TETRA TECH

MEMORANDUM

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SUBJECT:	General Aviation and Part 135 Activity Survey: Response Rate Calculation and Analysis of Non-response
DATE:	15 December 2011
REF:	Contract GS-10F-0017K/Order DTFAWA-07-F-00017 Option Year 4 (Modification 0015)

All surveys experience some degree of non-response. Because non-respondents may differ from respondents in terms of the variables collected in the survey, the occurrence of non-response gives rise to concerns about bias in the survey results. One approach to understanding the relationship is to conduct non-response bias studies. This memo includes assessments of the potential for both unit and item non-response bias in the 2010 General Aviation and Part 135 Activity Survey (GA Survey). The goal of the research was to measure, adjust for, report, and analyze unit and item non-response to assess their effects on data quality to inform end-users of the GA Survey. The analysis focuses on the potential for non-response bias in the key variable of interest from the survey: estimates of hours flown.

Procedures used to Maximize Survey Response Rates

The best approach to minimize non-response is to plan and implement data collection procedures aimed at achieving high response rates. Listed below are techniques established in the survey research literature that have been adopted by the 2010 GA Survey.

- Pre-notify participants
- Publicize the survey
- Design survey instruments carefully
- Manage survey length
- Use reminder notes
- Provide multiple response opportunities (Internet, mail, telephone)
- Monitor survey completion during the data collection period
- Establish survey importance
- Foster survey commitment
- Provide survey feedback
- Extensive training of interviewers for telephone follow-up

For owners and operators of single aircraft, survey data were collected through two venues—the Internet and mailings of the questionnaire. We first sent the owners/operators of sampled aircraft a postcard inviting them to complete the survey on the Internet. For aircraft that had no response by Internet, we mailed survey

questionnaires to owners/operators three times during the field period as well as a reminder/thank you postcard between the first and second mailings.

A slightly modified data collection procedure was used for respondents who own/operate three or more aircraft to reduce respondent burden and improve representation of activity among high-end and high-use aircraft. 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. Data collection for multiple-aircraft owners/operators followed the same timing as that for owners/operators of single aircraft and, like the single-aircraft owners/operators, three survey mailings were conducted as well as a reminder/thank you letter between the first and second mailing. To maximize survey response, we placed follow-up telephone calls to all multiple-aircraft owners/operators who had not responded previously by Internet or Mail. Telephone staff verify the survey reached the appropriate individual, encourage participation, and offer technical assistance. Staff will also collect essential data by telephone (e.g., number of aircraft by type, active status, and hours flown). This alternative data collection track for owners/operators of multiple aircraft accounts for 22.6 percent of all aircraft responding to the survey.

All survey mailings include cover letters explaining the purpose of the survey, how the data will be used, and how aircraft were selected into the sample. Recipients are assured their responses are confidential and participation is voluntary. Answers to frequently asked questions as well as a toll-free telephone number and an email address to contact are provided. The letter is printed on FAA letterhead and signed by the FAA Administrator. Nine national aviation associations endorse the survey effort and encourage aircraft owners to participate; their association logos are printed in the footer of the letter. Surveys sent to aircraft based in Alaska include an insert with a statement of support by three Alaska aviation associations.[1]

Unit Response Rate Calculations

The survey population for the 2010 GA Survey includes all civil aviation aircraft registered with the FAA that are based in the US or US territories and that were in existence and potentially active between January 1 and December 31, 2010. 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 Registry's list of aircraft as of December 31, 2010 is used to define the survey population. 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 identify and remove ineligible aircraft from the sample frame.[2] After excluding aircraft identified as ineligible for the survey 304,334 records remain, which is 81.4 percent of the Registry as of December 31, 2010.

The 2010 GA Survey sample included 84,982 aircraft. The sample is stratified by aircraft type, FAA region in which the aircraft is registered, whether the aircraft operates under a FAR Part 135 certificate, and whether the aircraft was manufactured within the past five years. To support analysis needs, the survey design includes a 100 percent sample of turbine aircraft, rotorcraft, special light-sport aircraft, aircraft certified to operate under Part 135, Alaska-based aircraft.

The unweighted unit response rate (RRU) for the 2010 GA Survey is 44.2 percent. The RRU 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)

[1] Aviation associations that support the survey include the Aircraft Owners and Pilots Association, Experimental Aircraft Association, General Aviation Manufacturers Association, Helicopter Association International, Light Aircraft Manufacturers Association, National Agricultural Aviation Association, National Air Transportation Association, National Business Aviation Association, and Regional Air Cargo Carrier Association. The Alaska Airmen's Association, Alaska Air Carriers Association, and the Medallion Foundation are also listed in survey forms sent to Alaska.

[2] Appendix A of *The General Aviation and Part 135 Activity Survey* describes ineligible aircraft on the sample frame.

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 included in the numerator. For aircraft that are included in the data collection procedures based on the abbreviated survey form, the number of hours flown is reported as the average across the fleet for up to six aircraft types.

In addition to completed and partial surveys, the denominator includes cases for which no response was received, insufficiently completed surveys (i.e., no data reported for hours flown), 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 primarily outside of the US, or exported overseas.

The weighted unit response rate (RRW) for the 2010 GA Survey is 49.5 percent. RRW is computed using the same basic formula as the unweighted response rate but takes into account the different probabilities of selection of sample units given the stratified sample design.

Item non-response rates (RRI) is calculated for each item on the GA Survey as the ratio of the number of respondents for which an eligible response was not obtained to the number of aircraft for which that item was presented. The number presented for an item is the number of eligible aircraft less the number of aircraft with a valid skip for the item. When an abbreviated questionnaire is used to obtain data from owners/operators of multiple aircraft that are part of a large fleet, the eliminated questions are treated as item non-response. The abbreviated form collects data on key variable 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.

Imputation of missing data is very 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. To further reduce the bias introduced by item non-response, a replacement value is selected from another aircraft in the survey that is similar to the non-respondent aircraft. For most variables, a nearest-neighbor imputation procedure is used so that missing data are replaced with values based on an aircraft with otherwise similar characteristics. Data are sorted by aircraft characteristics and starting values are selected randomly within that sorted sequence.

Table 1 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). It is important to recognize that the latter figures will have inflated imputation rates: data for many items are structurally missing because the questions were not asked on the short form.

Table 1. Imputation Rates for Item Non-Response in the 2010 GA Survey

Variable	Imputation Procedure	Percent Imputed (full survey form only)	Percent Imputed (incl. short form)
Hours by use (e.g., personal, business transport)	Mean values by aircraft type	1.1	2.0
Fractional ownership hours	Nearest neighbor by aircraft type by engine manufacture model	0.5	0.9
Hours rented/leased *	Nearest neighbor by aircraft type by engine manufacture model	1.9	23.8
Public use hours	Nearest neighbor by aircraft type by engine manufacture model	1.9	2.6
Hours by flight plans/flight conditions *	Mean values by aircraft type	1.8	23.8
Airframe hours *	Nearest neighbor by aircraft type by age	2.5	24.3
Number of landings	Nearest neighbor by aircraft type by engine manufacture model by age	3.0	4.3
Landing gear *	Nearest neighbor by aircraft type by engine manufacture model	2.2	24.1
Fuel type *	Nearest neighbor by aircraft type by engine manufacture model	2.4	24.2
Fuel burn rate	Nearest neighbor by aircraft type by engine manufacture model	2.1	3.7
Avionics equipment *	Nearest neighbor by aircraft type by engine manufacture model by age	3.5	29.5
State primarily flown	Assign state of registration from Registry Master	22.9	25.1

Percentages are based on unweighted survey responses (total 37,215).

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

In 2010, rates of imputations are typically less than two percent for sampled aircraft that completed the full survey form. Item non-response on key activity variables are consistently low—hours flown by use (1.1 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 (1.8 percent). Other variables have slightly higher imputation rates but are still well below four percent (airframe hours, landings, fuel consumptions, and avionics equipment). The state in which an aircraft is primarily flown is the only variable with markedly higher rates of imputation (23 percent). In fact, data on this variable are seldom missing, but many answers cannot be coded to a single state because respondents list more than one state, describe a region, or simply indicate “US.”

Over the last 10 years several changes have been made to the survey to reduce item non-response bias. (1) The layout of the questionnaire was made more user-friendly by increasing font size and space between questions; (2) existing instructions were simplified and new instructions were added based on pretest respondent feedback after completing the survey; (3) the confidentiality of survey results has been emphasized to reduce respondent concerns that data for specific items they report will be used inappropriately; (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 for them to refer to previous answers; and (6) instructions to enter a zero, rather than leave an item blank, has minimized the frequency of ambiguous answers.

Analysis of Potential Non-response Bias

The non-response bias analysis conducted on the 2010 GA Survey data examines the potential for bias in the estimates of the key survey design variable, number of hours flown in the calendar year, and looks at the effect of the non-response weighting adjustments that were made to reduce the bias.

Examination of Subgroup Response Rates. While the level of non-response does not necessarily translate to bias, large differences in the response rates of subgroups serve as indicators that potential biases may exist. For example, if the response rates for high-use and low-use aircraft were very different, any difference between the means of the respondents and non-respondents would result in a bias in the estimate of hours flown. A limitation of this approach is that response rates can only be calculated for those subgroups where the subgroup characteristics are known for both the respondents and non-respondents. In the GA Survey, this information is taken from the data on the sampling frame.

Table 2 presents a comparison of response rates by aircraft type. Overall, the analysis does not show notable differences in response rates across the seven major aircraft types.

Table 2. Response Rates by Aircraft Type (Unweighted)

Aircraft Type	Sample	Completes	Response Rate
Fixed Wing - Piston			
1 engine, 1-3 seats	6,761	3,075	45.5%
1 engine, 4+ seats	15,707	7,086	45.1%
2 engines, 1-6 seats	5,176	2,158	41.7%
2 engines, 7+ seats	2,749	1,090	39.7%
Fixed Wing - Turboprop			
1 engine	4,485	2,046	45.6%
2 engines, 1-12 seats	4,530	1,734	38.3%
2 engines, 13+ seats	1,157	375	32.4%
Fixed Wing - Turbojet	12,409	5,070	40.9%
Rotorcraft			
Piston	5,082	1,630	32.1%
Turbine: 1 engine	5,757	2,605	45.2%
Turbine: Multi-engine	1,640	780	47.6%
Other Aircraft			
Glider	1,746	900	51.5%
Lighter-than-air	2,472	985	39.8%
Experimental			
Amateur	6,495	3,926	60.4%
Exhibition	1,965	902	45.9%
Experimental: Other	1,958	704	36.0%
Light-sport	4,168	2,149	51.6%
Total	84,257	37,215	44.2%

Subgroups within major categories do show a few aircraft types with lower response rates. Among fixed wing turboprop aircraft with a twin-engine and 13 or more seats, the response rate is lower (32.4 percent). These aircraft are more often part of a multi-aircraft fleet and certificated to operate Part 135 so it is more difficult to identify and obtain the cooperation of a knowledgeable respondent for the aircraft. Because this type of aircraft generally fly more hours than other fixed wing turboprop aircraft, the lower response rate may reflect a downward bias on the estimates of aircraft activity.

Piston rotorcraft are less likely to respond to the survey than turbine rotorcraft. Piston rotorcraft tend to fly fewer hours than turbine rotorcraft so the lower response rate likely reflects an upward bias on the estimates of aircraft activity.

This approach does not account for any sampling weight adjustments. In the GA Survey, the sampling weight adjusts for variation based on aircraft type, FAA region, age of aircraft, and Part 135 status. Table 3 presents response rates weighted for sampling and shows the effect of the adjustment is to reduce non-response bias. However, the response rate for piston rotorcraft does not follow this pattern as the weighted and unweighted response rates are similar.

Table 3. Response Rates by Aircraft Type (Sample-Weighted)

Aircraft Type	Population	Completes	Response Rate
Fixed Wing - Piston			
1 engine, 1-3 seats	61,423	31,737	51.7%
1 engine, 4+ seats	122,700	63,029	51.4%
2 engines, 1-6 seats	14,571	5,975	41.0%
2 engines, 7+ seats	6,010	2,520	41.9%
Fixed Wing - Turboprop			
1 engine	4,449	2,046	46.0%
2 engines, 1-12 seats	4,571	1,732	37.9%
2 engines, 13+ seats	1,008	377	37.4%
Fixed Wing - Turbojet	12,088	5,070	41.9%
Rotorcraft			
Piston	4,985	1,630	32.7%
Turbine: 1 engine	5,682	2,605	45.8%
Turbine: Multi-engine	1,610	780	48.4%
Other Aircraft			
Glider	3,014	1,566	52.0%
Lighter-than-air	6,238	2,515	40.3%
Experimental			
Amateur	35,717	19,820	55.5%
Exhibition	3,025	1,405	46.4%
Experimental: Other	2,176	812	37.3%
Light-sport	10,237	4,632	45.2%
Total	299,505	148,251	49.5%

Comparison of Sample and Frame Estimates. The second approach for examining the potential for non-response bias in statistical estimates based on the GA Survey involves comparing sample estimates from the responding aircraft to the population values computed from the sampling frame. Clearly, only variables on the sampling frame can be used in such comparisons. The weights used in this comparison are based on the probability of selection, with no non-response adjustments. The strength of this approach is that any differences are due solely to non-response error.

Age of aircraft can be computed for all aircraft based on sample frame information (year of manufacture). Table 4 presents estimates of mean age of aircraft (in years) for the frame and the sample by aircraft type. The sample estimates are weighted by the sample weight. This analysis shows little evidence of non-response bias as the difference in mean age of aircraft is consistently very small. Of the 18 detailed aircraft types, 16 of the 18 estimates differ by less than 2 years. Only one estimate differs by more than 4 years (experimental-other).

Table 4. Mean Age of Aircraft by Aircraft Type: Frame and Survey Estimates

Aircraft Type	Sample Frame	Survey Estimates	
		Sample Weighted	Sample and Non-response Weighted
Fixed Wing - Piston			
1 engine, 1-3 seats	49.8	51.6	51.4
1 engine, 4+ seats	37.6	38.5	38.2
2 engines, 1-6 seats	39.0	39.0	39.0
2 engines, 7+ seats	37.7	37.1	37.2
Fixed Wing - Turboprop			
1 engine	14.3	14.6	14.2
2 engines, 1-12 seats	28.2	27.5	27.5
2 engines, 13+ seats	23.3	24.6	24.7
Fixed Wing - Turbojet	16.1	13.7	14.4
Rotorcraft			
Piston	23.1	21.8	22.3
Turbine (1 engine)	20.8	20.1	20.5
Turbine (multi-engine)	16.1	16.0	15.9
Other Aircraft			
Glider	34.6	35.0	34.9
Lighter-than-air	18.1	16.4	16.7
Experimental			
Amateur	16.5	14.9	15.2
Exhibition	38.3	37.1	37.3
Other	31.0	35.3	32.9
Light-sport			
Experimental	8.4	8.3	8.6
Special	3.0	3.0	3.0
Total	**34.6**	**35.4**	**35.1**

This approach has the same limitation as the response rate analysis presented above by not accounting for non-response adjustments. If the differences between subgroups are associated with characteristics that are used in the non-response adjustment process, then this approach does not reflect that fact.

Comparison of Sample-Weight Adjusted and Fully-Adjusted Estimates. The third approach to evaluating bias in the GA Survey is to compare estimates of hours flown in the calendar year that include the adjustment for non-response to estimates based on weights that do not have any non-response adjustments (base weights that take into account only the probability of selection). The main goal of the approach is to examine the effect of the non-response adjustments on the estimates. Large differences between the sample-weight adjusted and fully-adjusted estimates may indicate the potential for non-response bias on the key design variable of the GA Survey.

Table 5 presents a comparison of sample-weight adjusted and fully-adjusted estimates for number of hours flown by aircraft type. Estimates differ by fewer than 20 hours for 15 of the 18 categories suggesting that effect of non-response bias is relatively small. The three detailed aircraft types with larger differences in hours flown between sample-weighted- and fully-weighted-data include single-engine fixed wing turboprops (23.7 hours), fixed wing turbojets (42.6 hours), and single-engine turbine rotorcraft (40.9 hours).

Table 5. Annual Average Hours Flown by Aircraft Type, Sample-Weighted and Fully-Adjusted Estimates

Aircraft Type	Weighted for Sampling	Weighted for Sampling and Non-response
Fixed Wing - Piston		
1 engine, 1-3 seats	72.2	73.0
1 engine, 4+ seats	91.8	92.4
2 engines, 1-6 seats	108.3	104.6
2 engines, 7+ seats	146.1	137.5
Fixed Wing - Turboprop		
1 engine	281.5	257.8
2 engines, 1-12 seats	238.8	231.6
2 engines, 13+ seats	295.1	281.6
Fixed Wing - Turbojet	336.5	293.9
Rotorcraft		
Piston	225.5	221.4
Turbine (1 engine)	442.1	401.2
Turbine (multi-engine)	417.6	399.5
Other Aircraft		
Glider	47.7	48.4
Lighter-than-air	23.2	23.4
Experimental		
Amateur	42.5	42.9
Exhibition	48.2	48.3
Other	127.4	146.0
Light-sport		
Light-sport - Experimental	35.5	35.4
Light-sport - Special	84.4	83.9
Total	**110.0**	**111.0**

Comparison with External Data Sources. The fourth approach used to investigate the potential for non-response bias is to compare estimates from the GA Survey to estimates from other surveys with similar items. Large differences may indicate potential bias and the need for further study. However, differences cannot be solely attributed to non-response bias because there are many other possible sources of the differences. For example, estimates from the different surveys may not be comparable because of coverage disparities, time periods that are not the same, differences in question wording, context effects, and a host of other sources of non-sampling error. Despite these severe limitations, differences in estimates serve to alert users to potential concerns and may facilitate uncovering important issues.

There are no other survey data with similar measures against which to evaluate estimates from the GA Survey. As a result, several steps are undertaken annually to review the estimates and benchmark the results. These steps include review of activity estimates by experts in the FAA and industry that can speak knowledgeably about the relative activity of aircraft in different regions, among different aircraft categories, and for different uses (e.g., Part 135, air medical, business transportation). Estimates of selected aircraft types, such as rotorcraft, are compared with industry data available from associations such as HAI or manufacturers. Estimates of landings are compared with tower data and flight hours among high-use categories are examined in light of industry trends—e.g., growth in Part 135 operating organizations, pilot layoffs among large Part 135 operators during economic downturns.