# VALIDATING SHIFTS IN THE TOTAL DESIGN OF TRAVEL SURVEYS (A6)

*Anthony J. Richardson, The Urban Transport Institute (TUTI), Melbourne, Australia*

*T. Keith Lawton, Keith Lawton Consulting Inc, Oregon, USA*

## PURPOSE AND INTRODUCTION

The purpose of Workshop A6 was described by the conference organisers as follows: "The process of trying to achieve an optimum balance in survey design decisions to achieve the best total quality is known as the "total survey design" approach. In this approach, major efforts are taken to better understand, and therefore, to control both sampling and non-sampling errors throughout the design, capture, processing, and analysis of survey data. New approaches available to design travel surveys promise the capability of collecting better quality data while accommodating increasing budget restrictions and expectations. But the implications of these shifts in total survey design have not been well researched or documented. This workshop focuses on important issues in understanding the implications of implementing changes in survey design, such as improvements in telephone instruments, using GPS devices, or developing online survey systems. What are the implications in terms of the validity and reliability of the resulting information and for its utility for transportation planning and policy-making?"

The workshop was attended by 16 people[1] from 11 different countries. In addition, Liz Ampt presented a summary of a paper she was presenting in another workshop, because of its relevance to the topic of Workshop A6. The workshop also had the excellent services of a student from Chile, Mr José Moore, to keep things running smoothly.

[1] Jimmy Armogun (France), Hernan Carvajal Cortes (Chile), Bastian Chlond, (Germany), Kelly Clifton (USA), Bernhard Fell (Germany), Birgit Kohla (Austria), Matthias Kowald (Switzerland), Keith Lawton (USA), Mancoba Miotsa (South Africa), Viviana Muñoz (Chile), Kseniya Nafigina (Russian Federation), Mariela Nerome (Argentina), Leda Pereyra (Argentina), Tony Richardson (Australia), Petr Senk (Czech Republic), Alan Thomas (Chile), Liz Ampt (Australia), José Moore (Chile)

# SUMMARY OF TOTAL DESIGN PRINCIPLES

The workshop was designed to explore how the principles of Total Design could be adhered to when implementing new forms of travel survey, especially where new technologies are involved. Given the diversity of the workshop participants, however, it was felt that a good understanding of what was meant by Total Design Principles was an essential pre-requisite for fully participating in the workshop. The Workshop Chair therefore provided an introductory presentation on Total Design (or Tailored Design, as it is now called by its creator, Prof. Don Dillman).

The Total Design method was developed by Don Dillman, and has been refined over the years and presented in the form of three books (Dillman, 1978; Dillman, 2000; Dillman, 2007), with the name changing from Total Design to Tailored Design in the 2000 publication (nonetheless, most people still refer to it as Total Design). The most recent major publication has expanded the scope to "mixed-mode" surveys and added a couple of co-authors (Dillman, Smyth and Christian, 2009). The development of the Total Design method over the past 35 years parallels the developments in survey methodology. The 1978 publication, to quote Dillman et al (2009), "introduced and helped to legitimise both mail surveys, which were considered inferior to face-to-face interviews, and telephone surveys, only rarely used for surveying before that time". The 2000 publication covered new electronic modes of surveying including the internet and e-mail surveys. The 2007 update also introduced the role of mixed-mode surveys, in line with the new title of Tailored Design, where different methods may be more appropriate for different circumstances. The 2009 publication chronicles the demise of the telephone interview and the rise of the web survey. However, Dillman concludes that "despite its expanded use, the Web is not yet a satisfactory replacement for telephone or mail in many survey situations". The main change in the 2009 publication is that it "places front and center the design and implementation of mixed-mode surveys".

So, given the extensive pedigree of Total/Tailored Design, what exactly is meant by this concept? Dillman et al (2009) suggest that the names imply two aspects of design. Firstly, "Total" implies that attention must be paid to all aspects of the design; there is no "silver bullet" in the design process, but hundreds of small individual design designs must receive attention, from the specific wording of the pre-contact letter through to the visual design of the final questionnaire. Secondly, "Tailored" implies that no one method is applicable in all situations. Depending on the topic, the demographic composition of the population, the geographic location and the availability of secondary data sets (e.g. sampling frames), different methods may be most appropriate and in some cases a combination of methods (mixed-mode surveys) may be most appropriate.

More importantly, and underlying both Total Design and Tailored Design, is the idea of minimising Total Design Error (Groves, 1989), which is the summation of:

- Coverage Error
  - When not all members of the population have a known, non-zero chance of inclusion in the sample, and where the excluded members of the population are systematically different to the included members with respect to a variable of interest.
- Sampling Error
  - When the sample size is not large enough to be able to draw conclusions with the desired levels of precision, especially within sub-populations of interest.
- Non-Response Error
  - When not all those sampled respond to the survey and where those who do respond are systematically different to those who don't respond with respect to a variable of interest.
- Measurement Error
  - When the answers obtained from respondents are inaccurate or imprecise. Such inaccuracy is largely due to the inherent characteristics of the measurement device, and to the attention paid to the design of the survey instrument.

In evaluating any survey method, Total Design requires that attention be paid to all four of the above types of error. A new survey method should not be used just because it might be good at minimising one of these types of error, if it results in increased error in one or more of the other types, thus increasing the overall Total Design Error.

In the context of "Validating Shifts in the Total Design of Travel Surveys", this workshop concentrated on examining Total Design Error for three traditional survey methods and two emerging survey methods, namely:

- Face-to-Face Interviews
- CATI Interviews
- Paper-based Self-Completion Diaries
- Web Surveys
- GPS Surveys

Given the recent emphasis on mixed-mode surveys, some attention was also paid to the use of mixed-mode methods for travel surveys.

## PRESENTATION OF WORKSHOP PAPERS

The Workshop was supported by three papers presented in the workshop, plus seven poster papers related to the theme of the workshop. In addition, because one of the workshop paper authors was unable at the last minute to attend the conference, and her results were only

summarised by the workshop chair, a relevant paper presented in another workshop was also summarised in this workshop.

Abby Sneade from the UK Department of Transport presented a paper on "Using accelerometer equipped GPS devices in place of paper travel diaries to reduce respondent burden in a national travel survey". For the reasons of reducing respondent burden and reducing survey costs, the UK Department for Transport (DfT) had previously concluded that GPS data collection had real promise for the Great Britain National Travel Survey (NTS) and offered a suitable option for delivering affordable and practical improvements in the quality and reliability of the NTS diary data. In 2011, therefore, DfT undertook a pilot study of how the NTS might be run using GPS technology in place of the travel diary. It was expected that the results would determine how well the GPS methodology worked; identify any unforeseen problems and whether this method provided similar results to traditional methods. It was also expected to reveal whether the algorithms used to predict mode and purpose were accurate and well functioning and whether the certainty of these predictions were within acceptable parameters. If the pilot proved successful, it was expected that GPS methodology could be used from the inception of the next NTS fieldwork contract in 2013.

The results of the pilot study presented at the conference, however, did not confirm these expectations. While the GPS survey was expected to reduce respondent burden, it actually obtained a lower response rate (52%) than the traditional 7-day paper-based self-completion diary (59%). While 98% of those who participate found the GPS easy to use, there was still a sizeable number of people who distrusted the technology. In particular, 18% of household members with children aged 12-15 said that those children should not be asked to carry a GPS device.

There was also concern at the trip results obtained from the GPS survey, in comparison with the previous method. Fewer trips and trip stages were recorded in the GPS data, but the time and distance of the recorded trips were longer. In addition, the GPS data had far fewer walking trips and more rail trips. The distribution of trips over the day was different, with the GPS data not clearly recognising the morning and evening peaks. In addition, the GPS data had more trips to/from home, and fewer trips to/from work.

As a result of the pilot study, it was concluded that the GPS data did not produce similar results to the traditional diary survey, and that such a major discontinuity in data trends could not be tolerated in a major national survey. As a result, it was decided that the tender for the NTS beyond 2012 would continue to be on the basis of a diary survey. Reductions in cost and respondent burden would be achieved by removing

some of the existing questions that had not been used in analysis, thus reducing questionnaire length and respondent burden.

Kelly Clifton and Keith Lawton presented a paper on "Capturing and representing multimodal trips in travel surveys: a review of practice". Their concern was to identify efforts to capture multimodal trip making by identifying the issues that arise for data collection and representation of these trips. The paper included a review of a multitude of US-based household travel surveys with the purpose of identifying how the stages of multi-modal trips are collected in the travel survey and represented in the data structure. Based upon this review and the authors' experience with various travel surveys, the authors then made recommendations for approaches to practice, with an emphasis on various aspects of data collection and data representation.

As their presentation proceeded, it became clear that the sub-tile of the paper should have been "a review of practice in the USA", since many of the shortcomings identified pertained mainly to CATI surveys, and to current US practice. Most of the workshop participants were from outside the USA, and many commented that what was being suggested was already common practice in non-US locations. Nonetheless, the recommendations were a timely reminder of the procedures needed to ensure proper collection of multimodal travel behaviour.

Linda Christensen offered a paper on "The role of web interviews as part of a national travel survey" based on her work with the Danish National Travel Survey. Unfortunately Linda was unable to attend, and her presentation was made by the workshop chair, given its important findings with respect to mixed-mode surveys. For the 2006 Danish National Travel Survey, a mixed-mode survey involving CATI and web surveys was proposed in order to reduce costs, increase response rate (especially from younger respondents) and obtain better quality data.

The web survey was added to the traditional CATI NTS survey by asking the respondents to first check in on the web and answer the questions there. If they have not participated on the web after two days, they were called by telephone and administered the usual CATI survey. The analyses show that the overall response rate was only increased by 1% due to contact to people with no known telephone numbers. The young and people with low resources who are difficult to reach by telephone were also not participating on the web. It was concluded that the web interviews give a more correct picture of the number of trips than the CATI. But in fact the difference, 1.2%, was very little. The difference in kilometres was more important. The results also showed that only using the web would bias the results. More people with social resources would participate while elderly people would be less involved. It would also bias the results to more kilometres but not to more trips. It would also reduce participants

who are busy in their daily life, e.g. families with children. It was concluded that web interviews saved money. On a per-interview basis, web interviews were 74% cheaper than CATI interviews. However, overall, there was only a 15 % saving due to a low response rate on the web and the need for much more post processing of the web interview data compared to the CATI interview data. In general, the addition of the web surveys gave some marginal improvements, but not to the extent expected.

The finding about the effect on response rates is echoed by Dillman et al (2009), when he reports on findings from Dillman et al (2008) and others. In that study, respondents were given the option at the beginning between doing the survey by mail or on the web. Rather than increasing the response rate, he found that it decreased between 1 and 9 percentage points, a finding confirmed by other studies. He therefore advises against offering a choice of options, because it just creates another decision for the respondent to make thereby increasing respondent burden and reducing response rate. He found that response rates could however be increased by offering one option at a time. If the first option was not adopted, then respondents could be offered a second option (and a third etc). Since this also serves as a reminder each time a new option is provided, the response rate increases. Indeed, even if the method was not varied on the second and third contacts, one would likely see an increase in response rate. While this might be acceptable for time-insensitive measurements, it has been shown (Richardson, 2003) that while repeated contacts (which allow the specified Travel Day to slip over time, to avoid recall problems) do increase response rate, they also bias the measurement of travel, with decreasing trip rates in later contacts. One therefore needs to consider this issue if using mixed-mode methods sequentially in travel surveys.

An extra paper was presented in the workshop by Liz Ampt on “Diagnostic Testing: an innovative way to test survey design”. This paper was particularly concerned with the Measurement Error aspect of Total Design Error, and proposed a method by which respondents’ understanding of questionnaires and other survey materials could be tested. In this way, measurement error could be reduced because respondents better understood what they were being asked, while response rates could increase because of reduced respondent burden (due to reduced confusion for the respondent). Importantly, it was also highlighted how these methods could be used in mixed-mode surveys, to ensure that the questions in each of the survey methods were indeed asking for, and receiving, the same information.

# WORKSHOP FORMAT

The objective of the workshop was to elicit information from participants about the various types of survey error associated with three traditional and two emerging survey methods. However, the workshop had 16 participants from 11 different countries, covering a wide range of professional backgrounds and levels of experience, and also a wide range of proficiencies in the conference language (English). From past experience with such workshops, it was known that an unstructured discussion format would be dominated by those with more experience and those who were more proficient in the conference language (and those who simply like to talk). Therefore the workshop was structured using the Six Hats methods developed by Edward de Bono (1985).

Six Hats Thinking recognises that most unstructured discussions are inefficient ways of gathering information, with much time spent reacting to what others have said, defending pre-existing positions, or trying to convince others to agree with us. Six Hats Thinking recognises that such discussions can usefully be split into 5 different directions, and assigns a different colour "hat" to each of these modes of thinking, as follows:

- White Hat – information gathering
- Red Hat – emotions and intuition
- Yellow Hat – logical positive aspects
- Black Hat – logical negative aspects
- Green Hat – creative thinking

In addition, a sixth hat, the Blue Hat, is used for someone (the chairperson) to think about the thinking while the others are thinking about the topic.

Six Hats Thinking has been found to be much more thorough in exploring a topic, more efficient with time, and enables all participants to actually contribute to the outputs. For this workshop, only three of the hats were used; the workshop chair wore the Blue Hat to direct the thinking process, while each participant wore the Yellow Hat and then the Black Hat to think about the good and bad aspects of each of the five survey methods. They wore each hat for only 2 minutes, and initially worked on their own, writing down as many ideas as they could under each hat for each survey method. After this initial 20 minutes of individual work, the workshop chair gathered these ideas by going around the room and asking each person for just one idea that they had written down under that hat that had not already been mentioned. If they had no further ideas, they could just "pass". The process continued for each hat until no new ideas were forthcoming. The process then started at a different place in the room (to ensure that everyone had a chance of being an early contributor) for the next hat and survey method. This collective aspect of the Six Thinking Hats typically takes more time, since participants often need to explain or elaborate on their written notes, and this discussion often triggers more

discussions and further ideas from other participants. In the workshop, each hat/method took approximately 30 minutes to gather the ideas. Given the relatively limited time available in the workshop, only three of the survey methods (CATI, GPS, Web) were fully debriefed in this way. The effectiveness of the Six Hats method can be seen by reference to Table 1, which shows the number of different ideas collected under each hat for the three survey methods that were fully de-briefed.

**Table 1 Ideas Generated for three Survey Methods**

| Survey Method | Yellow Hat | Black Hat |
|---|---|---|
| CATI | 24 | 23 |
| GPS | 29 | 36 |
| Web | 30 | 27 |

To gauge the increase in efficiency in generating this information, a straw poll was asked of respondents as to how many individual ideas they had personally written down under each of the hat/method combinations. The number varied between 1 and 6 across all the combinations. Thus even the most experienced of the participants could not generate more than 6 ideas in the 2 minutes allowed (given more time, they might have generated a few more, but probably not). The collective numbers of ideas from the 16 participants was 4 to 6 times greater than that of the most productive individual.

# WORKSHOP OUTCOMES

While the lists assembled from this process are interesting in themselves, the objective of the workshop was not just to compile lists of good and bad points for each of the survey methods. Rather, the objective was to examine the different types of survey error, which contribute to Total Design Error, for traditional and emerging survey methods, so as to validate shifts in the total design of travel surveys. This is done below by tabulating the main Advantages (Yellow Hat) and Disadvantages (Black Hat) of each survey method, with respect to each of the four types of survey error that constitute Total Design Error (i.e. Coverage Error, Sampling Error, Non-Response Error and Measurement Error). These results are predominantly based on the outputs from the workshop participants.

## *FACE-TO-FACE SURVEYS*

The main advantages of a Face-to-Face Interview survey with respect to the four sources of Total Design Error are shown in Table 2, while the main disadvantages are shown in Table 3. In this context, a face-to-face interview refers to an interview of an entire household at their home.

**Table 2 Advantages of Face-to-Face Interview Survey**

| Type of Error | Advantages |
|---|---|
| Coverage Error | • Generally good lists of household addresses available. |
| Sampling Error | • Allows longer surveys, therefore more data per household. |
| Non-Response Error | • Highest Response Rates (60-75%) from a random sample of households. |
| Measurement Error | • The presence of an interviewer allows more accurate objective data to be collected.<br>• The interview is customisable to the needs of the respondent.<br>• The interviewer can explain terms, prompt, and note body language of the respondent. |

**Table 3 Disadvantages of Face-to-Face Interview Survey**

| Type of Error | Disadvantages |
|---|---|
| Coverage Error | • Could be difficult to survey households in remote areas. |
| Sampling Error | • More expensive per households, therefore fewer households can be surveyed within fixed budget. |
| Non-Response Error | • Some respondents may have a fear of a "stranger" entering their home. |
| Measurement Error | • Respondents may have poor representations of travel time when they self-report. |

## *SELF-COMPLETION SURVEYS*

The main advantages of a Self-Completion survey with respect to the four sources of Total Design Error are shown in Table 4, while the main disadvantages are shown in Table 5. In this context, a Self-Completion survey can be given to and collected from the respondent in various ways, e.g. personally delivered and collected, or mailed out and mailed back. Typically the former method gets higher response rates and better quality data but at a higher unit cost, whereas the latter has a lower unit cost but with lower response rates and poorer data quality.

**Table 4 Advantages of Self-Completion Survey**

| Type of Error | Advantages |
|---|---|
| Coverage Error | • Generally good lists of household addresses available. Postal surveys can reach remote areas as cheaply as built-up urban areas. |
| Sampling Error | • Less expensive per household than face-to-face interviews, therefore more households can be surveyed within fixed budget. |
| Non-Response Error | • Good Response Rates (60%) can be obtained from a random sample of households when the self-completion questionnaire is personally delivered and collected. |
| Measurement Error | • The fact that the respondent can choose the time to complete the survey gives them more time to think about the answer or to collect required information. |

**Table 4 Disadvantages of Self-Completion Survey**

| Type of Error | Disadvantages |
|---|---|
| Coverage Error | • Could be difficult to survey households in remote areas if questionnaires personally delivered and collected. |
| Sampling Error | • No specific disadvantage. |
| Non-Response Error | • Poor Response Rates (30%) are obtained from a random sample of households when the self-completion questionnaire is mailed to the respondent and then mailed back. |
| Measurement Error | • The absence of an interviewer who could prompt may mean that there could be an under-reporting of travel data.<br>• Some approximations with time and distance reporting. |

## *CATI SURVEYS*

The main advantages of a CATI survey with respect to the four sources of Total Design Error are shown in Table 6, while the main disadvantages are shown in Table 7. In this context, a CATI survey is assumed to use random-digit dialling as the sampling procedure, with a diary posted to the respondent upon recruitment. The travel data is then retrieved over the phone.

**Table 6 Advantages of CATI Survey**

| Type of Error | Advantages |
|---|---|
| Coverage Error | • Phone surveys can reach remote areas almost as cheaply as built-up urban areas. |
| Sampling Error | • Cheaper to administer, therefore more surveys can be performed within fixed budget. |
| Non-Response Error | • Multiple callbacks possible to reduce non-response. |
| Measurement Error | • Prompting possible to elicit details. |

**Table 7 Disadvantages of CATI Survey**

| Type of Error | Disadvantages |
|---|---|
| Coverage Error | • Fixed line phone coverage is decreasing.<br>• Hard to contact all members of household.<br>• Hard to sample mobile phones. |
| Sampling Error | • Phone sampling is not a random sample of the population. |
| Non-Response Error | • Poor Response Rates (<30%) are obtained from a random sample of households (if it could be chosen) because of recruitment and non-response loss.<br>• Call screening and other strategies make it difficult to make contacts with sample. |
| Measurement Error | • Limits on length of call limit amount of detail that can be collected.<br>• No visual aids<br>• Approximations of travel time and distance. |

## *GPS SURVEYS*

The main advantages of a GPS survey with respect to the four sources of Total Design Error are shown in Table 8, while the main disadvantages are shown in Table 9. In this context, a GPS survey is assumed to be a survey where GPS is the main means of data collection, using algorithms to process the travel traces to estimate mode and trip purpose.

**Table 8 Advantages of GPS Survey**

| Type of Error | Advantages |
|---|---|
| Coverage Error | • Depends on the means of contacting the potential sample. Random sampling is best. |
| Sampling Error | • Multi-day surveys are easier to administer, therefore more data can be collected within fixed budget. |
| Non-Response Error | • Lower respondent burden, therefore potentially higher response rates.<br>• No language difficulties. |
| Measurement Error | • Potentially high resolution time and space data.<br>• Actual data on route choice. |

**Table 9 Disadvantages of GPS Survey**

| Type of Error | Disadvantages |
|---|---|
| Coverage Error | • Black spots and cold starts limit coverage area. |
| Sampling Error | • Relatively expensive per household (at the moment), hence generally smaller samples. |
| Non-Response Error | • Still some reluctance to carrying GPS units, especially for school children.<br>• Generally low take-ups of GPS units (25-50%).<br>• People forget to charge or carry GPS with them. |
| Measurement Error | • Limited data on mode, purpose and vehicle occupancy.<br>• Processing algorithms complex (but improving)<br>• Difficulties in identifying trip start and end points. |

## *WEB SURVEYS*

The main advantages of a Web survey with respect to the four sources of Total Design Error are shown in Table 10, while the main disadvantages are shown in Table 11. In this context, a Web survey is assumed to be a survey where the respondents are recruited by some means, and then asked to complete the travel survey via a web interface.

**Table 10 Advantages of Web Survey**

| Type of Error | Advantages |
|---|---|
| Coverage Error | • Depends on the means of contacting the potential sample. Random sampling is best. |
| Sampling Error | • Potentially cheaper to administer, therefore more data can be collected within fixed budget. |
| Non-Response Error | • Potentially low respondent burden.<br>• Can appeal to some problem demographic groups.<br>• Respondent can answer in their own time. |
| Measurement Error | • Can have context-dependent questions.<br>• Potential for using online mapping to improve route and destination answers.<br>• Can do online error-checking to improve quality of responses. |

**Table 11 Disadvantages of Web Survey**

| Type of Error | Disadvantages |
|---|---|
| Coverage Error | • Limited web availability for some demographics.<br>• Firewalls and security measures may block potential respondents.<br>• Web survey panels are significantly biased. |
| Sampling Error | • No specific disadvantages.. |
| Non-Response Error | • Respondents can drop survey in mid-survey.<br>• Generally low response rates (30%) unless supplemented with another method.<br>• Too much online checking may induce respondents to discontinue.<br>• Login procedures may discourage respondents. |
| Measurement Error | • Cannot simply transfer paper survey designs, e.g. replacing lists with dropdowns.<br>• Difficult to design geocoding procedures for untrained respondents.<br>• The absence of prompting may mean that there could be an under-reporting of travel data. |

# CONCLUSIONS

The design and incremental refinement of traditional survey methods (face-to-face interviews and self-completion diaries) over many decades has led to a gradual reduction in Total Design Error by paying deliberate attention to the four components of Coverage Error, Sampling Error, Non-

Response Error and Measurement Error. Newer survey methods have been introduced largely as a means of reducing one or more of these sources of error. For example, GPS surveys offer the potential of much more accurate measurement of travel time and distance, while Web surveys offer the potential of lower cost and the promise of reaching traditionally low response rate groups. However, these methods must now themselves go through this incremental refinement process, by paying particular attention to their weaknesses in the four areas of Total Design Error. Only when the Total Design Error has been reduced below that of traditional survey methods will they be worthy substitutes for the traditional methods.

# REFERENCES


Ampt, L.(2011). Diagnostic Testing: an innovate way to test survey design, paper presented to the Ninth International Conference on Travel Survey Methods, Termas de Puyehue, Chile, November.

Christensen, L.(2011). The role of web interviews as part of a national travel survey, paper presented to the Ninth International Conference on Travel Survey Methods, Termas de Puyehue, Chile, November.

Clifton, K., Muhs, C.D. and Lawton, T.K. (2011). Capturing and representing multimodal trips in travel surveys: A review of the practice, paper presented to the Ninth International Conference on Travel Survey Methods, Termas de Puyehue, Chile, November.

De Bono E. (1985). Six Thinking Hats, Little, Brown and Company, Boston, MA

Dillman, D. A. (2000). Mail and Internet Surveys: The Tailored Design Method. John Wiley & Sons, New York.

Dillman, D. A. (2007). Mail and Internet Surveys: The Tailored Design Method (2nd Edn). John Wiley & Sons, Hoboken, New Jersey.

Dillman, D. A., (1978). Mail and Telephone Surveys: The Total Design Method. Wiley-Interscience, New York.

Dillman, D. A., Smyth, J.D. and Christian, L.M. (2009). Internet, Mail and Mixed-Mode Surveys: The Tailored Design Method. John Wiley & Sons, Hoboken, New Jersey.

Groves, R.M. (1989). Survey Errors and Survey Costs. John Wiley & Sons, New York.

Richardson, A.J,(2003). “Behavioural Mechanisms of Non-Response in Mailback Travel Surveys", Transportation Research Record, 1855, pp.191-199.

Sneade, A. (2011). Using accelerometer equipped GPS devices in place of paper travel diaries to reduce respondent burden in a national travel

survey, paper presented to the Ninth International Conference on Travel Survey Methods, Termas de Puyehue, Chile, November.