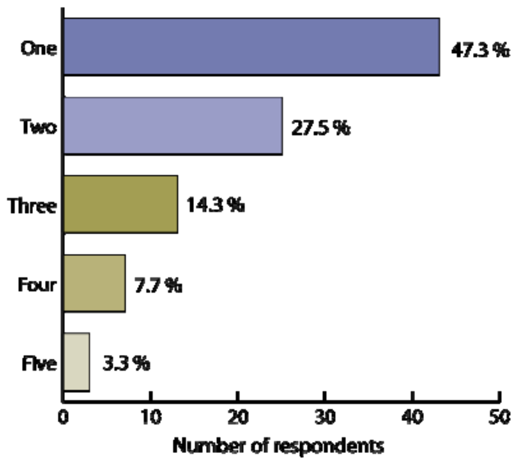
The number of respondents who made major modifications to their aircraft during construction is recorded in Figure 54. This shows that about one-third of people made major modifications. It is important to note that a major design change was not defined in the survey. The content of the comments provides some evidence that respondents understood the intent of the question. For example, one person referred to widening the fuselage, while another changed the canopy from a side-hinged to front-hinged operation so that if it became unlocked in flight, the canopy would not open.

Figure 54: Number of people who made major modifications



There were 175 major modifications made by 91 people as recorded in Figure 55. About 75 per cent made one or two major modifications, while the remaining 25 per cent made between three and five major modifications.

Figure 55: Number of major modifications made during construction

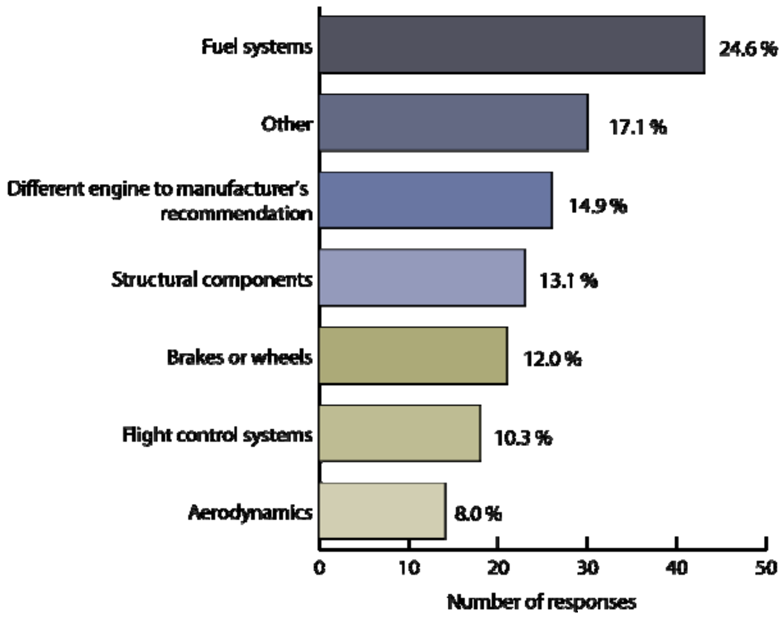


Respondents recorded major modifications during construction in one of six predetermined categories as recorded in Table 6. A very small number of people recorded additional modifications to electrical systems, avionics and miscellaneous items. Figure 56 records primary modifications shown in Table 6. This shows that respondents modified fuel systems most frequently (43 of 175 modifications), followed by a different engine to the manufacturer's recommendation (26 of 175), structural components (24 of 175) and brakes or wheels (21 of 175).

Table 6: Aircraft modifications with examples of modifications

Modification	Example
Structural components	Widen the fuselage
Flight control system	Dual controls, where the original design had a single control column, autopilot
Aerodynamics	Shortened the wings for aerobatic performance
Fuel systems	FADEC, which manages fuel burn and engine parameters
Different engine to manufacturer's recommendation	Automotive engine, where a certified or non-certified aircraft engine was recommended
Brakes or wheels	Dual hydraulic system

Figure 56: Type of modification during aircraft construction



Major build modifications are somewhat difficult to separate because aircraft functions and characteristics are inter-related. For example, shortening a propeller might be defined as an aerodynamic, engine, or performance modification. In addition, two other challenges are associated with interpreting major build modifications. The first relates to how a major design change is defined and the second relates to individual judgements about what a major design change is. For example, when plans are provided to a builder, they may not be very specific in describing details about fitting an engine, but simply state that the engine should be appropriately attached. Similarly, an aircraft may not include wheel fairings, but they are added during the build process. Is this a major design change? Ultimately, this data serves to illustrate that major changes are definitely made to aircraft but it is difficult to be specific.[41]

41 The ATSB considered examining the files of all ABAA aircraft with CAR 35 approved design changes, but felt it was beyond the scope of this report.

The CASA (2006) document *Exemption – maintenance on limited category and experimental aircraft,* illustrates what it considers a major design change is in the context of maintenance. This may well apply to major design changes during construction. A major modification is one that significantly affects the:

- weight and balance of the aircraft
- structural strength of the aircraft
- performance of the aircraft
- operational characteristics of the aircraft.

Many aircraft have transitioned from ABAA to the experimental category. This may be to enable modification of the aircraft or perform maintenance. About 45 per cent of aircraft built under ABAA have transitioned to the experimental category in this survey (56 of 124) but not enough details are available to compare design changes made under ABAA with those in the experimental category.

One respondent in the experimental category built their aircraft using a CAR 35 delegate, even though this was not required. Aircraft design changes have been the subject of a number of ATSB investigations[42], but good documentation and data is needed to evaluate the association between design changes and accidents, and this is not always available. Builders making major modifications in the experimental category are not required to seek assistance. Under ABAA, the SAAA encouraged members to discuss proposed modifications with its technical committee (Mitchell, 1993).

The SAAA builder assist program for the experimental category encourages people to discuss modifications with an appropriate person. Under ABAA, any deviation from approved documents or drawings, major or minor, is considered a modification that requires approval (Mitchell, 1993). One benefit of this, however, is that these aircraft do not generally have any flight restrictions. The experimental category places restrictions on flight until airworthiness can be proven through flight demonstration and testing. A period of between 25 and 40 hours is accepted by regulators worldwide as being long enough to demonstrate the aircraft is capable of flight. The aircraft builder or operator can then apply for the restrictions to be removed. It is possible, however, that latent airworthiness issues may take longer than 40 hours to become apparent.

The fact that experimental aircraft builders are free to build with few restrictions, does not take away from the need for comprehensive research by the builder. Gravity and air do not change, even when regulations do. Mitchell (1993) in an article for *Airsport* wrote that if extensive modifications are necessary, then maybe the builder selected the wrong aircraft.

3.5.4 Build challenges

In general terms, building an aircraft poses many challenges, but anecdotally, some systems seem to cause more heartache than others. In order to identify these challenges, respondents were asked to rate the build challenge from not challenging to very challenging. Build challenges were categorised according to airframe,

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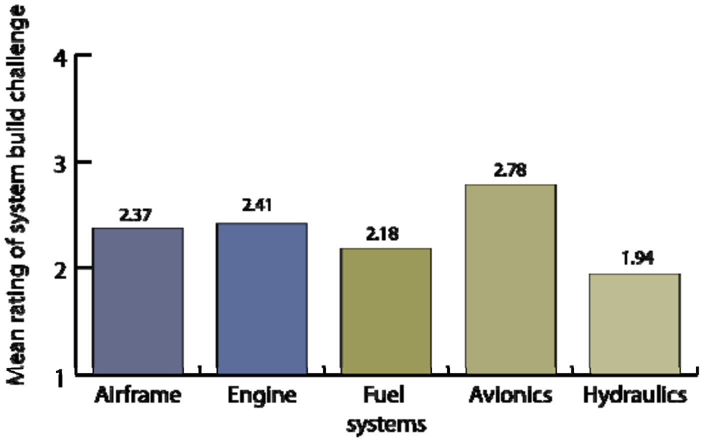
42 For example, Investigation 200206005 into the December 2002 fatal accident involving a Lancair IV-T aircraft, VH-CIV, which occurred during the test flight program of the recently built aircraft.

engine, fuel system, avionics, hydraulics, and other systems. The mean rating of build challenge shows avionics to be the most challenging, followed by engines and airframes. The individual ratings by system are recorded below.

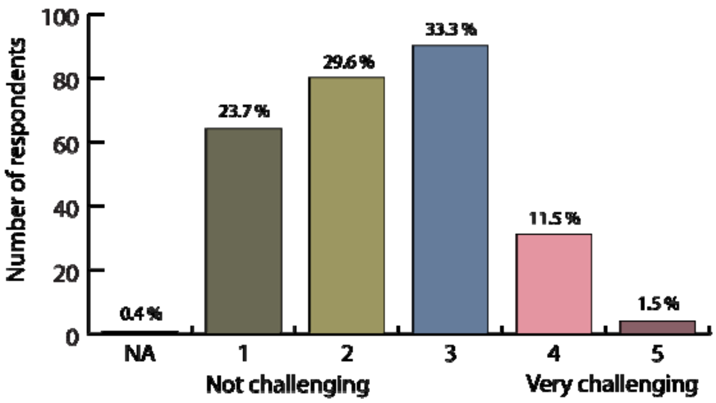
Figure 57: Mean rating of build challenge by system.



Airframe challenge

Airframe build challenge is recorded in Figure 58. This shows that most respondents found aircraft airframes to be challenging, somewhat challenging or not challenging. Thirty-five respondents found the aircraft airframe either quite challenging or very challenging. For eight of these 35 respondents, their aircraft had a unique design feature such as amphibious capability, canard design, more than one engine, or wood construction. In addition, three of these 35 people who encountered challenges made design modifications to the structure of the aircraft.

Figure 58: Build challenge for airframe



Aircraft engine challenge

Figure 59 records the rating of aircraft engine as a build challenge. The distribution of aircraft engine challenge is similar to airframe challenge, with slightly more respondents reporting quite challenging or very challenging. There were 45 respondents who rated aircraft engine as quite challenging or very challenging. Nine of these 45 respondents installed automotive engines, 11 installed non-certified aircraft engines and 25 installed certified aircraft engines. Respondents who installed automotive engines into their aircraft were about three times more likely to rate aircraft engine as quite challenging or very challenging ($\chi^2 = 6.57$, $p \leq$

0.01, odds ratio 3.27, 90 per cent confidence intervals 1.48 to 7.19) using certified engines as a comparison group. Respondents with non-certified aircraft engines did not rate challenge differently to those with certified aircraft engines ($\chi^2 = 0.85$, $p = 0.35$).

By modern automotive standards, aircraft engines are somewhat outdated. Aircraft engines usually have dual ignition systems because magnetos sometimes fail and the large bore size of aircraft engines requires a bigger spark for combustion to occur. Automotive engines potentially offer better fuel economy and the ability to adjust engine parameters electronically, but cooling these engines can be challenging (Farnham, 2005).

One respondent in this report commented on automotive engines, stating:

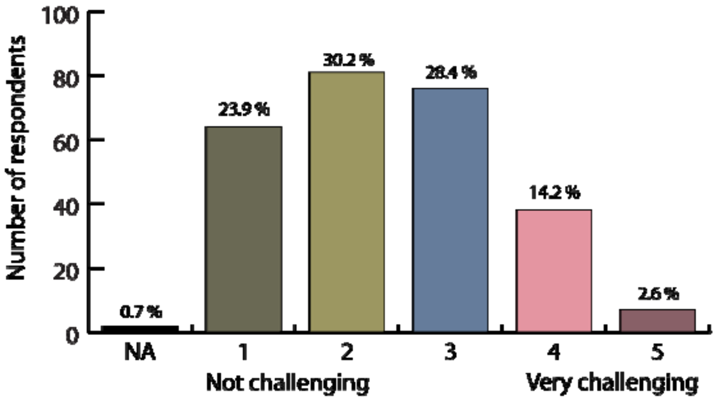
> It is important to select a proven design and follow the manufacturer's recommendation. I fitted an auto conversion and this was not successful. I am currently replacing the engine with a Lycoming. The moral is aircraft should have aircraft engines.

Although this respondent did not elaborate on what caused problems, a second person offered comment on a separate engine difficulty, stating:

> [I had a] problem (hard starting) with engine computers supplied with firewall forward package lead to engine rebuild and electronic control unit replacement resulting in extended build time. Subsequent doubt about quality control at US engine supplier led to local rebuild, including dyno tunings to optimise fuel mapping (second rebuild)…Australian engine computers (redundant system) used in place of original so proper fuel mapping required.

One respondent commented that they sought assistance with automotive adaption. Clearly this can be a challenging area. The survey did not ask if a firewall forward kit was used to install the engine, and this may affect the rating of challenge.

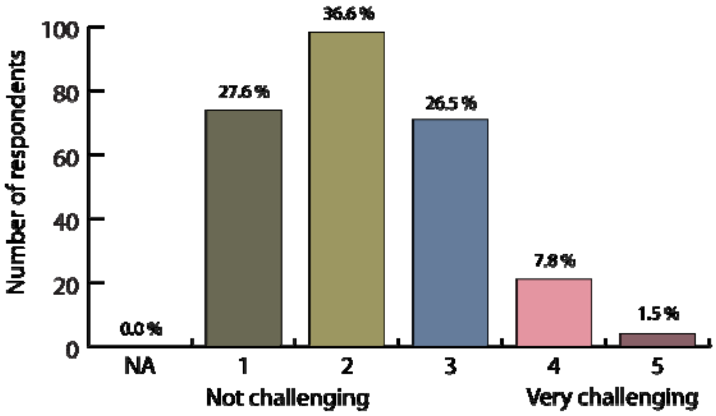
Figure 59: Build challenge for aircraft engine



Fuel system challenges

The relationship between build challenge and fuel systems is recorded in Figure 60. This shows that less than 10 per cent of respondents found fuel systems quite challenging or very challenging. Survey data were cross-tabulated to examine the association between major modifications and fuel system challenge. Among the 267 respondents who built and flew their aircraft, 43 made major modifications to their fuel system. Those who made major fuel system modifications were about two times more likely to rate the fuel system as quite or very challenging compared to those who found the fuel system either challenging, not very challenging or not challenging ($\chi^2 = 2.89$, $p = 0.09$, odds ratio 2.23, 90 per cent confidence intervals 1.01 to 4.91).

Figure 60: Build challenge for fuel system



Fuel systems did not generally present as much challenge as aircraft engines and airframes, using the quite challenging and very challenging ratings as a reference group. The descriptions of how fuel systems were modified in this report are not generally detailed enough to examine exactly what people found challenging.

Avionics challenge

Survey respondents found avionics quite a significant build challenge (Figure 61). About 30 per cent or 80 of 269 respondents found avionics to be quite challenging or very challenging, but the challenge appears to be independent of the type of instruments installed in the aircraft ($\chi^2 = 2.03$, $p = 0.36$). Certain general skills are required to build an aircraft such as following plans; what Gardner (1983) calls visual-spatial intelligence. However, it appears that avionics challenges this intelligence in a special way. The most challenging part of installing avionics usually lies in integrating different components (Figure 62).

Figure 61: Build challenge for avionics

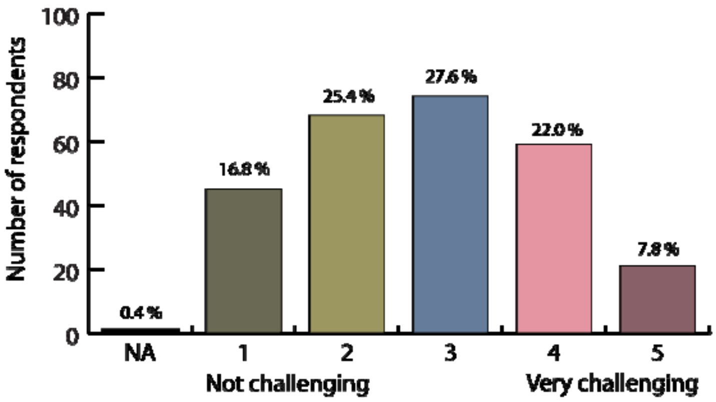


Figure 62: Example of an avionics wiring diagram

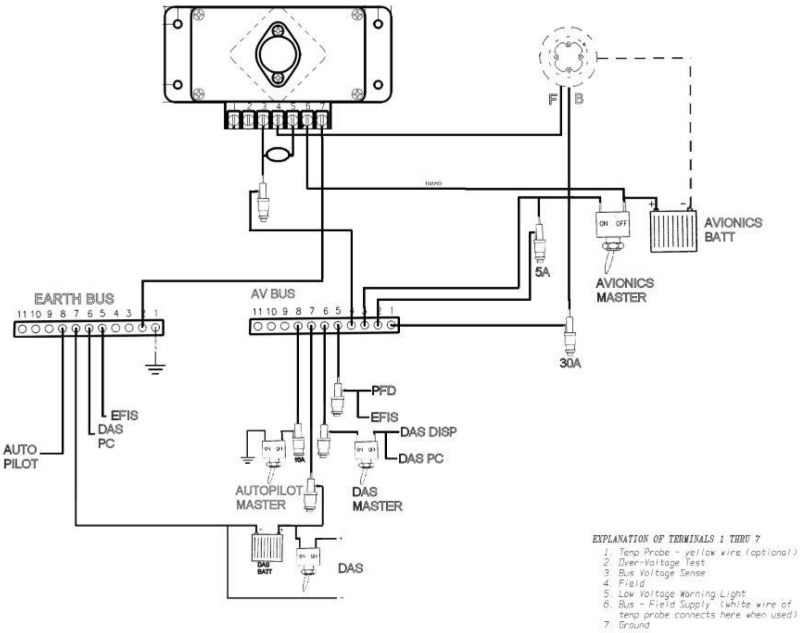
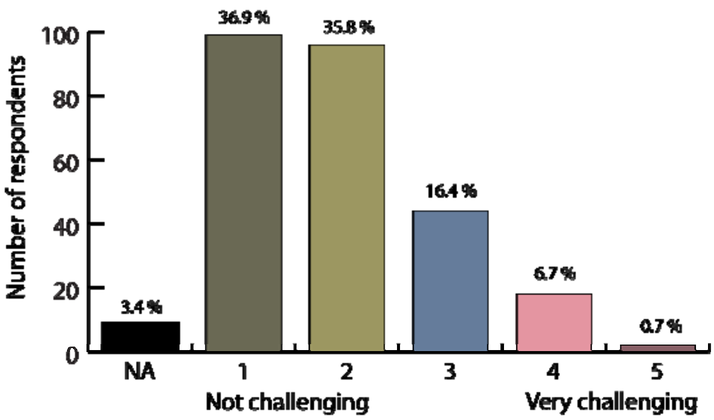


Figure 62 incorporates an additional alternator and computer

Hydraulics challenge

Build challenge associated with hydraulics is found in Figure 63. There were 20 of 261 respondents who found hydraulics quite challenging or challenging. Four respondents had aircraft with retractable gear, one has dual hydraulics, three made modifications to wheels or brakes, and one had an amphibious aircraft. Four of the respondents who indicated that hydraulics were quite challenging or very challenging built more than one ABE aircraft.

Figure 63: Build challenge for hydraulics



Other build challenges

The question relating to build challenge provided an open-ended *other* option and 20 respondents provided additional answers to the set options. Some of these answers related to building a component, and some to process or relationships associated with building an aircraft. The following items are a summary of those other build challenges:

- designing safety enhancements and getting approval
- disreputable local parts suppliers
- bubble canopy, windscreens and windows
- carving propellers
- painting, making cowls and composite material
- use of butyrate dopes and fabric
- certification and paperwork
- partnerships with other people.

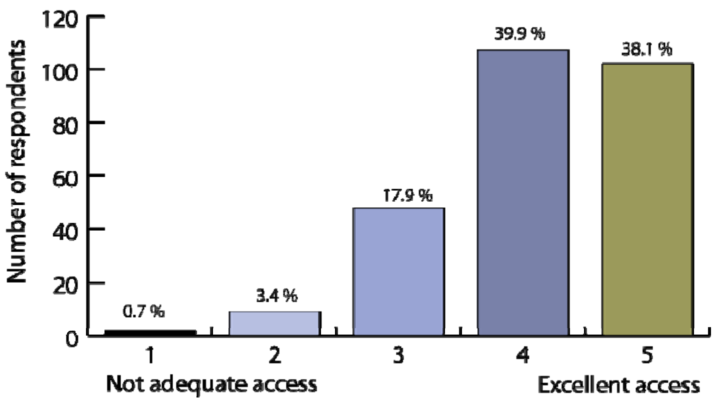
Summary of build challenges

Significant build challenges in this survey appear to relate to the aircraft design, major modifications from the original design and choice of engine, and installing avionics. Avionics were rated as most challenging overall but, significantly, some of the build challenges are interpersonal. Certain aircraft designs, such as wooden aircraft, appear to be more challenging as the generation of people with knowledge in how to build and maintain wooden aircraft are replaced by people with proficiencies in metal and composite aircraft. For some respondents, the build process was easy and the paperwork was difficult.

3.5.5 Build resources

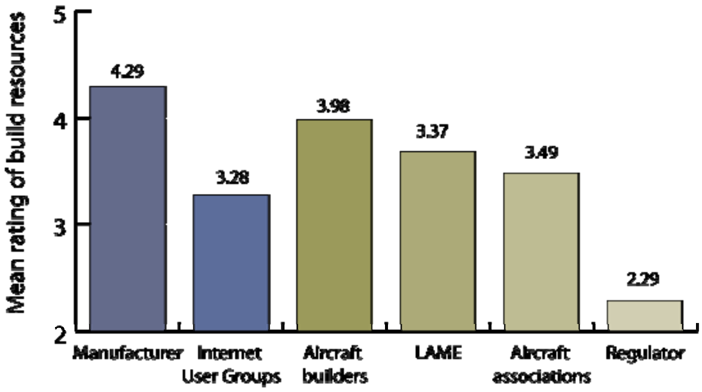
The survey requested that people rate their general access to information needed to construct their aircraft. Most respondents had very good or excellent access to build information (about 78 per cent), while a smaller proportion had adequate access (about 18 per cent). Eleven respondents (about 4 per cent) reported that they had less than adequate or no access to build resources as recorded in Figure 64.

Figure 64: General rating of access to build information



The importance of different types of build resources were rated by respondents. The mean rating (from 1 least important to 5 most important) is presented in Figure 65. On average, respondents indicated that manufacturer resources were the most important, followed by other aircraft builders and LAMEs. Aircraft associations and internet user groups were also seen as helpful on average, but the regulator was seen as least helpful. The details of the responses to these resources are described below.

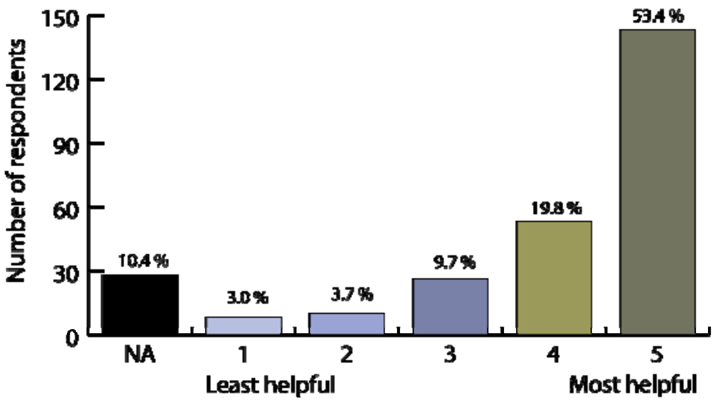
Figure 65: Mean ratings of helpfulness of build resources



Manufacturer resources

Figure 66 records how helpful manufacturer build resources (N=268) were to aircraft builders. About 75 per cent of respondents found the manufacturer resources to be very helpful, or most helpful when building their aircraft. Twenty-eight respondents recorded 'not applicable' for manufacturer build resources. Most of these respondents (25 of 28) were plans builders while the remaining three were slow-build kit aircraft owners. It is possible that people who fabricate parts from scratch using plans perceive themselves as the manufacturer, in which case the question appears redundant. In this case, it may have been better to ask if the plans were helpful, or clearly set out and easy to use. From the number of least important and less important responses to this question, it might appear that kit manufacturers have some room for improving their products and services.

Figure 66: Rating of manufacturer build resources



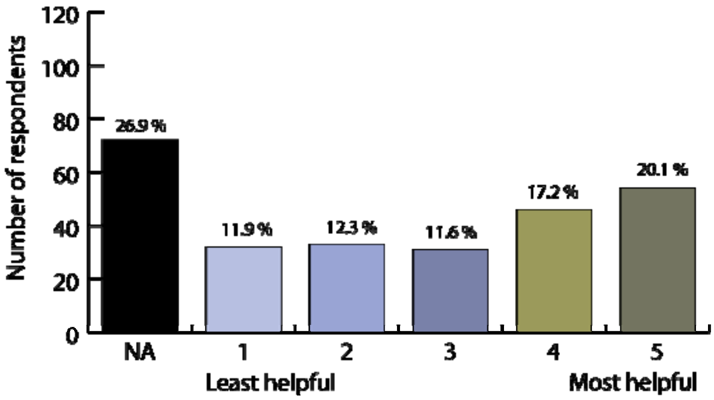
Although the survey did not ask a specific question about how manufacturer build resources could be improved, at least one person made comments about a particular manufacturer's build resources. The comment states '...kit manufacturers should have an obligation to notify owners of any problems.' Apparently, the kit manufacturer suggested that the problems encountered in this situation were due to poor build quality, rather than kit quality.

There were 196 people who rated the manufacturer's build resources as either very helpful or most helpful in building their aircraft (a rating of 4 or 5). These 196 people built aircraft by 41 different manufacturers or designers. On the other end of the spectrum, there were 18 respondents who rated manufacturer build resources as least helpful or less helpful, and these came from 12 different manufacturers or designers.

Internet user groups as a resource

Figure 67 records how helpful internet user groups were as a builder resource. This shows a mixed result with about 25 per cent of all respondents indicating internet user groups were not applicable. A further 25 per cent rated internet user groups as either least helpful or less helpful. About 10 per cent rated internet user groups as helpful, and 37 per cent found it very helpful or most helpful. In part, internet use relates to aircraft age and the nature of material held on the internet. Being relatively new, the internet would not have been in existence when some people built their aircraft. In many ways, it is understandable that a sizeable portion of ABE owners and builders did not think internet user groups were helpful. Accessing, evaluating, and using internet user group information can be a challenge even for the computer literate.

Figure 67: Rating of internet user groups as a resource



The internet is a means of transmitting data, as well as a repository of articles, comments, pictures, and other content, from a variety of people with different levels of expertise and experience. The information and advice on building ABE aircraft provided by internet user groups can be of variable quality. Because of its ability to send and store data, the internet may be used to electronically send build questions or photos to the manufacturer or a trusted forum where problem solving is taking place.

The internet is roughly divided into information and content that is free and for a fee. Websites, such as those constructed by the US Experimental Aircraft Association (EAA) and SAAA, block the browser of the site from viewing content using passwords and secure pages. This is most probably performed for many reasons including user pays and content control. It does, however, mean that relevant information may not be immediately available, and website portals in general (excluding EAA and SAAA) are often shrouded with information not directly relevant to the topic of ABE building and owning.

On the other end of the spectrum are amateur user group web pages where information is placed on a web page from a poorly formatted word processing file. This information does not conform to information processing principles, and sometimes the only way to find information is to use the ‘find’ function (Control-F on a PC and Apple-F for Mac) in the web browser. Some free websites recycle information from other web pages; a borrow (or steal) and incorporate process. An internet search engine may appear to return many useful web page groups, but when closely examined, it returns much of the same material, often slightly reformatted. In many cases, web pages and their content are poorly indexed, and many false positive website hits or documents are returned using 'OR' Boolean logic. Even among competent users of the English language, the same concept or issue can be referred to in a myriad of ways. Although search engines in general are improving, it will be a number of years before ABE builders and owners can take better advantage of lexicographical variation.

It is worth noting that the internet in general is not the same as electronic data repositories, such as ProQuest. Electronic data repositories, such as those used in libraries, are generally well indexed, and a complete document may be found, and where necessary printed or viewed online. Broken Uniform Resource Locator (URL) links on the internet will return a 'page not found 404 error'.

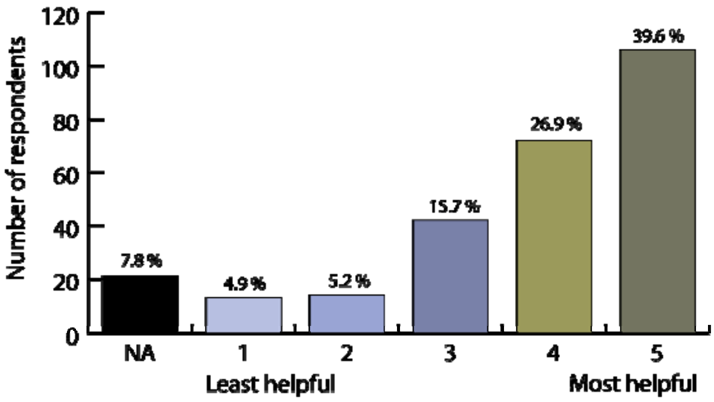
Chat forums and blogs are an interesting case in point. A chat forum is a special type of user group in cyberspace where questions can be posed and answered by people from across the world. Blogs tend to be more like diaries constructed by one, or a limited number of people. One research challenge in using the internet is to assess how credible a source is and whether the information is valid and current. It is customary for users of chat forums to use aliases; for aviation-related forums people use aviation terms or pilot ranks, such as 'Captain Smith' or 'Wing Commander VCA'. It may be necessary to read through a significant portion of what is written to assess the quality and validity of information. Some forums provide the ability to see all posts by user, so that this assessment process is more efficient. This relies upon the user keeping the same name, and refraining from making comments under multiple aliases. It is customary on a range of ABE chat forums for the user to provide some sort of indication of experience. For example, the signature block may contain something like 'Captain Crunch, RV-10, empennage complete, working on window frame, IFR rated.' This provides some indication of the experience of the person. A further challenge for people who host internet user groups is to moderate the comments, enforce rules of etiquette, and correct and remove comments.

In short, there are significant challenges associated with accessing and evaluating user group data. Computer literacy may influence perceptions of ABE user groups, but ultimately these groups represent opinions that must be evaluated to see if they are correct or useful. This requires good research skills.

Other aircraft builders as a resource

Figure 68 records how helpful other aircraft builders were as a build resource. This shows that about 66 per cent of respondents found other aircraft builders were a very helpful resource or the most helpful resource. In some circumstances, aircraft were built with another person, with one respondent saying 'my aircraft is 50/50 partnership in construction and ownership.' In this instance, the builders see another person as a resource to check plans, fabricate materials, and operate the aircraft.

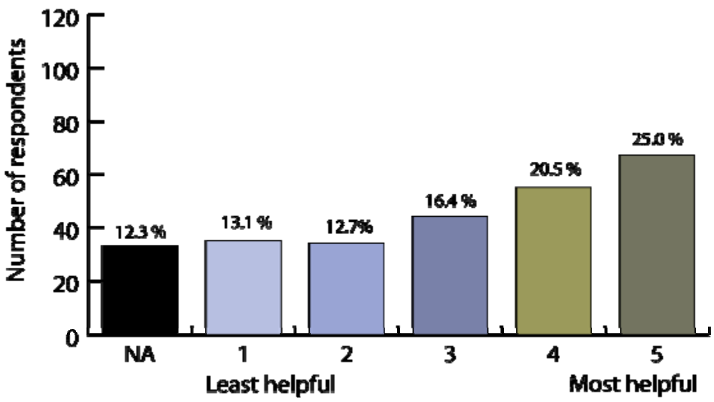
Figure 68: Rating of other aircraft builders as a resource



Licensed aircraft maintenance engineers as a build resource

A licensed aircraft maintenance engineer (LAME) is a person authorised under the Civil Aviation Regulations to carry out maintenance on aircraft, and issue a maintenance release. There are five types of LAMEs; airframe, engines, electrical, instruments and radio. Often, LAMEs hold more than one type of rating. A proportion of LAMEs are pilots and some of the respondents to this survey were either aircraft maintenance engineers (AME) or LAMEs.

Figure 69: Rating of LAME as a resource



The rating of LAMEs as a build resource is shown in Figure 69. This shows that the majority of respondents viewed LAMEs as a helpful resource overall. A LAME was seen as less helpful by about 25 per cent of respondents (based on scores of 1 or 2). A number of comments were made about LAMEs in this survey, some favourable, and other less favourable. One person commented that their aircraft was 'built from plans by a LAME, has always been VH- registered, and maintained by a LAME.' At least one person commented that:

> I switched to experimental as it was getting hard to find LAMEs qualified for timber airframes. On every occasion the LAME would say to me 'you know more about this aircraft than I do, inspect it with me.' I will continue to have the engine serviced by a LAME.

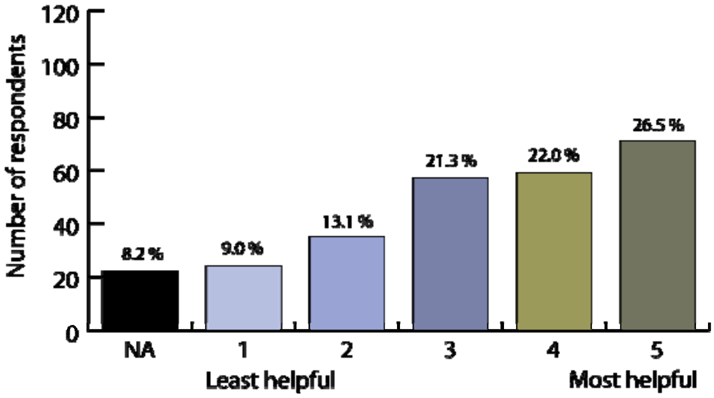
Perceptions about LAMEs are most likely influenced by the knowledge of the builder or owner, other resources available to the builder, and availability of, and previous experiences with LAMEs. For example, the builder of an experimental aircraft with a certified aircraft engine may seek assistance in fitting the engine, and having it maintained by a LAME (AMROBA, 2008).

Aircraft associations as a builder resource

There are two major aircraft associations in Australia for amateur aircraft builders, the SAAA and RA-Aus. Broadly speaking a number of smaller groups exist to assist people with building their aircraft including the Sport Aircraft Operations Group and the Sport Aircraft Builders Club.

Figure 70 records the rating of aircraft associations as a build resource. Two-thirds of people found aircraft associations helpful, very helpful or most helpful. About a third of people found aircraft associations less helpful, least helpful or not applicable.

Figure 70: Rating of aircraft associations



A number of comments were made about assistance from the SAAA. Comments like 'SAAA do an excellent job in building assistance' and 'the building fraternity, SAAA, and flying club provide mentoring regarding building, flying, and passing on of good knowledge.' Another person wrote 'I built my aircraft under the Builder Assistance Program (SAAA). Each stage inspection was carried out by a LAME…' while another person wrote 'the SAAA and their special programs were invaluable in completing the aircraft and establishing a test flight regime….' One person made a comment about how the SAAA program works by saying:

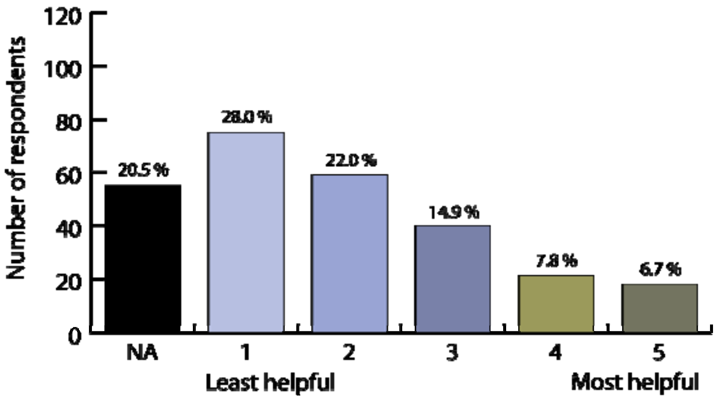
> … [it] has greatly helped to maintain construction quality control by peer group pressure, building on previous knowledge and using tried and proven ideas.

Respondents to the survey also recorded assistance from a number of overseas aircraft associations, and specialised associations such as aerobatic groups and associations.

Regulator as a builder resource

The rating of how helpful aviation regulators were as a builder resource is found in Figure 71. This graph is largely the reverse of most other building resources, with the majority of people rating it as not applicable, least helpful, or less helpful. On the most helpful end of the distribution, one person even named a particular employee of the regulator as a most helpful resource. Clearly, the primary role of the regulator is to develop and enforce safety standards.

Figure 71: Rating of regulator as a build resource



People completing this survey wrote a wide range of comments in relation to the regulator. One person considered 'the lack of CASAs interest or oversight in the sector of sport aviation…a national disgrace.' Some people praised the work of CASA as a resource, lamenting the fact that the experimental category tends to foster 'well-intentioned amateurs' using 'unstructured or ill-informed rumours which mature into law' when building an aircraft, rather than rudimentary airworthiness procedures developed by the DCA. One commenter thought that:

> more clarification is needed and maybe some CASA restrictions removed in relation to the modification and or rebuilding and placing into the experimental category previously certified aircraft types….

In relation to modifications, one respondent stated that most people associate CASA with fear, so they try to keep a low profile. This person considered CAR 35 essential for all modifications.

Commenting on freedom associated with the experimental category, one person stated it is essential that government 'keeps its hands off the experimental category.' Another commenter stated:

> The only person from the department that helped me through the building process was my local representative at [airport]. The rest of the Department was disinterested, ignorant of the process, or disruptive to the point where I considered flying outside the law.

Another person commented in the following way:

> The old ABAA system with CASA doing the inspection was too rigid, the current system is too loose and open to abuse. Somewhere in between is need[ed].

Summary of build resources

Examining comments about build resources, it is evident people use a range of build resources. One person stated:

> [I use] SAAA for general problems, discussion, assistance, LAMEs for continuing advice and guidance.

One way to develop a profile of build resources is to examine relationships between build resources. For example, are less helpful ratings for manufacturer resources associated with very or most helpful ratings for other aircraft builders as a resource?

The associations between different types of build resources are recorded in Table 22 in Appendix C. This shows a statistically significant correlation between most build resources; however, the associations are weak to moderate in strength, meaning that other resources or factors influence ratings on a given resource.[43] There is a positive relationship between all variables meaning that if one build resource rating is high, the other resource rating will also be high and vice versa.

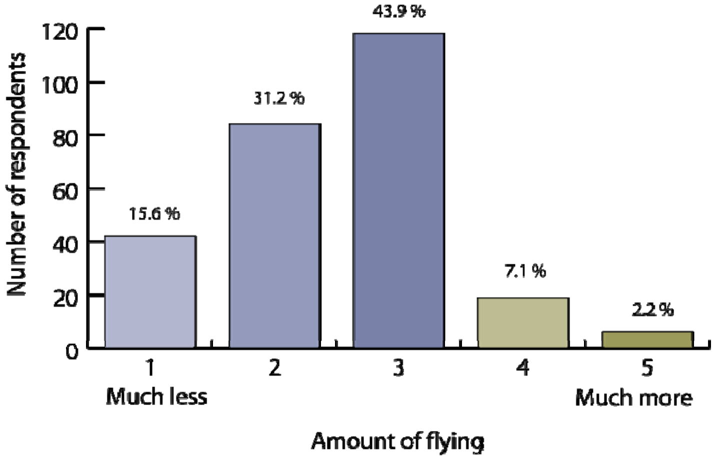
The strongest association in these data is between other aircraft builders as a resource and aircraft associations. In real terms, this means that approximately 10 per cent of the variation in aircraft builder ratings is accounted for by ratings for aircraft associations. For example, a higher rating on aircraft builders is associated with a higher rating on aircraft associations, and a low rating on one is associated with a low rating on the other variable. The weakest association is between other builders as a resource and manufacturers resources.

3.5.6 Flying activities during construction

Other flying while building

The amount of flying performed while building was recorded for 269 people (Figure 72). About 40 per cent (118 of 269) of respondents flew the same amount of time while building their aircraft, and about 50 per cent (126 of 269) flew less or much less than usual. Only a small number (25 of 269) actually flew more while they were building their ABE aircraft. The reasons why some people perform more flying during the aircraft build period cannot be precisely determined. One possibility is that the person usually works for a commercial air operator, and in addition to performing their usual flying work, they undertook transition training while preparing to fly their own aircraft.

Figure 72: Amount of flying performed while building



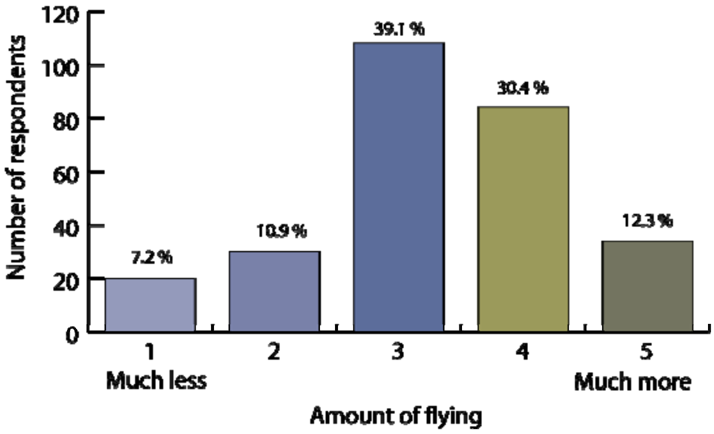
Other flying undertaken in the three months prior to maiden flight

In the three months prior to maiden flight, the amount of flying performed by the aircraft builder is reported by 276 respondents (Figure 73). Around 40 per cent of respondents flew about the same amount of time, while 118 of 276 (42.7 per cent)

[43] A correlation describes how two variables vary together (covary), and the size of the effect demonstrates how strong the relationship is. In these data, the size of the effect is not large, despite the fact that the correlation is statistically significant.

flew more or much more than usual. Interestingly, 50 of 276 flew less or much less time (18.1 per cent). In relation to reasons for flying less time, unfinished work may limit the amount of time available for the builder to fly. Alternatively, the person outlays money to complete the aircraft and has no money left for flying. Tasks such as rigging, weighing and balancing the aircraft, preparing paperwork for certification, calibrating fuel systems and instruments, and liaising with relevant authorities take up time (Wanttaja, 2006).

Figure 73: Amount of flying performed in the three months prior to the maiden flight



3.6 Test flight

Test flights represent the culmination of many hours of work. It is a time when the aircraft is completely assembled and ready for its first and subsequent flights. The event is usually associated with some degree of anticipation. The first flight is referred to as the maiden flight, and the subsequent period of testing before an aircraft is given a certificate of airworthiness or special certificate, is called phase one. This is at least 25 hours in length, and may be 40 or more hours for aircraft with non-certified aircraft engines, or significant modifications. An authorised person from the SAAA or a CASA inspector determines the amount of time to be flown. Under the ABAA, first of type aircraft were test flown by the regulator. Subsequently, an aircraft built under ABAA could be test flown by the builder. Under the current experimental legislation, test flights can be carried out by the builder or another person nominated by the builder.

Test flights can be associated with a number of first-time experiences including unusual smells and possible false alarms. It is a period when ABE accidents have occurred overseas (Wantajja, 2008), and in Australia.[44] Accidents during test flights are not limited to ABE aircraft. The 2009 fatal F-22 Raptor accident during a test flight (Cole, 2009), and two accidents during test flights of the Cessna 162 Skycatcher (Flight Global, 2009) demonstrate this problem in certifying production aircraft. Detailed preparation is needed and this must cover such things as system checks, taxi tests, maiden flight, testing of pitot-static systems, stall and spin testing, general performance, and engine run-up and cooling post flight (Askue, 1992; FAA, 1995).

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44 For example, the Lancair VH-CIV in 2006 (200206005), and Rutan VH-EZK in 1979 (197901423).

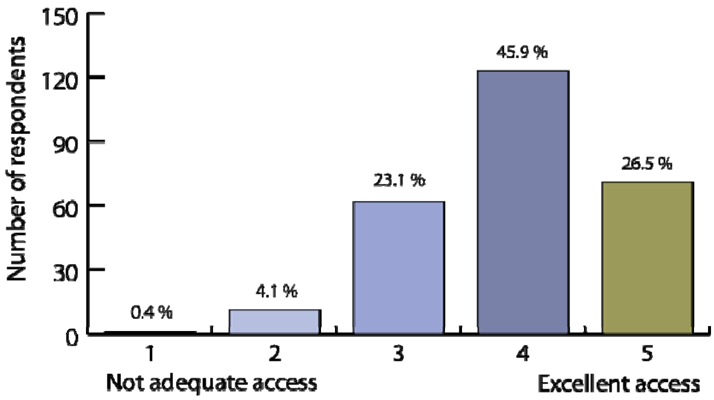
Based on the assumption that build resources may not necessarily directly relate to test flight resources, survey respondents were asked to rate test flight resources. In addition, they were given an opportunity to comment on the flight testing period, including whether they would do anything different in hindsight. Builders may choose to have someone else conduct the maiden flight or other parts of phase one for a range of reasons. By examining how builders use different types of pilots during flight tests, some insight is gained into their risk assessments and decisions. This section is structured in the following way:

- rating of test flight resources
- who performed maiden and phase one test flying
- if the builder would change anything in relation to test flight
- expectations about aircraft performance.

General rating of test flight resources

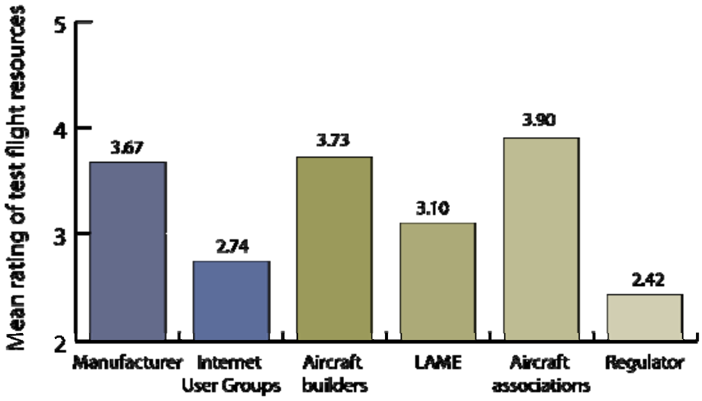
In general, most people had adequate, very adequate or excellent access to test flight resources. A very small proportion of people had less than adequate access and inadequate access to test flight resources. The proportion of people who did not have adequate access to build and test flight resources is similar.

Figure 74: General rating of test flight resources



The importance of different types of test flight resources were rated by respondents. The mean rating (from 1 least important to 5 most important) is presented in Figure 75. On average, respondents indicated that aircraft associations and aircraft builders were the most important test flight resources, followed by manufacturer and LAMEs. Internet user groups and the regulator were given the lowest mean ratings. The details of the responses to these resources are described below.

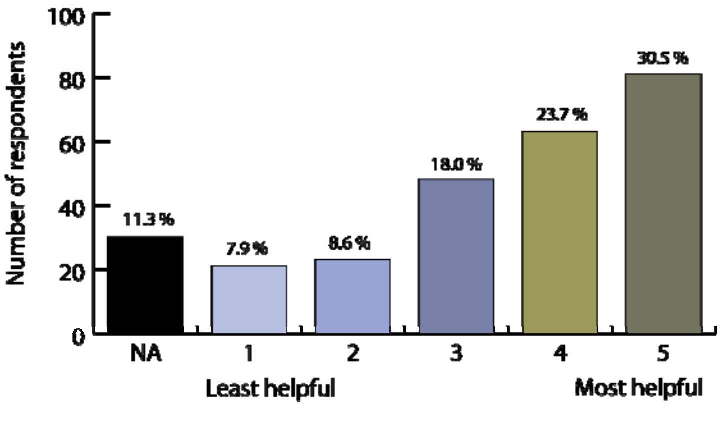
Figure 75: Mean rating of test flight resources



Manufacturers as a test flight resource

Many manufacturers publish flight test guides specific to their aircraft, including Van's, Falco, and Rutan. The majority of respondents to this survey found manufacturer test flight resources helpful, very helpful or most helpful. A small number did not find these resources very helpful, and some found the resources not applicable. This report does not assess why some people found manufacturer resources not applicable, but it may be that people who recorded a not applicable response had first of type aircraft and test flight was performed by the regulator. Another possibility is that some of these aircraft were built from plans and the question was considered redundant.

Figure 76: Rating of manufacturers as a test flight resource

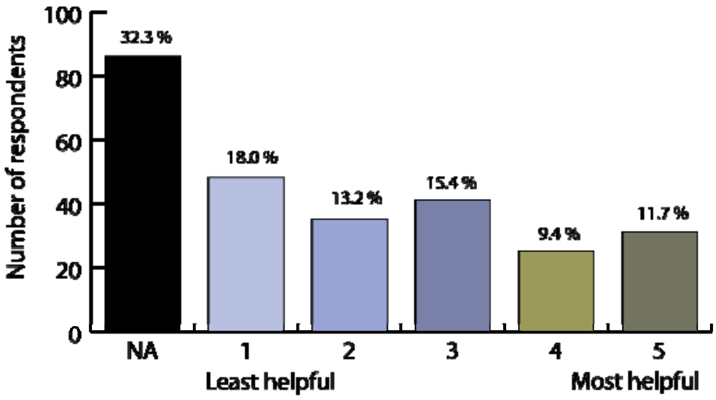


By comparison with manufacturer build resources (Figure 66) there were less respondents who rated manufacturer test flight resources as very helpful or most helpful (73.2 per cent for build and 54.2 percent for test flight). A similar proportion of people rated manufacturer builder and test flight resources as not applicable (10.4 per cent for build and 11.3 per cent for test flight). Overall, manufacturer test flight resources were seen as helpful, very helpful and most helpful, by around three-quarters of respondents.

Internet user groups as a test flight resource

Ratings given to internet user groups as a flight test resource are found in Figure 77. About 66 per cent of people rated the internet as not applicable, least important or less important. By comparison with internet user groups as a build resource, internet user groups as a test flight resource are even more likely to be seen as not applicable, least helpful or less helpful (51 percent as a build resource versus 66 per cent as a test flight resource). This may come down to a matter of trust, or better resources, such as a knowledgeable test pilot. As well, local advice may be seen as more trusted.

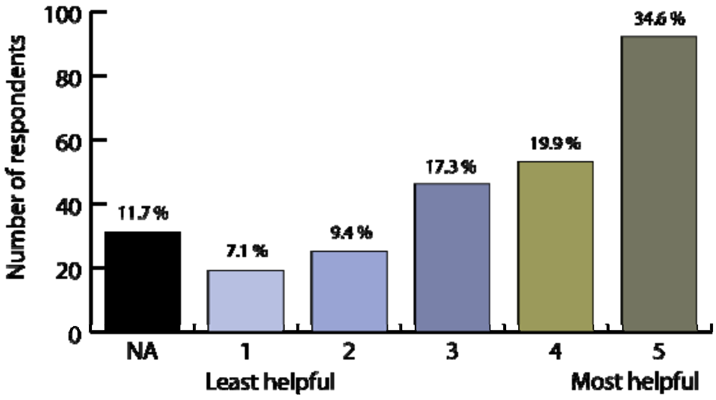
Figure 77: Rating of internet user groups as a test flight resource



Other aircraft builders as a test flight resource

Figure 78 records the ratings given to other aircraft builders as a test resource. Other builders were viewed as helpful, very helpful or most helpful by around 75 per cent of respondents. Largely, this shows them to be a helpful resource. Ratings of less helpful or least helpful may relate to the perceived value of the other builders, or bad experiences when relying on these people as a test flight resource. When comparing the ratings other builders as a build resource and other builders as a test flight resource, the two distributions are remarkably similar. The distribution of ratings for test flight is slightly lower for very and most helpful ratings.

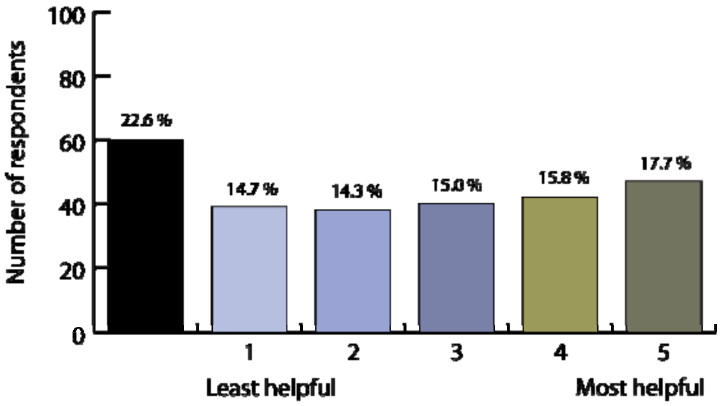
Figure 78: Rating of other aircraft builder as a test flight resource



LAMEs as a test flight resource

Figure 79 records the rating of LAMEs as a test flight resource. This shows a relatively even distribution of ratings in each category of about 15 per cent. This seems to suggest that as a test flight resource, LAMEs have a mixed response. It is possible that LAMEs found helpful by people in this survey may also be pilots, who are familiar with evaluating aircraft in flight. Data from this survey does clarify this area.

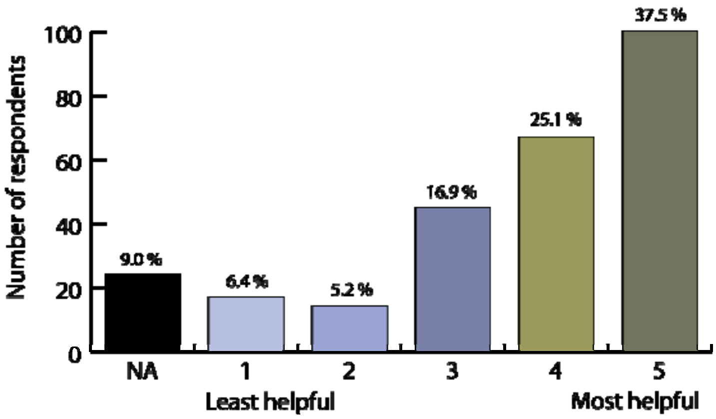
Figure 79: Rating of LAMEs as a test flight resource



Aircraft associations as a test flight resource

Figure 80 records the rating of aircraft associations as a test flight resource. This shows that about 80 per cent of people find aircraft associations helpful, very helpful or most helpful. It is significant that aircraft associations are seen as more helpful from a test flying perspective, than from a building perspective (Figure 70). For example, about 48 per cent of people found build resources very or most important, but about 62 per cent found aircraft association test flight resources helpful. The SAAA and RA-Aus associations have identified test flight as one of the important targets in a series of measures to ensure safe transition to flying operations.

Figure 80: Rating of aircraft associations as a test flight resource

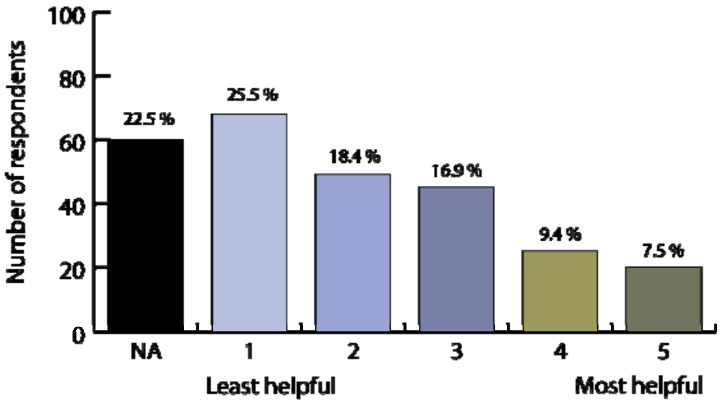


Regulator test flight resources

Rating of the regulator as a test flight resource is found in Figure 81. Similar to ratings of build resources (Figure 71), the regulator was not seen as very helpful or most helpful. About 15 per cent of people rated the regulator as helpful both as a build resource and as a test flight resource.

The role of the regulator as a test flight resource has probably diminished over time as the SAAA and other organisations have taken on self-administration responsibilities. At one stage, CASA published its own test flight manual. Some of the respondents to this survey wrote that they used this document when preparing for test flight.

Figure 81: Rating of regulator as a test flight resource



Associations between test flight resources

Correlations between all flight testing resources were positive and statistically significant. The strongest correlations were between LAMEs and the regulator, internet and LAMEs, and builders and LAMEs. In other words, respondents who used LAMEs as a resource were more likely to also use the regulator, internet and other builders as well. The weakest test flight resource correlation was between internet and associations. Correlations between test flight resources are found in Table 23 (Appendix C).

Other test flight resources

Survey respondents were given an opportunity to describe *other* flight test resources in addition to manufacturers, internet, other builders, associations, and regulators. There were a small number of responses in the *other* category including:

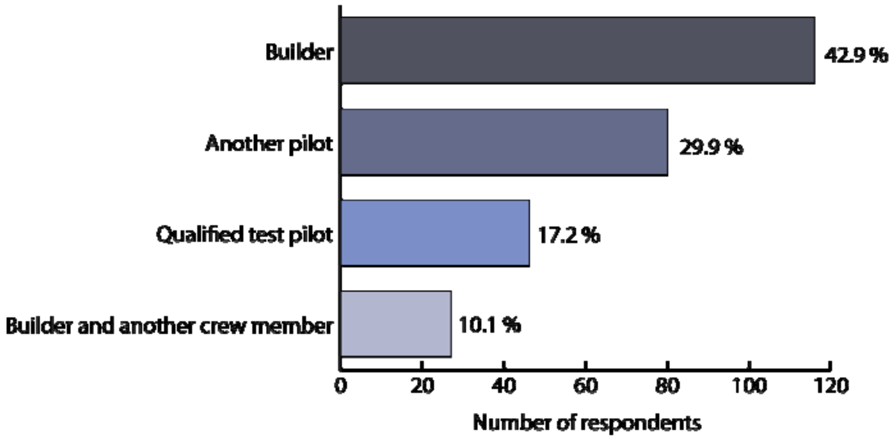
- test pilots or other experienced pilots
- newsletters or books
- aircraft distributor
- the name of a particular person from the regulator.

3.6.2 Initial test flights

Maiden flight

Two-hundred and sixty-eight of 278 respondents who built and flew an ABE aircraft recorded who conducted the maiden flight. Figure 82 shows that 115 of 268 respondents conducted the maiden flight themselves (builder), 80 of 268 used another pilot, 46 of 268 used a qualified test pilot, while 27 of 268 conducted the maiden flight in conjunction with another crew member.

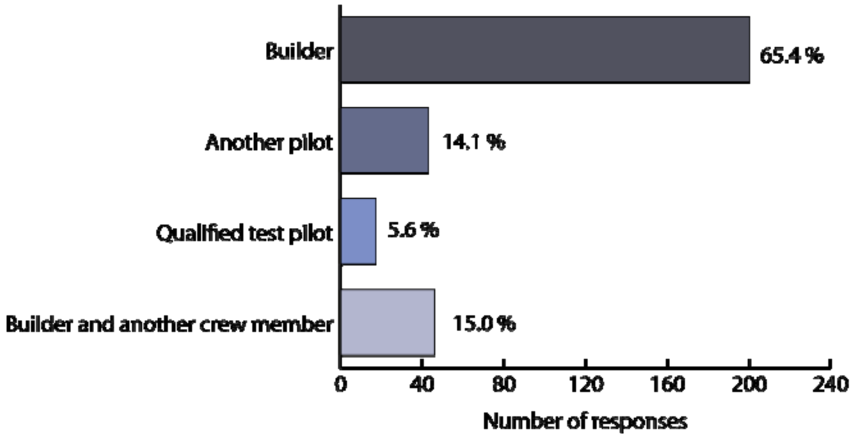
Figure 82: Who made the maiden flight



Phase one test flight

Phase one test flight was a multiple response question with a 'tick all that apply' option. Three-hundred and six responses were received from 268 respondents who built and flew an ABE aircraft. Two-hundred and thirty-two respondents provided one answer, 34 respondents provided two answers, and two respondents provided three answers. For phase one test flight, 200 of 306 (65 per cent) answered *you* (builder), 43 of 306 (14.1 per cent) answered *another pilot*, 17 of 306 (5.6 per cent) answered *qualified test pilot*, and 46 of 306 (15.0 per cent) answered *you (builder) and another crew member*.

Figure 83: Who made phase one test flights



3.6.3 Post-test flight evaluation

Two-hundred and sixty (260) people provided a response to the question asking if they would do anything different in relation to test flight. Two-hundred and six (206) of 260 (79.2 per cent) responded that they would not change anything, but 54 of 260 (20.8 per cent) said they would change certain aspects of what they had done. Content analysis of the comments revealed a number of different categories relating to:

- experience
- choice of airfield
- taxi testing
- emergency procedures
- test flight courses
- pilots in general
- preparation time
- onlookers
- SAAA and
- use of test flight time.

These categories are explored in the comments below.

Experience. Twenty respondents made comments relating to experience on type before test flight. Although it is not possible to know exactly how many hours the person had when the test flight was performed, the following are comments in relation to test flight:

- Gain more time in type first.
- More experience needed in tailwheel aircraft.
- Some more flying in the particular aircraft model to test the envelope on an aircraft that has been debugged.
- I had only 1 hour's experience on type and in hindsight wished I had some form of transitional training on similar aircraft.
- Get some dual time in same aircraft.
- Try to find an aircraft the same as mine to fly.

Choice of airfield. Two people made comments in relation to airfields. The comments related to the business of the airfield and runway length:

- Camden would have been a better choice of airfield compared to Bankstown.
- I would have preferred a longer runway and less traffic. [Airfield name] is marginal for test-flying ops.

Taxiing. Two people made comments in relation to taxi tests. They were:

- Minimise or eliminate high speed taxi trials.
- I would not repeat a fast taxi [test].

Emergency procedures. Two people made comments in relation to emergency procedures stating:

- o Probably have better emergency procedures in place. Have another aircraft as a chase plane if there were any problems.
- o Wear a recovery parachute for spin testing.

Test flight courses. Two people made comments in relation to completing test flying courses:

- o Complete a test flying course either on-line or attend personally.
- o Would like to have completed a course, even something basic, but 3-5 days of information & training at least.

Pilots. There were six people who made comments in relation to piloting. They included:

- o Within the first 25 hrs, a second pilot on board would be very helpful just to keep eye on your flying and the operation of the aircraft. Extra safety factor on new plane.
- o Use a test pilot.
- o Talk to SAAA flight advisor and pick a better test pilot for initial flights.
- o If possible use a pilot trained as a test pilot. But he or she would have to become very familiar with the particular systems in the aircraft.
- o Do the maiden flight myself.
- o Yes I would have a competent pilot take up a portion of the workload (monitoring).

Preparation. Four respondents talked about preparation stating:

- o Take a little more time in preparation. Because it was my own aircraft I found the distractions of finishing paper work and all the final little jobs required interrupted my preparation so that it wasn't as smooth as I would have liked. Previous experience testing another aircraft was much smoother without the distractions mentioned above.
- o Possibly prepare myself more thoroughly.
- o More written preparation.
- o Additional research and training.

Onlookers. Two respondents made comments about not having onlookers, while one other person suggested the media should have been present at the test flight stating:

- o Having previously conducted 9 first flights and always using the original ABAA flight test schedule I have learned that under no circumstances invite onlookers for 1st flight.
- o Only have minimum number of people know about looming test flight, i.e. 2 or 3 people at most.

Data collection. Three respondents, one commercial pilot and two private pilots, made reference to data collection in their test flight comments which included:

- o I prepared test flight plans and faxed them to ATC which helped both parties understand intentions at all times. I would allow more time for basic data collection so as not to hurry and lose accuracy and I would keep better track of weight for each test condition.
- o Use [a] tape recorder to collect data.

- Better recording of engine operating details for later analysis.

SAAA. Three people made comments in relation to services provided by the SAAA and these were:

- I would use a SAAA Flight Advisor. This service was not available at the time.
- Talk to SAAA flight advisor and pick a better test pilot for initial flights.
- Use [the] SAAA Test Flight Manual.

Use of time. Two respondents talked about the process of structuring test flight stating:

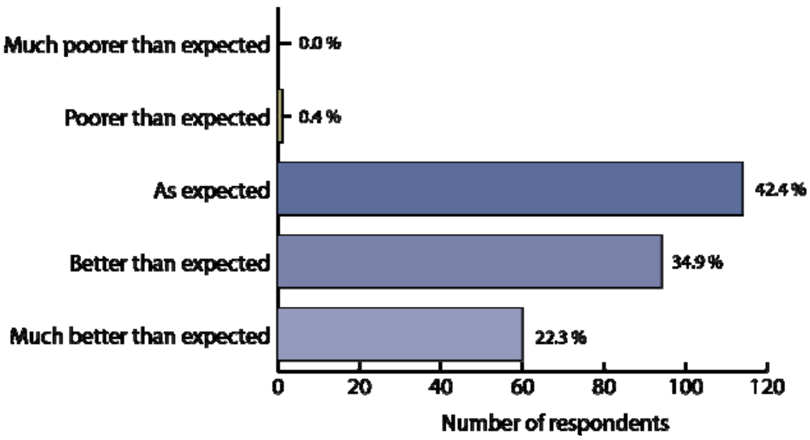
- More information about dangers of flight testing close to performance envelope limits.
- Flight testing took place [number {a few}] years ago when not as much emphasis was put into the flight test regime as is done now. I used a Flight Test schedule that proved adequate for flying off the test hours, however, further hours for completing the flight envelope in some structured manner would have been useful. These days the SAAA has a more comprehensive schedule and program plus suggested training in place which is a great improvement.

Aircraft handling after test flight

A person buying ABE aircraft plans or a kit, generally does so with reference to aircraft performance. Each ABE aircraft is slightly different, and to some degree this probably influences its handling characteristics. In order to build a picture of expectations about ABE aircraft, respondents were asked to rate how the aircraft performed after test flight.

About 40 per cent of people recorded their aircraft performed as expected, while about 35 per cent recorded that their aircraft performed better than expected. About 20 per cent thought their aircraft performed much better than expected, while less than one per cent thought the aircraft performed poorer than expected. It is possible that respondents who rated aircraft performance as better, or much better than expected, transitioned from certified general aviation aircraft to a higher performance aircraft. Alternatively, the result may reflect an element of surprise, or satisfaction at achieving a result beyond expectation.

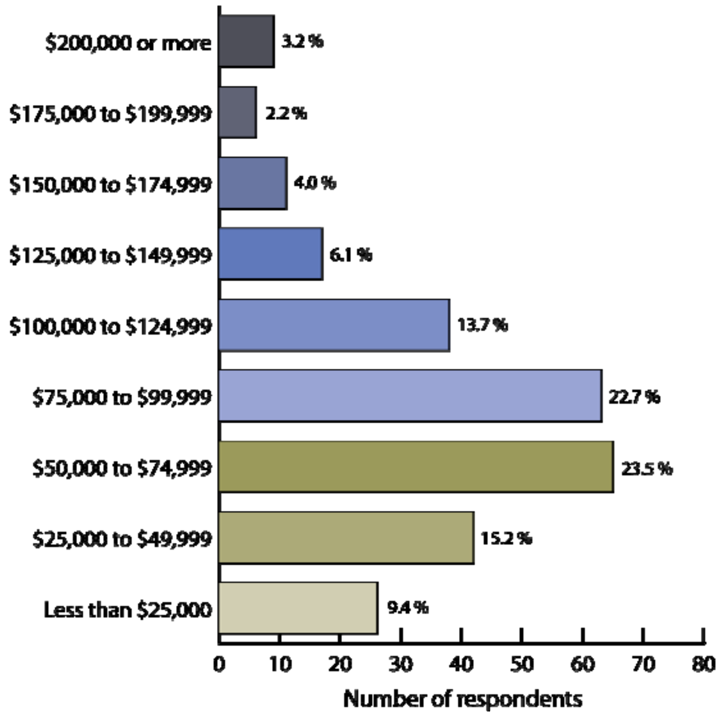
Figure 84: Aircraft performance after test flight



3.7 Aircraft building cost

Total aircraft cost is a major concern for builders of ABE aircraft. The majority of respondents recorded values of less than $100,000, and only a small proportion of respondents spent more than $175,000. Traditionally, plans-build aircraft are the cheapest to build, and quick-build aircraft are the most expensive (Larsen, 2005; Fuentes, 2005); this survey supports that contention.

Figure 85: Aircraft build cost



Only two of 63 respondents who built an ABE aircraft using the quick-build method spent less than $50,000, while 45 of 66 respondents using a plans-build method spent less than $50,000. There were 19 of 138 respondents using a slow-build option who spent less than $50,000. Clearly plans-build is the cheapest option.[45]

3.8 Second-hand aircraft

Second-hand aircraft purchase involves assessing the quality of an aircraft visually and in operation, as well as looking for documents to help form an opinion about how the product has been constructed, flown, and maintained. This can involve specialist knowledge, so respondents were asked to record which documents they obtained with their aircraft, and any person or organisation they used to help inspect the aircraft.

There were 79 people who purchased a second-hand aircraft, and 77 (97.5 per cent) obtained at least one purchase document. About 93 per cent (74 of 79) of respondents with second-hand aircraft got help to inspect the aircraft from at least one person or organisation.

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[45] $\chi^2 = 91.60$, $p < 0.01$. Mean and median values are not reported because data were collected in categories.

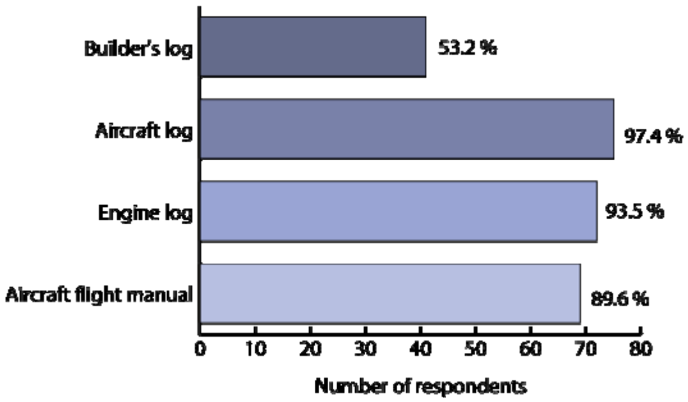
Second-hand documents

In total, there were 392 responses by the 77 respondents who obtained at least one purchase document. They obtained between one and eight documents, with six being the most frequently occurring (modal) number of documents. One respondent obtained an aircraft flight manual alone, and another respondent bought the aircraft without an aircraft log, but with an engine log and construction manual and plans. Most respondents obtained an aircraft and engine log (about 93 per cent). About 80 per cent of respondents obtained an aircraft flight manual, aircraft log, and engine log. Where respondents did not obtain a flight manual (8 of 77), two had flight test documents.

These data show that people tend to obtain packages of documents, rather than one document alone. For example, no respondent purchased a second-hand aircraft obtaining a builder's log alone. Similarly, of the 22 respondents who obtained pictures with their aircraft, only two respondents did not also obtain construction manuals and plans. Nineteen of 22 respondents obtaining pictures of the aircraft during construction, had between 6 and 8 documents in total. This most often included at least an aircraft log, engine log and builder log. Where a builder's log was not obtained (36 respondents), about 60 per cent obtained a construction manual and plans.

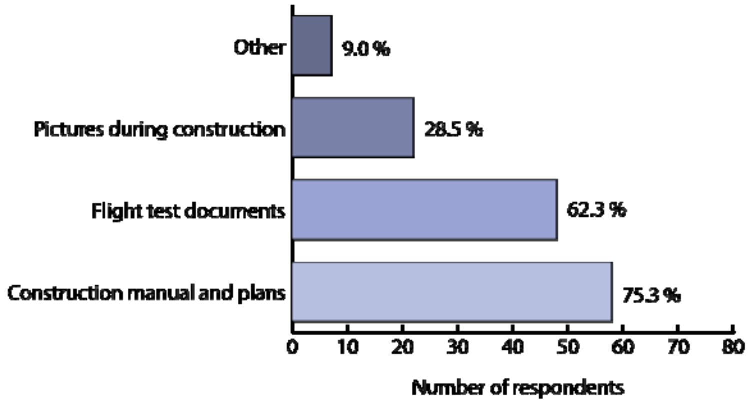
Documents were divided into two different categories; important, and nice-to-have. Important documents included the builder's log, aircraft log, engine log, and aircraft flight manual and these are found in Figure 86. There were 257 responses to these four documents. Second-hand owner-respondents most frequently obtained aircraft logs, engine logs and an aircraft flight manual. Builder's logs were obtained less frequently.

Figure 86: Important documents obtained by second-hand owners



Nice-to-have documents included pictures during construction, flight test documents, and construction manuals. Of the nice-to-have documents, construction manuals and plans, along with flight test documents were most frequently obtained. Pictures during construction were less frequently obtained. The other category included instrument manuals and parts lists. One person wrote that they viewed other aircraft built by the seller, being satisfied with the construction technique.

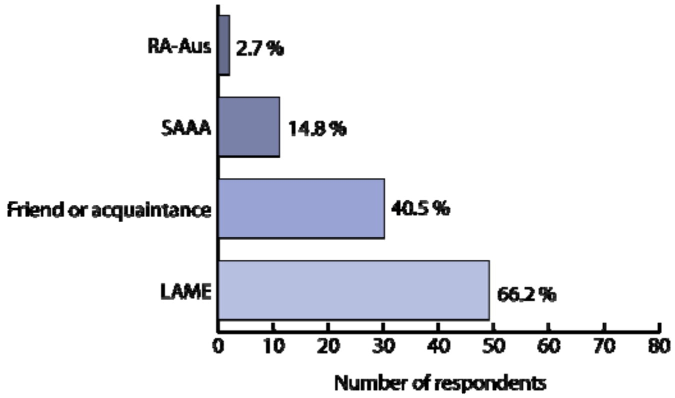
Figure 87: Nice-to-have documents obtained by second-hand owners



Second-hand help

There were 135 responses recorded from the 74 people who got help to inspect the second-hand aircraft. Licensed aircraft maintenance engineers were most often used, followed by a friend or acquaintance. Less frequently used were members of aircraft associations.

Figure 88: Second-hand help



For the 10 ‘other’ responses, six respondents made their own assessment, two stated they got help to inspect the aircraft from association or organisations outside of the SAAA or RA-Aus, and two people took chief flying instructors with them to inspect the aircraft.

3.9 Transition training

Transition training involves matching pilot skills with aircraft performance characteristics. This applies to builders of ABE aircraft as well as owners of second-hand aircraft. It is an important area which is receiving greater attention by the amateur-built aircraft community. This awareness has been partly driven by a move from lower to higher performance aircraft in ABE. To fly an aircraft, a pilot must have appropriate experience and skills; this is required by legislation. Sometimes, Australian insurance companies make transition training compulsory and specify the type of aircraft that must be flown. Different categories of pilots may need more or less transition training, based on previous experience.

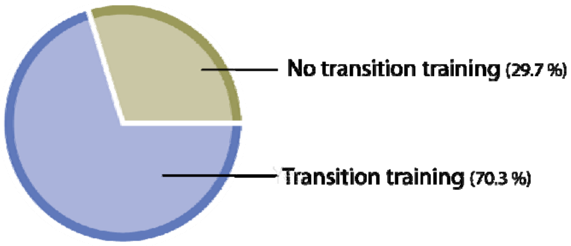
The concept of transition training closely relates to endorsements, but goes beyond them to encompass the process of making a gap-fit assessment. This assessment examines current and needed pilot experience. It also involves preparing a structured program of training to gain the right experience. The term *transition training* does not appear in CAR or CASR documents. Regulations 5 and 20 of the CAR specify the experience needed for pilot licences from student to air transport. The need for transition training has been recognised by production aircraft manufacturers (General Aviation Manufacturers Association, 1989), and amateur-built aircraft associations such as the EEA and the SAAA. This report explores transition training based on:

- type of flying and flying experience in hours
- current and highest pilot licences.

3.9.1 Access and usefulness

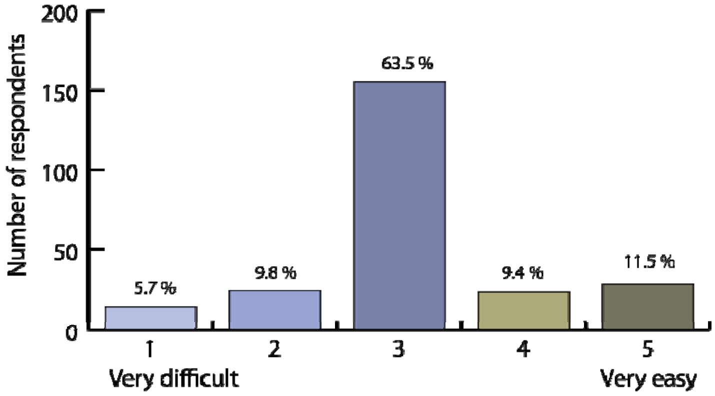
Figure 89 records the proportion of respondents who indicated they undertook transition training. Two-hundred and forty-eight (248) of 354 people (70 per cent) undertook transition training. Most respondents who undertook transition training, did so prior to the purchase of their aircraft.

Figure 89: Transition training undertaken



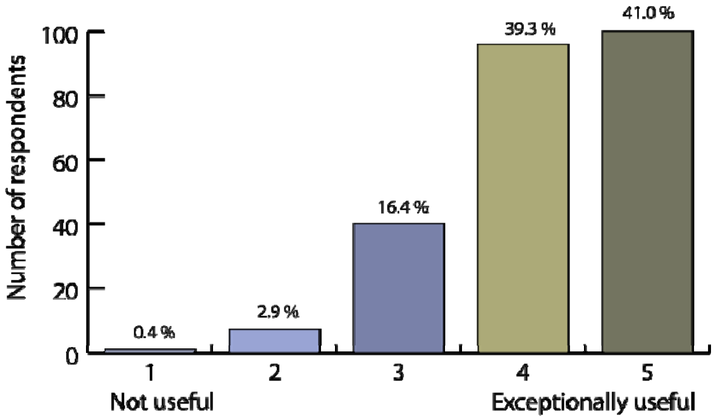
Rating of access to transition training is found in Figure 90. This shows that most respondents were readily able to access transition training. About 15 per cent found it somewhat difficult or very difficult to access transition training. It may be that these people were part of a niche aircraft market, or alternatively they may not have had friends who were willing to let them use their aircraft. Insurance may be null and void if someone other than the owner flies the aircraft, or the pilot may be geographically isolated, making training more difficult to access. Geographical isolation and insurance is not covered in this report.

Figure 90: Rating of access to transition training



Where people undertook transition training, most found it useful, very useful or exceptionally useful (Figure 91).

Figure 91: Rating of the usefulness of transition training



Until the mid 1970s, pilots in Australia were given an endorsement for each aircraft they flew, except amateur-built aircraft. In this instance, there was a general endorsement called Ultra Light Aircraft. Aircraft built during the ABAA and pre-ABAA period, had limitations on horsepower and stall speed, making these aircraft somewhat similar. That is no longer the case with the experimental category. There was no statistically significant relationship between transition training and the type certificate.

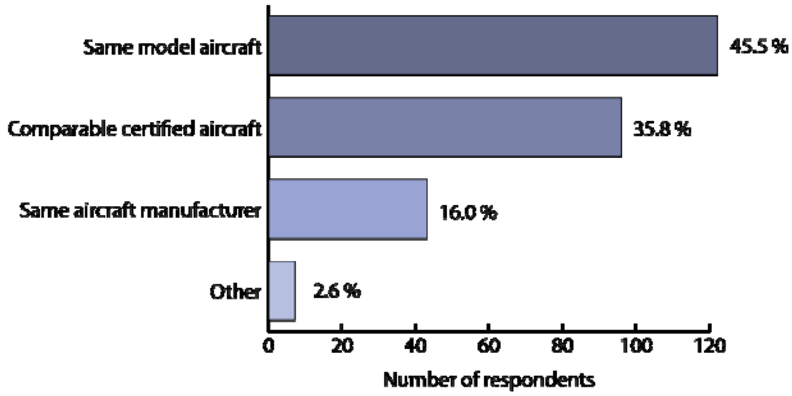
In order to further understand the different groups of people within transition training categories, the data were stratified by a number of other survey variables including licence type, pilot hours, aircraft performance and second-hand status. Some of these are discussed in the following section, but tables or figures of those variables not found significant are located in Appendix C.

Statistically significant associations were found between transition training and type of flying, total and ABE pilot hours, amount of flying in the three months prior to test flight, and undercarriage configuration. These are explored in the following section.

3.9.2 Aircraft and training

Transition training by the type of aircraft is recorded in (Figure 92). Two-hundred and sixty-eight responses were received by 248 respondents who performed transition training. About 45 per cent of respondents undertook transition training in the same model aircraft, and about 35 per cent undertook transition training in a comparable certified aircraft. Sixteen per cent undertook transition training in an aircraft by the same manufacturer or designer, and about two per cent in another type of aircraft. In the other category, the seven respondents made reference to comparable ABE aircraft, and RA-Aus aircraft.

Figure 92: Type of aircraft and transition training



3.9.3 Effect of pilot type, operation type and flying activity

Transition training by type of flying hours

Table 7 records transition training by the sector where pilots accumulated the majority of flying hours. This shows a statistically significant association between the type of flying and transition training.

Table 7: Sector of aviation and transition training

Type flying	Transition training		
Majority of hours	Yes	No	Total
Aerial work	2	3	5
Agricultural work	1	3	4
Airline / Air transport	17	12	29
Charter	3	2	5
Flying training	12	4	16
Private	211	79	290
Total	246	103	349

Statistically significant $\chi^2 = 9.32$, $p \leq 0.10$

Fifty-nine of 349 pilots accumulated the majority of their hours outside of private flying. Table 8 shows that people who accrued the majority of their flying hours in private flying were 1.8 times more likely to undertake transition training. This association is statistically significant.

Table 8: Private versus all other sectors of aviation by transition training

Sector	Transition training		
Majority of hours	Yes	No	Total
Private	211	79	290
All other	35	24	59
Total	246	103	349

Odds ratio 1.83, 90 per cent confidence interval 1.13 to 2.98, $\chi^2 = 4.25$, $p < 0.05$

Transition training by pilot licence

Three-hundred and forty-five of 353 total observations were available for analysing transition training by highest pilot licence. The association between *current* pilots licence and transition training was not statistically significant (Table 9). Likewise, the association between *highest* pilot licence and transition training, shown in Table 10, was also not statistically significant. One might expect to find an association between pilots licence and transition training, but a clear association is not found in these data.

Table 9: Transition training by current pilot licence

Current licence	Transition training		
	Yes	No	Total
Air transport	9	4	13
Commercial	10	9	19
Private	224	89	313
Total	243	102	345

Not statistically significant $\chi^2 = 3.1$, $p = 0.21$

Table 10: Transition training by highest pilot licence

Highest licence	Transition training		
	Yes	No	Total
Air transport	18	13	31
Commercial	29	17	46
Private	195	73	268
Total	242	103	345

Not statistically significant $\chi^2 = 4.14$, $p = 0.13$

Transition training by the total number of hours flown

Table 11 compares the total number of hours flown on all aircraft by transition training. Respondents who performed transition training had fewer total hours on average and this was statistically significant based on 351 cases. Using median hours to compare pilot hours, people who performed transition training had about 550 hours less total hours than people who did not undertake transition training.

Table 11: Total pilot hours all aircraft by transition training

Transition training	N	Mean	Median	Range
Yes	246	2,179	753	27,945
No	105	3,408	1,300	21,998
Total	351	2,547	865	27,998

Statistically significant Kruskal-Wallis $\chi^2 = 13.22$, $p < 0.01$

The same test applied to total hours flown on ABE aircraft only shows a remarkably similar result. Using median hours to compare pilot hours, people who performed transition training had accumulated about 75 less total ABE hours compared to those who did not perform transition training.

Table 12: Transition training by total pilot hours on ABE aircraft

Transition training	N	Mean	Median	Range
Yes	235	328	193	4,883
No	100	401	300	2,000
Total	335	350	200	4,883

Statistically significant Kruskal-Wallis $\chi^2 = 4.17$, $p < 0.05$

Transition from novice to expert has been the subject of serious study in aviation and a number of other disciplines (Drefus & Dreyfus, 1980). In the model by Dreyfus and Dreyfus (1980), people move through five distinct stages from novice to expert. The novice tends to adhere to rules, but the expert seems to possess an intuitive grasp of the situation, along with some idea of what to expect. It seems possible that those who perform transition training in general, may be close to the novice end of the continuum between novice and expert.

Transition training for second-hand or built aircraft

Table 13 compares the total respondents who completed transition training for those who built their aircraft compared to those who bought a second-hand aircraft. There was no statistical association, meaning that pilots who purchased second-hand aircraft were as likely to perform transition training as builders.

Table 13: Transition training by second hand aircraft

Second hand	Transition training		
Aircraft	Yes	No	Total
Yes	56	23	79
No	192	82	274
Total	248	105	353

Not statistically significant $\chi^2 = 0.02$, $p = 0.89$

3.9.4 Aircraft performance and training

Higher performance aircraft may require a different or an enhanced skill set to fly when compared with standard aircraft. A number of different measures can be used to examine aircraft performance including wing loading and stall speed. One might expect that people with higher performance aircraft may perform transition training.

Transition training by aircraft wing loading

The association between aircraft wing loading and transition training was explored in Table 14. No statistically significant difference was found between owners of aircraft with wing loading[46] greater than or equal to 100 m^2 and those less than 100 m^2.

Table 14: Transition training and aircraft wing loading

Wing loading	Transition training		
Square metres	Yes	No	Total
≥ 100	19	8	27
< 100	225	96	321
Total	244	104	348

Not statistically significant $\chi^2 = 0.0009$, $p = 0.97$

Stall speed

The association between aircraft dirty stall speed and transition training was explored in Table 15. No statistically significant difference was seen between owners of aircraft with a dirty stall speed of greater than or equal to 50 knots and those less than 50 knots with respect to transition training.

[46] Several other wing loading data divisions were made including 120, 110, 90 and 80 m^2, but none were statistically significant.

Table 15: Transition training and aircraft wing loading

Stall speed	Transition training		
Knots	Yes	No	Total
≥ 50	73	38	111
< 50	168	66	234
Total	241	104	345

Not statistically significant χ^2 =1.30, p = 0.25

Type of certificate

The type of certificate and transition training is found in Table 16 and Table 17. This shows that the type of certificate an aircraft was built and operated under was not associated with pilot transition training.

Table 16: Certificate aircraft built under and transition training

Certificate	Transition training		
Built	Yes	No	Total
ABAA	94	31	125
Experimental	152	74	226
Total	246	105	351

Not statistically significant χ^2 = 2.42, p = 0.12

Table 17: Certificate aircraft operates under and transition training

Certificate	Transition training		
Built	Yes	No	Total
ABAA	49	19	68
Experimental	197	85	282
Total	247	104	350

Not statistically significant χ^2 = 0.12, p = 0.72

Undercarriage configuration and transition training

Most pilots begin flying on fixed tricycle undercarriage aircraft. Additional skill is required to operate tail wheel aircraft and, but probably to a lesser extent, retractable undercarriage aircraft. The association between undercarriage configuration and transition training is shown in (Table 18). This table excludes helicopter and amphibious aircraft. The table below shows that owners of tail wheel aircraft were more likely to undertake transition training than those with fixed tricycle configurations. This is consistent with the fact that a tail wheel undercarriage configuration is a specific design feature endorsement. In other words, a person will have built or purchased a second-hand tail wheel aircraft and must be endorsed under CAO 40.1.0 to fly the aircraft. There was no significant relationship between retractable undercarriage, fixed tricycle aircraft and transition training (χ^2=1.62, p = 0.20). This is consistent with the fact that retractable undercarriage endorsements and manual propeller pitch control are often gained as a matter of course after PPL training or during CPL training.

Table 18: Type of undercarriage and transition training

Undercarriage	Transition training		
	Yes	No	Total
Fixed tricycle	89	50	139
Tail wheel	134	49	183
Retractable	20	6	26
Total	243	105	348

Comparing tail-wheel to fixed tricycle undercarriages, statistically significant, odds ratio 1.53, 90 per cent confidence intervals 1.03 to 2.29, χ^2 = 3.14, p < 0.08.

Transition training by type of aircraft instruments

Some anecdotal evidence on aviation internet forums suggests that there may be some challenges to transition from analogue instruments to glass cockpits. They point out that glass cockpits are beneficial because everything is contained in the one place, meaning there is less eye movement compared with analogue instruments. The relationship between transition training and the type of aircraft instruments is recorded in Table 19. The table below shows that in comparison with aircraft equipped with analogue cockpits, those with combination analogue and glass cockpits were more likely to conduct transition training.

Table 19: Transition training by type of aircraft instruments

Type of cockpit	Transition training		
Instruments	Yes	No	Total
Analogue	157	80	237
Analogue and glass	78	19	97
Glass	13	6	19
Total	248	105	353

Statistically significant, odds ratio 2.09, 90 per cent confidence interval 1.29 to 3.37, χ^2=6.62, $p \leq 0.01$, comparing analogue and glass, with analogue alone.

Transition training and flying while building

Table 20 records transition training by the amount of flying performed in the 3 months prior to test flight. A statistically significant result was observed in these data.

Table 20: Transition training by the amount of flying three months prior to test flight

Flying three months prior	**Transition training**		
Test flight	Yes	No	Total
Much less than usual	10	10	20
Less than usual	19	11	30
About the same	64	44	108
More than usual	67	17	84
Much more than usual	31	3	34
Total	191	85	276

Statistically significant χ^2 = 21.05, p<0.01

Table 21 records transition training by the amount of flying in the 3 months prior to test flight. A statistically significant association was found. In order to identify the magnitude of the difference, and the categories where differences occurred in transition training, by the amount of flying in the 3 months prior to test flight, two new variables were created. The first combined *much less* and *less than usual*, and the second combined *more than* and *much more than usual*. When respondent flying with about the same hours were compared to those with less or much less flying in the 3 months prior to test flight, there was no statistically significant difference in those who did transition training. However, when those performing more or much more flying in the 3 months before flight testing were compared to those with less or much less test flying, those performing more or much more flying were about three and a half times more likely to have undertaken transition training.

Table 21: Transition training by the amount of flying three months prior to test flight

Flying three months	**Transition training**		
Prior to test flight	Yes	No	Total
Less, or much less	29	21	50
About the same	64	44	108
More, or much more	98	20	118
Total	191	85	276

Statistically significant for more, or much more, compared to much less, or less, odds ratio 3.54, 90 per cent confidence intervals 1.91 to 6.59. Not statistically significant for about the same to much less, or less, odds ratio 1.05, 90 per cent confidence interval 0.59 to 1.86.

3.9.5 When transition training was not undertaken

These data tell us about who has undertaken transition training, but not about the need to undertake transition. The need for transition training must be considered in parallel with the relevant experience of the pilot. Clearly, some sectors of aviation have broader and much more transferrable experience and may not need transition training. From this survey, we know the sector of aviation where the majority of their hours have accumulated, but not what type of aircraft people have flown. Drilling down to characterise people by type of flying, without specific details of the aircraft flown and type of operation, can lead to a range of answers.

For example, in a recent ATSB paper, *Immediately Reportable Matters involving Charter Operations, 2001 to 2006*, it was reported that the five most common aircraft models used for charter operations were Fairchild SA227, Piper PA-31 Navajo, Aero Commander 500, Cessna 210 and Cessna 206. These are single and twin-engine aircraft, with fixed and retractable undercarriages. Aerial work covers an even broader range of activities. It seems possible that charter and aerial work pilots might be better prepared to fly higher performance ABE aircraft than most private pilots. They must fly into unusual or different aerodromes, fly at different times of the day and night, and fly complex aircraft, but the ABE aircraft they fly are not necessarily high performance.

It is instructive to examine the comments of respondents who accrued the majority of hours outside of private flying, but did not perform transition training. Only some people who did not perform transition training provided comments in relation to transition training. One respondent with over 6,000 hours experience in charter operations stated:

> With my experience I get to test a few (I did not conduct transition training), but did an hour with the previous owner. (I) had about 500 hours on other tail wheel (aircraft). Present licence endorsed for any singles up to 5,000 kg – you still want some dual if possible.

A further respondent who did not perform transition training with over 9,000 hours said:

> I would consider transition training for anyone not current or competent on high performance agile aircraft to be essential!

Finally, an air transport pilot with over 3,500 hours said:

> From what I have seen ABE builders have a healthy respect for the aircraft they have build and that is due mostly to seeing what goes into the airframe, engine, etc. I feel that subsequent owners (and some builders) may need some education on the limitations on these aircraft, i.e.: just because the aircraft isn't under as much scrutiny as a certified machine, it doesn't make flying it through V_{NE} safer. Limits are limits, whether regulated or not.

A few private pilots who did not perform transition training commented on either transition training or currency on type.

One private pilot who built a Lancair and has over 900 hours in total on all aircraft wrote:

> I converted from gliding to power on my first LNC2. Control responses were similar and conversion was not a problem. Converting from conventional power to a Lancair is probably much more difficult and hazardous with likelihood of PIOs. I would strongly recommend pilots have a detailed conversion course. Installation of an angle of attack indicator with auditory warning on high performance aircraft could also be a mandatory requirement (all Lancair fatalities have been due to stall/spin incidents).

A private pilot who built a Long-EZ and has over 5,000 hours on all aircraft said:

> It should be mandatory that any non-builder pilot should have a thorough knowledge of all the aircraft's systems and idiosyncrasies. Both builder and non-builder pilots should demonstrate recent currency and proficiency in an aircraft with similar performance to the one they are buying/building before they fly.

Another pilot who built an RV-7 and has over 250 hours on all aircraft said:

> It would be easy for some builders to bite off more than they can chew with relation to their choice of aircraft. I mean builders often love the challenge of building and may overlook their ability as low time pilots to eventually fly it e.g. a Lancair is a great plane to build but is not necessarily the best for Australian conditions.

3.9.6 Bias and transition training

It is possible that a slightly larger number of people may have undertaken some form of transition training, but not with their current aircraft. Although the intention of question 42 was to inquire if a person had ever conducted transition training, the instructions at the beginning of the survey told respondents to record details of the most recent aircraft. It is evident that at least one person interpreted the transition training question according to that rule. This person had built one aircraft, and purchased a second-hand aircraft. They stated:

> Built Glasair over 13 years, transition training was conducted (after test flying by test pilot), by long time instructor. I have not flown this aircraft since [date]. In retirement I no longer have need of a fast aircraft and have opted for one of more simple construction with not so high maintenance e.g fixed pitch vs constant prop, fixed vs retractable gear.

3.10 Maintenance

Aircraft maintenance is a critical part of the flying process where an aircraft is inspected, repaired, modified, over-hauled, in part or as a whole. This involves evaluating kit manufacturer or designer service bulletins and regulator airworthiness directives, documenting parts used, testing and evaluating the success of the maintenance, and devising a schedule of maintenance, such as when particular procedures need to be performed. Maintenance-related accidents have been the subject of much research in aviation generally (e.g. Hobbs, 2003; Hobbs, 2008; Goldman, Fieldler & King, 2002) and a recent study of ABE maintenance-related accidents has been carried out by Goldman *et al.* (2003). This study found that maintenance-related accidents were over-represented in GA accidents based on the number of hours flown. Maintenance is probably one of the most contentious areas of VH- registered ABE aircraft operation, and since the experimental category was introduced there is at least some evidence that ‘many [people] may be less than fully equipped for this task’ (SAAA, 2009).

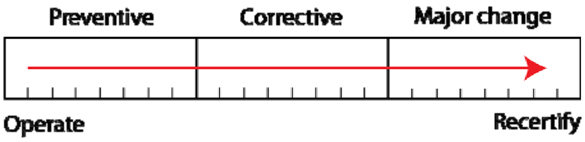
As pointed out in *An Overview of Human Factors in Aviation Maintenance* (Hobbs, 2008), maintenance tends to be either preventive or corrective - it is also referred to as scheduled and unscheduled maintenance. Hobbs (2008) notes that aircraft maintenance involves a lot of documentation, with LAMEs spending as much time using a pen as using a spanner. The corollary to this is that in general, more time is spent thinking about how to approach a maintenance task than the time taken to actually perform the task.

According to CASA (2006), maintenance is distinguished from a major design change when any of the following changes occur:

- weight and balance of the aircraft
- structural strength of the aircraft
- performance of the aircraft
- operational characteristics of the aircraft.

There is an important boundary between maintenance and major changes. For example, moving an ABAA aircraft to experimental and placing a larger horsepower engine on the aircraft, is not considered maintenance according to the regulator. Figure 93 depicts the boundary between normal maintenance involved in operating an aircraft and major change that will require recertification.

Figure 93: Relationship between aircraft operation, maintenance and major changes



In relation to certified aircraft, aircraft maintenance is divided into five distinct areas: airframe, engines, avionics, electrics, and radio.

Each category of maintenance is tested and endorsed, with specialisation occurring based on aircraft type, size and system-based distinctions. For certified aircraft, there is a complex interaction between operators, manufacturers, the state of registry and state of manufacture or design (ATSB, 2002) as recorded in Figure 94. A similar information flow exists for ABAA aircraft in Australia, although not many airworthiness directives have been issued. It is worth noting that important airworthiness directives have been issued for Kitfox, Rutan, Lancair, Sonerai, Van's, Piel and Stephens ABE aircraft.[47] Airworthiness directives are aimed at operational aircraft, but there may be some interplay with aircraft under construction or undergoing flight testing.

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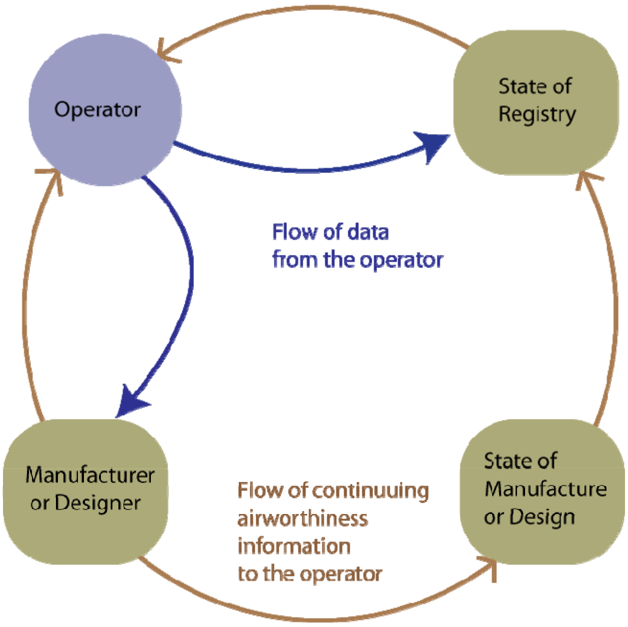
[47] AD/AKRO/1 Airspeed Restriction, AD/EMERAUDE/1 Anti Spin Strakes – Installation, AD/KITFOX/1 Wing Structural Integrity, AD/KITFOX/2 Flaperon Mass Balance, AD/KITFOX/3 Alumnium Fuel Tanks, AD/LANCAIR/1 Canopy Latching, AD/LANCAIR/2 Fuel Tanks, AD/LANCAIR/3 Fibre Composite Primary Structure, AD/RUTAN/1 Rudder Travel – Modification, AD/SONERAI/1 Flight Restriction and Limitations – Placard and Modification, AD/VG-RV/1 Elevator Trim Tab.

Figure 94: Information flows associated with continuing airworthiness for certified aircraft



A permit to fly under ABAA requires aircraft to have all modifications approved, in addition to a check to ensure that airworthiness directives for aircraft currently in service addressed where necessary. However, in relation to experimental aircraft, the flow of information depicted in Figure 94 will not necessarily occur as there is no requirement for CASA, as the registering authority, to be involved in the continuing airworthiness loop unless CASA considers that operation of the aircraft is a danger to public safety. All responsibility for checking kit manufacturer directives, service bulletins, and other maintenance documents rests entirely with the builder, or a LAME for second-hand ABE aircraft. Horneman (2008) points out that most ABE aircraft are maintained according to CASA Schedule 5. Experimental aircraft must be maintained in accordance with CAR 42CB, which refers to the issue of experimental certificates under CASR 21.195A.

Calls have been made by amateur aircraft builders since the 1970s for a workable syllabus on aircraft maintenance.[48] The Sport Aircraft Operations Group has been negotiating with CASA to develop a Basic Airworthiness Administration Syllabus. Horneman (2008) makes the following maintenance recommendations for ABE aircraft operators:

- research the aircraft's maintenance requirements
- regularly check kit or designer websites for updates
- consult people and organisations with appropriate experience for the type of flying performed
- consult with a LAME
- develop a risk management process.

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48 In a letter to the editor of *Australian Airsport* in 1973, Zapletal proposed a workable syllabus to deal with the owner maintenance problem under ABAA, pointing out that although clear drawings and guidance are found in an aircraft build project, there is no such guide for maintenance.

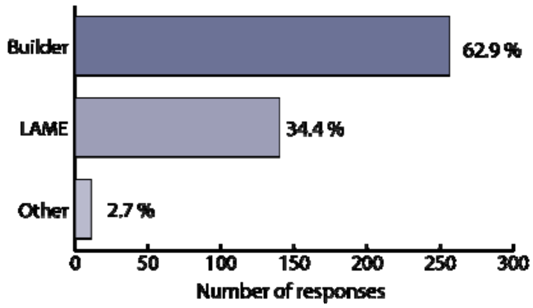
Amateur-built and experimental aircraft owners who perform maintenance may have less time pressures than RPT services where delays in returning aircraft to service may be a significant cost for airlines. On the other hand, not all people who own aircraft have a mechanical background. Even where a person does have the necessary skills to perform maintenance, they may not be approved to do it. For example, one respondent to the survey in this report owned two identical aircraft, the first built by the respondent, and the second by another person. Both have the same engine and propeller, but the owner is only allowed to perform maintenance on the respondent-built aircraft.

Amateur Built Aircraft Approval aircraft owners with a maintenance authority and all experimental aircraft owners, can perform some or all of the maintenance on their aircraft. Based on the idea that not everyone will want to maintain all aspects of an aircraft, a series of survey questions requested information on who performs airframe, engine, and avionics. These were multiple response questions with the possibility of up to four answers for each major component.

3.10.1 Airframe maintenance

Figure 95 records who performed airframe maintenance. There were 407 responses from 353 respondents, 303 of 407 (85.8 per cent) providing one response, 46 of 407 (13.0 per cent) providing two responses and 4 of 407 (1.1 per cent) providing three responses. This shows that the respondent most frequently performed airframe maintenance, followed by a LAME and then another person; this included co-builders, other aircraft builders, and the original kit manufacturer.

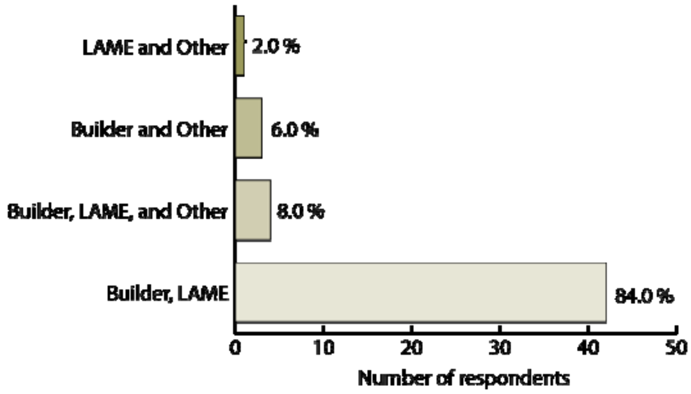
Figure 95: Airframe maintenance



Airframe maintenance more than one person

Figure 96 records values where more than one person performed airframe maintenance. This shows that the most common arrangement was the respondent and a LAME.

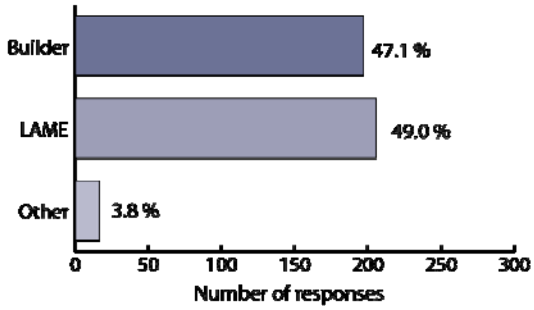
Figure 96: Airframe maintenance multiple people



3.10.2 Engine maintenance

Three-hundred and fifty-three (353) people provided 418 answers to the question on who performed engine maintenance. Two-hundred and ninety-three of 418 (83 per cent) provided one answer, 55 of 418 (15.6 per cent) provided two answers, and 5 of 418 (1.4 per cent) provided three answers. This shows that a LAME performed maintenance on engines among 49 per cent of respondents, followed by the respondent (47.1 per cent), and another person (3.8 per cent). The *others* in this category were engine dyno tuners for automotive engines. The proportion of respondents who used a LAME for engine maintenance was significantly higher than for airframes (50 per cent versus 34 per cent).

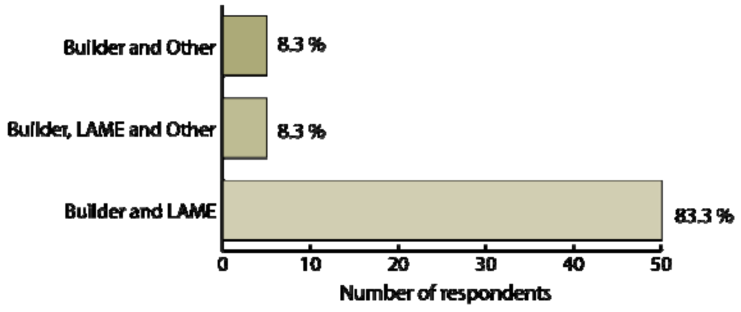
Figure 97: Engine maintenance



Engine maintenance more than one person

Figure 98 records respondents where multiple people performed engine maintenance. This shows that the respondent and a LAME was the most frequently occurring combination of people, accounting for 83 per cent of respondents using more than one person for engine maintenance.

Figure 98: Engine maintenance multiple



3.10.3 Avionics maintenance

Four-hundred and three responses were provided by 347 respondents for avionics maintenance. There were 296 respondents who provided one response (85.3 per cent), 46 who provided two responses (13.3 per cent), and five who provided three responses (1.4 per cent). Figure 97 records who performed avionics maintenance. This shows that avionics maintenance was mostly either performed by a LAME or by the respondent.

Figure 99: Avionics maintenance

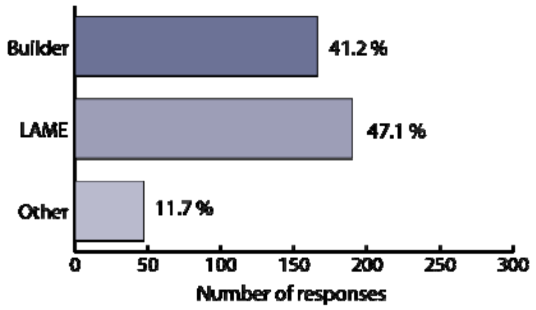
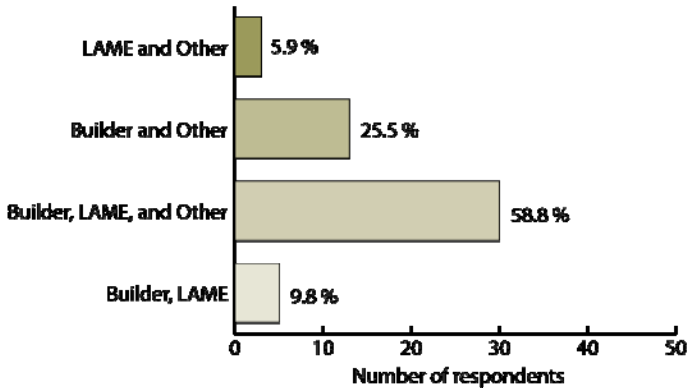


Figure 100 records respondents where multiple people performed avionics maintenance. This shows that the respondent, and a LAME and other person was the most frequently occurring combination of people. *Licensed aircraft maintenance engineer and other* occurs least frequently.

Figure 100: Avionics maintenance multiple



3.10.4 Maintenance comments

Thirty-five people made comments in relation to maintenance. These comments generally clarified the approach taken by the builder or operator. The comments fell roughly into three areas; knowledge and skills, options and control over maintenance, and transitions to other aircraft registers. Not all comments are included, but indicative comments are shown below.

Transitions from VH- register

One person wrote:

> I have recently moved this aircraft from the VH register to Recreational Aviation Australia. This was in order to do my own maintenance.

Control and accreditation

One owner with concerns about oversight of sport aviation stated:

> I am concerned at the growth of the ‘ cheque book’ builders and the practice of rewarding them with the right to maintain their aircraft as a part of the experimental certificate, indeed the emerging expectation of the maintenance rights for second and subsequent owners without any formalised training or at best the most minimalist training available.

Another person stated:

> I would like to see an accreditation system in place for suitably trained or qualified persons (owners) to maintain experimental aircraft they have not built, that is, second hand owners of experimental aircraft.

One person commented on the process where maintenance and major changes cross over:

> By performing my own maintenance, I can make absolutely certain that no alterations are carried out on the structure and aerodynamics, without Reg 35 approval. The big thing is not to rely on an approved workshops and their hefty charges and questionable work.

Knowledge and skills

Speaking of the difference between building and maintaining an aircraft, one person commented:

> Just because you built it, doesn’t mean you have the expertise to maintain it. Most builders I know are prudent in gaining professional advice regarding maintenance if they are unsure of their skills in a certain area. One thing building teaches you is ‘how much you don’t know’…a very valuable lesson.

The picture that emerges from maintenance data in this report is that there are three groups of people. There are those who get all maintenance done by a LAME, those who do all maintenance themselves, and those who involve a team of people. Some people are not interested in performing maintenance, while other people, not currently performing maintenance, are looking for the education that might allow them to perform their own maintenance, particularly for second-hand aircraft.

4 CONCLUSIONS

Amateur-built and Experimental (ABE) aircraft are an integral part of Australian aviation, making up about eight per cent of all VH- registered aircraft. This report has outlined some of the key features of this population of aircraft owners. The picture that emerges is diverse, reflecting the two systems available in Australia to build ABE aircraft, and the needs of builders and owners. It has shown that most ABE owners were near or at retirement age, and mainly private pilots. Their experience had been gained mostly in private flying, but they generally performed more flying than the average private pilot. On average, 30 per cent of total flying hours were performed in ABE aircraft.

Metal aircraft and composite aircraft made up about 80 per cent of all aircraft built or owned, and monoplanes were favoured in about 90 per cent of aircraft. About two-thirds of people used a certified engine, and where an automotive engine was used, more challenges generally arose during the build process. A little less than half the aircraft surveyed were complex aircraft, and about eight per cent of aircraft were equipped for instrument flight. The wing loading of many of the aircraft surveyed was similar to certified aircraft, but some high performance ABE aircraft have higher wing loading than certified aircraft.

About 42 airframe hours were accumulated in the last year per aircraft, while about 236 airframes hours were accumulated in total. The type of flying influenced airframe hours with the highest airframe hours being in touring and sports or aerobatic flying. The majority of aircraft owned by survey respondents were in the experimental category, and a shift from Amateur Built Aircraft Approval to experimental aircraft was observed in about 16 per cent of respondents.

Respondents built and flew their ABE aircraft for a variety reasons, rating build challenge, personal satisfaction, aircraft performance, purchase price, operating cost, and the ability to perform maintenance with significant importance. The ability to customise their aircraft presented a mixed result with about 50 per cent of people seeing a standard aircraft as desirable.

About 80 per cent of respondents built and flew their aircraft and, of these people, the vast majority only built one aircraft; one person built eight aircraft. Respondents chose ‘slow-build’ kits most frequently, followed by plans and ‘quick-build kits’. Those building by plans generally required about 3,000 hours to build, while slow-build required 2,400 hours and quick-build 1,250 hours. A small number of people purchased a partially built kit.

About a third of aircraft builders made major build modifications during construction, with fuel systems, engines, and structural components being the systems most frequently modified. During the build phase, most respondents were challenged with engines and avionics, and in general most people had good access to build resources during construction. People found manufacturer resources, other builders, and aircraft associations helpful during the build phase, but a mixed result was found for internet user groups, and licensed aircraft maintenance engineers (LAMEs) and the aviation regulator were not seen as very helpful.

About half of all pilots who built an aircraft (rather than buying it second-hand) flew less, or much less during the build process. About 70 per cent of pilots flew much more in the 3 months leading up to the test flight phase. Pilots in this category were more likely to perform transition training.

About half the respondents spent between $50,000 and $100,000 to build their aircraft, with approximately 2.5 per cent spending greater than $200,000. In relation to the test flight phase, the manufacturer, aircraft association, and other aircraft builders were seen as helpful, while LAMEs presented a mixed result, and the internet user groups and aviation regulator were not rated as very helpful.

About two-thirds of builders performed flying during phase one test flight, but only 42 per cent performed the maiden flight. The maiden flight was more often performed by another pilot or a qualified test pilot. Combined crew operations were conducted in 10 per cent of maiden flights, and this jumped to 15 per cent for phase one flights.

Most builders did not think they would change anything about the test flight (phase one) (80 per cent). The 20 per cent who said they would do things differently in hindsight talked about issues including more flying time on the aircraft , different choice of airfield, taxi tests, emergency procedures, flight courses, better preparation, and making better use of the flight testing period to collect data.

Some form of transition training was undertaken by 70 per cent of pilots, and these pilots generally found transition training helpful. The majority of respondents trained in either the same model aircraft as the one they built or purchased, or in a comparable certified aircraft. Private pilots were more likely to undertake transition training, and those with more total pilot hours were less likely to undertake transition training. Pilots who purchased second-hand aircraft were as likely to undertake transition training as builders. Neither wing loading, aircraft complexity, or the type certificate the aircraft was built, or operates under, influenced transition training. Builders of tail wheel undercarriage aircraft were more likely to undertake transition training.

When purchasing aircraft second-hand, most people obtained documents as a package, and the majority of people took a trusted person with them to inspect the aircraft, a LAME being the most commonly-used person.

A range of people performed maintenance on ABE aircraft and their systems. This creates a unique mix of people who address different aircraft systems. For about 85 per cent of respondents, one person performs maintenance on airframe, engine and avionics. The second-hand status and type of certificate influenced who performed this work. Up to four different combinations of people can perform maintenance on different systems. The builder or operator tended to perform airframe maintenance, but performed less engine and avionics maintenance. A LAME was less likely to perform airframe maintenance, but more likely to perform engine and avionics maintenance. People in the *other* category of maintenance included engine mechanics, co-builders or other builders.

This report has presented an interesting picture of VH- registered ABE aviation in Australia. While many of these facts have been known anecdotally, this report places greater specificity on different aspects of ABE aircraft building and operation. It provides a valuable reference point for aircraft operators, those considering ABE aircraft, aviation regulators, and aircraft associations. In developing a better understanding of this sector of aviation, relevant parties are in a better position to plan, build and operate ABE aircraft into the future.

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APPENDIX A: SOURCES AND SUBMISSIONS

Sources of Information

The primary sources of information used during this research, in addition to the survey, were:

- Civil Aviation Safety Authority; Aircraft Register, and Pilot Licence database
- Bureau of Infrastructure, Transport and Regional Economics; General Aviation Activity Survey
- Australian Transport Safety Bureau *Aviation Safety Survey – Safety Climate Factors*
- Janes, All the World's Aircraft.

A more detailed description of the methods used to distribute the survey is provided in the Methodology (Chapter 2) and a full list of information sources is provided in the References (Chapter 5).

Submissions

A draft of this report was provided to the Civil Aviation Safety Authority, the Sport Aircraft Association of Australia, Recreational Aviation Australia, the Sport Aircraft Operations Group, the Bureau of Infrastructure, Transport and Regional Economics, the Civil Aviation Historical Society, Aviation Historical Society of Australia.

Submissions were received from the following parties:

- Bureau of Infrastructure, Transport and Regional Economics;
- Civil Aviation Safety Authority
- Sport Aircraft Association of Australia
- Recreational Aviation Australia
- Sport Aircraft Operations Group
- Aviation Historical Society of Australia.

The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

APPENDIX B: SURVEY

Australian Government
Australian Transport Safety Bureau

Survey of flying VH-registered Amateur-built/Experimental (ABE) Aircraft

(ABAA or Experimental)

General aviation has evolved considerably over the last couple of decades. As the production of certified aircraft has declined, other areas have experienced growth. One that continues to gain popularity is Amateur-built/ Experimental (ABE) aircraft. The ABE market has opened up in the last few years and aircraft construction, test flight and safety have become discussion points on numerous internet forums.

Importantly, there has been no formal study of ABE operations in Australia, and little in the way of objective analysis to inform members of this community. The increasing popularity of these aircraft has prompted the Australian Transport Safety Bureau (ATSB) to conduct a survey of flying VH-registered owners and builders of ABE aircraft.

Purpose of collection

The purpose of this survey is to gain insight into why people choose ABE aircraft, and what they do in constructing, preparing to fly, and maintaining their aircraft. Aviation associations can use this information to tailor their programs, and individual aircraft builders can use it as an information resource. This survey has been developed in consultation with key ABE aircraft representatives. It will provide safety insights into the ABE aircraft community from an Australian perspective. Data from the survey will be published by the ATSB as part of a wider study examining safety trends in ABE aircraft.

Focus

This survey focuses on Amateur-built (ABE) aircraft currently operating under the following Certificate of Airworthiness (C of A):

- Amateur Built Aircraft Acceptance (ABAA); or
- Experimental (Special Category of Airworthiness)

Confidentiality

No information in this survey identifies you, and anything you provide to the ATSB is confidential.

How to take part in the survey

Please complete this survey online at **www.atsb.gov.au** or
on paper by 31 December 2007. Please return paper surveys to:

Mail: ATSB, Aviation Safety Research
ABE Survey
Reply Paid 967
Civic Square ACT 2608

If you need help

If you have any problems completing this survey, please contact the Australian Transport Safety Bureau:

Telephone: 1800 621 372 (during business hours)
Email: abe.survey@atsb.gov.au
Facsimile: 02 6247 3117

Instructions

- Questions in this survey apply to VH-registered aircraft currently flying and built under the Amateur Built Aircraft Acceptance (ABAA) or (Experimental) Special Certificate of Airworthiness categories.
- Please use a black pen when completing the survey.
- If exact figures are not available please provide careful estimates.
- If you need more space to answer a question, write the question number on a separate piece of paper and attach it to the survey.

1. What is the make of your aircraft?

- *If you have built more than one aircraft, record details of the most recent aircraft built.*
- *For owners of second hand aircraft, record details of your most recent aircraft.*

Tick one only.

- ☐ Vans (Van Grunsven)
- ☐ Neico (Lancair)
- ☐ Jabiru
- ☐ Rand
- ☐ Glasair (Stoddard-Hamilton)
- ☐ Other (please specify)

2. What is the model of your aircraft?

Example: RV-6A or Glasair III.

3. Please record the type of engine used in your aircraft.

Tick one only.

- ☐ Certified aircraft engine
- ☐ Non-certified aircraft engine
- ☐ Automotive engine

4. Does your aircraft have any of the following features?

Tick all that apply.

- ☐ Manual propeller pitch control
- ☐ Retractable undercarriage
- ☐ None of the above

5. Is your aircraft equipped to operate under the following flight rules?

Tick one box.

- ☐ Visual Flight Rules (VFR)
- ☐ Night Visual Flight Rules (NVFR)
- ☐ Instrument Flight Rules (IFR)

6. What type of instrumentation does your aircraft have?

Tick one box.

- ☐ Analogue display instruments
- ☐ Glass cockpit display instruments
- ☐ Combination analogue and glass

7. In the past 12 months, how many hours has your aircraft logged?

Record all hours flown by any person.

Hours

8. In total, how many hours has your aircraft logged?

Record all hours flown by any person.

Hours

9. Did you buy your aircraft second hand?

Second hand means fully completed by someone else.

- ☐ Yes
- ☐ No – **Go to Question 12**

10. When purchasing your aircraft, were you able to obtain any of the following documents?

Tick all that apply.

- ☐ Builder's log
- ☐ Aircraft log
- ☐ Engine log
- ☐ Flight test documents
- ☐ Aircraft flight manual
- ☐ Construction manual and plans
- ☐ Pictures during construction
- ☐ Other (please specify)

11. When purchasing your aircraft, did you get help to inspect the aircraft from any of the following people or organisations?

Tick all that apply.

- ☐ Friend or acquaintance
- ☐ Sport Aircraft Association of Australia (SAAA)
- ☐ Recreational Aviation Australia (RA-Aus)
- ☐ Licensed Aircraft Maintenance Engineer (LAME)
- ☐ Other (please specify)

12. Have you ever completed and flown an ABE aircraft?

ABAA or Experimental Certification.

- ☐ Yes
- ☐ No – **Go to Question 30**

13. How many VH-registered ABE aircraft have you built?

Built using ABAA or Experimental Certification.

- ***Excludes:*** *Aircraft only ever registered with Recreational Aviation Australia (RA-Aus).*
- ***Includes:*** *Aircraft originally registered and flown on the VH register, then transferred to RA-Aus register and aircraft that have transferred from RA-Aus to the VH register.*
- *If you have built more than one aircraft, tell us the make and model of those other aircraft at the end of this survey.*

☐ Number of ABE aircraft built

14. Did you build your aircraft using the following process?

If you built your aircraft using a combination of methods (e.g. empennage quick build, but fuselage slow build), record the method that best characterises the build process.

Tick one box.

☐ Plans only (from scratch)
☐ Slow build kit
☐ Quick build kit

15. Did you purchase a partially built aircraft?

Built using ABAA or Experimental Certification.

☐ Yes
☐ No

16. How many hours did it take to build the aircraft, and over what number of years or months was it built?

- *Record workshop time, rather than time thinking about construction.*
- *If you built the aircraft in less than a year record details in the month column.*

Example:
1,500 hours over 4 years and 3 months

☐ Hours over ☐ Years ☐ Months

17. During the build process, how challenging were the following systems?

	Not				Very
Airframe (e.g. flight controls)	☐	☐	☐	☐	☐
Engine	☐	☐	☐	☐	☐
Fuel system	☐	☐	☐	☐	☐
Avionics	☐	☐	☐	☐	☐
Hydraulics (e.g. brakes)	☐	☐	☐	☐	☐
Other (please specify)	☐	☐	☐	☐	☐

18. During the build process, did you make any major modifications to your aircraft in any of the following ways?

Tick all that apply.

☐ Structural components
☐ Flights control system
☐ Aerodynamics
☐ Fuel systems
☐ Different engine to manufacturer's recommendation
☐ Brakes or wheels
☐ No changes

20. During the build process, please rate your access to information needed to construct your aircraft?

Tick one box.

☐ Excellent access
☐ Very good access
☐ Adequate access
☐ Less than adequate access
☐ Not adequate access

21. During the build process, how helpful were the following information resources?

	Least				Most	NA
Manufacturer's resources	☐	☐	☐	☐	☐	☐
Internet user groups	☐	☐	☐	☐	☐	☐
Aircraft builders	☐	☐	☐	☐	☐	☐
LAME	☐	☐	☐	☐	☐	☐
Aircraft Assoc. (e.g. SAAA)	☐	☐	☐	☐	☐	☐
Regulator (e.g. CASA)	☐	☐	☐	☐	☐	☐
Other (please specify)	☐	☐	☐	☐	☐	☐

22. In relation to preparing for Phase 1 test flight, please rate your access to information?

Tick all that apply.

☐ Excellent access
☐ Very good access
☐ Adequate access
☐ Less than adequate access
☐ Not adequate access

23. During test flight preparation, how helpful were the following resources?

	Least				Most	NA
Internet user groups	☐	☐	☐	☐	☐	☐
Aircraft builders	☐	☐	☐	☐	☐	☐
Manufacturer's resources	☐	☐	☐	☐	☐	☐
LAME	☐	☐	☐	☐	☐	☐
Aircraft Assoc. (e.g. SAAA)	☐	☐	☐	☐	☐	☐
Regulator (e.g. CASA)	☐	☐	☐	☐	☐	☐
Other (please specify)	☐	☐	☐	☐	☐	☐

24. Who made the maiden flight?

Tick one box.

- ☐ You
- ☐ Another pilot
- ☐ You and another crew member
- ☐ Qualified test pilot

25. For the rest of Phase 1, who made the test flights?

Tick all that apply.

- ☐ You
- ☐ Another pilot
- ☐ You and another crew member
- ☐ Qualified test pilot

26. How would you rate your preparation for the test flights?

Tick one box.

- ☐ Excellent
- ☐ Very good
- ☐ Adequate
- ☐ Some room for improvement
- ☐ Significant room for improvement

27. Would you do anything differently to prepare for test flight?

Write NIL if you would not do anything differently.

28. Following flight testing, how would you rate your aircraft handling characteristics?

Tick one box.

- ☐ Much better than expected
- ☐ Better than expected
- ☐ As expected
- ☐ Poorer than expected
- ☐ Much poorer than expected

29. How much flying did you do while building your aircraft?

Tick one box.

- ☐ Much more than usual
- ☐ More than usual
- ☐ About the same
- ☐ Less than usual
- ☐ Much less than usual

30. How long have you owned your aircraft?

- *For builders, from the time the aircraft flew.*
- *For second hand owners, from the time of purchase.*

☐ Years ☐ Months

31. Under which ABE Certificate of Airworthiness was your aircraft built?

Tick one box.

- ☐ Amateur Built Aircraft Acceptance
- ☐ Experimental Certificate
- ☐ RA-Aus

32. Under which ABE Certificate of Airworthiness do you currently operate?

Tick one box.

- ☐ Amateur Built Aircraft Acceptance
- ☐ Experimental Certificate

33. Was your aircraft issued a Certificate of Airworthiness prior to 1998?

ABAA or Experimental Certification.

- ☐ Yes
- ☐ No
- ☐ Not known

34. What is the highest pilot licence you have held?
Tick one box.
- ☐ Student
- ☐ Private
- ☐ Commercial
- ☐ Air transport

35. What licence privileges do you currently exercise?
Tick one box.
- ☐ Student
- ☐ Private
- ☐ Commercial
- ☐ Air transport

36. In the last 12 months, how many hours have you logged on any aircraft and ABE aircraft?

All aircraft ____ Hours

Amateur-built ____ Hours

37. In total, how many hours have you logged on any aircraft and ABE aircraft, and over how many years have those been logged?
Example: 3,000 hours over 15 years

	Total hours	*Over years*
All aircraft		
Amateur-built		

38. Please record where the majority of your flying hours as a pilot were accrued?
Tick one box.
- ☐ Airline / Air transport
- ☐ Charter
- ☐ Aerial work
- ☐ Private
- ☐ Agricultural work
- ☐ Flying training

39. In relation to reasons for purchasing your ABE aircraft, please rate the importance of the following items.

	Least				*Most*	*NA*
Build challenge	☐	☐	☐	☐	☐	☐
Maintain aircraft	☐	☐	☐	☐	☐	☐
Purchase price	☐	☐	☐	☐	☐	☐
Customisation	☐	☐	☐	☐	☐	☐
Performance	☐	☐	☐	☐	☐	☐
Cheaper to operate	☐	☐	☐	☐	☐	☐
Personal satisfaction	☐	☐	☐	☐	☐	☐
Other (please specify)	☐	☐	☐	☐	☐	☐

40. What type of flying do you mostly perform in your aircraft?
Tick one box.
- ☐ Local flying
- ☐ Sports or aerobatics
- ☐ Touring
- ☐ Other (please specify)

41. In the 3 months prior to initially flying your ABE aircraft, how much flying did you do compared with flying while building the aircraft?
Tick one box.
- ☐ Much more than usual
- ☐ More than usual
- ☐ About the same
- ☐ Less than usual
- ☐ Much less than usual

42. Did you undertake transition training prior to flying your aircraft?
- ☐ Yes
- ☐ No – **Go to Question 46**

43. In relation to transition training, did you fly any of the following aircraft prior to test flight?
Tick all that apply.
- ☐ Same model aircraft (certified or ABE)
- ☐ Same aircraft manufacturer
- ☐ Comparable certified aircraft
- ☐ Other (please specify)

44. How difficult was it for you to find someone to conduct transition training?
Tick one box.

- ☐ Much easier than expected
- ☐ Easier than expected
- ☐ Not difficult
- ☐ Somewhat difficult
- ☐ Very difficult

45. Please rate how useful transition training was in preparing to fly your aircraft.
Tick one box.

- ☐ Exceptionally useful
- ☐ Very useful
- ☐ Useful
- ☐ Not very useful
- ☐ Not useful at all

46. Which people perform maintenance on your aircraft?
Tick all that apply.

	You	*LAME*	*Other (please specify)*	
Airframe	☐	☐	☐	
Engine	☐	☐	☐	
Avionics	☐	☐	☐	

47. Approximately how much money ($AUD) did you spend building your aircraft to flight readiness.
Tick one box.

- ☐ Less than $25,000
- ☐ $25,000 to $49,999
- ☐ $50,000 to $74,999
- ☐ $75,000 to $99,999
- ☐ $100,000 to $124,999
- ☐ $125,000 to $149,999
- ☐ $150,000 to $174,999
- ☐ $175,000 to $199,999
- ☐ $200,000 or more

48. Please record your age.
Tick one box.

- ☐ 16 to 24 years
- ☐ 25 to 24 years
- ☐ 35 to 44 years
- ☐ 45 to 54 years
- ☐ 55 to 64 years
- ☐ 65 to 74 years
- ☐ 75 years or older

49. Please record any comments you would like to make in relation to ABE aircraft below.

50. Please record how long it took you to complete this survey.

Minutes

Thank you for participating in this survey.

Please send this survey to:
ATSB, Aviation Safety Research
ABE Survey
Reply Paid 967
Civic Square, ACT 2608

Please send this survey to:
ATSB, Aviation Safety Research
ABE Survey
Reply Paid 967
Civic Square, ACT 2608

Australian Government
Australian Transport Safety Bureau

Australian Transport Safety Bureau
PO Box 967, Civic Square ACT 2608
1800 621 372
www.atsb.gov.au
•
The Australian Transport Safety Bureau (ATSB) is an operationally independent body within the Australian Government Department of Transport and Regional Services and is Australia's prime agency for transport safety investigations.

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APPENDIX C: TABLES OF RESPONSES

Build resources statistical associations

Table 22: Correlation matrix of build resources using Spearman's rho

Resource	Datum	1	2	3	4	5	6
(1) Manufacturer	Coefficient Sig	1.000					
(2) Builders	Coefficient Sig	0.083 0.171	1.000				
(3) Internet	Coefficient Sig	0.238 0.000	0.210 0.000	1.000			
(4) LAME	Coefficient Sig	0.127 0.036	0.227 0.000	0.219 0.000	1.000		
(5) Association	Coefficient Sig	0.089 0.143	0.331 0.000	0.212 0.000	0.210 0.000	1.000	
(6) Regulator	Coefficient Sig	0.040 0.510	0.092 0.129	0.292 0.000	0.281 0.000	0.280 0.000	1.000

Test flight resources statistical associations

Table 23: Correlation matrix of test flight resources using Spearman's rho

Resource	Datum	1	2	3	4	5	6
(1) Manufacturer	Coefficient Sig	1.000					
(2) Builders	Coefficient Sig	0.242 0.000	1.000				
(3) Internet	Coefficient Sig	0.288 0.000	0.422 0.000	1.000			
(4) LAME	Coefficient Sig	0.273 0.000	0.414 0.000	0.452 0.000	1.000		
(5) Association	Coefficient Sig	0.230 0.000	0.335 0.000	0.172 0.004	0.296 0.000	1.000	
(6) Regulator	Coefficient Sig	0.252 0.000	0.289 0.000	0.370 0.000	0.514 0.000	0.347 0.000	1.000

Transition training statistical tests

Table 24: Transition training and flight rules

Flight rules	Transition training		
	Yes	No	Total
IFR	22	8	30
NVFR	32	10	42
VFR	194	85	279
Total	248	103	351

$\chi^2 = 0.89$, $p = 0.64$

Table 25: Transition training and aircraft complexity

Complexity	Transition training		
Aircraft	Yes	No	Total
Yes	100	40	140
No	148	65	213
Total	248	105	353

$\chi^2 = 0.15$, $p = 0.69$

Table 26: Transition training and manual pitch propeller

Propeller	Transition training		
Manual	Yes	No	Total
Yes	60	26	86
No	188	79	267
Total	248	105	353

$\chi^2 = 0.01$, $p = 0.90$

Table 27: Maiden flight by transition training

Maiden flight	Transition training		
	Yes	No	Total
Builder	77	39	116
Another pilot	62	19	81
Qualified test pilot	30	16	46
Builder and another crew member	20	7	27
Total	189	81	270

$\chi^2 = 3.09$, $p = 0.37$

Table 28: Build hours by transition training

Transition training	N	Mean	Median	Range
Yes	173	2,552	2,300	8,680
No	74	2,432	2,000	11,650
Total	247	2,516	2,200	11,680

Kruskal-Wallis $\chi^2 = 1.39$, $p < 0.23$

Table 29: Transition training and age

Age	Transition training		
Years	Yes	No	Total
≥ 55	154	71	225
< 55	94	34	128
Total	248	105	353

Not statistically significant, odds ratio 0.78, 90 per cent confidence intervals 0.52 to 1.17, $\chi^2 = 0.9733$, $p = 0.3239$.

Table 30: Transition training by current advanced pilot licence

Current licence	Transition training		
	Yes	No	Total
Advanced	19	13	32
Private	224	89	313
Total	243	102	345

Not statistically significant $\chi^2=2.07$, $p=0.15$

Table 31: Transition training by time owned in years

Transition training	N	Mean	Median	Range
Yes	247	5.70	3.66	33.91
No	104	6.18	4.41	29.91
Total	351	5.85	3.91	33.91

Not statistically significant Kruskal-Wallis $\chi^2 = 0.05$, $p = 0.82$

Table 32: Transition training by reason for purchase aircraft performance

Performance	Transition training		
Rating	Yes	No	Total
More important	200	91	291
Less important	37	11	48
Total	237	102	339

Not statistically significant $\chi^2 = 1.36$, $p = 0.24$

Table 33: Transition training by reason for purchase operating costs

Operating costs	Transition training		
Rating	Yes	No	Total
More important	177	77	254
Less important	59	21	80
Total	236	98	334

Not statistically significant $\chi^2 = 0.48$, $p=0.48$

Amateur-built and experimental aircraft
Part 1: A survey of owners and builders of VH- registered non-factory aircraft