Australian Government
Civil Aviation Safety Authority

VFR Equipment Survey Results

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CONTENTS

1. Executive Summary

A survey was conducted by the Office of Airspace Regulation (OAR) from 15 March 2021 to 16 May 2021 which assessed the equipage rates for various navigation, communication and surveillance technologies used on aircraft operated under the Visual Flight Rules (VFR) in Australia. The survey was hosted on CASA's consultation hub and open to all pilots, operators and aircraft owners who operate under the VFR. 1936 voluntary responses were received containing details of 2245 unique aircraft. The responses collected were shown to be statistically representative of VFR operations in Australia and were used to determine estimates of equipage of various technologies. Results are shown as 90% confidence intervals to give more reliable measures:

Technology	Equipage rates
Radio	Between 3.8% and 5.4% of aircraft flown under the VFR have no radio. Most of these are gliders and paragliders.
ADS-B	Between 28.9% and 31.8% of aircraft flown under the VFR have some form of ADS-B on board and more than 40% of general aviation aircraft have some form of ADS-B installed.
Transponder	Between 39.8% and 42.8% of aircraft flown under the VFR have a Mode A and/or C transponder and between 24.7% and 27.5% of aircraft have no transponder at all. More than 90% of gliders, paragliders and gyroplanes do not have a transponder.
Electronic Flight Bag	Between 78.9% and 82.1% of pilots/operators use an Electronic Flight Bag.
Low-cost ADS-B	Low-cost ADS-B units are more commonly used in sports aviation aircraft than in general aviation aircraft. Between 67.2% and 70.8% of pilots/operators are aware that low-cost ADS-B can be used with aircraft flown under the VFR. Of those individuals who are aware of the change, between 45.5% and 49.6% of are interested in purchasing low-cost ADS-B for their use.

Table A: Summary of findings

2. Introduction

A voluntary survey was conducted by the Office of Airspace Regulation (OAR) from 15 March 2021 to 16 May 2021 which assessed the equipage rates for various navigation, communication and surveillance technologies on board aircraft operated under the Visual Flight Rules (VFR) in Australia. This report uses the results of the survey to estimate the proportion of Australian registered aircraft with various onboard equipment. It also estimates the number of pilots and operators who utilise various equipment.

2.1. Purpose

This report is intended to provide OAR, and CASA more broadly, with an indication of the equipment on board Australian aircraft flown under the VFR. This information will support CASA by providing an understanding of the capability of Australian aircraft and guide future airspace changes to improve aviation safety.

2.2. Scope

The results of the survey are used to represent all VFR activity in Australia. All statistics in this report are intended to be used as statistical representation of all aircraft flown under the VFR and all pilots who fly under VFR. This includes pilots and aircraft who may also operate under the Instrument Flight Rules (IFR).

3. Data and methodology

This section provides a breakdown of the data used for analysis and the methods applied.

3.1. Data sources

The survey was conducted via the CASA consultation hub[1] and was open from 15 March 2021 to 16 May 2021. Pilots, operators and aircraft owners were asked to voluntarily respond. Once the survey was closed results were obtained and examined by the OAR. A summary of responses to the questions can be found in Attachment A. In total:

- 1936 responses were recorded
- Details of 2724 airframes were provided
- Of these, details of 364 airframes were provided multiple times, so these were combined
- 296 aircraft could not be identified from the information provided, so these records were removed
- 114 aircraft were mostly used for IFR, so not suitable for this analysis and were removed from this analysis

That leaves **2245** unique aircraft and **1936** pilots, operators and aircraft owners for the analysis.

[1] https://consultation.casa.gov.au/

Additional data was also sourced to support the analysis of the survey. Supporting data was obtained from:

- The Bureau of Infrastructure, Transport and Regional Economics (BITRE) to estimate the total number of aircraft currently in use by type of aircraft[2]. Results from the 2019 data collection were used.
- The CASA aircraft register[3] to determine the aircraft type when it was not provided in the survey records.
- The movements database stored on the CASA Enterprise Data Warehouse (EDW). Movements from 1 January 2018 to 31 December 2020 were used to estimate the VFR movements by airport. This data is originally sourced from Airservices and contains limited information on individual flights.
- The Australian Bureau of Statistics (ABS) for population density in Australia[4].
- Airservices for maps of Control Terminal Areas (CTA)[5] and coverage of ADS-B and radar[6].

3.2. Statistical methods

In most cases a stratified sampling approach was used when examining the survey results. Results were stratified by the type of registration and where appropriate the location aircraft are flown. Details of the specific formula applied are provided in Appendix A. For the majority of this report, aircraft are split into two groups – general aviation; which includes "VH"-registered aircraft but does not include gliders, paragliders or gyroplanes, and sport's aviation; which includes aircraft registered with sports and recreational organisations. This distinction is intended to match with the definitions in the BITRE reference report.

Rather than report a single proportion for all estimates, confidence intervals are used for most results instead. This provides readers a more accurate idea of what the result may be in reality. All reported confidence intervals are a 90% interval. Each of the "proportion plots" places the proportion of fitment for the given segment on the plot and provides a 90% confidence interval for each group on the right-hand side. Each group is mutually exclusive unless otherwise specified.

In all cases, any recorded answer of "I don't know" was treated as a non-response.

Heat maps are generated by Kernel Density Estimates using gaussian distributions. To generate these plots the location information was reviewed and manually cleaned. It is possible that some errors were made during this process, or some locations were omitted. However overall, the plots should be representative of VFR activity.

3.3. Assumptions

To apply this approach to the collected survey data, the following assumptions were made:

[2]BITRE 2020, *Australian Aircraft Activity*, https://www.bitre.gov.au/publications/ongoing/general_aviation_activity
[3] CASA 2021, *Civil Aircraft Register*, https://www.casa.gov.au/aircraft/civil-aircraft-register
[4] ABS, 2021, *Regional Population,* https://www.abs.gov.au/statistics/people/population/regional-population/2019-20#data-downloads-geopackages
[5] Airservices 2021, *Product Group B: CTA_RUN14APR2021_EFF17JUN2021,* Canberra ACT
[6] Airservices 2019, *CASA Surveillance Coverage*, Canberra ACT

Assumption	Effect on Summary Statistics
Survey is a random survey. Meaning that the respondents are selected randomly.	Assumption may not be valid since responses are voluntary. It is possible that some segments of the industry are not captured in the survey and bias is introduced. If this is the case, any results included in this report may not accurately represent all Australian aircraft.
All responses about aircraft equipment reflect equipment on board the aircraft "most commonly flown in"/ "the aircraft which records the highest number of flight hours" for that operator.	May lead to inaccurate results if this is not true, as the intention is to represent common operations in Australia.
Following the clean-up of the survey data, assessed aircraft are all unique. Likewise, each response is submitted by a unique individual.	Introduces a bias to the results if this is not true and may reduce the validity of reported statistics.
Supporting data collected is a valid representation of current VFR activity in Australia.	Potential minor impact on reported results if there have been any major changes between when supporting data was collected and when the survey was conducted.
VFR movements obtained from the CASA EDW are often estimated based on the aircraft type observed or the number of observed flights conducted under the IFR. However, the movements examined are still an accurate representation of VFR activity in Australia.	This data is used to verify that the survey is an accurate representation of flights conducted under the VFR in Australia. This verification may not be valid if this assumption does not hold.
General aviation can be represented by aircraft on the CASA aircraft register which are not classified as glider, paraglider or other types which are considered under sports aviation by BITRE. All other aircraft types fall into the sports aviation category.	This assumption is applied to match with the results shown in the BITRE Australia Aircraft Activity report. The assumption has the potential to mislead some readers if the definitions are not well understood.
Dividing aircraft flown under the VFR into two subgroups, "general aviation" and "sports aviation" is reasonable for stratification and these groups are mutually executive.	The assumption has the potential to mislead some readers if the definitions are not well understood. It may also lead to inaccurate results if groups are not actually mutually exclusive.

Table 1: Assumptions applied in the analysis

4. Assessment of suitability of results

Prior to using the survey results to represent all aircraft and pilots operating under the VFR it is necessary to determine whether the data collected can actually be used to represent all VFR activity. To determine this, two activities were completed.

- The geographical distribution of flights was examined
- The proportion of individual aircraft types captured in the survey were examined

4.1. Geographical distribution of flights

First, the airports where aircraft in the survey are typically flown to and from were plotted and used to create a heat map:

Location where aircraft captured in survey are typically operated

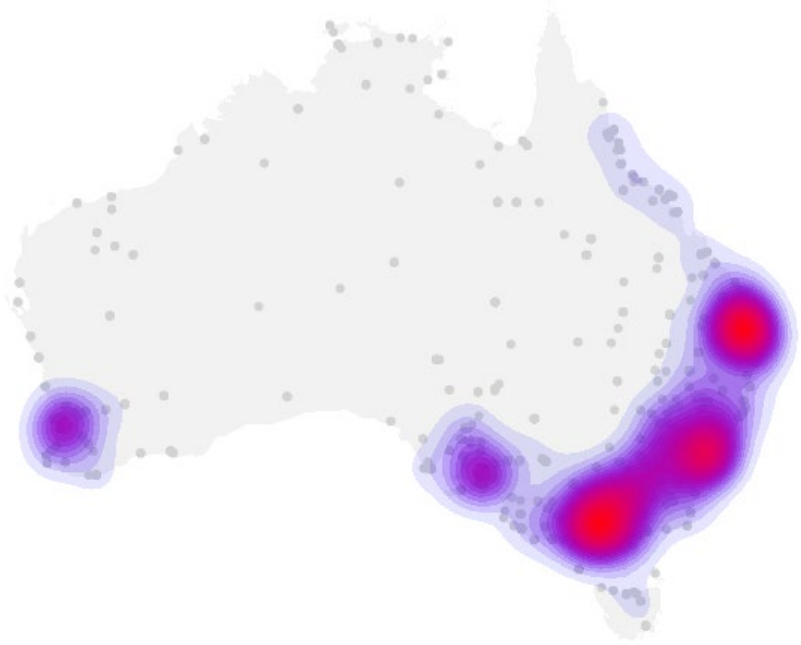


Figure 1: Kernel Density Estimate of activity from aircraft captured in survey

This was then compared to where aircraft operating under VFR are believed to operate in Australia using the CASA EDW movement data. Readers should note that a large number of flights are estimated in this database as counts of actual flights are not always available.

Estimate of where aircraft flown under the VFR are operated

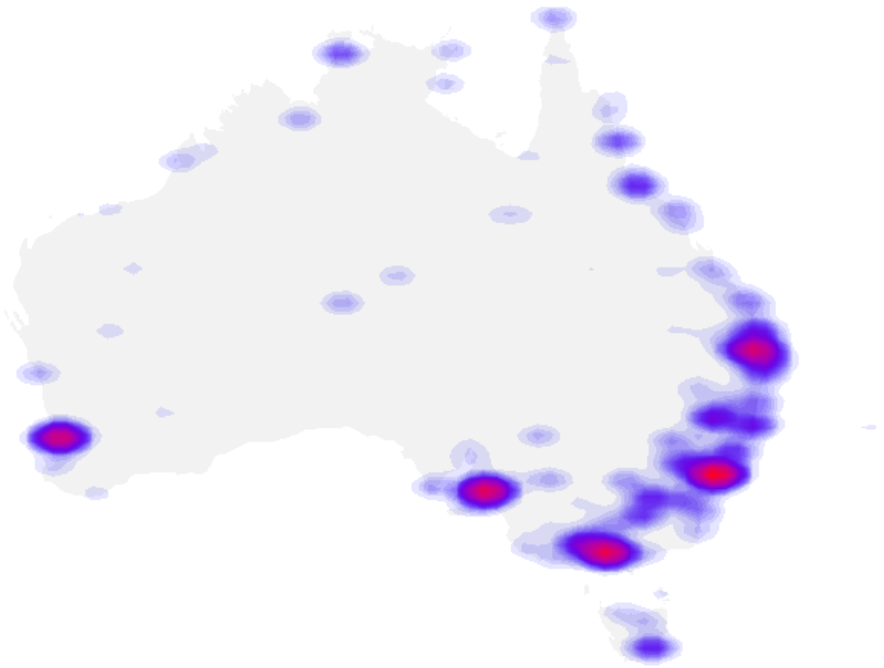


Figure 2: Kernel Density Estimate of VFR activity in Australia based on data stored sourced from Airservices and stored in the CASA EDW

Comparing Figure 1 with Figure 2 shows similar areas with higher density across the country, however Figure 2 includes a finer level of detail. As an additional comparison, population density in Australia was sourced from the ABS and plotted. This data was used to represent where people are likely to want to travel to and from.

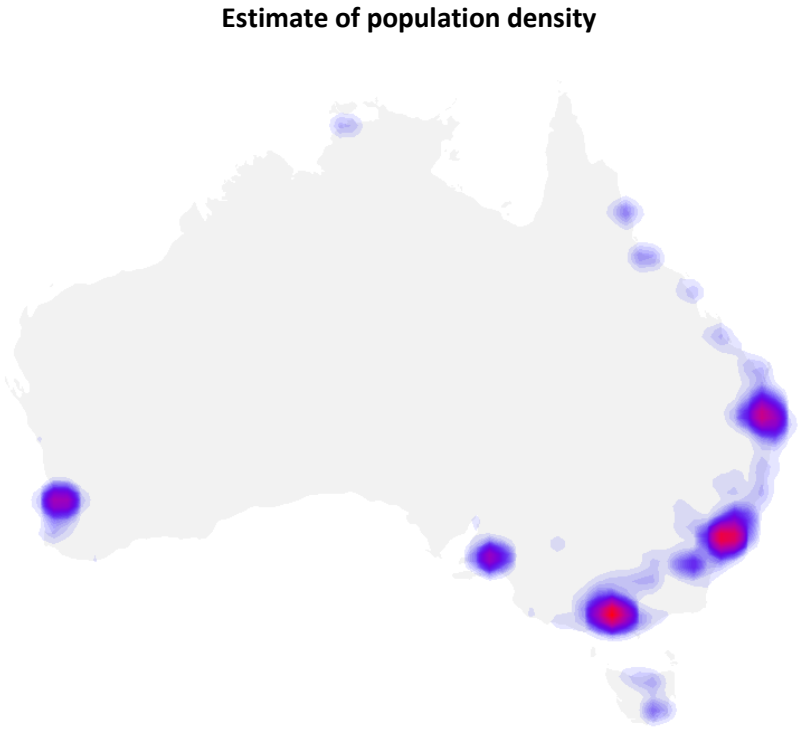


Figure 3: Kernel Density Estimate of population density in Australia

The figures above each show similar areas with higher density, indicating that survey has a reasonable coverage of operations around the country. Activity around Darwin is possibly slightly under represented, but most other regions seem to be a reasonable representation.

4.2. Proportion of examined aircraft by type

The second check is to examine the aircraft types identified in the survey to make sure they consistently represent aircraft flown in Australia. This is done by comparing the aircraft types in the survey to those identified by BITRE. The results are as follows:

	Survey	Total aircraft in operation according to BITRE	Proportion surveyed
General aviation	1498	9462	15.8%
Sports aviation	747	8453	8.8%

Table 2: Proportion of aircraft flown under the VFR surveyed

Based on Table 2 a higher proportion of general aviation aircraft have been surveyed than sports aviation. This can be accounted for by adjusting the way statistics are calculated in the following section, so does not create any issue for the calculated results.

Sports Aviation are examined further:

	Survey	Total aircraft in operation according to BITRE	Proportion surveyed
Ultralight	353	3210	11.0%
Gliders	269	1281	21.0%
Paragliders	113	3631	3.1%
Gyroplanes	12	331	3.6%

Table 3: Proportion of sports aviation aircraft surveyed

For sports aviation, the survey results may be over representing gliders and underrepresenting paragliders and gyroplanes, but this might be because the aircraft types where not always correctly represented in the survey. This has the potential to introduce a bias in the survey. To minimize the impact of this, sports aviation aircraft will be presented as single group. Where appropriate further information on the groups shown in Table 3 will be provided.

Finally, general aviation aircraft are examined further by examining the types of aircraft provided in the survey. For this assessment, only the number of registered aircraft could be obtained, rather than the number of activity aircraft:

Aircraft Manufacturer	No. in survey	No. on CASA reg	Proportion of fleet surveyed
Cessna Aircraft Company	413	3552	11.6%
Piper Aircraft Corp	269	1803	14.9%
Amateur Built Aircraft	254	1660	15.3%
Beech Aircraft Corp	47	620	7.6%
Robinson Helicopter Co	38	1264	3.0%
Kavanagh Balloons	32	294	10.9%
De Havilland Aircraft Company	31	232	13.4%
Cirrus Design Corporation	27	203	13.3%
Mooney Aircraft Corp	25	152	16.4%
American Champion Aircraft Corp	21	103	20.4%

Table 4: Proportion of most common general aviation aircraft types surveyed

Table 4 shows that the proportion of common aircraft types surveyed is reasonably consistent. However, while fixed wing aircraft are consistently represented it seems that helicopters are under represented in the survey. This should be kept in front of mind when the reader examines results presented in this analysis.

Overall, the survey appears to be representative of aircraft flown under the VFR in Australia.

5. Results

The survey collected information about the equipage of multiple type of communication, surveillance and navigation equipment. Each is presented separately in this section.

5.1. Radio Equipage

Survey respondents were asked if aircraft are equipped with a radio and the responses were used to generate the following estimates:

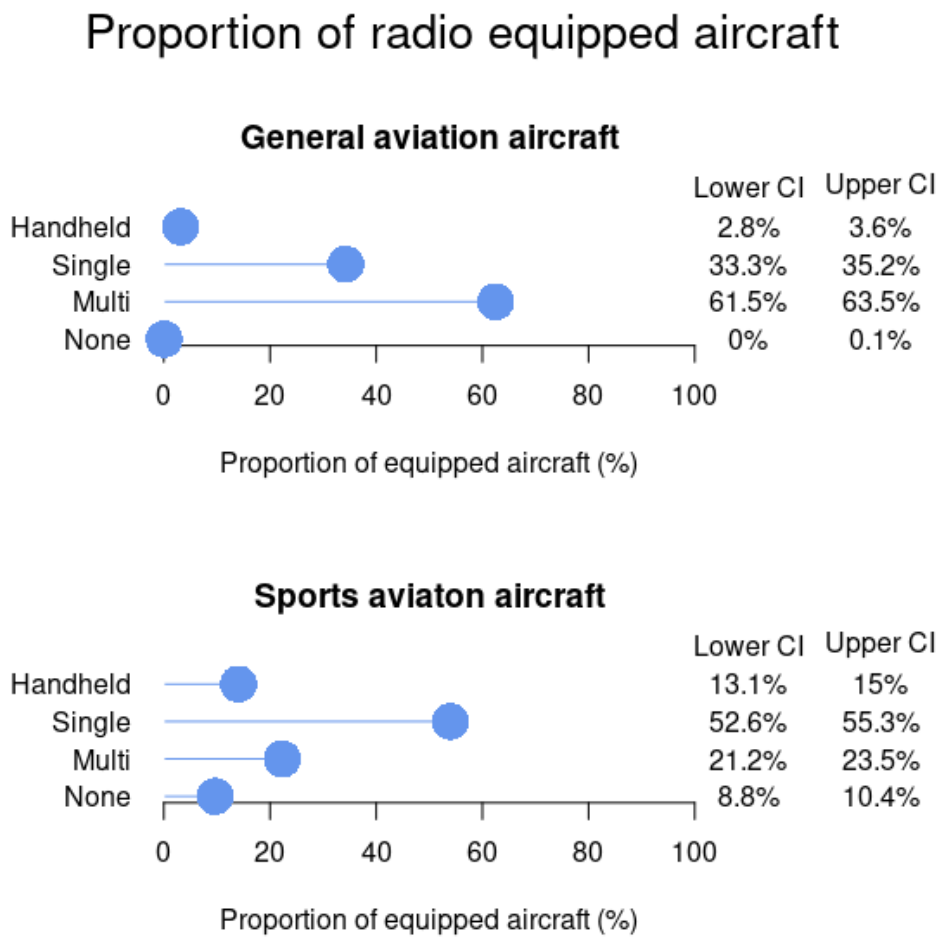


Figure 4: Plot of proportion and confidence intervals (CI) for radio equipage of aircraft flown under the VFR

Combining these results together shows that between 3.8% and 5.4% of aircraft operated under the VFR have no radio. Almost all of these are gliders and paragliders. Paragliders seem to contribute the highest number of aircraft without a radio, as shown in the table below. Very few general aviation aircraft or ultralights do not carry a radio.

Group	Proportion of aircraft that have a radio
Ultralights	98.2% - 99.0%
Gliders	93.0% - 93.7%
Paragliders	53.4% - 59.9%
Gyroplanes	~100%

Table 5: Proportion sports aviation aircraft which are radio equipage

Interestingly, between 61.5% and 63.5% of general aviation aircraft have more than one radio. Most general aviation aircraft that are occasionally used for IFR activity have more than one radio, however, even among general aviation aircraft that are only used for VFR approximately half have more than one radio.

5.2. ADS-B Equipage

Survey respondents were asked if aircraft are equipped with ADS-B and the responses were used to generate the following estimates:

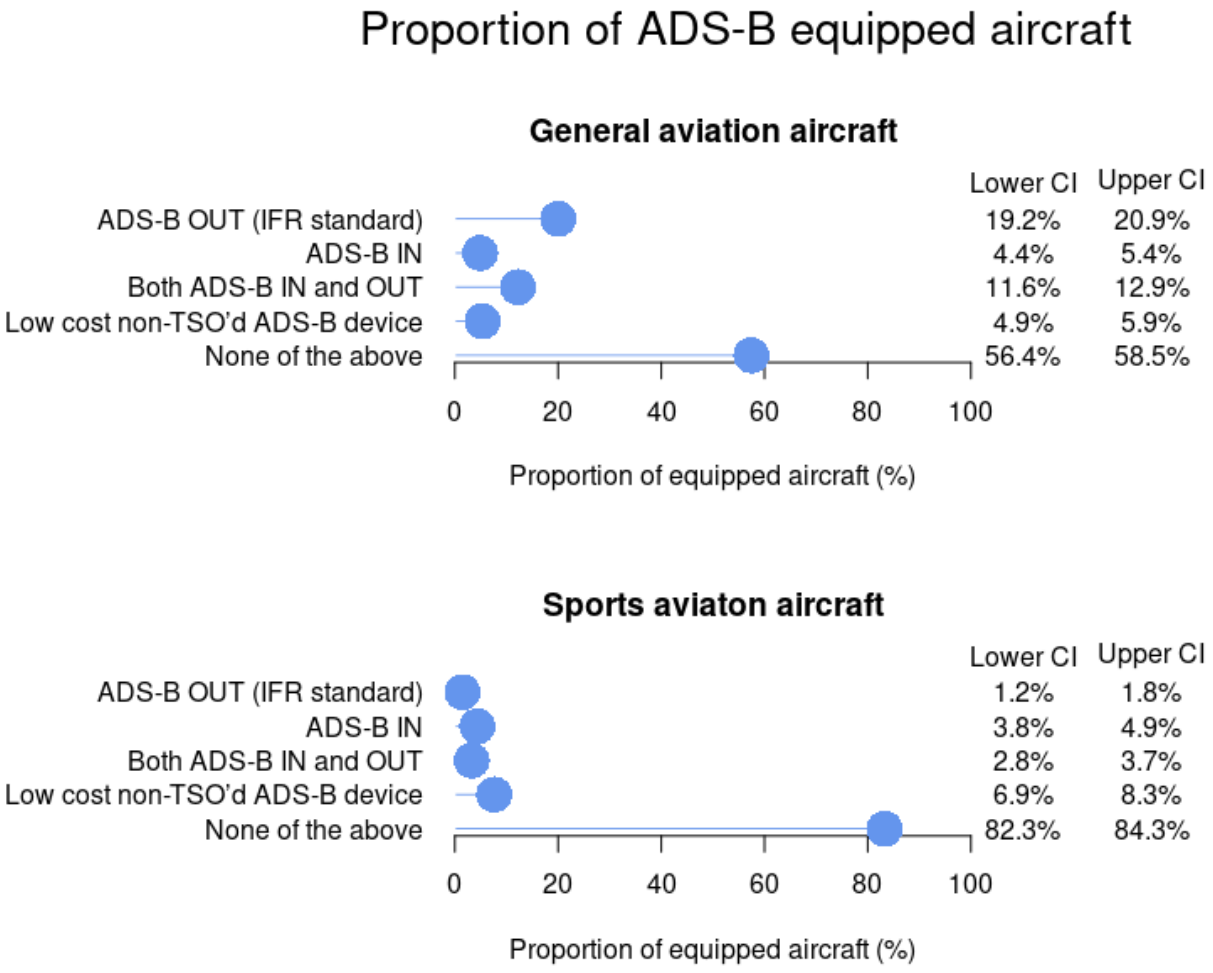


Figure 5: Plot of proportion and CI for ADS-B equipage of aircraft flown under the VFR.

The results suggest that more than 40% of general aviation aircraft have some form of ADS-B installed, or at least used on board the aircraft. Readers should keep in mind that not all ADS-B can be used by Air Traffic Services (ATS). Between 30.4% and 34.1% of general aviation aircraft have ADS-B OUT which is detectable by ATS.

Group	Proportion of aircraft that have ADS-B OUT which is currently detectable by ATS
General aviation	30.4% - 34.1%
Sports aviation	3.5% - 6.0%
Overall	17.5% - 21.0%

Table 6: Proportion aircraft flown under the VFR that are detectable my ATS

Low-cost ADS-B units are more commonly used in sports aviation aircraft than in general aviation aircraft. Combining the results of Figure 5 indicates that between 28.9% and 31.8% of aircraft flown under the VFR have some form of ADS-B on board.

Equipage rates by where aircraft are commonly operated were examined further and compared to areas where ATS surveillance coverage is known to exist[7]. To simplify the analysis, coverage at 5,000ft was used to determine if an aircraft is within surveillance coverage when arriving or departing from each airport. There are known limitations with this surveillance data, some of the coverage boundaries may be inaccurate and some ground stations may be missing all together. With that in mind, the results shown in Figure 6, Figure 7 and Table 7 should only be treated as general information and not exact results.

[7] This is based on ground-based ADS-B and radar coverage that is used as part of Airservices ATS System. It is likely that additional ground stations exist that pilots may benefit from, but these are not considered in this analysis.

Surveillance coverage at 5,000 ft and location that aircraft included in the survey operate to and from

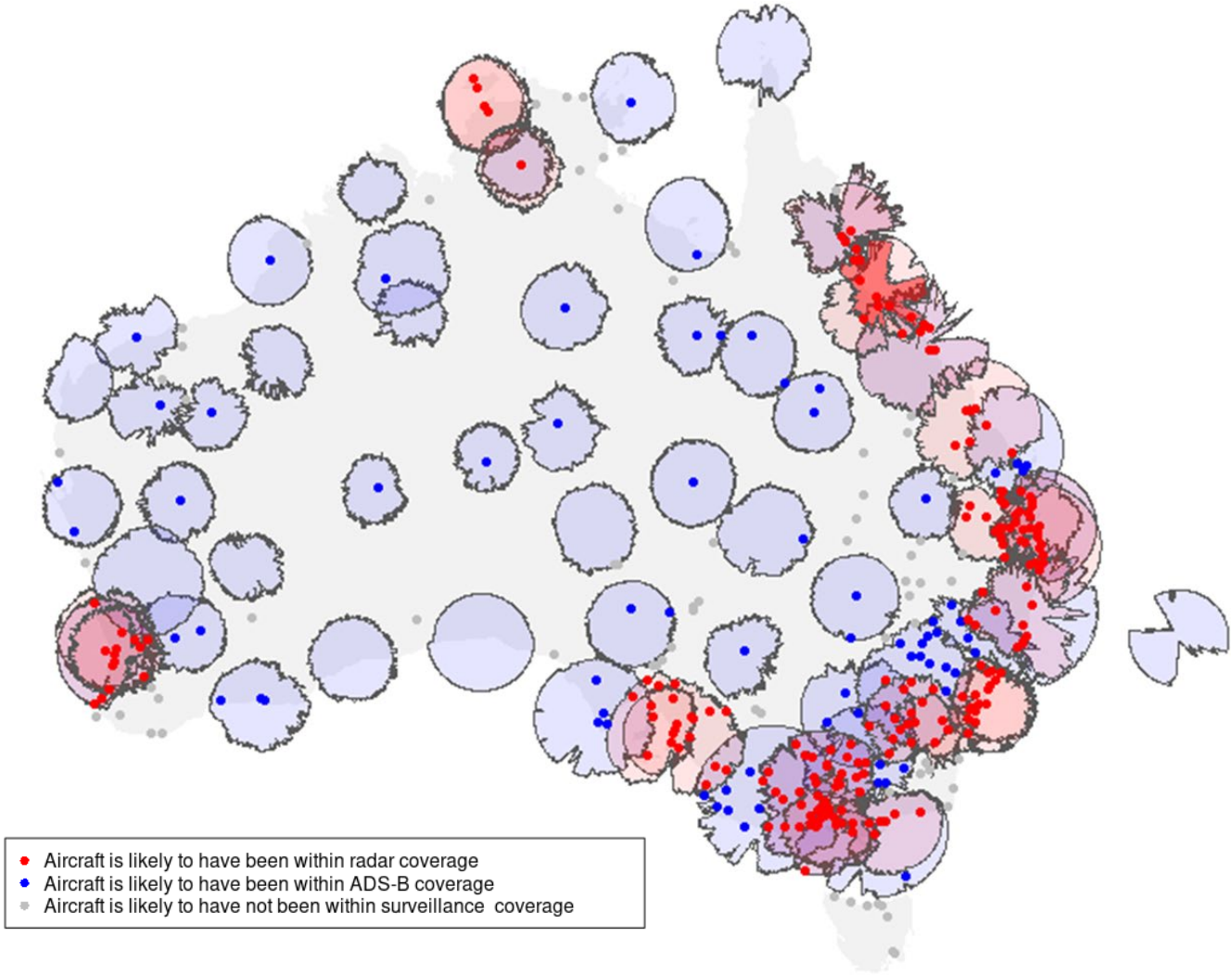


Figure 6: Map of radar coverage (red) ADS-B coverage (blue) at 5,000 ft; and where survey participants said they/their aircraft commonly depart/arrive from. There are known inaccuracies with the plotted surveillance coverage, so results should only be treated as general information and not an exact representation

Aircraft in the survey can make up multiple points in Figure 6, so each aircraft can fly in a mixture of radar, ADS-B and no coverage. In fact, more that 99% of aircraft are flown within radar and/or ADSB coverage at some point. For the less than 1% of aircraft that never operate in the plotted surveillance coverage, it appears a relatively high proportion of them are equipped anyway. Using these results, the following estimates were calculated:

Coverage	Group	Proportion of aircraft that have some form of ADS-B (IN and/or OUT)
Within radar	General aviation	42.1% -45.2%
	Sports aviation	20.3% - 24.5%
Within ADS-B	General aviation	40.5% - 43.8%
	Sports aviation	22.2% - 27.0%
No coverage	General aviation	33.8% - 38.5%
	Sports aviation	7.2% - 11.1%

Table 7: Proportion of ADS-B equipage of aircraft flown under the VFR by the coverage they are likely to operate within. There are known inaccuracies with the plotted surveillance coverage, so results should only be treated as general information and not an exact representation

Generally, aircraft are slightly better equipped in areas with more surveillance coverage, probably because they gain the most benefit and airspace tends to be more complex in this part of the country. Further detail is provided in the figure below.

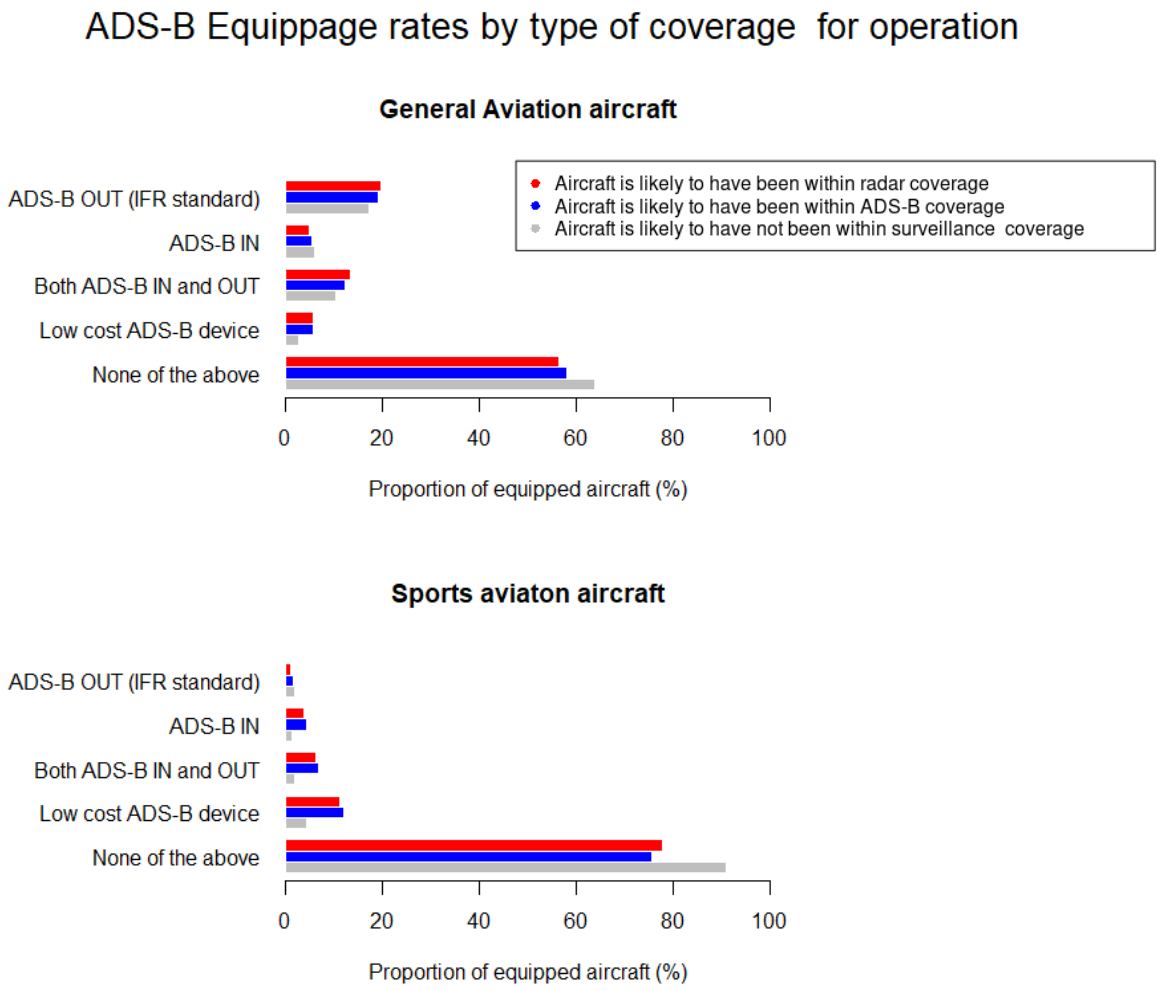


Figure 7: Plot of proportions for ADS-B equipage of aircraft flown under the VFR. For ease of reading, confidence intervals are not provided in this plot. Confidence intervals are provided in Appendix B. There are known inaccuracies with the plotted surveillance coverage, so results should only be treated as general information and not an exact representation

The results shown in Figure 7 are generally consistent with the results shown in Figure 5. Interestingly, it seems that slightly more aircraft that operate outside of surveillance coverage have only ADS-B IN then those that operate within surveillance coverage.

5.3. Transponder Equipage

Survey respondents were asked if aircraft are equipped with a transponder. The responses were used to generate the following estimates:

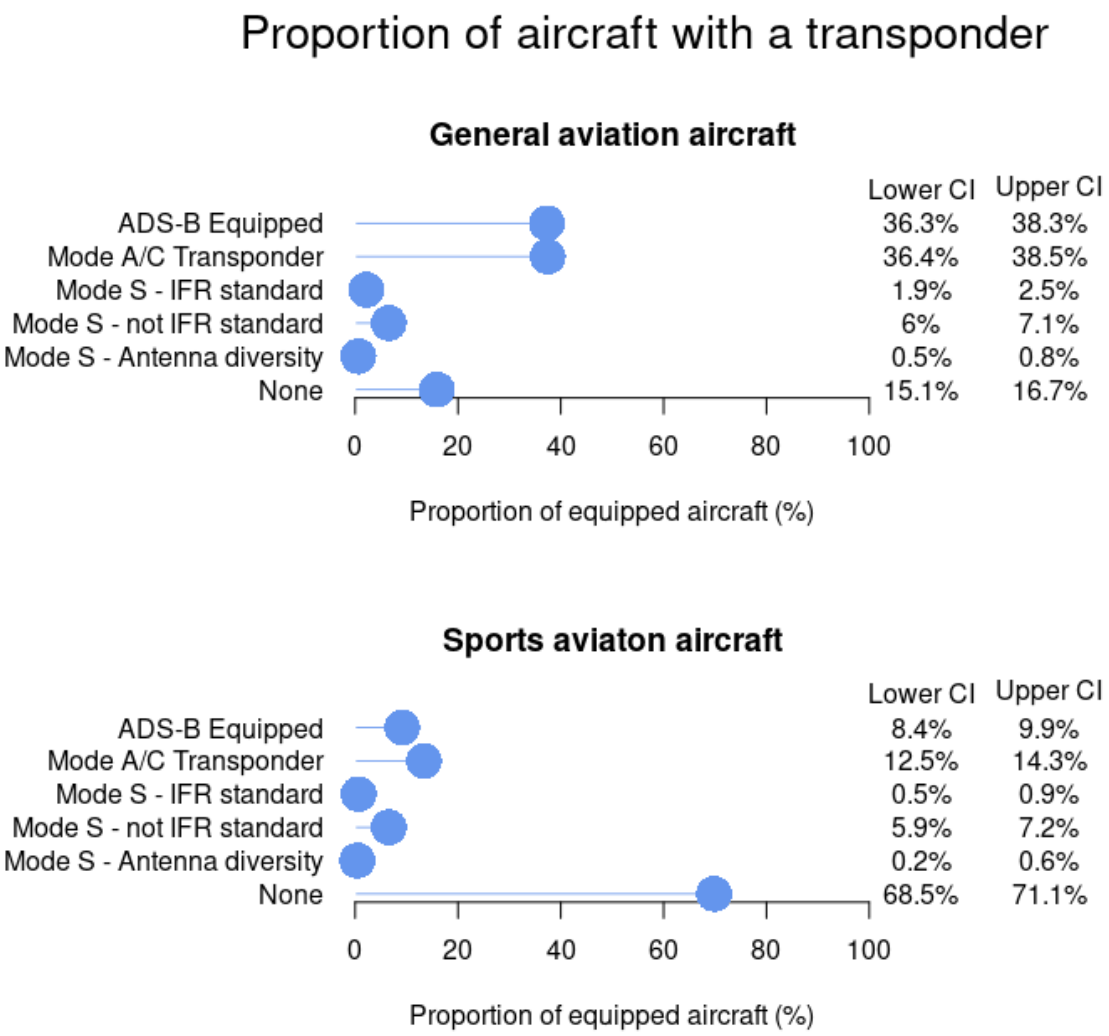


Figure 8: Plot of proportion and CI for transponder equipage of aircraft flown under the VFR[8]

This suggests that it is not common for aircraft to be equipped with a Mode S transponder if they are not equipped with ADS-B. This is not unexpected as there are no Mode S requirements for general aviation aircraft and Mode S capability is usually provided with an ADS-B installation. Between 39.8% and 42.8% of all aircraft flown under the VFR have a Mode A and/or C transponder and between 24.7% and 27.5% of aircraft have no transponder at all. More than 90% of gliders, paragliders and gyroplanes do not have a transponder. These aircraft by far make up the highest proportion of aircraft without a transponder.

[8] The ADS-B equipped category does not include Low-cost ADS-B in this case

Group	Proportion of aircraft that have a transponder
Ultralights	53.7% - 56.8%
Gliders	10.4% - 11.2%
Paragliders	0.28% - 1.6%
Gyroplanes	7.8 - 8.9%

Table 8: Proportion sports aviation aircraft which have a transponder

The location where aircraft with a transponder and aircraft without a transponder were examined more closely:

Estimate of where aircraft flown under the VFR with a transponder operate

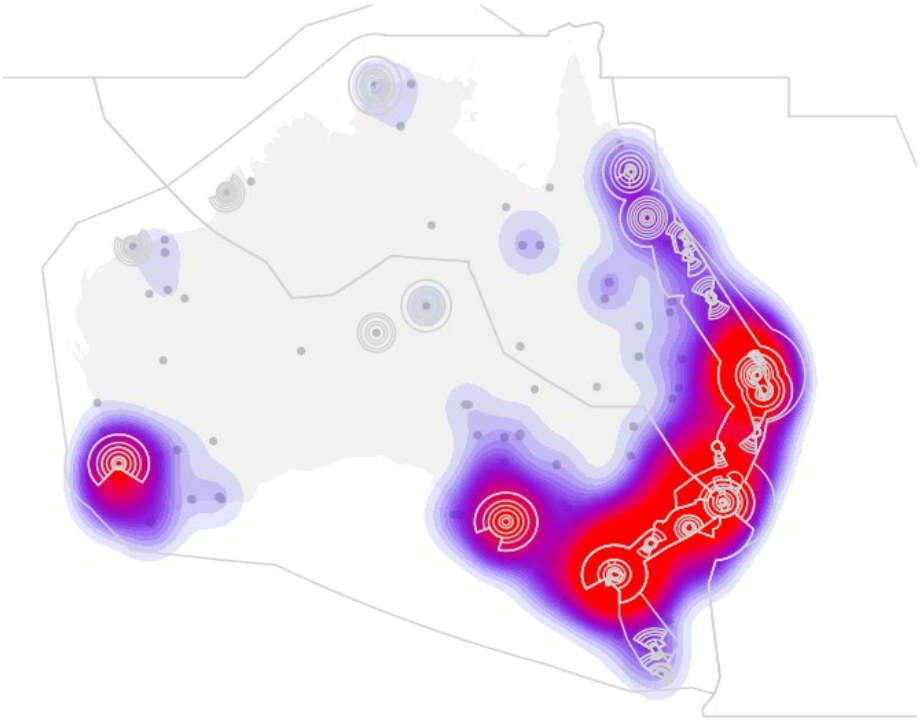


Figure 9: Kernel Density Estimate of VFR activity in Australia for aircraft with a transponder

Estimate of where aircraft flown under the VFR without a transponder operate

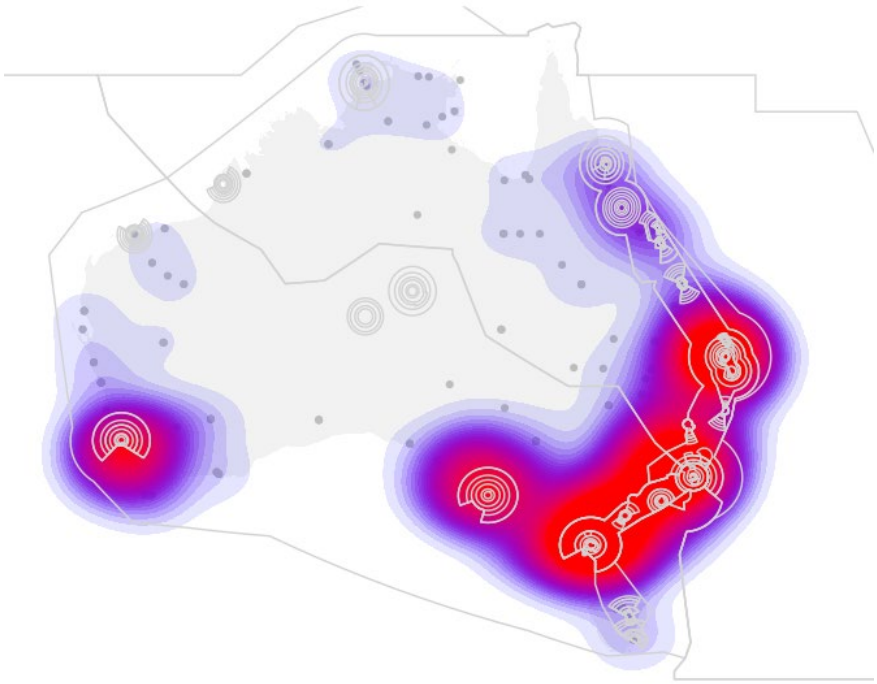


Figure 10: Kernel Density Estimate of VFR activity in Australia for aircraft without a transponder

The figures above show that aircraft with a transponder typically operate closer to controlled airspace whereas aircraft without a transponder are typically more spread out over the country. However, the difference is only slight and there are still plenty of aircraft without a transponder that operate close to controlled airspace.

For aircraft that indicated they are equipped with ADS-B between 46.8% and 50.4% of general aviation aircraft indicated they have Mode S with antenna diversity. For sports aviation aircraft with ADS-B between 13.9% and 20.7% indicated they have Mode S with antenna diversity.

For those survey respondents who indicated that the aircraft they operate is equipped with a transponder, the survey asked if the transponder has been serviced in the last 2 years. The responses were used to generate the following estimates:

Group	Proportion of aircraft that have tested their transponder at a maintenance facility in the last 2 years
General aviation	92.1% - 93.4%
Sports aviation	76.1% - 80.8%
Overall	83.6% - 88.4%

Table 9: Proportion of transponders that have been serviced in the last 2 years

These estimates indicate that a high proportion of transponders have been serviced within the last two years. While very few gliders, paragliders and gyroplanes have a transponder installed, of these that do, most have had the transponder tested within the last 2 years. Note that it is possible that some aircraft have not had their transponder tested in the last 2 years because they did not have an operational requirement to have a transponder. For example, the aircraft may not have been operated in an area that requires a transponder after the 2-year testing/calibration requirement had lapsed. A transponder that has not been tested within the 2-year period is considered, from an airworthiness compliance point of view, to be unserviceable.

5.4. Navigation Equipment

Survey respondents were asked what navigation equipped aircraft have on board and the responses were used to generate the following estimates:

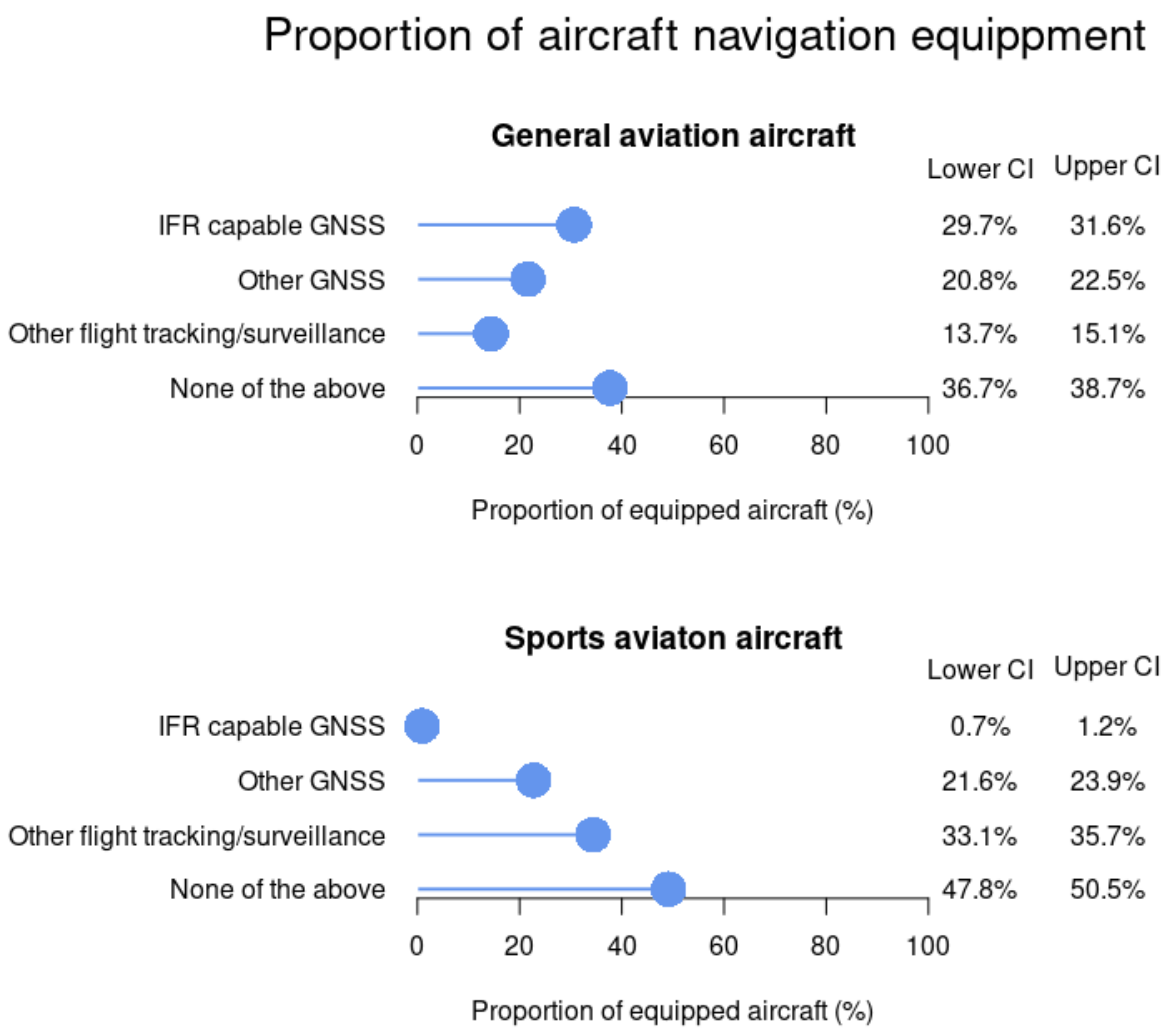


Figure 11: Plot of proportion and CI for navigation equipment on board aircraft flown under the VFR[9]

The most common GNSS or Flight tracking/surveillance devices are FLARM, which are equipped on between 35.8% and 44.5% of gliders. A range of Garmin navigator devices are used on a wide variety of aircraft types. Results from this part of the survey are questionable and it is possible that respondents had an inconsistent understanding of what should be covered by “Other GNSS”, “Other flight tracking/surveillance” and “None of the above”. For this reason, results should not be treated as an exact representation.

[9] In this case, fields are not mutually exclusive

5.5. Electronic Flight Bag

Survey respondents were asked if they use an Electronic Flight Bag (EFB) and the responses were used to generate the following estimates:

Group	Proportion of pilots that use an EFB
General aviation	84.5% - 87.9%
Sports aviation	65.8% - 72.1%
Overall	78.9% - 82.1%

Table 10: Proportion of VFR pilots that use an EFB

Both Avplan and Ozrunways are popular EFB applications, however other products are also used. In some cases, pilots use multiple applications. Respondents were also asked if their EFB is linked to ADS-B:

Group	Proportion of pilots that link EFB with ADS-B
General aviation	13.7% - 17.6%
Sports aviation	20.3% - 28.8%
Overall	15.9% - 19.4%

Table 11: Proportion of VFR pilots that use an EFB linked with ADS-B

Interestingly, pilots of general aviation aircraft have a higher level of EFB use, but a higher proportion of sports aviation pilots have their EFB linked to ADS-B. Examining aircraft that have some form of ADS-B shows that for pilots who fly general aviation aircraft, only between 28.5% and 36.0% link ADS-B to their EFB. Whereas for pilots who fly sports aviation aircraft equipped with ADS-B, between 64.1% and 80.4% link ADS-B to their EFB.

5.6. Low-cost ADS-B

Low-cost combined ADS-B IN and ADS-B OUT devices (such as the uAvionix SkyEcho 2) are now permitted to be used in aircraft flown under the VFR. Survey respondents were asked if they are aware of this change. The responses were used to generate the following estimates:

Group	Aware that Low-cost ADS-B can be used with aircraft flown under the VFR
General aviation	65.9% - 70.4%
Sports aviation	67.5% - 73.8%
Overall	67.2% - 70.8%

Table 12: Proportion of VFR pilots that are aware of the availability of low-cost ADS-B

For those individuals who are aware of the change, between 45.5% and 49.6% are interested in purchasing low-cost ADS-B for their use. Most people will purchase a unit in more than 6 months. For those individuals who are not interested in purchasing a unit the main reasons cited were an inability to power the unit in the aircraft (mostly for gliders and paragliders), the price of the unit and a lack of space in the aircraft.

6. Summary

The survey results proved to be a reasonable representation of aircraft flown under the VFR in Australia. Generally, most aircraft are equipped with a radio with the exception of glider and paragliders. Over 40% of aircraft used for general aviation are equipped with ADS-B. Between 30.4% and 34.1% of general aviation aircraft have ADS-B out which would be detectable by ATS. The up-take of low-cost ADS-B units is still quite low, with only 4.9% - 5.9% of general aviation operations making use of them. The up-take of low-cost units is slightly higher amongst sports aviation operators, where 8.2% - 10.1% of operations use them. Uptake of low-cost ADS-B may be improved by increasing awareness of the units.

Between 24.7% and 27.5% of aircraft flown under the VFR have no transponder at all. It's apparent that a lot of aircraft without a transponder are in fact operated close to controlled airspace which means they may gain a safety benefit from being equipped.

Use of electronic flight bags is very common amongst VFR pilots/operators. However, pairing them with an ADS-B device is not common, particularly among general aviation pilots/operators.

Technology	Equipage rates
Radio	Between 3.8% and 5.4% of aircraft flown under the VFR have no radio. Most of these are gliders and paragliders.
ADS-B	Between 28.9% and 31.8% of aircraft flown under the VFR have some form of ADS-B on board and more than 40% of general aviation aircraft have some form of ADS-B installed.
Transponder	Between 39.8% and 42.8% of aircraft flown under the VFR have a Mode A and/or C transponder and between 24.7% and 27.5% of aircraft have no transponder at all. More than 90% of gliders, paragliders and gyroplanes do not have a transponder.
Electronic Flight Bag	Between 78.9% and 82.1% of pilots/operators use an Electronic Flight Bag.
Low-cost ADS-B	Low-cost ADS-B units are more commonly used in sports aviation aircraft than in general aviation aircraft. Between 67.2% and 70.8% of pilots/operators are aware that low-cost ADS-B can be used with aircraft flown under the VFR. Of those individuals who are aware of the change, between 45.5% and 49.6% of are interested in purchasing low-cost ADS-B for their use.

Table 13: Summary of findings

Appendix A Determination of proportions

A stratified sampling approach was used when examining the survey results. Results were stratified by the type of registration and where appropriate the location aircraft are flown.

The proportion of aircraft with various types of equipment is estimated as:

$$\hat{p} = \frac{y}{n}$$

Where:

$$\hat{p} = estimated\ proportion\ of\ equipped\ aircraft$$

$$y = \text{"Yes"}\ responses\ in\ the\ survey$$

$$n = total\ number\ of\ valid\ responses$$

To accurately represent the number of equipped aircraft in each case, a 90% confidence interval was used. For each type of aircraft, the variance in the response is estimated as the proportion of the total number of aircraft surveyed multiplied by the proportion of the type of aircraft with all active aircraft and the variance of the survey results.

Mathematically, this is expressed as:

$$\widehat{V(\hat{p}_h)} = \left(1 - \frac{n_h}{N_h}\right)\left(\frac{N_h}{N}\right)^2 \frac{\hat{p}_h(1 - \hat{p}_h)}{n_h - 1}$$

Where:

$$\widehat{V(\hat{p}_h)} = Estimated\ variance\ for\ the\ hth\ proportion$$

$$\hat{p}_h = Estimate\ of\ proportion\ of\ \text{"Yes" responses}$$

$$n_h = Number\ of\ survey\ responses\ for\ the\ hth\ type\ of\ aircraft$$

$$N_h = Total\ number\ of\ active\ hth\ type\ of\ aircraft$$

$$N = Total\ number\ of\ active\ \ "VH"\ or\ RAAus\ aircraft$$

This allows the total variance between groups to be measured as:

$$\widehat{V(p)} = \sum \widehat{V(\hat{p}_h)}$$

In some cases it's not possible to use this approach, partially where the proportion of pilots and operators is examined rather than the proportion of aircraft. In this case a variance is calculated using an infinite population and not a stratified approach:

$$\widehat{V(p)} = \frac{\hat{p}(1 - \hat{p})}{n - 1}$$

There are other cases with stratification is not appropriate, but the total population is known, in these cases variance is calculated by treating the results as a simple random survey. Mathematically, this is expressed as:

$$\widehat{V(p)} = \left(1 - \frac{n}{N}\right)\frac{\hat{p}(1 - \hat{p})}{n - 1}$$

Appendix B Statistical summary of survey data

The tables in this section provide the statistical results for all items presented above. This information should be sufficient to reproduce most of the plots shown in the report (any figures containing a map can not be reproduced by this data).

Table 14: Radio equipage rates

		y	p	sd	LowerCI	UpperCI	Nh	N
General Aviation	**None**	1	0.0006676	0.0003235	0.0001355	0.0011996	9462	17915
	Multi	936	0.6248331	0.0060635	0.6148595	0.6348067	9462	17915
	Single	513	0.3424566	0.0059428	0.3326815	0.3522317	9462	17915
	Handheld	48	0.0320427	0.0022056	0.0284149	0.0356706	9462	17915
Sports Aviation	**None**	72	0.0963855	0.0048678	0.0883788	0.1043923	8453	17915
	Multi	167	0.2235609	0.006872	0.2122574	0.2348644	8453	17915
	Single	403	0.5394913	0.0082214	0.5259683	0.5530143	8453	17915
	Handheld	105	0.1405623	0.0057329	0.1311325	0.1499921	8453	17915

Table 15: Radio equipage sports aviation

		y	p	sd	LowerCI	UpperCI	Nh	N
Glider	**None**	23	0.0855019	0.0023007	0.0817175	0.0892862	1281	8453
	Multi	30	0.1115242	0.00259	0.1072641	0.1157843	1281	8453
	Single	18	0.0669145	0.0020559	0.0635328	0.0702962	1281	8453
	Handheld	198	0.7360595	0.0036266	0.7300943	0.7420247	1281	8453
Gyroplanes	**None**	1	0.0833333	0.0032034	0.0780641	0.0886025	331	8453
	Multi	3	0.25	0.0050188	0.2417448	0.2582553	331	8453
	Single	0	0	0	0	0	331	8453
	Handheld	8	0.6666667	0.0054638	0.6576795	0.6756538	331	8453
Paragliders	**None**	58	0.5132743	0.0199691	0.4804281	0.5461206	3631	8453
	Multi	0	0	0	0	0	3631	8453
	Single	49	0.4336283	0.0197993	0.4010613	0.4661953	3631	8453
	Handheld	6	0.0530974	0.0089584	0.0383621	0.0678326	3631	8453
Ultralights	**None**	23	0.0651558	0.0047127	0.0574041	0.0729075	3210	8453
	Multi	134	0.3796034	0.0092667	0.364361	0.3948458	3210	8453
	Single	5	0.0141643	0.0022564	0.0104528	0.0178758	3210	8453
	Handheld	191	0.5410765	0.0095154	0.5254251	0.5567279	3210	8453

Table 16: ADS-B equipage rates

		y	p	sd	LowerCI	UpperCI	Nh	N
General Aviation	None of the above	821	0.5745276	0.0063671	0.5640547	0.5850006	9462	17915
	Low cost non-TSO'd ADS-B device	77	0.0538838	0.0029077	0.0491011	0.0586666	9462	17915
	Both ADS-B IN and OUT	175	0.1224633	0.0042217	0.1155192	0.1294073	9462	17915
	ADS-B IN	70	0.0489853	0.0027796	0.0444133	0.0535573	9462	17915
	ADS-B OUT (IFR standard)	286	0.20014	0.0051526	0.1916648	0.2086152	9462	17915
Sports Aviation	None of the above	613	0.8328804	0.006204	0.8226757	0.8430852	8453	17915
	Low cost non-TSO'd ADS-B device	56	0.076087	0.004409	0.0688348	0.0833391	8453	17915
	Both ADS-B IN and OUT	24	0.0326087	0.0029535	0.0277506	0.0374668	8453	17915
	ADS-B IN	32	0.0434783	0.0033912	0.0379002	0.0490563	8453	17915
	ADS-B OUT (IFR standard)	11	0.0149457	0.0020177	0.0116268	0.0182645	8453	17915

Table 17: Transponder equipage rates

		y	p	sd	LowerCI	UpperCI	Nh	N
General Aviation	None	226	0.1588194	0.0047187	0.1510578	0.166581	9462	17915
	Mode S - Antenna diversity	9	0.0063247	0.0010235	0.0046412	0.0080081	9462	17915
	Mode S - not IFR standard	93	0.0653549	0.0031907	0.0601066	0.0706031	9462	17915
	Mode S - IFR standard	31	0.021785	0.0018846	0.0186851	0.0248849	9462	17915
	Mode A/C Transponder	533	0.3745608	0.0062486	0.3642828	0.3848387	9462	17915
	ADS-B Equipped	531	0.3731553	0.0062438	0.3628851	0.3834255	9462	17915
Sports Aviation	None	511	0.6980874	0.0076571	0.6854927	0.7106822	8453	17915
	Mode S - Antenna diversity	3	0.0040984	0.0010656	0.0023457	0.0058511	8453	17915
	Mode S - not IFR standard	48	0.0655738	0.0041286	0.0587828	0.0723647	8453	17915
	Mode S - IFR standard	5	0.0068306	0.0013738	0.004571	0.0090902	8453	17915
	Mode A/C Transponder	98	0.1338798	0.0056795	0.1245378	0.1432218	8453	17915
	ADS-B Equipped	67	0.0915301	0.0048095	0.0836191	0.0994411	8453	17915

Table 18: Transponder equipage sports aviation

		y	p	sd	LowerCI	UpperCI	Nh	N
Glider	ADS-B Equipped	20	0.0746269	0.0021673	0.071062	0.0781918	1281	8453
	Mode A/C Transponder	6	0.0223881	0.0012201	0.0203811	0.024395	1281	8453
	Mode S - IFR standard	1	0.0037313	0.0005028	0.0029042	0.0045584	1281	8453
	Mode S - not IFR standard	2	0.0074627	0.0007098	0.0062952	0.0086302	1281	8453
	Mode S - Antenna diversity	0	0	0	0	0	1281	8453
	None	239	0.891791	0.002562	0.887577	0.8960051	1281	8453
Gyroplanes	ADS-B Equipped	0	0	0	0	0	331	8453
	Mode A/C Transponder	0	0	0	0	0	331	8453
	Mode S - IFR standard	0	0	0	0	0	331	8453
	Mode S - not IFR standard	1	0.0833333	0.0032034	0.0780641	0.0886025	331	8453
	Mode S - Antenna diversity	0	0	0	0	0	331	8453
	None	11	0.9166667	0.0032034	0.9113975	0.9219359	331	8453
Paragliders	ADS-B Equipped	1	0.0092593	0.0039177	0.0028152	0.0157034	3631	8453
	Mode A/C Transponder	0	0	0	0	0	3631	8453
	Mode S - IFR standard	0	0	0	0	0	3631	8453
	Mode S - not IFR standard	0	0	0	0	0	3631	8453
	Mode S - Antenna diversity	0	0	0	0	0	3631	8453
	None	107	0.9907407	0.0039177	0.9842966	0.9971848	3631	8453
Ultralights	ADS-B Equipped	46	0.1337209	0.0065942	0.1228745	0.1445674	3210	8453
	Mode A/C Transponder	92	0.2674419	0.0085757	0.2533361	0.2815476	3210	8453
	Mode S - IFR standard	4	0.0116279	0.002077	0.0082115	0.0150443	3210	8453
	Mode S - not IFR standard	45	0.130814	0.0065331	0.120068	0.1415599	3210	8453
	Mode S - Antenna diversity	3	0.0087209	0.0018014	0.0057579	0.011684	3210	8453
	None	154	0.4476744	0.0096341	0.4318277	0.4635211	3210	8453

Table 19: GNSS equipage sports aviation

		y	p	sd	LowerCI	UpperCI	Nh	N
General Aviation	Other Flight Tracking/surveillance	216	0.1441923	0.0043993	0.136956	0.1514285	9462	17915
	Other GNSS	324	0.2162884	0.0051561	0.2078073	0.2247695	9462	17915
	IFR capable GNSS	459	0.3064085	0.0057734	0.2969121	0.3159049	9462	17915
Sports Aviation	Other Flight Tracking/surveillance	257	0.3440428	0.0078357	0.3311543	0.3569314	8453	17915
	Other GNSS	170	0.227577	0.0069155	0.2162019	0.238952	8453	17915
	IFR capable GNSS	7	0.0093708	0.0015892	0.0067568	0.0119848	8453	17915

Australian Government
Civil Aviation Safety Authority

Attachment A

VFR communication and surveillance equipment: Summary report

This report was created on Monday 17 May 2021 at 08:36 and includes **1936** responses.

The consultation ran from 15/03/2021 to 16/05/2021.

Contents

If you would like to go into the draw to win one of 10 annual subscriptions to the Flight Safety Australia magazine, enter your name, email and phone number below. 9

Name	9
Phone number	9
Email	9

How would you describe yourself?

Demographic

Option	Total	Percent
Pilot who doesn't own an aircraft	348	17.98%
Pilot who owns an aircraft	1526	78.82%
Aircraft operator	62	3.20%
Not Answered	0	0.00%

What is the aircraft type you most commonly fly?

A/c flown

There were **349** responses to this part of the question.

What is the aircraft registration?

A/C rego fly

There were **349** responses to this part of the question.

What is the aircraft type you own which records the highest number of flight hours?

Aircraft owned

There were **1529** responses to this part of the question.

What is the aircraft registration?

A/C rego owned

There were **1413** responses to this part of the question.

What is the aircraft type you operate which records the highest number of flight hours?

A/C type operated

There were **65** responses to this part of the question.

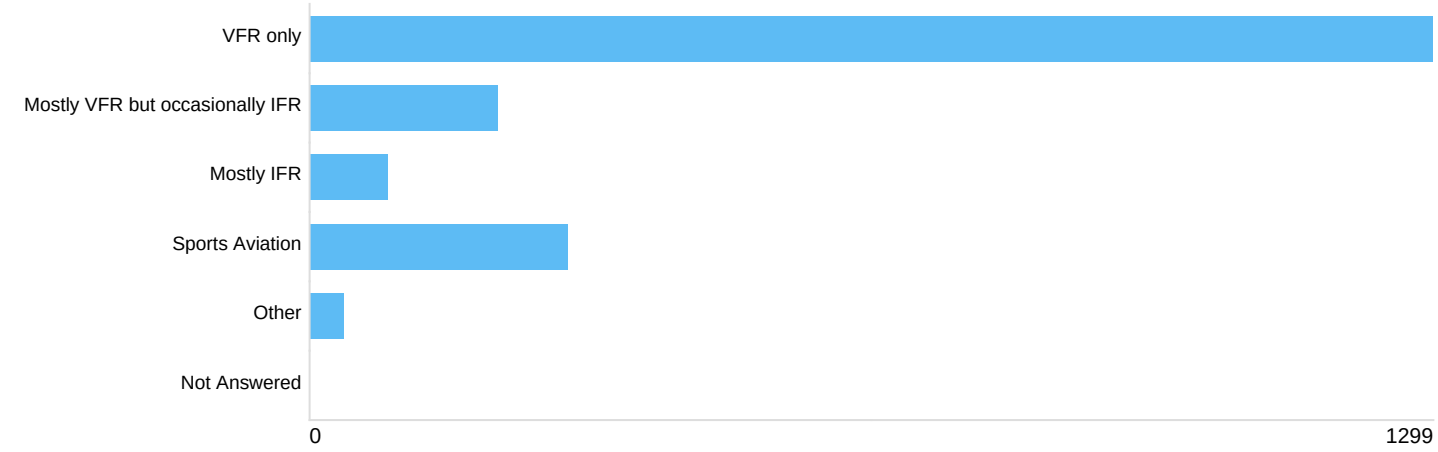
What is the aircraft registration?

A/C type operated

There were **55** responses to this part of the question.

How is the aircraft used?

AC use



Option	Total	Percent
VFR only	1299	67.10%
Mostly VFR but occasionally IFR	215	11.11%
Mostly IFR	89	4.60%
Sports Aviation	296	15.29%
Other	37	1.91%
Not Answered	0	0.00%

Other

There were **74** responses to this part of the question.

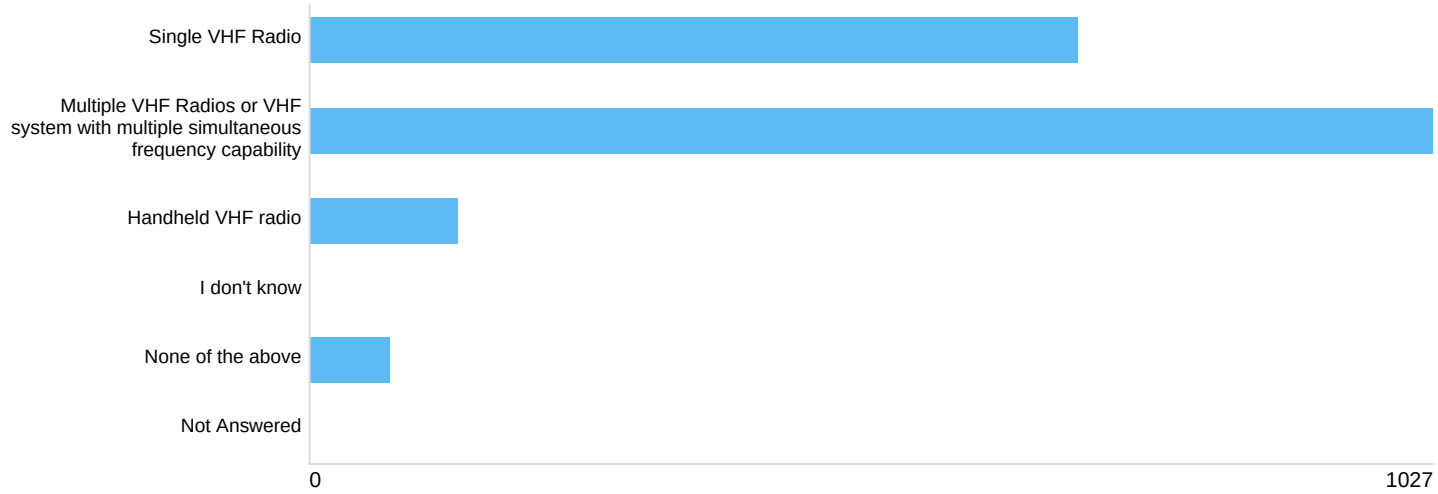
Which airport/s does the aircraft typically operate to and from? Please use the ICAO code, IATA code or airport name.

AC airports

There were **1936** responses to this part of the question.

What radio equipment does the aircraft have?

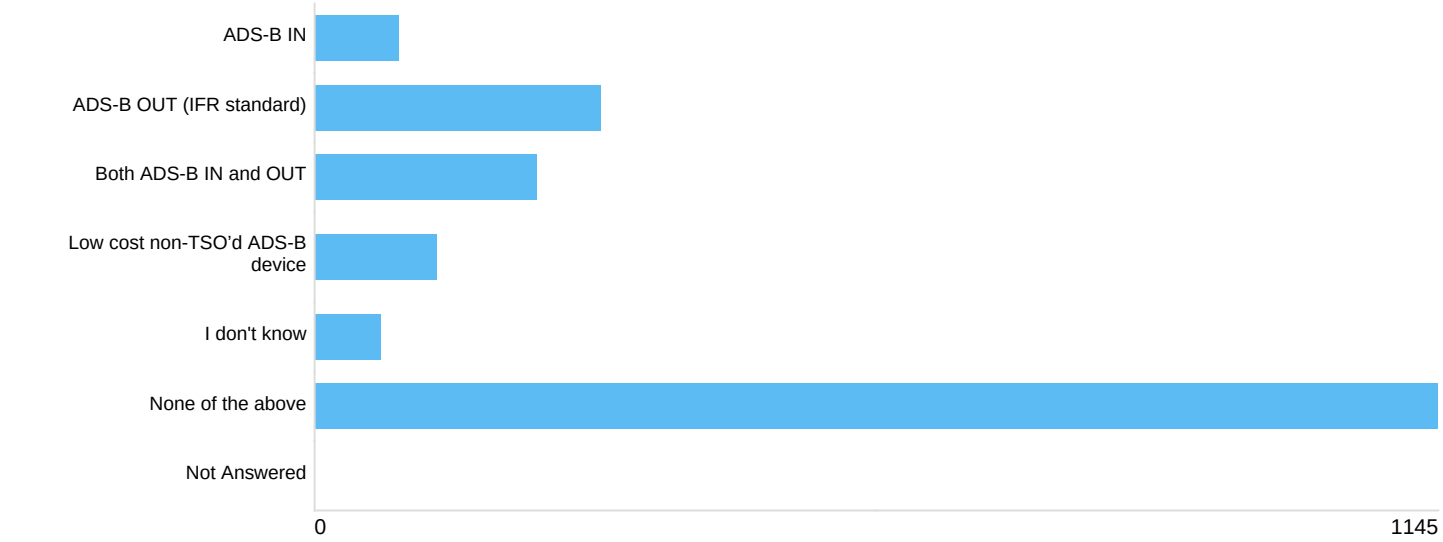
Radio equipment



Option	Total	Percent
Single VHF Radio	701	36.21%
Multiple VHF Radios or VHF system with multiple simultaneous frequency capability	1027	53.05%
Handheld VHF radio	135	6.97%
I don't know	0	0.00%
None of the above	73	3.77%
Not Answered	0	0.00%

Is the aircraft ADS-B equipped?

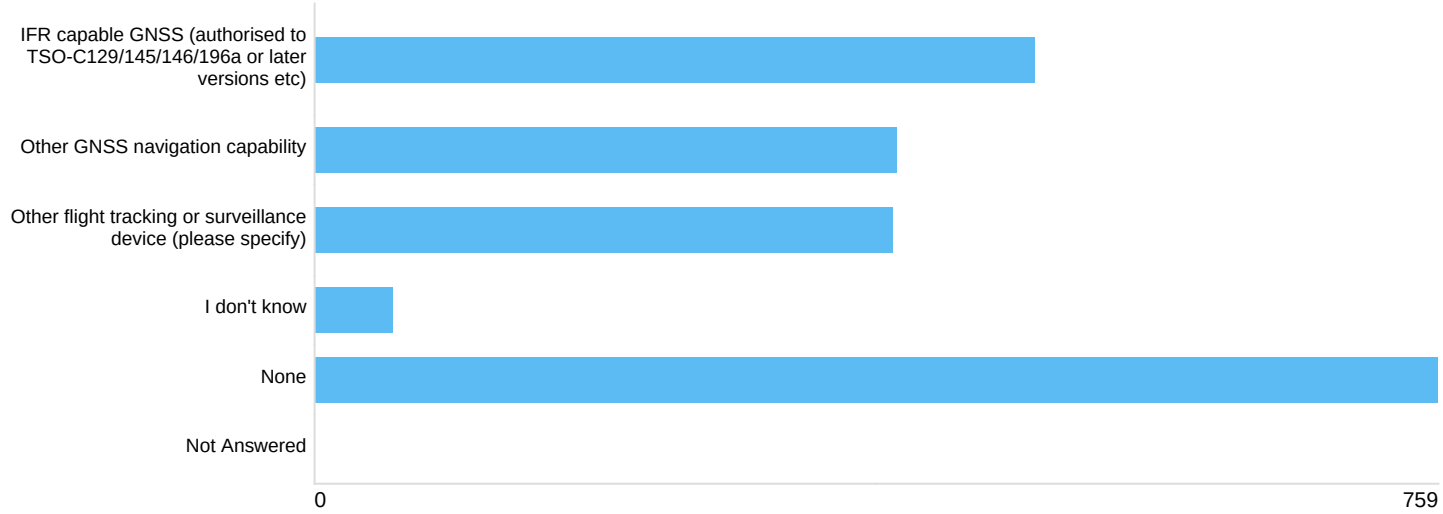
ADS-B



Option	Total	Percent
ADS-B IN	84	4.34%
ADS-B OUT (IFR standard)	290	14.98%
Both ADS-B IN and OUT	226	11.67%
Low cost non-TSO'd ADS-B device	124	6.40%
I don't know	67	3.46%
None of the above	1145	59.14%
Not Answered	0	0.00%

Does the aircraft have any of the following equipment? Select all that apply.

Other equipment



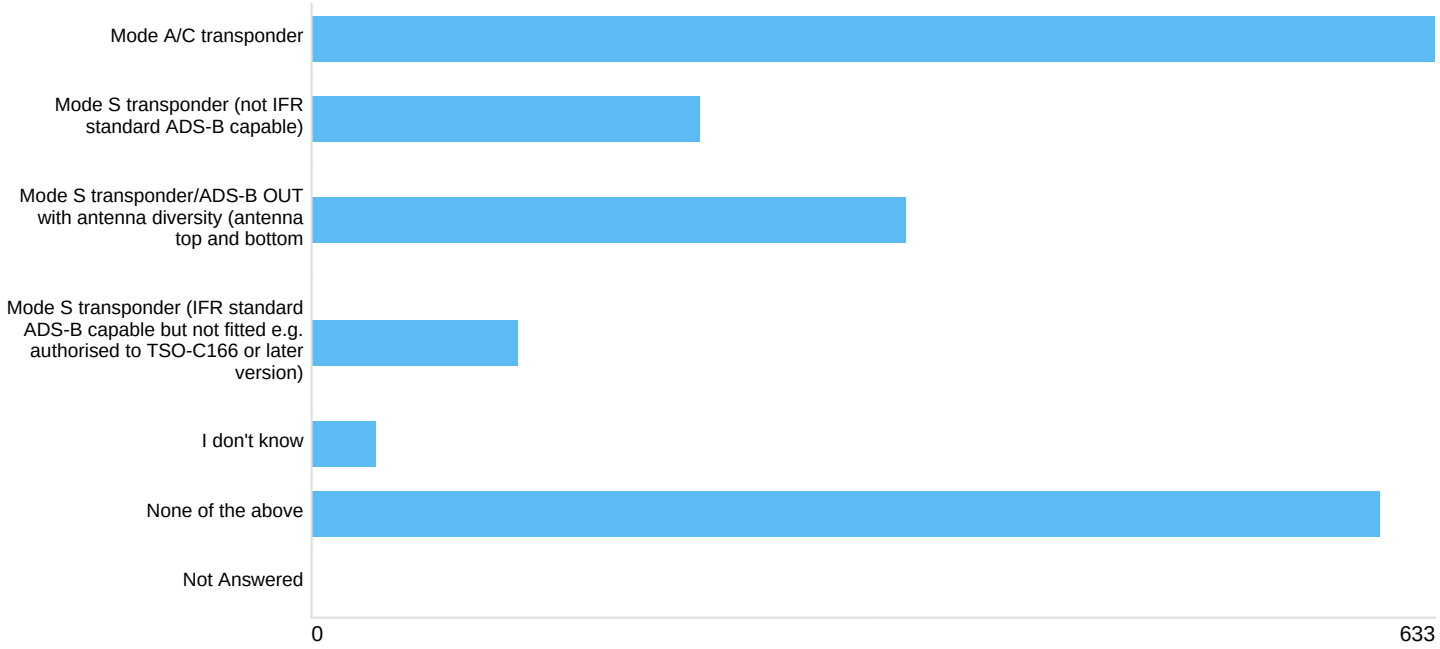
Option	Total	Percent
IFR capable GNSS (authorised to TSO-C129/145/146/196a or later versions etc)	485	25.05%
Other GNSS navigation capability	392	20.25%
Other flight tracking or surveillance device (please specify)	390	20.14%
I don't know	52	2.69%
None	759	39.20%
Not Answered	0	0.00%

Other device

There were **408** responses to this part of the question.

Does the aircraft have a transponder?

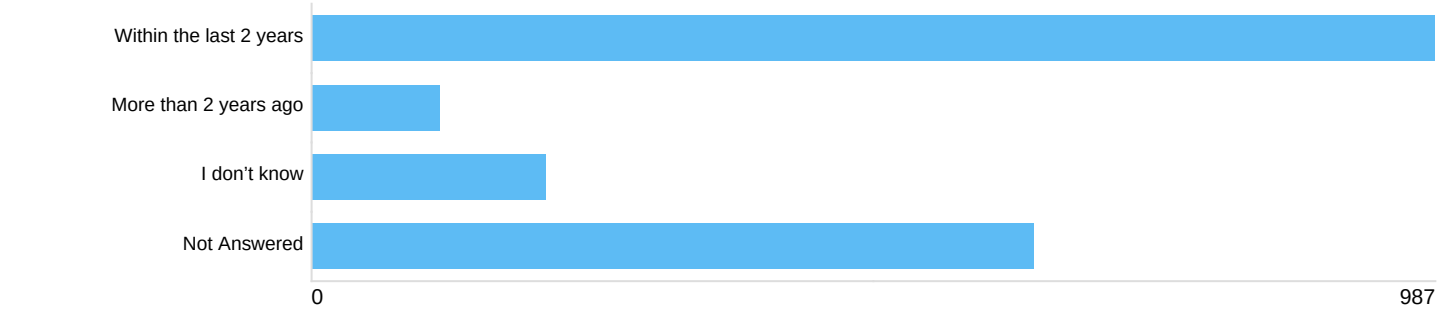
Transponder type



Option	Total	Percent
Mode A/C transponder	633	32.70%
Mode S transponder (not IFR standard ADS-B capable)	218	11.26%
Mode S transponder/ADS-B OUT with antenna diversity (antenna top and bottom	334	17.25%
Mode S transponder (IFR standard ADS-B capable but not fitted e.g. authorised to TSO-C166 or later version)	115	5.94%
I don't know	35	1.81%
None of the above	601	31.04%
Not Answered	0	0.00%

When was the transponder last tested at a maintenance facility?

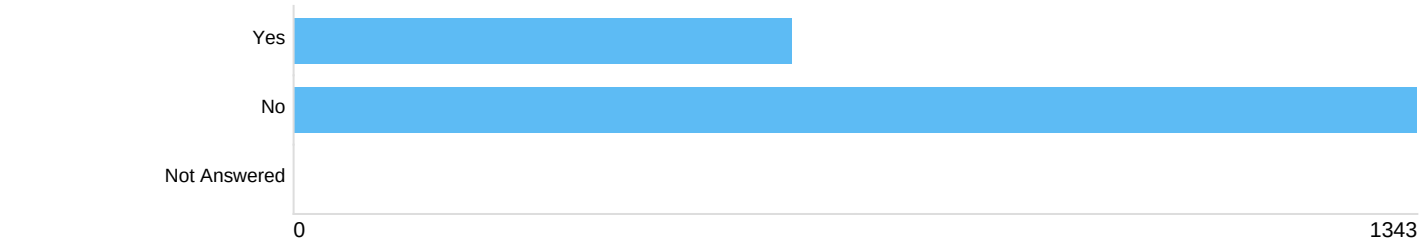
Transponder maintenance



Option	Total	Percent
Within the last 2 years	987	50.98%
More than 2 years ago	111	5.73%
I don’t know	205	10.59%
Not Answered	633	32.70%

Do you fly/operate more than one aircraft with the same type of equipment onboard?

Multiple AC



Option	Total	Percent
Yes	593	30.63%
No	1343	69.37%
Not Answered	0	0.00%

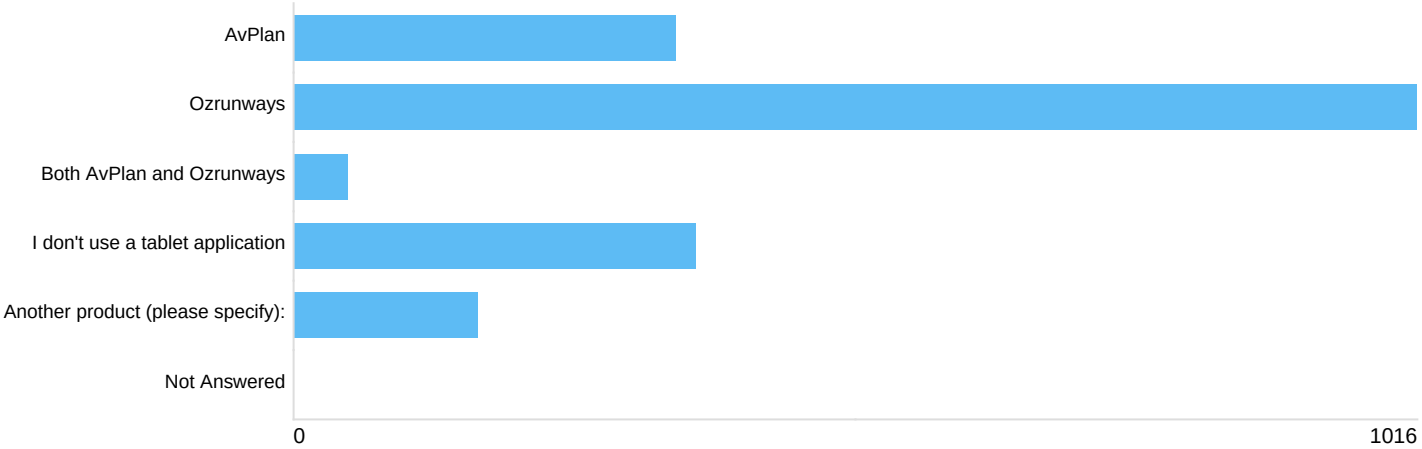
What are the aircraft registrations and aircraft types (make and model) with the same type of equipment?

Multiple aircraft

There were **600** responses to this part of the question.

Which electronic tablet application do you use?

EFB



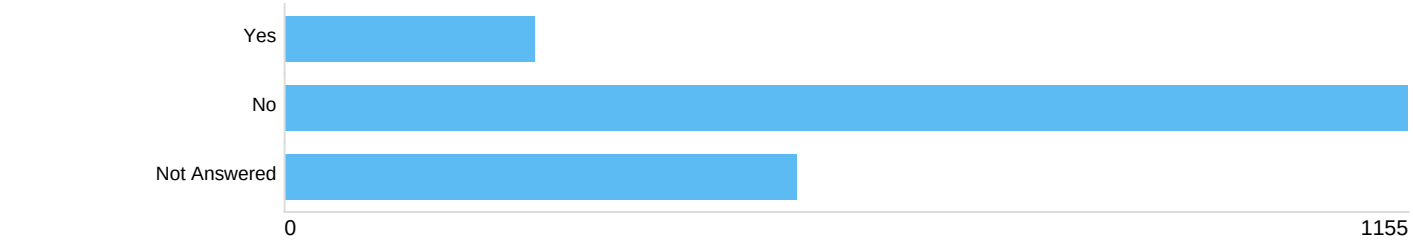
Option	Total	Percent
AvPlan	345	17.82%
Ozrunways	1016	52.48%
Both AvPlan and Ozrunways	48	2.48%
I don't use a tablet application	362	18.70%
Another product (please specify):	165	8.52%
Not Answered	0	0.00%

Other

There were **196** responses to this part of the question.

Is your electronic tablet application paired with an ADS-B receiver?

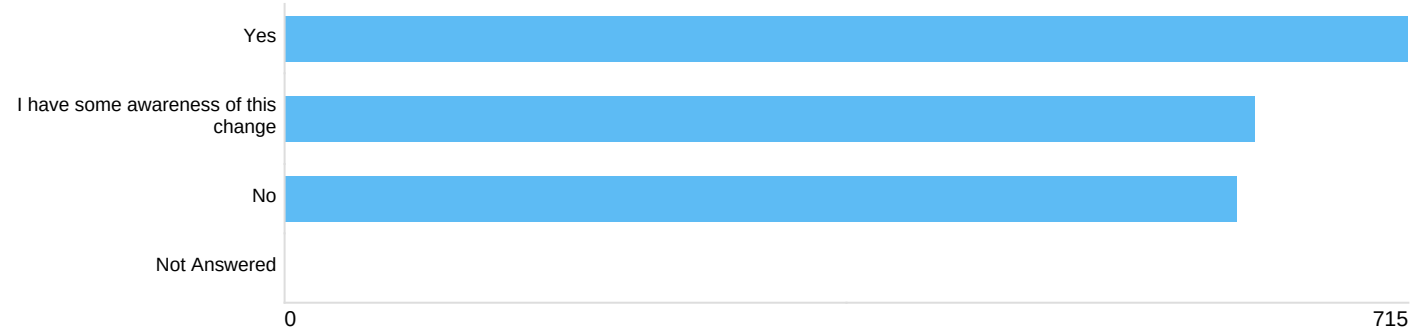
ADS-B receiver



Option	Total	Percent
Yes	256	13.22%
No	1155	59.66%
Not Answered	525	27.12%

Low cost combined ADS-B OUT and ADS-B IN devices (such as the uAvionix SkyEcho 2) are now permitted to be used in VFR aircraft. Are you familiar with this change?

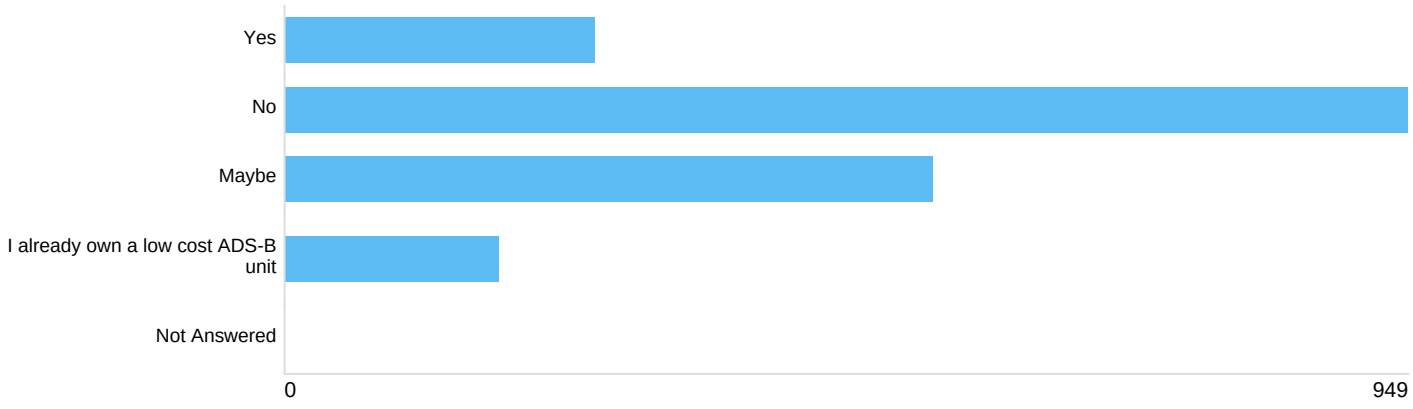
ADS-B awareness



Option	Total	Percent
Yes	715	36.93%
I have some awareness of this change	616	31.82%
No	605	31.25%
Not Answered	0	0.00%

Are you considering purchasing a low-cost ADS-B unit in the future?

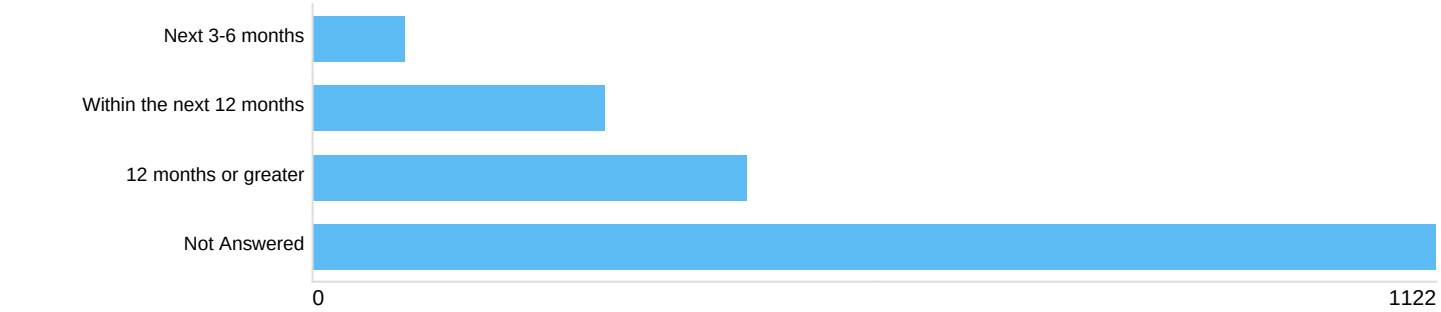
ADS-B purchasing



Option	Total	Percent
Yes	261	13.48%
No	949	49.02%
Maybe	546	28.20%
I already own a low cost ADS-B unit	180	9.30%
Not Answered	0	0.00%

When are you considering purchasing a unit?

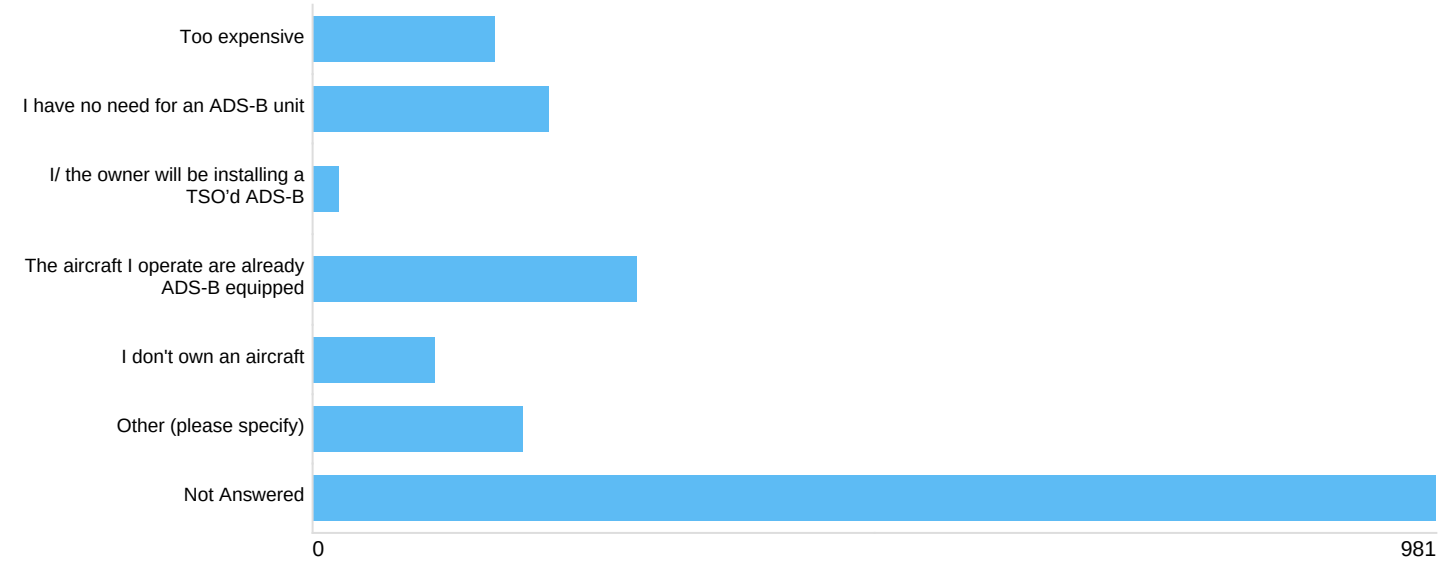
ADS-B purchase timeline



Option	Total	Percent
Next 3-6 months	91	4.70%
Within the next 12 months	290	14.98%
12 months or greater	433	22.37%
Not Answered	1122	57.95%

Why are you not considering a low-cost ADS-B unit?

ADS-B unit - not considered



Option	Total	Percent
Too expensive	158	8.16%
I have no need for an ADS-B unit	205	10.59%
I/ the owner will be installing a TSO'd ADS-B	21	1.08%
The aircraft I operate are already ADS-B equipped	282	14.57%
I don't own an aircraft	106	5.48%
Other (please specify)	183	9.45%
Not Answered	981	50.67%

ADS-B not purchase

There were **208** responses to this part of the question.

Would you like to provide any further information that is relevant to this survey?

Further relevant information

There were **752** responses to this part of the question.

If you would like to go into the draw to win one of 10 annual subscriptions to the Flight Safety Australia magazine, enter your name, email and phone number below.

Name

There were **1225** responses to this part of the question.

Phone number

There were **1215** responses to this part of the question.

Email

There were **1211** responses to this part of the question.