APPENDIX A

METHODOLOGY FOR THE 2013 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 2013 survey was conducted. The 2013 statistics in this report were derived from the 36th GA Survey, which was implemented in 2014.

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.

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 was first affected by expiration and cancellation of registrations in 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 2002–2013. 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. The FAA is engaged in re-calibration efforts and expects to publish validated 2011 data at a later date.[2]

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

[2] 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"
2013	Added "Specify" option if fuel type was "Other" Added response categories for reason not flown ("Under maintenance or repair," "Parted out/salvaged," and "In storage") The text "Corporate/Executive Transportation" was removed from the description of this use category and replaced with "Business Transportation – (*with* a paid flight crew)." The definition of this use is unchanged.

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[3]
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.)
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

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)[4]
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 certified to fly Part 135 (2 categories) Introduced 100 percent samples of turbine aircraft, rotorcraft, on-demand Part 135, and Alaska-based aircraft
2005	Introduced light-sport aircraft as an 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.

[3] 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.

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

Year	Change in sample design or survey population
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 2013 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, 2013, 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) operations
- 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, 2013).

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 2013 survey population, we used the Registry's list of aircraft effective through December 31, 2013.[5]

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:

[5] The Civil Aviation Registry updates the Master file approximately weekly but not on a schedule that corresponds exactly to December 31st. For the purpose of constructing the 2013 survey population, we used a Registry Master file that was made available on January 7, 2014, and reflected records processed through January 3, 2014.

- 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, 2013
- Aircraft that are flagged Postmaster Return (known to have incorrect address information) on the aircraft Registration file prior to 2004 (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. For the 2013 survey, the following exclusions apply:

- Aircraft listed as "sale reported" for more than 12 months (prior to January 1, 2013)[6]
- Aircraft listed as "registration pending" for more than 12 months (prior to January 1, 2013)
- Aircraft with registrations that expired on or before December 31, 2013.

The registration requirements mean that aircraft failing to re-register or renew cannot legally operate and their registrations are cancelled. The 2013 survey applied this exclusion to the survey population and 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, 2013, but subsequently re-registered or were newly assigned a time-limited status of "sale reported" or "registration pending" by March 10, 2014, were retained in the population. Of the 21,970 aircraft with expired registrations at year-end 2013, 885 had re-registered or updated their statuses by March 10, 2014 and were retained in the 2013 survey population.

The Registry Master file used to define the 2013 survey population included 317,973 aircraft. This represents a decrease of almost 10 percent compared with the Registry file from 2012 (352,198). After excluding the aircraft described above, 270,026 records remain, which is 85 percent of the Registry. The 2013 survey population of 270,026 represents a decrease of 4.2 percent from 2012 (281,804 – 270,026 / 281,804).

[6] The registration rule allows aircraft to be listed as sale reported 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 small. The error of including ineligible aircraft has a smaller impact on statistical estimates of activity than erroneously excluding eligible and potentially active aircraft.

The 2013 GA Survey Sample

The 2013 survey sample design is the same as that for the 2012 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.

Aircraft are classified into one of the nine FAA regional offices by the state or US territory of registration. Table A.4 summarizes how states and territories are mapped to region.[7]

Table A.4: Regions and States/Territories Constituting Region

Region	States/Territories
Alaska	Alaska
Central	Iowa, Kansas, Missouri, Nebraska
Eastern	Delaware, Maryland, New Jersey, New York, Pennsylvania, Virginia, Washington, D.C., West Virginia
Great Lakes	Illinois, Indiana, Michigan, Minnesota, North Dakota, Ohio, South Dakota, Wisconsin
New England	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont
Northwest Mountain	Colorado, Idaho, Montana, Oregon, Utah, Washington, Wyoming
Southern	Alabama, Florida, Georgia, Kentucky, Mississippi, Navassa Island, North Carolina, Puerto Rico, South Carolina, Tennessee, US Virgin Islands
Southwestern	Arkansas, Louisiana, New Mexico, Oklahoma, Texas
Western-Pacific	American Samoa, Arizona, Baker, Howland, and Jarvis Islands, California, Guam, Hawaii, Johnston Atoll, Kingman Reef, Midway Islands, Nevada, Palmyra Atoll, Wake Island

We define 15 aircraft types to execute the sample design as shown in Table A.5. 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.

[7] The FAA defines the regions at www.faa.gov/about/office_org/headquarters_offices/arc/ro_center. Statistical estimates reported by region in which an aircraft is primarily flown follow the same mapping based on the (self-reported) state in which the aircraft is primarily operated.

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.

Table A.5: 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 2013 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 2009 inclusive).

Altogether the aircraft sampled at 100 percent contributed 53,762 observations to the 2013 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 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.[8] The 2013 survey sample includes an additional 31,728 aircraft that are selected at a rate of less than 1.0, which is an increase over 2012 when an additional 29,185 aircraft were sampled.

The 2013 GA Survey sample included 85,490 aircraft. Table A.6 summarizes the population counts and sample sizes by aircraft type.

[8] In 2013, an additional six strata were sampled at 100 percent to meet precision requirements (4,075 aircraft).

Table A.6: Population and Survey Sample Counts by Aircraft Type

Aircraft Type	Population	Sample Size	Sample as Percent of Population
Fixed Wing - Piston	**183,653**	**36,312**	**19.8**
1 engine, 1–3 seats	52,391	8,027	15.3
1 engine, 4+ seats	114,057	17,183	15.1
2 engines, 1–6 seats	11,996	7,571	63.1
2 engines, 7+ seats	5,209	3,531	67.8
Fixed Wing - Turboprop	**10,282**	**10,282**	**100.0**
1 engine	4,723	4,723	100.0
2 engines, 1–12 seats	4,182	4,182	100.0
2 engines, 13+ seats	1,377	1,377	100.0
Fixed Wing - Turbojet	**12,783**	**12,783**	**100.0**
Rotorcraft	**11,510**	**11,510**	**100.0**
Piston	4,167	4,167	100.0
Turbine (1 engine)	5,578	5,578	100.0
Turbine (multi-engine)	1,765	1,765	100.0
Other Aircraft	**7,209**	**2,381**	**33.0**
Glider	2,811	1,182	42.0
Lighter-than-air	4,398	1,199	27.3
Experimental	**42,302**	**9,935**	**23.5**
Amateur	30,502	5,426	17.8
Exhibition	2,887	1,552	53.8
Experimental light-sport*	7,019	1,780	25.4
Other experimental	1,894	1,177	62.1
Special light-sport	**2,287**	**2,287**	**100.0**
Total	**270,026**	**85,490**	**31.7**

* 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, 2013; displayed in a museum; or operated primarily under Part 121 or 129—are used to remove aircraft from the sample and proportionally 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.7 shows selected interval widths and their corresponding confidence.

Table A.7: 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 2013, where the total hours flown is estimated to be 1,277,018 and the percent standard error of the estimate is 1.7, the following computation applies:

Lower confidence limit: 1,277,018 – 1.96(1.7/100)(1,277,018) = 1,234,468

Upper confidence limit: 1,277,018 + 1.96(1.7/100)(1,277,018) = 1,319,568

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 1,234,468 and 1,319,568.

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 2013 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 or email.

- Cover letters accompanying each survey mailing explained the purpose of the survey and 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 raise awareness of the survey and encourage cooperation.

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

The survey efforts 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 question wording and definitions to questions. The questionnaire is re-examined regularly 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 or operators.

- Comprehensive editing and verification procedures to ensure the accuracy of data transcription to machine-readable form.

- Analysis of preliminary data files to identify unusual or illogical values and place follow-up inquiries with participants to verify or correct 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 design. Where survey reports appear nonsensical or contradict FAA regulations, 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.8 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).[9] The questions that are not asked on the short form are noted with an asterisk.

Table A.8: Variables with Imputed Values, Imputation Procedure, and Percentage Imputed

Variable	Imputation Procedure[10]	Percent Imputed (full survey form only)	Percent Imputed (incl. short form)
Hours by use (e.g., personal, business transport)	Mean values by aircraft type	0.5	2.7
Fractional ownership hours	Nearest neighbor by aircraft type by make model series	0.3	0.4
Hours rented/leased *	Nearest neighbor by aircraft type by make model series	1.0	28.3
Public use hours	Nearest neighbor by aircraft type by make model series	1.0	2.3
Hours by flight plans/flight conditions *	Mean values by aircraft type	1.0	28.3
Airframe hours *	Nearest neighbor by aircraft type by hours flown[11]	1.8	29.1
Number of landings	Nearest neighbor by aircraft type by make model series by age	1.9	5.6
Landing gear *	Nearest neighbor by aircraft type by make model series	1.1	28.4

[9] The “full” and “short” forms of the survey are described below in the section “Data Collection Methods.”

[10] Prior to the 2012 survey, most imputations were executed by aircraft type by engine manufacture model. Beginning 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.

[11] Prior to the 2012 survey year, 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[10]	Percent Imputed (full survey form only)	Percent Imputed (incl. short form)
Fuel type *	Nearest neighbor by aircraft type by make model series	2.0	29.2
Fuel burn rate	Nearest neighbor by aircraft type by make model series	1.6	5.4
Avionics equipment *	Nearest neighbor by aircraft type by make model series by age	1.6	29.8
State primarily flown	Assign state of registration from Registry	16.9	25.4
Year of manufacture (Registry data field)	Nearest neighbor by aircraft type by make model series	1.9	2.9

Percentages are based on unweighted survey responses (total 37,060).

* 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 2013 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 or operator provided the information on the Internet survey[12], 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 840 aircraft were assigned year of manufacture based on survey self-report and 1,863 were assigned a year from the Aircraft Bluebook. After these aircraft were assigned values, year of manufacture was imputed using nearest neighbor techniques for 1,089 aircraft.[13]

In 2013, rates of imputations for most variables are 1 to 2 percent for aircraft that completed the full survey form. Item non-response on key activity variables are low—hours flown by use (0.5 percent), fractional ownership hours (0.3 percent), rented or leased hours (1.0 percent), public use hours (1.0 percent), and hours by flight conditions (1.0 percent). Other variables have slightly higher imputation rates but are still at or below 2 percent (airframe hours, landings, fuel consumption, and avionics equipment). The state in which an aircraft is primarily flown has

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

[13] 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 187 of the 1,863 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.

higher rates of imputation (16.9 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.”

Survey Content

The 2013 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 2013, hours flown by use, and total lifetime airframe hours
- The state in which the aircraft was primarily flown
- 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 2013
- 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 2013 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 2013 survey also included an end-of-field-period postcard or email (Figure B.9).

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 April 25, 2014). All single-aircraft surveys received through September 16 (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 or email. With the exception of the final postcard, each mailing was sent to owners or operators who 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 2012 survey but had not yet completed a 2013 survey by the end of August. We mailed the first questionnaire on June 5, 2014, followed by the reminder/thank-you postcard on July 14, 2014. The second and third mailings were sent July 17, 2014, and August 14, 2014, respectively. The end-of-field-period follow-up postcard was mailed on August 8, 2014 and the end-of-field-period email was sent on August 11, 2014.

Collecting Data from Owners/Operators of Multiple Aircraft

The 2013 GA Survey continued the effort initiated in 2004 to increase cooperation among respondents who own or operate multiple aircraft. The 2013 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 or 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 or 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.

Data collection owners or operators of multiple aircraft followed similar timing as that for 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 and sent a reminder letter between the first and second mailings. Each mailing was sent to owners or operators of multiple aircraft who had not yet responded to the survey and had not been assigned a final disposition. The first survey mailing was sent May 5, 2014, followed by a reminder letter on June 5, 2014. The second and third mailings were sent June 26, 2014, and August 14, 2014, respectively. All large fleet surveys received through September 22 were processed and included in analysis.

To maximize survey response, we placed follow-up telephone calls to multiple-aircraft owners or operators who had not responded. The telephone effort, which was prioritized by fleet size, began June 2, 2014, and continued through the field period. The calling effort focused on encouraging survey participation and ensuring that survey mailings were reaching the

appropriate person in the organization. In some instances, the caller was able to collect key information by telephone (e.g., flown/not flown and hours flown) if the full survey form would not be returned before data collection ended.

The alternate survey form for owners or operators of multiple aircraft has reduced respondent burden and improved representation of activity among high-end and high-use aircraft. In 2013, 27.5 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.[14] 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

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 analyzed.

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 US Postal Service, and cases of unknown eligibility. The last category includes aircraft in which the owners cannot be identified or cannot report about aircraft activity

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

(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.9 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 2013 GA Survey was 43.7 percent. Over 60 percent of responses were received on the Internet and 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.9: Response Rate by Mailing

Mailing	Completes	Response Rate	% Total Response
Internet	23,322	27.4%	62.9%
1st Mailing	8,754	10.3%	23.6%
2nd Mailing	3,033	3.6%	8.2%
3rd Mailing	1,951	2.3%	5.3%
Overall	37,060	43.7%	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 2013 survey, about 1,700 surveys were returned undeliverable and we were unable to obtain updated address information. The survey sample itself included about 1,200 aircraft that could not be contacted because their status was “Sale Reported,” “Registration Pending,” or the address was known to be incorrect (i.e., Postmaster Return status on the Registry). Applying guidelines for defining the GA population developed with the FAA and Registry personnel, these aircraft are deemed potentially active and therefore eligible for the survey.

There has been a steady increase in the Internet response as a percentage of all returned surveys over the past 13 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, more than 60 percent of responding aircraft answered the 2013 survey on-line.

Table A.10 shows response rates by aircraft type. The overall response rate in 2013 is 43.7 percent. Participation is highest among experimental amateur aircraft (58 percent) and multi-engine turbine rotorcraft (56 percent). Response among gliders and light-sport aircraft is also near 50 percent. Piston rotorcraft have the lowest rates of participation.

Table A.10: Response Rate by Aircraft Type

Aircraft Type	Sample	Invalid Sample[15]	Completes	Response Rate
Fixed Wing - Piston	**36,312**	**191**	**15,783**	**43.7%**
1 engine, 1–3 seats	8,027	42	3,611	45.2%
1 engine, 4+ seats	17,183	66	7,763	45.4%
2 engines, 1–6 seats	7,571	53	3,020	40.2%
2 engines, 7+ seats	3,531	30	1,389	39.7%
Fixed Wing - Turboprop	**10,282**	**74**	**4,106**	**40.2%**
1 engine	4,723	22	2,020	43.0%
2 engines, 1–12 seats	4,182	42	1,563	37.8%
2 engines, 13+ seats	1,377	10	523	38.3%
Fixed Wing -Turbojet	**12,783**	**272**	**4,855**	**38.8%**
Rotorcraft	**11,510**	**89**	**4,874**	**42.7%**
Piston	4,167	30	1,417	34.3%
Turbine: 1 engine	5,578	49	2,471	44.7%
Turbine: Multi-engine	1,765	10	986	56.2%
Other Aircraft	**2,381**	**9**	**1,110**	**46.8%**
Glider	1,182	3	601	51.0%
Lighter-than-air	1,199	6	509	42.7%
Experimental	**9,935**	**67**	**5,192**	**52.6%**
Amateur	5,426	28	3,124	57.9%
Exhibition	1,552	11	665	43.2%
Experimental light-sport*	1,780	8	876	49.4%
Experimental Other	1,177	20	527	45.5%
Special light-sport	**2287**	**8**	**1,140**	**50.0%**
Total	**85,490**	**710**	**37,060**	**43.7%**

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

[15] We remove non-GA aircraft from the population before the sample is selected, but some 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.