APPENDIX A

METHODOLOGY FOR THE 2012 GENERAL AVIATION AND PART 135 ACTIVITY SURVEY

Purpose of Survey

The General Aviation and Part 135 Activity Survey (GA Survey) provides the Federal Aviation Administration (FAA) with information on general aviation and on-demand Part 135 aircraft activity. The survey enables the FAA to monitor the general aviation fleet so that it can anticipate and meet demand for National Airspace System (NAS) facilities and services, assess the impact of regulatory changes on the fleet, and implement measures to assure the safe operation of all aircraft in the NAS. The data are also used by other government agencies, the general aviation industry, trade associations, and private businesses to identify safety problems and to form the basis for research and analysis of general aviation issues.

Background and History

Prior to the first implementation of the annual GA Survey in 1978, the FAA used the Aircraft Registration Eligibility, Identification, and Activity Report (AC Form 8050-73) to collect data on general aviation activity. The form was sent annually to all owners of civil aircraft in the United States and served two purposes: a) Part 1 was the mandatory aircraft registration revalidation form; and b) Part 2 was voluntary and applied to general aviation aircraft only, asking questions on the owner-discretionary characteristics of the aircraft such as flight hours, avionics equipment, base location, and use. The FAA used this information to estimate aircraft activity.

In 1978, the FAA replaced AC Form 8050-73 with a new system. Part 1 was replaced by a triennial registration program. In January 1978, the FAA implemented a new procedure, known as triennial revalidation, for maintaining its master file. Instead of requiring all aircraft owners to revalidate and update their aircraft registration annually, the FAA only required revalidation for those aircraft owners who had not contacted the FAA Registry for three years. This less frequent updating affected the accuracy and representation in the master file: a) the accuracy of information about current owners and their addresses deteriorated; and, b) the master file retained information on aircraft that would have been re-registered or purged from the file under the previous revalidation system.

Part 2 of AC Form 8050-73 was replaced by the General Aviation Activity Survey. Conducted annually, the survey was based on a statistically selected sample of aircraft, and it requested the same type of information as Part 2 of AC Form 8050-73. The first survey took place in 1978 and collected data on the 1977 general aviation fleet.

In 1993, the name of the survey was changed to the General Aviation and Air Taxi Activity Survey to reflect that the survey included air taxi (that is, on-demand Part 135) aircraft. Starting in 1999, information about avionics equipment, which had been collected only every other year, was requested every year. As a result, the survey's name was changed to the General Aviation and Air Taxi Activity and Avionics Survey. In 2006, "Part 135" replaced the term "Air Taxi" in the survey title, the word "Avionics" was removed (though avionics data were still collected annually), and the survey was named the General Aviation and Part 135 Activity Survey. This is the name under which the 2012 survey was conducted. The 2012 statistics in this report were derived from the 35th GA Survey, which was implemented in 2013.

In 2010, the FAA eliminated the voluntary Triennial Aircraft Registration Report Program and established mandatory re-registration and renewal for all civil aircraft.[1] Effective October 1, 2010, all aircraft on the Civil Aviation Registry would be required to re-register within the next three years. Thereafter, the re-registered aircraft, as well as aircraft registering after October 1, 2010, must renew their registrations every three years. Aircraft registrations would be cancelled if owners do not re-register or renew the registration by their assigned deadlines. The rule also placed time restrictions on statuses of "sale reported" and "registration pending." Effective October 1, 2010, aircraft could be listed in the sale reported category for a maximum of six months without filing an application for its registration. Similarly, aircraft could have a pending registration application for a maximum of 12 months, by which time the registration process must be complete or its N-Number assignment would be cancelled.[2]

The mandatory registration requirements were phased-in over three years. Time limitations on selected statuses were effective October 1, 2010. Aircraft were assigned a re-registration deadline based on the month in which their certificate was issued; the first of these quarterly deadlines was March 31, 2011, and the last was December 31, 2013. As described in subsequent sections of this appendix and summarized in Table A.3, the GA Survey was first affected by the registration rule in the 2010 survey year as a result of the time limitations on selected statuses. The definition of the GA population and the survey sample would be affected by expiration and cancellation of registrations beginning with the 2011 survey year.

Over time, the registration rule should improve the accuracy of Registry information about current owners and their addresses, and purge the master file of aircraft that do not exist or are not potentially active. As a result, the Registry will provide a more accurate list of civil aircraft and better contact information for conducting the GA Survey. The immediate impact on the GA Survey involves the definition of the survey population, which excludes aircraft that do not have valid registrations as summarized in Table A.3 and in later sections of this appendix.

The GA Survey has undergone periodic revisions to content, implementation, and definition of the GA population in order to remain current with regulations, activity patterns, and aviation technology. Chapter 1 of this report ("Historical General Aviation and Air Taxi Measures") presents statistical estimates of fleet size and activity for survey years 2001–2012. When comparing estimates across years it is important to be aware of the changes in survey content and design, data collection methods, sample and population definitions as summarized in Tables A.1 through A.3. Chapter 1 does not include estimates for the 2011 survey year and comparisons are made to the 2010 survey year. The FAA is actively engaged in re-calibration efforts and expects to publish validated 2011 data at a later date.[3]

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[1] *Federal Register* Vol 75, No. 138, Tuesday, July 20, 2010, Rules and Regulations, "Re-Registration and Renewal of Aircraft Registration."

[2] This summary focuses only on aspects of the registration rule that affect the design of the GA Survey. See the publication of the rule in the Federal Register cited above (Vol 75, No. 138, July 20, 2010) for a complete description.

[3] Until validated 2011 estimates are available, please use the 2011 data from FAA's Aviation Forecast estimates (http://www.faa.gov/about/office_org/headquarters_offices/apl/aviation_forecasts/aerospace_forecasts/2013-2033/).

Table A.1: Changes in Form or Content of Survey Questionnaire, by Survey Year

Year	Change in form or content of survey questionnaire
1993	Added sightseeing and external load to use categories
1996	Added public use (i.e., flights for the purpose of fulfilling a government function) to use categories
1999	Significant re-design of the entire survey form to reduce item non-response, add new content, and be compatible with optical scanning Added air medical services to use categories Discontinued the use of a catch-all "other" category as used in previous years Began collecting avionics data every year, rather than every other year
2000	"Public use" asked as a separate question, independent of other use categories (e.g., business transportation), because it was not mutually exclusive with respect to other flight activity
2002	Use categories refined to be mutually exclusive and exhaustive and match definitions used by National Transportation Safety Board (NTSB) for accident reporting
2004	Air medical services was divided into two separate types to capture air medical flights under Part 135 and air medical flights not covered by Part 135 A more clearly defined "other" category was reintroduced
2005	Fractional ownership question was changed from yes/no to a percentage Reduced the number of fuel type response categories by removing obsolete options Average fuel consumption (in gallons per hour) was added Revised questions about avionics equipment by adding and rearranging items
2007	Location of aircraft revised to ask the state or territory in which the aircraft was "primarily flown" during the survey year rather than where it was "based" as of December 31st of the survey year Percentage of hours flown in Alaska was added Questions on percentage of hours flown under different flight plans, flight conditions, and day/night were revised into a single tabular format Number of types of landing gear systems was expanded Ice protection equipment was revised and prohibition from flight in icing conditions was added Questions about avionics equipment were revised to reflect changes in technology
2009	Two questions about avionics equipment were revised: "Air Bag/Ballistic Parachute" was asked as two items—"Air Bag" and "Ballistic Parachute" "ADS-B (Mode S)" was separated into two questions—"ADS-B (Mode S) Transmit Only (Out)" and "ADS-B (Mode S) Transmit and Receive (In)"
2010	Removed the skip instruction in the mail survey based on responses to Part 121/129 operations Added "Specify" option if reason not flown was "Other"

Table A.2: Changes in Data Collection Methodology, by Survey Year

Year	Change in data collection methodology
1999	Non-respondent telephone survey conducted to adjust active aircraft and hours flown estimates[4]
2000	Discontinued non-respondent telephone survey because of the variability of telephone non-respondent factors Added Internet response option
2003	Added a reminder/thank-you postcard between the first and second mailings
2004	Introduced "large fleet" summary form to allow owners/operators of multiple aircraft to report aggregate data for their entire fleet on a single form Initiated telephone follow-up effort to contact owners/operators of multiple aircraft who had not responded. (Protocol encourages and facilitates participation by providing alternate forms and offering technical assistance but survey is not conducted by telephone.)
2009	Initiated telephone follow-up effort to contact owners/operators of single aircraft who completed partial survey. (Protocol encourages and facilitates participation by offering technical assistance but survey is not conducted by telephone.)
2010	Mailed end-of-field-period follow-up postcard to owners/operators of single aircraft that participated the previous survey year but had not yet completed the current year's survey[5] Discontinued telephone follow-up with owners/operators of single aircraft who completed partial survey due to low effectiveness Telephone follow-up efforts with owners/operators of multiple aircraft included some collection of key variables by telephone and were not limited to encouraging participation.

Table A.3: Changes in Sample Design or Definition of Survey Population, by Survey Year

Year	Change in sample design or survey population
1993	Number of aircraft types classified by the sample was expanded from 13 to 19
1999	Sample design revised to stratify by aircraft type (19 categories) and FAA region (9 categories)[6]
2003	Aircraft with known incorrect addresses and identified as "Postmaster Return" status on the Registry were retained in the definition of the survey population and eligible for sample selection
2004	Aircraft listed on the Registry as "registration pending" or "sold" (if sold status less than five years ago) were retained in the definition of the survey population and eligible for sample selection Sample design revised to stratify by aircraft type (19 categories), FAA region (9 categories), and whether the aircraft is owned by an entity certified to fly Part 135 (2 categories) Introduced 100 percent samples of turbine aircraft, rotorcraft, on-demand Part 135, and Alaska-based aircraft

[4] Telephone surveys of non-respondents also were conducted in 1977, 1978, 1979, 1997, and 1998. Please refer to the 1999 GA Survey report for a full discussion of the telephone survey of non-respondents.

[5] For the 2012 survey, this postcard was sent to owners/operators of single aircraft who participated in the 2010 survey but had not yet completed the 2012 survey. We were not able to compare the 2012 sampled aircraft with participation in the 2011 survey.

[6] Before 1999, the sample was stratified by aircraft type (19 categories) and state/territory (54 categories).

Year	Change in sample design or survey population
2005	Introduced light-sport aircraft as a 20th aircraft type sampled at 100 percent. Light-sport included aircraft with special or experimental airworthiness as well as aircraft for which airworthiness was not yet final.
2006	Sample design simplified to 14 aircraft types (removed distinctions based on number of seats and eliminated "Other" subcategories of piston, turboprop, and turbojet aircraft) Sample design included 100 percent sample of aircraft manufactured in the past five years
2008	100 percent sample of light-sport aircraft was limited to special light-sport aircraft. Experimental light-sport and light-sport without completed airworthiness sampled at a rate less than 1.0. Results in sample design with 15 aircraft types.
2010	Aircraft excluded from the survey population if "sale reported" or "registration pending" more than 12 months. These aircraft no longer eligible for sample selection due to implementation of the re-registration rule.
2012	Aircraft excluded from the survey population if registration was expired. These aircraft no longer eligible for sample selection because they do not have valid registrations due to implementation of the re-registration rule.

Survey Population and Survey Sample

The survey population for the 2012 General Aviation and Part 135 Activity Survey includes all civil aircraft registered with the FAA that are based in the US or US territories and that were in existence, potentially active between January 1 and December 31, 2012, and had a valid registration. This includes aircraft operating under:

- Part 91: General operating and flight rules
- Part 125: Certification and operations: Airplanes having a seating capacity of 20 or more passengers or a maximum payload capacity of 6,000 pounds or more (but not for hire)
- Part 133: Rotorcraft external load operations
- Part 135: On-demand (air taxi) and commuter operations not covered by Part 121
- Part 137: Agricultural aircraft operations.

Aircraft operating under Part 121 as defined in Part 119 are excluded from the survey population. Foreign air carriers, which operate under Part 129, are also not part of the survey population. Civil aircraft that are known not to be potentially active during the survey year are excluded from the population (e.g., aircraft on static display, destroyed prior to January 1, 2012).

The Aircraft Registration Master File, maintained by the FAA's Mike Monroney Aeronautical Center in Oklahoma City, Oklahoma, serves as the sample frame or list of cases from which a sample of civil aircraft is selected. The Registration Master File ("Registry") is the official record of registered civil aircraft in the United States. For the purpose of defining the 2012 survey population, we used the Registry's list of aircraft as of December 31, 2012.

The Registry, like many sample frames, is an imperfect representation of the survey population. While it may exclude a small number of aircraft that operate under the FAA regulations

governing the operation of general aviation and on-demand Part 135 aircraft, it also includes aircraft that are not part of the survey population. Prior to sample selection, several steps are taken to remove ineligible aircraft from the sample frame. Specifically, this includes removing the following:

- Aircraft whose registration has been cancelled or revoked
- Aircraft based in Europe or registered to a foreign company that has not returned flight hour reports
- Aircraft that operate under Part 121
- Aircraft destroyed or moved to static display prior to January 1, 2012
- Aircraft that are flagged Postmaster Return (known to have incorrect address information) on the aircraft Registration file prior to 2003 (ten years prior to survey year).

The registration rule that became effective October 1, 2010 introduced criteria that affect the definition of the survey population. The rule places time restrictions on statuses of "sale reported" or "registration pending," and registrations will be cancelled for aircraft that do not re-register or renew by their deadlines. As noted in Table A.3, the survey population excluded aircraft listed as "sale reported" or "registration pending" beyond the allowable time limits beginning with the 2010 survey. Beginning in 2012, aircraft with expired registrations were excluded.[7] For the 2012 survey, these exclusions can be summarized as follows:

- Aircraft listed as "sale reported" for more than 12 months (prior to January 1, 2012)[8]
- Aircraft listed as "registration pending" for more than 12 months (prior to January 1, 2012)
- Aircraft with registrations that expired on or before December 31, 2012.

The registration requirements mean that aircraft failing to re-register or renew cannot legally operate and their registrations are cancelled. The 2012 survey was among the first to apply this exclusion to the survey population and we allowed a grace period during which expired aircraft might re-register and still be included in the population. Specifically, aircraft that held expired registrations as of December 31, 2012, but subsequently re-registered or were newly assigned

[7] Time-limitations on selected statuses, such as "sale reported," were effective October 1, 2010, and affected the definition of the 2010 survey population. The first re-registration deadline was March 31, 2011 and would have affected the population for the 2011 GA Survey, which was implemented by a different contractor.

[8] The registration rule allows aircraft to be listed in the sale reported category for a maximum of six months. For the purpose of defining the survey population, we allow aircraft to hold this status for 12 months because we cannot consistently differentiate among aircraft that did or did not hold valid statuses for the other six months of the year. The number of aircraft mistakenly included in the survey population should be relatively small. The error of including ineligible aircraft has a less significant impact on statistical estimates of activity than erroneously excluding eligible and potentially active aircraft.

a time-limited status of "sale reported" or "registration pending" by March 31, 2013,[9] were retained in the population. Of the 32,186 aircraft with expired registrations at year-end 2012, 2,310 had re-registered or updated their statuses by March 31, 2013 and were retained in the 2012 survey population.

The Registry Master file included 352,198 aircraft as of December 31, 2012. This represents a decrease of almost 6 percent compared with the Registry file from 2010 (373,896). After excluding the aircraft described above, 281,804 records remain, which is 80 percent of the Registry as of December 31, 2012. The 2012 survey population of 281,804 represents a decrease of 7.4 percent from 2010 (304,334 – 281,804 / 304,334).[10]

The 2012 GA Survey Sample

The 2012 survey sample design is the same as that for the 2010 survey year. The sample is stratified by aircraft type (15 categories), FAA region in which the aircraft is registered (9 categories), whether the aircraft operates under a Part 135 certificate (2 categories), and whether the aircraft was manufactured in the past five years (2 categories). Aircraft operated under a Part 135 certificate were identified using the FAA's Operations Specifications Subsystem (OPSS) database that was merged with the Registry by N-Number. The four stratifying variables yield a matrix of 540 cells.

We define 15 aircraft types to execute the sample design as shown in Table A.4. The classification distinguishes among fixed wing aircraft, rotorcraft, experimental aircraft, light-sport, and other aircraft. Within the major categories of fixed wing and rotorcraft, we differentiate aircraft by type and number of engines (e.g., piston, turboprop, turbojet, turbine, single- and two-engines). Experimental aircraft are subdivided by amateur-built status and airworthiness certification, and we classify "other" aircraft as gliders or lighter-than-air. Light-sport is subdivided into special and experimental based on airworthiness certification. Light-sport aircraft for which airworthiness certificates are not yet final are included with experimental light-sport.

Prior to the 2006 survey year, we defined 20 aircraft types and distinguished aircraft by size as well as by type and number of engines. Beginning in 2006, subcategories based on number of seats were eliminated to increase the efficiency of the sample. Three "other" aircraft types were eliminated because improvements in the Registry have left few aircraft in these residual categories.[11]

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[9] The March 31, 2013 Registry was used because an archive of quarterly files was available and quarterly dates corresponded to re-registration deadlines.

[10] After the population was initially defined, we identified 547 aircraft that were incorrectly excluded. These aircraft held conflicting statuses on two data sources used to define the population and execute the sample design. After investigation and discussion with the FAA, we determined the aircraft should be included in the 2012 survey. The population and sample files were updated promptly and without affecting survey implementation. The sampling probabilities were not affected because the newly retained cases were part of 100 percent samples.

[11] The following three categories were eliminated: Fixed wing piston–other, fixed wing turboprop–other, and fixed wing turbojet–other. The few aircraft in the major category that cannot be classified are assigned to the modal category for that group (e.g., unclassifiable fixed wing turboprops are assigned to fixed wing turboprop–2 engines, 1–12 seats).

Although the sample design uses 15 aircraft types, statistical estimates are reported for 18 types, further differentiating aircraft by number of engines and number of seats. Starting in 2009, estimates were reported separately for experimental- and special light-sport. In the 2012 survey year, statistical estimates for experimental light-sport aircraft are reported in the experimental category rather than the light-sport category. This change only affects how results are reported; it does not impact the sample design or sampling probabilities.

Table A.4: Aircraft Types Used for Sample Design and for Reporting Survey Results

Aircraft Types in the Sample Design	Aircraft Types for Reporting Results
Fixed wing piston (1 engine)	Fixed wing piston (1 engine, 1–3 seats)
Fixed wing piston (2 engines)	Fixed wing piston (1 engine, 4 or more seats)
Fixed wing turboprop (1 engine)	Fixed wing piston (2 engines, 16 seats)
Fixed wing turboprop (2 engines)	Fixed wing piston (2 engines, 7 or more seats)
Fixed wing turbojet	Fixed wing turboprop (1 engine)
Rotorcraft (Piston)	Fixed wing turboprop (2 engines, 1–12 seats)
Rotorcraft (Turbine, 1 engine)	Fixed wing turboprop (2 engine, 13 or more seats)
Rotorcraft (Turbine, multi-engine)	Fixed wing turbojet
Glider	Rotorcraft (Piston)
Lighter-than-air	Rotorcraft (Turbine, 1 engine)
Experimental (Amateur)	Rotorcraft (Turbine, multi-engine)
Experimental (Exhibition)	Glider
Experimental (Light-sport)	Lighter-than-air
Experimental (Other)	Experimental (Amateur)
Light-sport (Special)	Experimental (Exhibition)
	Experimental (Light-sport)
	Experimental (Other)
	Light-sport (Special)

Aircraft Sampled at 100 Percent

The 2012 survey sample included several types of aircraft that were sampled at a rate of 1.0. Because of the FAA's interest in better understanding the operation of these aircraft, all such aircraft listed in the Registry were included in the survey sample to ensure a sufficient number of responses to support analysis and provide more precise estimates of fleet size and aircraft activity. These include:

- 100 percent sample of turbine aircraft (turboprops and turbojets)
- 100 percent sample of rotorcraft
- 100 percent sample of special light-sport aircraft
- 100 percent sample of aircraft operating on-demand Part 135
- 100 percent sample of aircraft registered in Alaska
- 100 percent sample of aircraft manufactured within the past five years (since 2008 inclusive).

Since 2004, the survey design has included 100 percent samples of turbine aircraft, rotorcraft, aircraft certificated to operate under Part 135, and Alaska-based aircraft. In 2005, we added the 100 percent sample of light-sport aircraft. In 2006, we added the 100 percent sample of recently-manufactured aircraft. In 2008, we revised the 100 percent sample of light-sport aircraft to include only special light-sport aircraft. Experimental light-sport and those without final airworthiness documentation are sampled at less than 100 percent but in sufficient numbers to support statistical estimates of flight activity. Altogether the aircraft sampled at 100 percent contributed 56,218 observations to the 2012 survey sample.

Aircraft Sampled at Less than 100 Percent

Aircraft that are not part of a 100 percent sample are selected based on sampling fractions defined for each cell in the sample design matrix. Flight hours is the primary measure needed by the FAA. Sample fractions for each sample strata are defined to optimize sample size to obtain a desired level of precision for an estimate of flight activity. Data from the previous survey year[12] on average hours flown, variability in hours flown by region and aircraft type, and response rates are used to set precision levels and target sample sizes for each strata. Aircraft are randomly selected from each cell in the matrix, subject to the desired sample size. Strata where the desired sample size exceeds the population are examined and the sample size is adjusted to include all observations.[13] The 2012 survey sample includes an additional 29,185 aircraft that are selected at a rate of less than 1.0, which is an increase over 2010 when an additional 23,537 aircraft were sampled.

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[12] Data from the previous survey year were not available so the 2012 sampling rates were informed by results from the 2010 GA Survey.

[13] In 2012, an additional eight strata were sampled at 100 percent to meet precision requirements (4,985 aircraft). These strata are not considered to be among the 100 percent samples in the sample design and are not described as such in this document.

The 2012 GA Survey sample included 85,403 aircraft. Table A.5 summarizes the population counts and sample sizes by aircraft type.

Table A.5: Population and Survey Sample Counts by Aircraft Type

Aircraft Type	Population	Sample Size	Sample as Percent of Population
Fixed Wing - Piston	**191,032**	**32,831**	**17.2**
1 engine, 1–3 seats	55,562	7,402	13.3
1 engine, 4+ seats	116,841	15,583	13.3
2 engines, 1–6 seats	12,844	6,581	51.2
2 engines, 7+ seats	5,785	3,265	56.4
Fixed Wing - Turboprop	**11,235**	**11,235**	**100.0**
1 engine	5,452	5,452	100.0
2 engines, 1–12 seats	4,334	4,334	100.0
2 engines, 13+ seats	1,449	1,449	100.0
Fixed Wing - Turbojet	**12,682**	**12,682**	**100.0**
Rotorcraft	**11,863**	**11,863**	**100.0**
Piston	4,447	4,447	100.0
Turbine (1 engine)	5,650	5,650	100.0
Turbine (multi-engine)	1,766	1,766	100.0
Other Aircraft	**7,992**	**3,501**	**43.8**
Glider	2,955	1,346	45.5
Lighter-than-air	5,037	2,155	42.8
Experimental	**44,850**	**11,141**	**24.8**
Amateur	32,200	5,808	18.0
Exhibition	2,991	1,827	61.1
Experimental light-sport*	7,632	2,067	27.1
Other experimental	2,027	1,439	71.0
Special light-sport	**2,150**	**2,150**	**100.0**
Total	**281,804**	**85,403**	**30.3**

* Includes light-sport aircraft with experimental airworthiness and light-sport aircraft for which airworthiness certification is not final

Weighting the Survey Data

Data from completed surveys are weighted to reflect population characteristics. The weights reflect the proportion of aircraft sampled from the population in each sample strata and differential response as well as adjustment for aircraft that are not part of the survey population.

Initially, each aircraft for which we receive a completed survey is given a weight that reflects sampling fraction and differential response. That is:

WEIGHT = (Population N_{ijkl}/Sample N_{ijkl}) * (Sample N_{ijkl}/N $Respondents_{ijkl}$)

where i, j, k, and l represent the four sample strata of aircraft type, FAA region, Part 135 status, and whether an aircraft was manufactured in the past five years.

The weight is subsequently adjusted to reflect information about non-general aviation aircraft. That is, survey responses that identify an aircraft as not being part of the survey population—e.g., destroyed prior to January 1, 2012; displayed in a museum; or operated primarily as an air carrier under Part 121 or 129—are used to remove aircraft proportionally from the sample and from the population. This adjustment is done at the level of the 15 aircraft types. The procedure assumes that ineligible aircraft occur in the same proportion among survey respondents and non-respondents. To the extent that ineligible aircraft are less likely to receive and complete a survey, this approach will underestimate the adjustment for aircraft that are not part of the general aviation population.

Errors in Survey Data

Errors associated with survey data can be classified into two types—sampling and non-sampling errors. Sampling errors occur because the estimates are based on a sample of aircraft rather than the entire population and we can expect, by chance alone, that some aircraft selected into the sample differ from aircraft that were not selected.

Non-sampling errors can be further subdivided into a) errors that arise from difficulties in the execution of the sample (e.g., failing to obtain completed interviews with all sample units), and b) errors caused by other factors, such as misinterpretation of questions, inability or unwillingness to provide accurate answers, or mistakes in recording or coding data.

Sampling Error

The true sampling error is never known, but in a designed survey we can estimate the potential magnitude of error due to sampling. This estimate is the standard error. The standard error measures the variation that would occur among the estimates from all possible samples of the same design from the same population.

This publication reports a standard error for each estimate based on survey sample data. An estimate and its standard error can be used to construct an interval estimate ("confidence interval") with a prescribed level of confidence that the interval contains the true population figure. In general, as standard errors decrease in size we say the estimate has greater precision (the confidence interval is narrower), while as standard errors increase in size the estimate is less precise (the confidence interval is wider). Table A.6 shows selected interval widths and their corresponding confidence.

Table A.6: Confidence Interval Estimates

Width of interval	Approximate confidence that interval includes true population value
1 Standard error	68%
2 Standard error	95%
3 Standard error	99%

This report presents a “percent standard error” for each estimate, which is the standard error relative to the mean. The percent standard error is the ratio of the standard error to its estimate multiplied by 100. For example, if the estimate is 4,376 and the standard error is 30.632, then the percent standard error is (30.632/4,376) x 100 = 0.7. Reporting percent standard errors makes it possible to compare the precision of estimates across categories.

Estimates and percent standard errors reported in Table 2.1 in Chapter 2 ("Population Size, Active Aircraft, Total Flight Hours, and Average Flight Hours by Aircraft Type") provide an example of how to compute and interpret confidence intervals. To obtain a 95 percent confidence interval for the estimated number of total hours flown for twin-engine turboprops in 2012, where the total hours flown is estimated to be 1,361,729 and the percent standard error of the estimate is 1.3, the following computation applies:

Lower confidence limit: 1,361,729 – 1.96(1.3/100)(1,361,729) = 1,327,032

Upper confidence limit: 1,361,729 + 1.96(1.3/100)(1,361,729) = 1,396,426

In other words, if we drew repeated samples of the same design, 95 percent of the estimates of the total hours flown by twin-engine turboprops would fall between 1,327,032 and 1,396,426.

Non-sampling Error

Sampling error is estimable and can be reduced through survey design (e.g., by increasing sample size), but it is difficult, if not impossible, to quantify the amount of non-sampling error. Although extensive efforts are undertaken to minimize non-sampling error, the success of these measures cannot be quantified.

Steps taken to reduce non-sampling error include strategies to reduce non-response and efforts to minimize measurement and coding errors. To this end, implementation and design of the 2012 GA Survey incorporated the following steps to maximize cooperation among sample members:

- Two modes of administration to facilitate access to the survey—a postcard invitation to complete the survey on the Internet followed by a mail survey to be completed by pen or pencil.

- Three mailings of the survey to individuals who had not yet responded, as well as a reminder/thank-you postcard and, for single-aircraft owners/operators, an end-of-field-period follow-up postcard.

- Cover letters accompanying each survey mailing clearly explained the purpose of the survey as well as the endorsement (organizational logos) of several aviation associations.

- Cover letters assured owners of the confidentiality of their responses and informed them: “Names of individuals are never associated with responses. There is an identification number on your survey only so [survey contractor] knows who should receive the letter.”

- Use of additional sources to obtain updated contact information and help ensure the mail survey reaches the sample member (e.g., National Change of Address, updates from aviation associations).

- Use of a toll-free telephone number and e-mail address to respond to questions.

- Collaboration with aviation organizations and industry groups to encourage cooperation of owners/operators of multiple aircraft.

- Telephone follow-up to owners/operators of multiple aircraft who had not yet responded.

The survey efforts also minimize measurement error by increasing the likelihood that respondents share a common understanding of survey questions and reducing errors in data coding. These efforts include:

- Close collaboration with the FAA, other federal agencies, and aviation groups to refine and clarify question wording as well as definitions to questions. The questionnaire is re-examined each year to identify ambiguities or revisions necessary to remain consistent with aviation regulations and definitions.

- Periodic re-design of the survey questionnaire (question wording, response structure, or survey format), and pre-testing significant revisions with a sample of aircraft owners/operators to ensure reliability of new or revised measures necessary to meet FAA reporting needs.

- Comprehensive editing and verification procedures to ensure the accuracy of data transcription to machine-readable form as well as internal consistency of responses.

We undertake extensive effort to reduce measurement error, particularly where we can anticipate systematic or repeated error on the part of survey respondents, but it is impossible to eliminate all measurement error. Survey participants may misunderstand questions or misreport flight activity in ways that cannot be anticipated or prevented through survey or questionnaire design. Where survey reports appear nonsensical or contradict FAA regulations (e.g., lighter-than-air aircraft providing air medical services), we manually verify that the data were processed accurately. Instances in which a small number of illogical reports occur may be suppressed and are indicated in table notes. No additional steps are taken to “cleanse” the data of apparently

illogical reports or assign them to other categories. To do so would introduce additional and systematic error that would be misleading and would affect other uses of the data.

Imputation of Missing Data

Imputation of missing data is important for stabilizing the estimates of aircraft activity and equipment. Values are imputed for variables if the survey response is incomplete, the survey form did not include the question, or the Registry data field is blank. Table A.7 lists the variables for which values are imputed, describes the imputation procedure, and shows the percentage of cases with imputed data. The table shows rates of imputation among aircraft that received the full survey form (first column of numbers) as well as rates of imputation for all survey responses, including those that returned a short form (last column).[14] The questions that are not asked on the short form are noted with an asterisk.

Table A.7: Variables with Imputed Values, Imputation Procedure, and Percentage Imputed

Variable	Imputation Procedure[15]	Percent Imputed (full survey form only)	Percent Imputed (incl. short form)
Hours by use (e.g., personal, business transport)	Mean values by aircraft type	1.2	4.3
Fractional ownership hours	Nearest neighbor by aircraft type by make model series	0.5	2.3
Hours rented/leased *	Nearest neighbor by aircraft type by make model series	1.9	29.2
Public use hours	Nearest neighbor by aircraft type by make model series	1.9	3.6
Hours by flight plans/flight conditions *	Mean values by aircraft type	1.9	29.2
Airframe hours *	Nearest neighbor by aircraft type by hours flown[16]	2.3	29.6
Number of landings	Nearest neighbor by aircraft type by make model series by age	3.1	6.7
Landing gear *	Nearest neighbor by aircraft type by make model series	2.2	29.5
Fuel type *	Nearest neighbor by aircraft type by make model series	3.3	30.1

[14] The “full” and “short” forms of the survey are described below in the section “Data Collection Methods.”
[15] In previous years, most imputations were executed by aircraft type by engine manufacture model. In 2012, we determined that make model series information on the Registry had improved and was available for all aircraft. Engine information is not consistently present.
[16] In previous years, airframe hours were imputed by aircraft type by age. This procedure resulted in (continued) missing values for many aircraft and age was replaced by hours flown in 2012.

Variable	Imputation Procedure[15]	Percent Imputed (full survey form only)	Percent Imputed (incl. short form)
Fuel burn rate	Nearest neighbor by aircraft type by make model series	2.9	7.9
Avionics equipment *	Nearest neighbor by aircraft type by make model series by age	3.5	35.4
State primarily flown	Assign state of registration from Registry	23.7	27.0
Year of manufacture (Registry data field)	Nearest neighbor by aircraft type by make model series	2.7	3.8

Percentages are based on unweighted survey responses (total 37,119).

* Question not asked on the abbreviated survey form administered to owners/operators of multiple aircraft.

The Registry provides information on year of manufacture, but this data field can be missing for many aircraft. To improve the quality of statistical estimates reported by age of aircraft, the 2012 survey used other sources to supplement the Registry before imputing values based on nearest neighbor techniques. First, if year of manufacture was missing but the owner/operator provided the information on the Internet survey[17], we used the self-reported value. Second, we matched Registry records on aircraft make-model with the Aircraft Bluebook and applied manufacture dates listed by the Bluebook for a make-model and corresponding range of serial numbers. A total of 951 aircraft were assigned year of manufacture based on survey self-report and 1,655 were assigned a year from the Aircraft Bluebook. After these aircraft were assigned values, year of manufacture was imputed using nearest neighbor techniques for 1,419 aircraft.[18]

In 2012, rates of imputations for most variables are 2 to 3 percent for sampled aircraft that completed the full survey form. Item non-response on key activity variables are low—hours flown by use (1.2 percent), fractional ownership hours (0.5 percent), rented or leased hours (1.9 percent), public use hours (1.9 percent), and hours by flight conditions (1.9 percent). Other variables have slightly higher imputation rates but are still below 4 percent (airframe hours, landings, fuel consumptions, and avionics equipment). The state in which an aircraft is primarily

[17] Year of manufacture is asked only on the Internet version of the single-aircraft survey form.

[18] Information on year of manufacture in the Aircraft Bluebook is often mapped to make-model and a range of serial numbers. For example, Air Tractor AT-401 aircraft with serial numbers 665 through 679 were manufactured in 1987; Air Tractor AT-401 aircraft with serial numbers 680 through 706 were manufactured in 1988. In 215 of the 1,655 cases, we assigned the median year of manufacture from the Aircraft Bluebook because a specific year of manufacture was not listed. This usually occurred when serial number information was not available. For example, Air Tractor AT-401/B aircraft were listed without serial numbers and were manufactured between 1995 and 2001, so we assigned the median value (1998). We assigned the median year of manufacture only if the range of years was ten years or less. If the years of manufactures spanned more than ten years, we used nearest neighbor techniques to impute year of manufacture. Assigning a year of manufacture from published resources for aircraft that could not be mapped to the Aircraft Bluebook or that had ranges of years of manufacture greater than ten would require intensive, manual effort to research each aircraft individually.

flown has higher rates of imputation (23.7 percent). The state in which an aircraft is primarily flown has a higher rate of imputation in part because many responses cannot be coded to a single state; for example, respondents list more than one state, describe a region (e.g., “Midwest”), report “various” or “US.”

Over the past ten years, the survey questionnaire has undergone re-design efforts and data collection methods have been developed to reduce item non-response. 1) The layout of the questionnaire was made more user-friendly by increasing font size and space between questions; 2) instructions were simplified or added based on respondent feedback from pretests and FAA review; 3) confidentiality of survey results has been emphasized; 4) respondents have been encouraged to report their best guess if they do not have exact information; 5) questions were revised to simplify the computations performed by respondents and eliminate the need to refer to previous answers; and 6) instructions to enter a zero, rather than leave an item blank, has reduced the frequency of ambiguous answers.

Survey Content

The 2012 GA Survey questionnaire requests the aircraft owner or operator to provide information on flight activity, flight conditions, where the aircraft was flown, and aircraft characteristics. Variables derived from the survey responses include:

- Number of total hours flown in 2012, hours flown by use, and total lifetime airframe hours
- The state in which the aircraft was primarily flown and hours flown in the state of Alaska
- Hours flown by flight plan and flight conditions, including flight under Instrumental Meteorological Conditions (IMC) and Visual Meteorological Conditions (VMC) during the day and night
- Hours flown as part of a fractional ownership program, rented or leased, or used to fulfill a government function
- Type of landing gear and number of landings in 2012
- Fuel type and average fuel burn rate
- Avionics equipment installed in the aircraft.

Data Collection Methods

Collecting Data from Owners/Operators of a Single Aircraft

Appendix B presents the materials used to conduct the 2012 survey. The survey form administered to owners/operators of a single aircraft is shown in Figure B.1. The postcard invitation to the Internet component and the reminder/thank-you postcard are shown in Figures B.2 and B.3. Surveys sent to aircraft owners who started, but did not complete, an Internet survey included a special insert (Figure B.4). Surveys mailed to Alaskan addresses included an insert with the endorsement of Alaska aviation associations encouraging owners to participate

(Figure B.5). Each of the three mailings for the survey was accompanied by a cover letter, shown respectively in Figures B.6, B.7, and B.8. The data collection effort for the 2012 survey also included an end-of-field-period postcard (Figure B.9).

The protocol for the 2012 survey is similar to that used since the 2000 survey. The survey data were collected from owners and operators of the sampled aircraft through two modes—the Internet and mailings of the questionnaire. We implemented the Internet component before the mailing portion to maximize the number of responses collected electronically. We first sent the owners/operators of sampled aircraft a postcard inviting them to complete the survey on the Internet (mailed on June 5, 2013). All single-aircraft surveys received through September 29 (on-line or by mail) were processed and included in analysis.

We mailed survey questionnaires to owners/operators of sampled aircraft three times during the field period as well as a reminder/thank-you postcard between the first and second mailings and an end-of-field-period follow-up postcard. With the exception of the final postcard, each mailing was sent to owners/operators that had not yet responded to the survey at that time or had not been assigned a final disposition. The final postcard was sent only to owners/operators that had participated in the 2010 survey[19] but had not yet completed a 2012 survey by the end of August. We mailed the first questionnaire on July 9, 2013, followed by the reminder/thank-you postcard on July 30, 2013. The second and third mailings were sent August 13, 2013, and September 4, 2013, respectively. The end-of-field-period follow-up postcard was mailed on August 27, 2013.

Collecting Data from Owners/Operators of Multiple Aircraft

The 2012 GA Survey continued the effort initiated in 2004 to increase cooperation among respondents who own or operate multiple aircraft. The 2012 survey employed data collection tools and methods similar to those introduced in 2004, including telephone contact with owners/operators of multiple aircraft to encourage participation among non-responders after the first mailing. The survey forms, cover letters, and reminder letter are presented in Appendix B, Figures B.10–B.14.

The responses of multiple-aircraft owners/operators are important for accurately estimating general aviation activity. Because of the increased burden of reporting for multiple aircraft, there was a concern that these operators were less likely to respond to the survey. After selecting the sample, we identify groups of aircraft belonging to the same operator using several resources: FAA's Operations Specifications Subsystem (OPSS), databases available from aviation associations, and the Registry.

Owners/operators of multiple aircraft receive an abbreviated survey form to minimize the reporting burden. The form, developed in cooperation with several aircraft operators and aviation associations, allows an operator to report a summary of activity for a group of aircraft of a similar type instead of requiring the operator to complete a separate and longer questionnaire for each individual aircraft. This survey form (Figure B.10) collects data on key variables for major classes of aircraft (e.g., hours flown, how flown, fuel consumption, fractional ownership, and number of landings). The form does not collect data on flight conditions, fuel type, landing gear, or avionics.

[19] Data from the 2011 GA Survey were not available to identify sampled aircraft that had completed the survey in the immediate prior year. About one-third of the aircraft owners/operators who were sent the end-of-field-period postcard ultimately completed the survey.

Data collection for multiple-aircraft owners/operators followed similar timing as that for owners/operators of single aircraft. We programmed an Internet survey that matched the hard-copy survey form and the on-line survey remained open throughout the field period. We mailed survey questionnaires three times during the field period as well as a reminder letter between the first and second mailings. Each mailing was sent to owners/operators of multiple aircraft that had not yet responded to the survey at that time and had not been assigned a final disposition. The first survey mailing was sent June 10, 2013, followed by a reminder letter on July 10, 2013. The second and third mailings were sent July 30, 2013, and August 27, 2013, respectively. All large fleet surveys received through September 29 were processed and included in analysis.

To maximize survey response, we placed follow-up telephone calls to multiple-aircraft owners/operators who had not responded. The telephone effort, which was prioritized by fleet size, began June 24, 2013, and continued through the field period. The calling effort focused on encouraging survey participation as well as ensuring that survey mailings were reaching the appropriate person in the operator's organization. In some instances, the caller was able to collect key information by telephone (e.g., flown/not flown and hours flown) when the owner/operator would be unable to return the full survey form before data collection ended.

The alternate survey form for owners/operators of multiple aircraft has reduced respondent burden and improved representation of activity among high-end and high-use aircraft. In 2012, 28.6 percent of all completed surveys followed this data collection track.

Response Rate

The response rate is calculated conservatively following guidelines published by the American Association for Public Opinion Research (AAPOR), a professional association that establishes standards, "best practice" guidelines, and a code of ethics for professional survey researchers and research firms.[20] Specifically, the response rate is computed as the number of completed and partial surveys returned divided by the total number of eligible aircraft in the sample using the following formula.

$$RR = (C + P) / (C + P) + (NR + INS + REF + PMR + UNK)$$

Where

RR = Response Rate

C = Completed survey

P = Partial survey

NR = No response

INS = Insufficient complete; a partial survey that is not sufficient to count as a complete

REF = Refused

[20] The American Association for Public Opinion Research. 2000. *Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys*. Ann Arbor, MI: AAPOR.

PMR = Post Master Returned, no new address

UNK = Unknown eligibility

The numerator is comprised of completed surveys and partial surveys that provide enough information to be used for analysis. Partial surveys must include information on hours flown to be included in the numerator.

In addition to completed and partial surveys, the denominator includes cases for which no response was received, insufficiently completed surveys, refusals, surveys returned as undeliverable by the USPS, and cases of unknown eligibility. The last category includes aircraft in which the owners cannot be identified or cannot report about aircraft activity (e.g., owner is deceased and the survivors cannot report on the aircraft activity, survey recipient does not own the aircraft listed).

The denominator includes aircraft that were sold or destroyed during the survey year. The survey collects data on flight activity for the portion of the year the aircraft was eligible to fly, and data collection efforts attempt to identify and mail surveys to new owners.

The denominator excludes aircraft known not to be part of the general aviation fleet or known not to be eligible to fly during the survey year. These are aircraft that were destroyed prior to the survey year, displayed in a museum, operated primarily as an air carrier, operated outside of the US, or exported overseas.

Table A.8 shows the final response rate by mailing and overall, along with the number of completed surveys. The number of completed surveys shown here excludes duplicate surveys after cleaning the returned survey data to retain the form with the most complete information. The overall response rate for the 2012 GA Survey was 43.8 percent. About 60 percent of responses were received on the Internet and slightly more than one-quarter were received from the first mailing. The second and third mailings had lower response, but these rates are calculated conservatively. For example, the Mail 3 response rate is the proportion of sampled aircraft that returned that hard-copy survey. If a third mailing was sent, but the survey was later completed on-line then the response is recorded as “Internet.”

Table A.8: Response Rate by Mailing

Mailing	Completes	Response Rate	% Total Response
Internet	22,431	26.4%	60.4%
1st Mailing	9,833	11.5%	26.5%
2nd Mailing	2,895	3.4%	7.8%
3rd Mailing	1,960	2.3%	5.3%
Overall	37,119	43.8%	100.0%

As noted above, the response rate is calculated conservatively and retains all non-responding surveys, sampled units with bad addresses, and sampled aircraft of unknown eligibility in the denominator. In the 2012 survey, 4,197 surveys were returned undeliverable and we were

unable to obtain updated address information. In addition, the survey sample itself included about 1,300 aircraft that could not be contacted because their status was “Sale Reported,” “Registration Pending,” or the address was already known to be incorrect (i.e., Postmaster Return status on the Registry).[21] Applying guidelines for defining the GA population developed with the FAA and Registry personnel, these aircraft are deemed potentially active and therefore eligible for selection into the survey.

There has been a steady increase in the Internet response as a percentage of all returned surveys over the past 12 years. Since the on-line survey form was introduced in 2000, participation via the Internet has increased over 80 percent: Initially accounting for one-third of all completed surveys, 60 percent of responding aircraft answered the 2012 survey on-line.

Table A.9 shows response rates by aircraft type. The overall response rate in 2012 is 43.8 percent. Participation is highest among multi-engine turbine rotorcraft (67 percent) and experimental amateur aircraft (57 percent). Response among single-engine turbine rotorcraft, gliders, and light-sport aircraft is also near 50 percent. Piston rotorcraft and other experimental aircraft have the lowest rates of participation.

[21] Surveys were sent to aircraft listed as “Registration Pending” or “Sale Reported” at Mail 2 and Mail 3 if the Registry has updated address information. Less than 20 percent of these surveys were subsequently completed in 2012.

Table A.9: Response Rate by Aircraft Type

Aircraft Type	Sample	Invalid Sample[22]	Completes	Response Rate
Fixed Wing - Piston				
1 engine, 1–3 seats	7,402	57	3,248	44.2%
1 engine, 4+ seats	15,583	63	6,773	43.6%
2 engines, 1–6 seats	6,581	49	2,532	38.8%
2 engines, 7+ seats	3,265	30	1,256	38.8%
Fixed Wing - Turboprop				
1 engine	5,452	27	2,290	42.2%
2 engines, 1–12 seats	4,334	40	1,604	37.4%
2 engines, 13+ seats	1,449	20	634	44.4%
Fixed Wing - Turbojet				
2 engines	12,682	127	5,287	42.1%
Rotorcraft				
Piston	4,447	40	1,394	31.6%
Turbine: 1 engine	5,650	46	2,778	49.6%
Turbine: Multi-engine	1,766	33	1155	66.6%
Other Aircraft				
Glider	1,346	8	658	49.2%
Lighter-than-air	2,155	19	943	44.1%
Experimental				
Amateur	5,808	41	3,313	57.4%
Exhibition	1,827	23	778	43.1%
Experimental light-sport*	2,067	4	948	46.0%
Experimental Other	1,439	10	426	29.8%
Special light-sport	2,150	4	1,102	51.4%
Total	85,403	641	37,119	43.8%

* Experimental light-sport includes aircraft with experimental airworthiness certification and light-sport aircraft for which airworthiness certificates are not final.

[22] Even though efforts are made to remove non-GA aircraft from the population before the sample is selected, surveys are returned indicating that the aircraft should not be part of the survey population (e.g., the aircraft was destroyed or salvaged, placed on static display, used only in ground maintenance school training). The Invalid Sample represents such aircraft, which are excluded from response rate calculations.