WORKING PAPER
ITS-WP-04-11

New Technology and Travel Surveys: The Way Forward

By

Rahaf Alsnih

April, 2004

ISSN 1440-3501

INSTITUTE OF TRANSPORT STUDIES

The Australian Key Centre in Transport Management

The University of Sydney and Monash University

Established under the Australian Research Council's Key Centre Program.

NUMBER: Working Paper ITS-WP-04-11

TITLE: New Technology and Travel Surveys: The Way Forward

ABSTRACT: Traditional survey methods are fast reaching their "use by" dates. It is much harder for researchers to contact households through the telephone as a result of call screening and answering machine devices. In relation to face to face interviews, housing estates and buildings are increasingly becoming fenced off and protected by security systems making it virtually impossible for the researcher to enter the premises, if not expected, as well as the fact that more often than not, householders are not available at the time when the survey is being conducted. In addition, the over use of marketing surveys has led people to believe that every survey they are asked to complete is of this type. Together, these difficulties have led to rising item and unit non-response, and consequently, rising unit costs. This is not only a phenomena associated with travel surveys, but rather the entire realm of social science research.

Development of the World Wide Web has had some dramatic impacts on the global environment, in relation to communication, information and research. The development of web based surveys (internet-based or e-mail), is commonly seen as a combative measure to rising costs and the declining response problem faced by most survey practitioners. Despite the phenomenal uptake of this technology by industry and individuals, some people are still to embrace this new medium. This poses some interesting questions for researchers wanting to utilise this technology to combat low response rates.

One of the major concerns today, in relation to web based surveys, is sample bias. Internet users are usually of higher socio-economic status. In addition, people who have access to the internet are not always certain of their ability to utilise the internet, let alone complete a web based survey. These are important issues that need to be considered if web based surveys are to be used.

KEY WORDS: ***Travel Surveys, Internet Surveys, Survey Design, Coverage Bias***

AUTHOR/S: Rahaf Alsnih

CONTACT: Institute of Transport Studies (Sydney & Monash)
The Australian Key Centre in Transport Management, C37 The University of Sydney NSW 2006, Australia

Telephone: +61 9351 0071
Facsimile: +61 9351 0088
E-mail: itsinfo@its.usyd.edu.au
Internet: http://www.its.usyd.edu.au

DATE: April, 2004

1. Introduction

Over the last decade, when conducting surveys by telephone, more calls had to be made to achieve contact (Zmud, 2003; Dillman, 1998). However, a high number of calls remained unresolved. This is a result of households adopting new technology such as answering machines, caller id, increased cell phone use (some households only have cell phones and not a land line; it is costly to obtain these numbers if wanting to contact these households by telephone), multiple phone line households[1], and silent numbers. In addition, thirty percent of households in the U.S. have unlisted telephone numbers (Dillman, 1998). These factors make it much harder for the researcher to successfully contact the household, resulting in greater survey costs (Zmud, 2003; Groves and Couper, 1998; Dillman, 1998; Cook *et al*., 2000).

Due to increased difficulties in contacting prospective respondents, thus contributing to low response rates for both mail and telephone surveys, and advances in technology, new survey modes have emerged that are relatively cheap to administer. For example, e-mail surveys require the same level of effort to respond as telephone surveys (Dillman, 1998). There is no need for reply paid envelopes; e-mail and web surveys decrease respondent burden, in relation to self-administered surveys (Dillman, 1998).

However, some problematic issues have been identified in relation to web-based surveys. The most important of these are sample representativeness, data quality, anonymity (e-mail based surveys) and information security, technological incompatibilities and disruptions. This paper will look at the evolution of survey methodologies in social science and transport research. Design issues in relation to internet surveys will be discussed along with the advantages and disadvantages of internet based surveys. Experiences of the author will shed some light on important design features of internet based surveys, in a travel context. Furthermore, special issues in terms of travel surveys will be discussed.

2. Survey Methodology and Response Rates

Social science survey methodology has evolved to adapt to new technology and the benefits that arise from using this technology. Figure 1 shows the evolution of data collection methods.

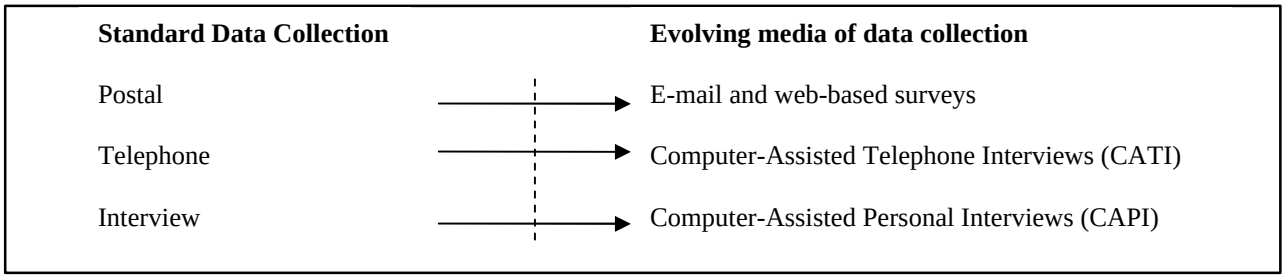

Figure 1: Evolution of Data Collection Methods
Source: Adapted from Illieva *et al*., 2002

[1] The number dialled could be dedicated to a fax machine or modem; therefore, direct contact with an individual may not be achieved.

Survey methodologies have changed as a combined result of the following:

1. Changes in societal organisation and culture;
2. Available technology;
3. Sources of cost and efficiency; and
4. Acknowledgement of contributing factors to survey error (Dillman, 1998).

The adoption of new data collection modes is viewed as a way to combat decreasing response rates.

Travel surveys have long had the problem of poor response rates and increasing high unit costs. The complex nature of data required often leads to the development of a rather complicated survey instrument. This, in addition to the survey environment, contributes to the high incidence of non-response. The non-response issue for travel surveys has resulted in biased data sets[2] because characteristics of non-respondents are different to characteristics of respondents (Richardson, 2000; De Heer and Moritz, 1997). For example, characteristics of non-respondents to travel surveys, found in numerous studies, are:

1. Very low and very high income;
2. High and low mileage drivers;
3. Young single males and females;
4. Zero vehicle use;
5. People residing in metropolitan areas, and
6. Households with children (De Heer and Moritz, 1997; Richardson, 2000; Kam and Morris, 1999).

Non-response bias must be minimized to obtain a more accurate picture of people's travel behaviour.

Given this and other problems encountered in travel and social science research, researchers have embraced the idea of web-based surveys for the following reasons:

1. Low distribution and retrieval costs;
2. Automated data entry;
3. The ability to include visual aids and animation to assist in the respondent's recollection of travel over the assigned travel days;
4. Quick response times;
5. Automated skip patterns and randomisation of questions (particularly important in stated choice experiments); and
6. Researchers can obtain information about response behaviour (Gunn, 2002; Illieva *et al*., 2002; Lazar *et al.,* 1999; Bosnjak and Tuten, 2001; Couper, 2000; Schonlau *et al*., 2001; Thompson *et al*., 2003).

Despite the benefits of web based surveys, the application of these in the present survey environment results in coverage error because not everyone has access to the internet (Dillman and Bowker, 1999). This results in relatively low response rates to web based

[2] High rates of unit non-response are generally associated with non-response bias. Non-response error is a function of the non-response rate and the difference between respondents and non-respondents on the statistic of interest (Keeter *et al.,* 2000).

surveys, especially for surveys of the general population. For example, Table 1 shows that the average response rates for eleven studies which used both mail and e-mail data collection methods were 46.16 and 38.72 respectively. Given that these studies were not of the general population, response rates were not especially high. This may be related to internet user ability; internet users with less internet experience and ability, may have not responded to the survey, or may have been unsure how to return the completed survey.

Table 1: Response time and response rate: e-mail vs. mail

Authors	**Technique**	**Response Time (days)**	**Response Rate (%)**
Ranchhold and Zhou (2001)	E-mail	N/A	6
	Mail		20
Bachman et al. (1996)	E-mail	4.68	52.5
	Mail	11.18	65.6
Weible and Wallace (1998)	E-mail	6.1	29.8
	Mail	12.9	35.7
Schaefer and Dillman (1998)	E-mail	9.16	58
	Mail	14.39	57.5
Tse et al. (1995)	E-mail	8.09	6
	Mail	9.79	27
Mehta and Sivadas (1995)	E-mail	2-3	54.3
	Mail	21	56.5
Wygant and Lindorf (1999)	E-mail	2	50
	Mail	9.16	32
Parker (1992)	E-mail	N/A	68
	Mail		38
Schuldt and Totten (1994)	E-mail	N/A	19.3
	Mail		56.5
Tse (1998)	E-mail	2.58	7
	Mail	8.49	52
Kiesler and Sproull (1986)	E-mail	9.6	75
	Mail	10.8	67
E-mail average response time and rate		**5.59**	**38.72**
Mail average response time and rate		**12.21**	**46.16**

Source: Source: Illieva *et al*., 2002

Furthermore, it appears that the response rates, shown in Table 1 are based on the number of completed surveys (retrieval stage only). Transport surveys are usually two stage surveys; a recruitment stage and a retrieval stage. Thus, for comparison, the retrieval response rate for a recent study conducted by the Institute of Transport Studies (ITS), The University of Sydney, was 54.5 percent. This is much higher than the average response rates for the mail and e-mail studies shown in Table 1. Importantly however, the methodology behind the internet survey conducted by ITS was different to those of the studies listed in Table 1. The internet study conducted by ITS involved telephone recruitment and this enabled an e-mail message to be sent to recruited respondents, housing the URL and password required to access the survey. The studies listed in Table 1 did not utilise this methodology, or the same type of survey. However, it is unlikely that a difference in measurement, arising from the different data collection

modes alone, resulted in the relatively large difference in response rates[3]. Different survey methodologies, different survey types, as well as the survey topic and the survey environment, affect response rates (Ettema *et al*, 1996; Melevin *et al*., 1998; Schneider and Johnson, 1994).

3. Types of Web Based Surveys

There are different types of web based surveys. It is important to recognize the different types of web based surveys, thus a brief description of the types is provided. There are essentially three types of internet questionnaires:

1. Open to any visitor – There is no control over who visits or completes survey, other than the fact that the sample is only of internet users;
2. Closed – Respondents are invited to visit the website and complete the survey which is usually password protected. Respondents may be recruited through the telephone, or e-mail, and provided with the URL and password, through an e-mail or letter. This survey type is most likely to be used in a two or more stage survey[4]; and
3. Hidden – This is better known as a pop-up survey. Visitors to the web site are randomly selected to participate in the survey. A hidden window pops-up alerting people of the survey and asks whether viewers would like to participate. Obviously, this type of internet survey is only viewed by people visiting the web site (Bradley, 1999; Gunn, 2002; Couper, 2000).

In terms of E-mail surveys, there are only two types:

1. Simple e-mail message with questions; and
2. E-mail message which acts like a cover letter, and includes the survey attachment.

An e-mail message with an embedded URL is not an e-mail survey, described as such in some of the literature consulted (Bradley, 1999). The respondent is requested to participate through an e-mail message and asked to access the survey through the included URL. Essentially, this is e-mail recruitment for an internet survey.

With internet based surveys, the assumption is that the respondent has internet access and is confident in the use of this technology. However, in the U.S. in 2002, internet penetration was only 65 percent of households (Adler and Rimmer, 2002). This has important implications for web based surveys in relation to sample representativeness, especially if the survey is of the general population. For example, in a study by Myles and Tibert (1998), it was found that the internet sample was not representative of the population in relation to an election outcome, even after weighting. In addition, if recruiting respondents through e-mail, people change their Internet Service Provider,

[3] Topic salience is more likely to be the major factor affecting response rates given that respondents to the ITS study were households recently affected by bushfires and these households were asked to take part in a bushfire evacuation study.

[4] The first stage is the recruitment stage and this may be through mail, CATI or e-mail. Travel surveys are usually 2 stage surveys whereby recruitment is through CATI and retrieval traditionally through mail back or CATI.

and in turn, change their e-mail address more often than they change their household address. Their mailboxes may also be full. This usually results in more non-deliverables when compared to traditional mail-out surveys (Cobanolgu *et al*., 2001), and is a reason why e-mail surveys are not as popular as internet based surveys. The rest of this paper will predominantly refer to internet based surveys.

4. Sampling and Representativeness

Probability based sampling is when the sample is selected by chance, and population members have an equal and known chance of being selected. Most common types of probability based sampling include simple random, systematic, stratified and cluster. Statistical inference is only possible with probability based sampling; hence, is most commonly used in scientific research applications (Couper, 2000; Schonlau *et al*., 2001).

In relation to closed internet surveys, the sampling frame[5] is often referred to as an external sampling frame; respondents are recruited from other sources and invited to the internet (Bradley, 1999). This may reduce coverage error somewhat, compared to the other internet survey types, because people are recruited from sources other than e-mail lists and visitors to websites. Although, only people with access to the internet are able to respond to the survey.

However, despite the use of probability based sampling, various forms of error and bias arise in the resultant data set from internet surveys[6]:

1. Coverage bias -- This is a function of both the proportion of the target population that is not covered by the frame and the difference on the survey statistic between those covered and those not. Many people still do not have access to the internet;
2. Sampling error -- The result of surveying a sample of the population rather than the entire population. This is a major concern for internet surveys of the general population because the sample obtained is not representative of the population;
3. Measurement error -- The result of inaccurate responses that stem from poor question wording (poor survey design), poor interviewing, survey mode effects and aspects of respondent behaviour such as the lack of motivation and deliberate false answers[7]. Measurement error could also rise from the effects of different browsers; respondents see different structures of the survey according to the capability of their internet browser (Couper, 2000; Dillman and Bowker, 1999; Thompson *et al*., 2003); and
4. Non-response bias -- Demographic characteristics of internet users are different to those of non-users. For example, online surveys over represent males[8], college

[5] A list of sampling units from which the sample can be selected (Alvarez and VanBeselaere, 2003).

[6] These forms of error and bias also result from the use of other survey modes, but these examples are in relation to the internet survey mode.

[7] Survey design is discussed in detail later in this paper.

[8] Males were more likely to respond to internet surveys whereas females were more likely to respond to telephone surveys (Dillman *et al.*, 2001).

graduates and the young (Couper, 2000; Adler and Rimmer, 2002; Woong Yun and Trumbo, 2000; Bradley, 1999; Thompson *et al*., 2003). Also, not everyone has access to the internet therefore this may compound non-response bias (Dillman *et al*., 2001; Couper, 2000; Dillman and Bowker, 1998).

As previously mentioned, not everyone has access to the internet, and of those who do, it is not known how competent these individuals are in relation to web navigation. The following section lists the different types of computer user and describes the issues that accompany this.

5. Respondent and Equipment Capabilities

Computers with internet connection have different capabilities (Bradley, 1999). This effects how respondents access and view the web based survey. This is shown in Table 2.

Table 2: Types of Computer User

	User Capability		**Equipment Capability**	
type	*E-mail able*	*Browser able*	*E-mail able*	*Browser able*
1	yes	yes	yes	yes
2	yes	yes	yes	
3	yes	yes		yes
4	yes	yes		
5	yes		yes	yes
6	yes		yes	
7	yes			yes
8		yes	yes	yes
9		yes	yes	
10		yes		yes
11			yes	yes
12			yes	
13				yes

Source: Bradley, 1999.

In Table 2, it appears as though developments in technology have outpaced user ability, further emphasising the need to understand computer user familiarity with the internet. In addition, the thirteen different types of computer user identified, with respect to web based surveys, have not been adequately addressed, or acknowledged by some survey practitioners. Yet, understanding the types of computer user would result in better survey design and better application of survey methodology. Also from Table 2, it can be shown how the types of error may arise. Coverage error results because not everyone has access to the internet, and of those who do, the capability of users varies greatly[9] (Bradley, 1999); sampling error results because at present, the sample is only representative of internet users; measurement error arises due to different levels of respondent and equipment capability[10]; and non-response error is the combined outcome

[9] Some people's experience in computer use may be so limited that they are unable to complete the survey. This type of computer user may have certain demographic characteristics; thus, adding to coverage and non-response bias.

[10] Obviously, more research is required to obtain the current status in relation to user capability. Also, an understanding of the concept of confidence in internet use is necessary to facilitate the development of

of failures in technology (server breakdowns), browser capability (time to taken to download pages) and computer literacy problems of respondents (Dillman *et al*., 1999). This may also pose problems in the future because respondents may become very frustrated with internet surveys if their browser is incompatible; bad experiences will make it harder to obtain respondent co-operation to future internet surveys. The way to limit the possibility of these problems is to ensure that a simple survey design is adopted.

6. Quality and Validity of Web Based Surveys

Technological and user capabilities also affect the quality of the data obtained. It is important for survey research to obtain data of good quality; poor quality research usually stems from bad survey design and inappropriate use of survey modes. Thus, data quality is a combination of the following:

1. Low unit and item non-response;
2. Honest responses;
3. Completeness of responses in relation to open ended questions; and
4. No data entry errors (this should not be an issue for internet surveys due to the automation of data entry) (Shonlau *et al*., 2001).

However, data quality is usually measured by the number of item and unit non-responses. Some evidence suggests that higher item non-response rates occur for e-mail surveys compared to mail surveys. Yet, for open ended questions, responses retrieved through e-mail are more complete and informative than for the same questions retrieved through the mail (Shonlau *et al*., 2001; Woong Yun and Trumbo, 2000). This depends ultimately on the survey topic and design. Interestingly, researchers readily accept that face to face and Computer Aided Personal Interviews yield data of better quality due to relatively high response rates. These interview methods are also more likely to produce socially desirable responses (Dillman,1998). However, this does not necessarily equate to better measurement (Dillman, 1998). For example, a study conducted by ITS found that increasing the response rates of two travel surveys, by re-contacting households that initially refused or were not available, led to the introduction of another bias. This is so because households that required only three calls to become responding households had very different trip rates to responding households that required six calls. Therefore, even though response rates increased, data quality was compromised, especially in relation to a key statistic; mean trip rates. This is an area that ITS will investigate further in the future.

A major concern with online surveys, especially if of the general population, relates to the validity of data due to the sampling frame; the issue of representativeness arises as well as that some people are more computer literate than others and this may contribute to measurement and non-response error. In addition, a complex online survey will add to computer literacy problems and increase the rate of unit and item non-response. This also effects the quality and validity of data obtained from online surveys.

more appropriate internet survey instruments. Important questions arise: How is confidence in internet use to be measured and what are the key indicators?

One study, wherein the sample was experienced in internet use, claimed that web responses contained fewer random and systematic errors than telephone responses (Gunn, 2002). Another study claimed that 69.4 percent of e-mail respondents completed 95 percent of the survey whereas only 56.6 percent of mail respondents completed 95 percent of the survey (Illieva *et al*., 2002)[11]. According to a study conducted by Cobanoglu *et al*. (2001), it was found that the data of highest quality was for web-based surveys. However, again the target population was a sample confident[12] in internet use; internet users have been identified as having higher levels of socio-economic status than non-internet users (Dillman *et al*., 2001; Adler and Rimmer, 2002; Alvarez and VanBeselaere, 2003; Arentze *et al*., 2004). Miller *et al*. (2002), found in their study that web-based surveys did not compromise data quality nor was a measurement difference observed in relation to pen and pencil surveys with respect to test reliability of alcohol measures. However, more research is needed to confirm this finding in relation to studies of the general population.

It is important to realise that for a survey of the general population, the incidence of item and unit non-response would be much greater. Despite this problem, the benefit of online travel surveys is that they may capture a group of traditional non-respondents to conventional travel surveys; the larger households and households of higher socio-economic status. For example, the results of two studies using the internet for data collection, showed that respondents to internet travel surveys were predominantly larger households[13] and households of higher socio-economic status, compared to the households which responded through the mail, or telephone interviews (Adler and Rimmer, 2002; Arentze *et al*., 2004). Households responding over the internet recorded higher trip rates than the households which responded through the mail (Adler and Rimmer, 2002). Larger household size should naturally equate to more trips and the number of adults in the household has a positive relationship with number of trips made; hence, the results observed (Adler and Rimmer, 2002; De Heer and Moritz, 1997; Richardson, 2000; Kam and Morris, 1999).

In addition, it may be that busy people, traditionally non-contactable households, find the internet option more appealing because they are not bound to sit and respond at a certain time, which occurs during a CATI or personal interview. They are also not required to send anything back physically; something which they do not have time to do. Busy people, also, are usually not at home; hence, the non-contact status when the survey is being undertaken.

However, it cannot be stated that web based travel surveys, as the single survey mode used, result in a better measurement of trip rates because higher trip rates can be calculated. The instrument may be useful to capture trip rates of larger households and households of higher socio-economic status, because these households preferred to respond over the internet, but other demographic groups are not captured by this survey mode.

[11] Interestingly, these authors question the sincerity of internet responses (Illieva *et al*., 2002).

[12] No definition of confidence in internet use was provided.

[13] Households primarily classed as larger households, were mainly recruited by telephone and requested to complete a travel survey over the internet

Web based surveys, as single mode surveys, should only be conducted if all of the target population have access to the internet. (Dillman *et al.*,1998). Of equal importance, if not more so, is to assess how computer literate people with access to the internet are (Dillman *et al.*, 1998). Households may have access to the internet, yet certain members asked to participate in the survey may not be experienced in web navigation (Lazar and Preece, 1999). This is often overlooked by survey practitioners.

7. Strengths and Weaknesses

7.1 Single mode and multimode

In the past, travel surveys were often single mode mail surveys. This was because technology was not available to support other survey collection methods. Further enhancements to CATI techniques, first implemented in the 1960s, led to the wide use of CATI during the 1980s and 1990s for most national surveys in the U.S. (Dillman, 1998). However, as previously mentioned, the usefulness of both mail and CATI recruitment and data retrieval methods decreased dramatically over the last few years due to public annoyance of research surveys in general[14], and increased difficulties in contacting households personally, or through the telephone, due to more call screening devices, multiple phone lines, and increasing use of mobile phones.

Despite this, however, some people still prefer to respond through mail and telephone surveys. For example, a Non-Response Study conducted by ITS in conjunction with NuStats, offered non-respondents to a travel survey, the choice of four data retrieval methods: mail, internet, telephone and personal interview. The initial respondents chose to respond through the mail (77.8 percent). This was not surprising given the low socio-economic status characteristic of the areas investigated[15] and the fact that the survey modes were applied in a hierarchical manner. The mail option was offered first; for the households that did not respond through the mail or internet, CATI was then offered, etc. However, the internet option was offered at the same time the mail option was, and respondents preferred the mail option.

From the results just described, and findings in the literature, it is advised that internet surveys be part of a mixed mode survey (Couper, 2000; Gunn, 2002; Schonlau *et al.*, 2001; Schaefer and Dillman, 1998). This will overcome representation problems associated with web based surveys in the present survey environment, and in turn, improve response rates (Illieva *et al.*, 2002; Schonlau *et a*l., 2001; Lazar and Preece, 1999). In addition, mixed mode surveys allow for the introduction of web-based surveys to households not accustomed to this technology; people may become more aware of the uses of the internet, and in the future, they may readily embrace internet surveys by gaining an understanding about the internet prior to participating in future internet surveys (Cobanoglu *et al.*, 2001).

[14] A likely result of the over surveying associated with marketing.
[15] Internet usage, and hence internet surveys, are linked to households of higher socio-economic status; the mail survey option is often linked to households of lower socio-economic status (Dillman *et al.*, 2001; Adler and Rimmer, 2002; Alvarez and VanBeselaere, 2003; Arentze *et al.*, 2004).

Some arguments against the use of multi-mode surveys are due to concerns about social desirability, acquiescence (especially in relation to face to face interviews), primacy and recency effects, and question order effects (Dillman, 1998; Woong Yun and Trumbo, 2000). However, differences between modes can be insignificant if a simple survey design is adopted (Cobanoglu *et al*., 2001). For example, two studies found that mode effects were insignificant in relation to e-mail versus mail responses; both survey modes had similar design features and structure (Schaefer and Dillman, 1998). Responses to web surveys are expected to resemble responses to mail surveys because both survey modes have similar question structure, and both modes are self administered (Dillman *et al.*, 2001). In addition, whether a particular survey mode results in data of better quality, ultimately depends on the survey design, survey methodology, and the research topic under investigation. The likelihood of problems associated with the use of multi-modal surveys can be reduced if a simple and coherent survey structure is adopted for all survey modes to be employed.

8. Advantages of Web Based Surveys

Web based surveys are popular because:

1. They are easier to execute – it is simple to send e-mail reminders to recruited respondents, and multiple mail outs to respondents are not required;
2. Faster response time – enables reminders to be sent sooner rather than later and this should positively affect response rates;
3. Automation of data entry saves times and other resources, as well as the likelihood of correct data entry. Automation of data entry allows for a dynamic error checking ability; and
4. This medium is much cheaper especially if large samples are required (Illieva *et al*., 2002; Schonlau *et al*., 2001; Lazar and Preece, 1999; Couper *et al.*, 2001; Thompson *et al*., 2003; Gunn, 20002).

In addition, complex skip patterns in internet surveys are not seen by respondents improving their cognitive ability leading to the likelihood of good quality data (Gunn, 2002). However, given the current survey environment, measurement error may prevail if mail and internet survey modes are only used. If there are complex skip patterns, than the mail mode is likely to suffer from high levels of item and unit non-response because respondents to the mail survey are usually of lower socio-economic status. This problem may be overcome if simple survey designs are employed.

Surveys incorporating Stated Choice experiments benefit greatly from the internet mode because it allows for the automatic randomisation of choice sets that each respondent sees. This is very important and reduces the burden associated with the randomisation of choice sets in pen and paper surveys[16] as well as decreases the likelihood of error in relation to manual randomisation of Stated Choice Sets.

Another advantage of internet based surveys to the survey practitioner is getting a better understanding of respondent behaviour. Internet based surveys can supply metadata in

[16] Numerous forms of the same survey need to be printed to incorporate all the randomization of choice set possibilities. This consumes a lot of precious resources, adding to survey costs.

addition to the responses given to the survey questions; a reconstruction of the response process (Bosnjak and Tuten, 2001). However, in order to obtain the complete log for each individual, each question needs to be displayed separately, and each page of the questionnaire must be downloaded separately from the server and not reside in the Web browser's cache (Bosnjak and Tuten, 2001). This area requires further investigation, especially in relation to internet travel surveys; not much is known about respondent behaviour to internet travel surveys.

An advantage of electronic surveys from the respondent's perspective, over traditional survey modes, is that they can be completed at the respondents' discretion, they can be visually pleasing and easy to complete (Cook *et al*., 2000). Respondent burden is reduced because respondents are not required to physically return anything; they do not have to send anything through the mail. This may be especially appealing to busy people who simply do not have extra time to do this and would actually perceive this as a chore. For example, reasons stated by respondents, for completing a travel survey over the internet, were:

1. More convenient and saves time;
2. Easier;
3. Faster way to respond;
4. Less expensive;
5. Postal service not secure;
6. More user friendly over the internet[17]; and
7. Quicker and easier over the internet (Adler and Rimmer, 2002).

9. Disadvantages

Coverage bias is major disadvantage of web based surveys (Cook *et al*., 2000; Dillman and Bowker, 1998). Interestingly, however, one paper claimed that e-mail and internet surveys provide access to a wide audience (Illieva *et al*., 2002). This may be so if the survey is not of the general population. Also stated in this paper was that researchers have less control over who accesses the survey than for mail surveys (Illieva *et al.*, 2002). This is not necessarily so; the method of recruitment employed, and the type of internet survey used are the determining factors. For example, if respondents are contacted through e-mail and the URL is embedded in this message, then researchers have control over who enters the survey.

Technological problems are also a major disadvantage associated with web based surveys (Thompson *et al*., 2003; Couper, 2000). Server disruptions can occur without the researcher's knowledge. This leads to a loss in online survey time and results in many avoidable survey terminations. In addition, technological problems can be exacerbated if complex survey designs are employed; surveys may appear differently in different browsers. The different appearance of the survey may distract from the respondent's cognitive ability. This may increase the likelihood of measurement error if only the internet survey mode is used because people with different levels of computer literacy may answer questions differently. Also, technological problems may compound measurement error if more than one survey mode is used. This is so because if a combination of self administered survey modes and interview aided survey modes are

[17] This was a sample familiar with the internet.

used for the same survey, a complex survey design will most likely lead to incorrect and missing information coming from the self administered survey modes.

Complex internet surveys, coupled with technological limitations (e.g., old personal computers, incompatible browsers, etc.) can make it either impossible for the respondent to download the survey. In addition, it may take a copious amount of time to download the survey that the respondent closes the survey before the download is complete (Dillman and Bowker, 1999; Gunn, 2002). The likely outcome is a biased sample because of the high number of internet survey terminations. In addition, internet surveys with complex skip patterns need to be vigorously tested to ensure that skip patterns are behaving as required and that data entry is occurring correctly (Schonlau *et al*., 2001).

Table 3 depicts the some of the advantages and disadvantages of web based surveys in relation to mail surveys.

Table 3: Comparison of mail, fax and web-based surveys

	Mail	**Web-based**
Coverage	high	low
Speed	low	high
Return Cost	preaddressed/pre-stamped envelope	no cost to the respondent
Incentives	Cash/non-cash incentives can be included	coupons may be included*
Wrong addresses	low	high
Labour needed	high	low
Expertise to construct	low	high
Variable cost to each survey	about $1.00	no cost (U.S.)

** Cash incentives[18] may be offered to participants during the recruitment phase if mail or CATI recruitment is employed (pre-incentive).*

Source: Adapted from Cobanolgu *et al*., 2001.

A fax survey mode is not recommended due to the difficulties that may be encountered during recruitment and retrieval stages of the survey; similar to problems faced by telephone surveys in the present survey environment.

[18] In a Non-Response Study, conducted by ITS, cash incentives were found to be the most preferred by respondents; hence, likely to be the most effective in boosting response rates.

Table 4 shows examples of costs associated with mail and web based surveys.

Table 4: Summary of Costs

Method	Fixed Cost	Unit Cost	Quantity	Variable Cost	Total Cost
Mail	$67.50	$1.93	100	$193.00	$260.50
Web	$107.50	$0.00	100	$0.00	$107.50
Total	$242.50	$2.45	300	$245.00	$487.50

Source: Cobanolgu *et al*., 2001.

Table 4 shows that the fixed costs for web based surveys are much higher than for mail surveys due to the level of expertise and time required to develop the web based surveys (Schonlau *et al*., 2001). If a small sample is required, internet surveys are likely to be more expensive than traditional survey modes due to high fixed costs associated with programming the survey. To some extent, this fixed cost can be reduced by using templates, that incorporate design principles for web based surveys, or highly reusable software. For example, ITS uses a system where the survey components can be specified from an XML file. This means that a web survey can be constructed by a person of only moderate technical competence, in a reasonably short period of time. Any additional capabilities that need to be programmed into the system can be reused in future surveys: they do not need to be programmed again. Additionally, reusable software is more reliable and so requires less testing, which further reduces fixed costs. At ITS, a high fixed cost for the first web survey led to significantly lower subsequent fixed costs. Also, variable costs are negligible for web based surveys compared to the variable costs for mail surveys. In the end, total costs for web based surveys are much less than for mail surveys.

From the perspective of respondents, a major disadvantage of web based surveys relates to anonymity and data security, despite that the personalisation of contact was sometimes favoured by respondents (Woong Yun and Trumbo, 2000; Thompson *et al*., 2003; Illieva *et al.*, 2002). This is also a concern of survey practitioners because data recorded should not be tampered with or seen by external sources. Placing the survey on a secure server should alleviate security problems. For e-mail surveys, the issue of anonymity cannot be addressed, other than stating to respondents that the collective response is what will be analysed and that the individual response will not be identified. In addition, the use of e-mail surveys in relation to travel behaviour research is not likely due to problems associated with recruitment and the fact that attachments housing the travel survey are likely to be of a size that recreational internet connections are unable to cope with. Furthermore, embedding the travel survey into the e-mail is unlikely because of the limited tools available in e-mail.

10. Design Considerations

In the early days of web surveys, design traditionally focused more on programming than survey methodology. Nowadays, navigation and flow are realised as important elements in the design of web based surveys because of the visual stimulus and the fact that respondents have control over the comprehension of questions read; good survey

design is therefore crucial, as it is for all self administered surveys[19]. There are a myriad of ways to develop and structure web based surveys due to colour, fonts and styles, etc. However, fancy web surveys usually require a longer time to download and may accentuate browser incompatibilities (Gunn, 2002; Dillman *et al.*, 1998). Plain web surveys give a better response rate than those with a fancy design and structure (Dillman *et al.*, 1998). In addition, fancy design may distract the respondent from the survey task; cognitive research has found that surveys with complex skip patterns confuse the respondent if questions are not numbered appropriately because respondents believe they are to answer every question (Couper *et al.*, 2001; Gunn, 2002). For example, in a multi-modal survey, the mail survey cannot have a "hidden" complex skip pattern. This contributes to the increased likelihood of measurement error.

Longer questionnaires are associated with lower response rates and take longer to download; people get annoyed with this and close before the download is complete (Gunn, 2002). The results of a Non-Response Study conducted by ITS, showed that shorter surveys, requiring less time to complete (under 20 minutes), were preferred by respondents; it is important to keep the questionnaire brief and concise, and to break the survey into sections, if required. For example, another internet survey devised by ITS to understand household evacuation behaviour during an urban bushfire emergency, was divided into three sections. The first asked about household demographics. This is not typical; however, given that no income related questions were asked (most often the questions causing households to terminate or refuse), demographic questions were asked first to ease respondents into the survey. The second section related to the respondents' most recent bushfire experience, and the third section was the Stated Choice experiment.

Before beginning to design the survey, the researcher must be aware of the research environment at the time that the survey is to be conducted, the population to be surveyed (this should be well planned and described in the research methodology stage), and technological limitations associated with internet surveys (Schonlau *et al.*, 2001). This will help in the development of a good survey instrument, regardless of the data collection mode to be used[20].

According to Dillman *et al.* (1998), there are three criteria associated with good web survey design:

1. Web survey design should consider technological and user limitations;
2. Logic of how computers operate and how people expect surveys to operate must be considered; and
3. Web surveys should be designed to enable their incorporation in a mixed mode survey.

With this in mind, the successful implementation of web based surveys involves three crucial steps:

1. Design the survey on paper – This is essential if the survey is to be used as part of a mixed mode survey; other survey modes will be adapted from the pen and

[19] Design is also important for face to face and CATI interviews; however, the interviewer can help the respondent through the questions, whereas for mail and internet surveys, interviewers are not available.
[20] This is most useful when adopting a mixed mode survey strategy.

paper survey. This will help minimise measurement error. Both internet surveys, undertaken by ITS, were designed on paper first. One of these was offered as an internet survey only; from focus groups, conducted prior to commencement of the survey, it was discovered that households would prefer to respond to the survey over the internet[21]. The other, a Non-Response Survey, was part of a mixed mode survey;

2. The survey methodology should be pre-determined, and
3. The survey should be carefully transformed from its pen and paper status to the web. The survey must be error proof, and should be accessible from all browsers to reduce respondent burden and download time (Lazar and Preece, 1999). This reinforces the need to adopt a simple survey design.

10.1 Design Principles

The following are design principles specifically for web-based surveys. These principles may also be applied to the design of other mode type surveys, with slight modification.

Firstly, an introduction to the web survey should be welcoming, motivational, convey the ease of responding, state who is commissioning the study and instruct the respondent how to proceed (Dillman, *et al*., 1998; Lazar and Preece, 1999). Figure 2 and 3 show the introduction and welcoming screens of the Bushfire Survey, conducted by ITS.

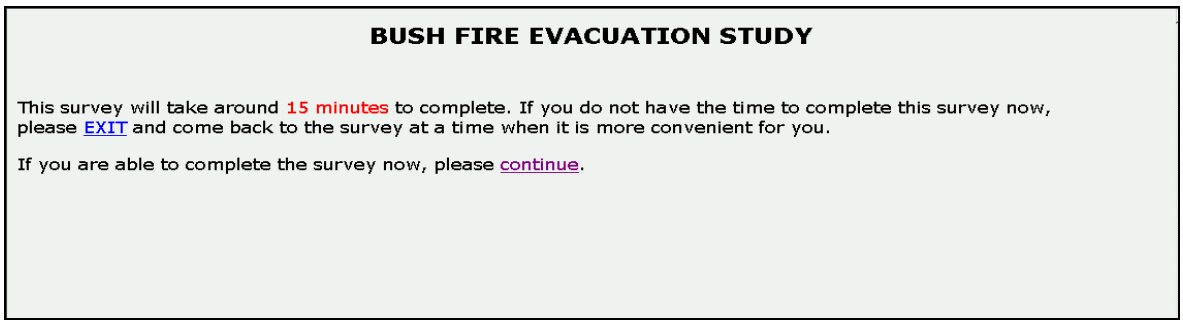

Figure 2: Introduction Screen for the Bushfire Study

[21] Households lived in relatively remote locations around metropolitan Sydney, Australia; respondents associated mail back survey with a heavy burden.

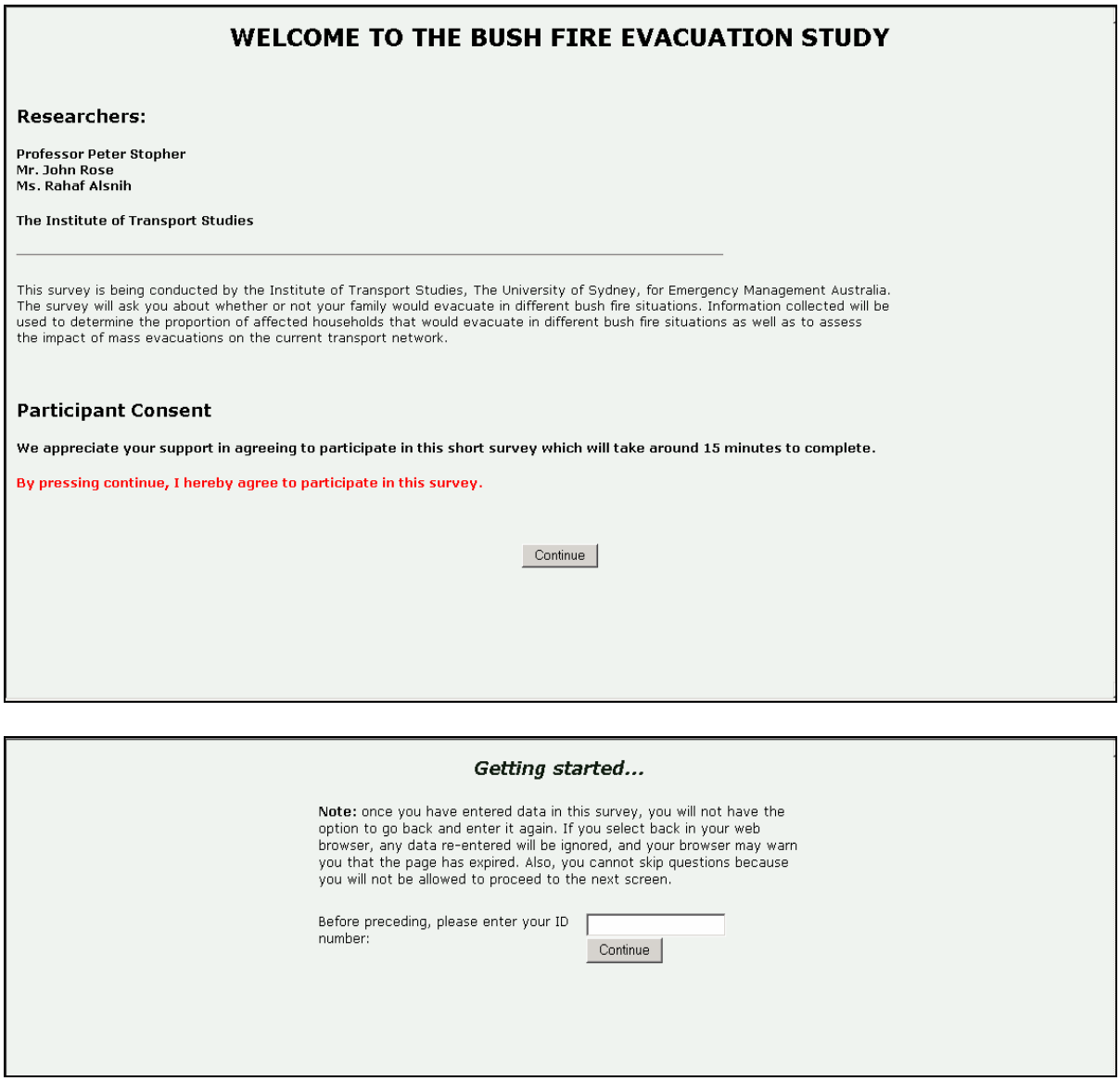

Figure 3: Welcome Screen to the Bushfire Survey

From Figures 2 and 3, it can be seen that the time it takes to complete the survey is clearly stated, who is commissioning the research as well as the researchers undertaking the study are clearly identified. A key feature was that respondents were informed of the time it will take to do the survey before they actually entered the survey. This enabled the respondent to close the survey if they did not have the time to complete the survey at that moment. This helped ease respondent frustration and reduce avoidable terminations.

The second design principle relates to the layout of web-based surveys. The first question of the survey should be clearly visible on the first screen of the actual survey. It should also be easily understood and this may be achieved by limiting the line and question length so as not to distract respondents' attention from the question; hence, distract from the flow process of the survey (Dillman *et al*., 1998).

Thirdly, instructions to navigate through the survey should be clear and shown throughout the survey, and should be placed before the proceeding question or section is shown.

Fourthly, depending on the research, the survey and target population, respondents may not have to answer every question to progress through the survey. This may be achieved through the use of scroll down screen surveys (Dillman *et al*., 1998). However, allowing respondents to view all the questions may lead to respondents believing that the survey will take them longer than specified and this may result in avoidable terminations. In addition, when scroll down surveys are used, it cannot be determined if a respondent opens the survey and decides not to complete it or whether the respondent has completed all the survey but forgot to send it (Couper *et al*., 2001; Bosnjak and Tuten, 2001).

If question order and logical progression are features of the survey, then every question will have to be answered; therefore, scroll down screen surveys cannot be used. Question length and wording become even more important because the respondent's level of comprehension must be maintained to enable high quality data to be obtained, given the increased level of respondent burden.

Both internet surveys, designed by the Institute of Transport Studies, were not scroll down screen surveys because both incorporated a Stated Choice Experiment. Given that respondents could not scroll down to view the entire survey, for flow and logical reasons, the survey was programmed to allow respondents, who chose to exit the survey before completing the stated choice task, to re-enter the survey. They were directed to the beginning of the scenario sequence[22] that they previously did not complete, to rekindle the logical thought process. This extra programming helped decrease respondent burden because respondents did not have to re-enter previously entered information. This also reinforced the password protection ability because previously entered data could not be changed.

Fifthly, caution should be adopted when using multiple response questions and data entry boxes. This is so because respondents may choose the first few categories for convenience, resulting in a primacy bias (Dillman *et al*., 1998). In addition, check boxes (those required for multiple response questions) are different to radio buttons and this may lead to measurement error within the survey[23] (Dillman *et al*., 1998; Gunn, 2002). However, in the future, randomisation of multiple response entry boxes can be programmed to counteract the primacy bias problem.

Data entry boxes should be used sparingly to reduce respondent burden. For example, respondents who completed the bushfire survey actually enjoyed participating because the survey did not take much of their time to complete (around 12 minutes), the

[22] For the bushfire survey, a series of scenario sequences were presented whereby the first of these described a fire at a distance of kilometres away from the respondent's home, the next described the fire at a distance of hundreds of metres away from the respondent's home, and the last scenario in the sequence described the fire at a distance of tens of metres away from the respondent's home.

[23] According to Couper *et al.* (2001), there is no significant difference in the time required to complete a survey with regard to radio button format or short or long entry box format. However, more research is required in this area.

questions were straight forward[24] and the survey did not require much data entry at all (minimum use of entry boxes).

Lastly, the word "Finally", should be shown at the beginning of the last section of the survey to inform respondents that they have almost completed the survey. The use of program indicators can actually increase download times; however, indicating to respondents where they are up to is preferred by respondents. By simply showing the question the respondents are up to, will address this problem, i.e. q12 of 26 (Gunn, 2002).

Importantly, before the study is undertaken, a pilot test should be conducted to assess the survey's appearance, flow, design, and respondents' comprehension of the questions asked. This will enable any revision of the survey instrument to be made before the main survey is due to commence.

11. Recruitment and Repeated Contacts for Web Based Surveys

Interaction with the respondent can be classified as three distinct phases: contact, response and follow-up. Each of these phases may be conducted using a different medium; telephone, mail, web or face to face (Schonlau *et al*., 2001). For initial contact, this should not be by e-mail because it is not known how often people check or if people access their e-mail regularly (Bradley, 1999). For surveys of the general population, this will add to the coverage bias problem encountered by internet surveys in the present survey environment. In addition, it may be best to use a number of recruitment modes in order to achieve a higher contact rate.

Past research has indicated that increasing the number of contacts will result in higher response rates: it was found that the number of contacts increased response rates regardless of the survey mode(s) used (Dillman and Bowker, 1999). Pre-notification (as for traditional mail out and telephone surveys), simple survey design, personalised cover letters and follow up reminders have been shown to increase response rates to web based surveys (Cook *et al*., 2000). For example, pre-notification of an online survey resulted in a faster response time (Cook *et al.*, 2000). This usually relates to higher response rates and data of better quality (Richardson, 2000). Response time to web based surveys can also be controlled by the researcher to a certain degree, by informing respondents that the survey will remain online for a limited time (Illieva *et al*., 2002). ITS adopted this approach for two of its recent internet based surveys; when respondents were recruited, they were informed of the online availability of the survey.

A cover letter should be sent out before the main data collection period begins. Cover letters legitimise the study in the minds of respondents, given that the research agency undertaking the study is clearly shown, and respondents are provided with a number to contact to voice any concerns or questions. In addition, confidentiality assurances must

[24] Focus groups allowed for the development of terminology used by respondents and this helped the respondents comprehend the survey questions.

also be stated in cover letters and this further enhances the study's legitimacy from the perspective of the respondent; confidentiality assurances given "in writing".

For respondents with internet access, an e-mail contact with an embedded URL adds the personal approach and this improves response[25] (Dillman, 1978; Dillman, 2000); research has found that personalised letters sent to respondents, informing them about the survey, increases response rates and also ensures that the right (target) respondent will respond to the survey (Illieva *et al*., 2002). For example, respondents to the bushfire survey were initially contacted by telephone (recruited), and e-mail addresses were obtained during this conversation allowing for the URL and password[26] of the survey to be sent to the respondents through e-mail. Given that no incentives were offered, and that respondents could only respond over the internet, the response rate was relatively high. It may have been even higher had technical problems with the server, on which the survey was located, not arise. This prevented a number of respondents from accessing the survey and, because of their frustration and lack of knowledge about the actual problem, these respondents did not re-attempt to access the survey.

This emphasises the importance of the use of multi-modal surveys in surveys of the general population, especially when one of the modes offered is the internet, despite that the above example was not a study of the general population. In addition, it is important to give people the option to choose how to respond. For example, one of the results of the Non-Response Study, conducted by ITS, was that people prefer to be given the option of how to respond. They appreciate this and therefore, this is more likely to improve response rates and yield data of better quality.

12. Review of a Recent Internet Travel Survey

Currently internet travel surveys are not really user friendly for novice computer users (Adler and Rimmer, 2002). In addition, principles of survey design let alone principles of web survey design have not been applied; the appearance of web based travel surveys is cluttered, giving the impression of a burden riddled survey which is more likely to contribute to the problem of non-response (see Adler and Rimmer, 2002, for an example of such an internet travel survey). In the study conducted by Adler and Rimmer (2002), it was interesting that none of the respondents encountered any browser problems. In contrast, problems were encountered by some of the respondents to an internet survey conducted by ITS. Some respondents could not access the survey due to browser incompatibilities. This further demonstrates the coverage problem with internet surveys in the present survey environment.

Adler and Rimmer (2002) designed web based survey templates for household travel diary surveys, travel origin/destination surveys, travel mode choice surveys and transit customer satisfaction surveys. These incorporated the following components:

[25] Two conflicting arguments: personalisation is the reason why response rate to e-mail surveys is higher yet anonymity is considered a problem for e-mail surveys (Illieva *et al*., 2002). This really depends on the research topic, the research environment and who is conducting the research.

[26] The use of passwords may add to the novelty factor and may also entice a feeling of importance in the respondents' minds. This may also lead to higher response rates. This type of respondent behaviour is termed as reciprocity (Kalfs and vanEvert, 2003).

- The flow and design developed was to exploit the capabilities of the web; it was not adapted from paper or CATI design. This contradicts web survey design principles developed by Dillman *et al*, (2002), Dillman *et al*., (1998) and Gunn (2002);
- Detailed survey based logic and consistency checks;
- Respondent interactive geocoding. This adds to respondent burden and assumes that people are able to read maps without difficulty. Again, this poses problems if the sample is drawn from the general population;
- Detailed instructions/help;
- Mutli-lingual instrument options; and
- Web-based administration tools to help facilitate web based survey administration processes.

The internet travel survey templates seem very useful. In reality, the application of these templates is not going to produce good travel data, because they do not account for the problems associated with internet travel surveys in the present survey environment. However, not all templates are useless. The use of re-usable software, given that the survey from which this was based adopts the web survey design principles discussed, can provide numerous benefits such as time and cost savings as well as the development of further programming skills.

In the study conducted by Adler and Rimmer (2002), in relation to the internet household travel survey, respondents were asked to provide a unique identifier (first name or initials) for each member of the household. This may add to respondents' privacy concerns. It is better to provide households with an identification number and each household member with a unique person number. This would also address the proxy problem. For example, internet surveys with password protection, whereby respondents are allocated a unique identifier can only enter the survey once. This creates a problem because proxy reporters cannot re-access the survey, if only one household identification number is allocated. By providing each household member with a unique identifier, there no longer is a problem of survey accessibility. However, this may result in more proxy reporting than that desired. This is a problematic issue for other data collection modes also.

13. Issues for the Future

Travel surveys are complex instruments and traditionally contain the following:

1. A household form – this obtains demographic information about the household;
2. A vehicle form – this obtains household vehicle information; and
3. Travel Diaries (most now are activity based) – this obtains travel and activity information undertaken by each household member on an allocated day.

Obtaining all this information over the internet is likely to lead to a relatively long survey task. This will create problems for people with limited download and time access to the internet. In addition, anecdotal evidence suggests that respondents choosing to

respond over the internet have shorter attention spans[27] (Schonlau *et al*., 2001). If this is true, this has great implications for internet travel surveys. People with shorter attention spans are therefore less likely to complete the survey. However, more research is required to confirm or deny this.

The present survey environment limits the use of internet surveys, for studies of the general population, due to problems with population coverage and the fact that internet user ability, and the type of internet access respondents with access to the internet have, is unknown. Given these obstacles, internet travel surveys should be part of mixed mode travel surveys. The internet mode may be useful to capture traditional non-respondent groups to travel surveys, such as the households which are difficult to contact. Traditional survey modes, such as mail and telephone, will capture other respondent groups better than the internet option at this stage. In addition, the use of multi-modal surveys will provide respondents with a choice as to how they would like to respond and this should increase response rates; a low response rate is a common problem encountered by most travel surveys.

In the future, people may become tired of internet surveys due to the overuse of this medium for marketing purposes. It again, may become difficult to obtain a high response rate to internet travel surveys despite a reduction in the coverage problem in the future. Before this arises, it would be useful to gain an understanding about internet respondent behaviour. Bosnjak and Tuten (2001) have identified seven distinct response behaviors in web based surveys. These are:

1. Complete responders- view and answer all questions,
2. Unit non-responders- do not participate in the survey. There are two types of non-responder, the technically hindered from participating or the respondent who purposely withdraws,
3. Answering drop-outs: recruited participants who provide answers to questions but drop out before completion,
4. Lurkers- recruited participants who view all of the questions but do not answer any questions,
5. Lurking drop-outs- recruited participants who represent a combination of answering drop outs and lurkers,
6. Item non-responders- recruited participants who view all of the survey but only answer some of the questions, and
7. Item non-responding drop-outs- recruited participants who are a mixture of answering drop-outs and item non-responders.

There is a need to investigate internet respondent behaviour, and to identify if any particular socioeconomic group behaves in a particular manner when responding to surveys over the internet. This knowledge would enable the development of a better web survey instrument, especially in relation to internet travel surveys. In addition, Bradley (1999) found that internet surveys released at a particular time of day may result in a certain sample profile. However, research is required to confirm or deny this finding, especially in relation to travel surveys.

[27] How “short” these attentions spans are, is not known.

Web based travel surveys are useful but much work is still needed to improve the paper instrument let alone the internet instrument. Internet versions of travel surveys may also require accompanying compact disks, housing maps and other relevant information, to participating households to avoid browser and downloading problems. The effect of this on overall response is not known.

It is also unknown what the effects of panel conditioning are in relation to web panel surveys (Couper, 2000), nor are we familiar with the effects of monetary incentives on non-response rates in relation to web surveys. Overall, much research and development is still required in relation to internet surveys, and especially internet travel surveys.

Acknowledgements

I would like to thank Mr Andrew Collins, a Research Analyst, at the Institute of Transport Studies, for his comments on an earlier draft of this paper.

References

Adler, T., and Rimmer, L. 2002, "Documentation for SBIR Phase II Final Report: Computer-Based Intelligent Travel Survey System, DTRS57-00-C-10030", Prepared for the FHWA, Retrieved on 14/01/04, from http://www.fhwa.dot.gov/ohim/trb/sbir/sbir.htm

Alvarez, R.M. and VanBeselaere, C. 2003, "Web-Based Surveys", Retrieved on 20.02.04, from http://survey.caltech.edu/encyclopedia.pdf

Arentze, T., Hofman, F., and Timmermans, H. 2004, "Prediciting Multi-Faceted Activity-Travel Adjustment Strategies in Response to Possible Congestion Pricing Scenarios Using an Internet-Based Stated Adaptation Experiment", *Transport Policy*, Vol.11, No. 1, pp31-41.

Bosnjak, M. and Tuten, T.L., 2001, "Classifying Response Behaviors in Web-Based Surveys", *Journal of Computer-Mediated Communication*, Volume 6, No. 3, Retrieved on 22/01/01, from www.ascusc.org/jcmc/vol6/issue3/boznjak.html

Bradley, N., 1999, "Sampling for Internet Surveys; An Examination of respondent selection for internet research", *International Journal of Market Research*, Vol. 41., No. 4, pp. 387-395.

Cobanoglu, C., Warde, B, and Moreo, P.J., 2001, "A Comparison of Mail, Fax and Web-Based Survey Methods", *International Journal of Market Research*, Vol. 43, No. 4, pp 441-452.

Cook, C., Heath, F., Thompson, R.L. 2000, "A Meta-Analysis of Response Rates in Web-or Internet Based Surveys", *Educational and Psychological Measurement*, Volume 60, pp 821-836.

Couper, M.P., Traugott, M.W., and Lamias, M.J. 2001, "Web Survey Design and Administration", *Public Opinion Quarterly*, Vol. 65, No. 2, pp 230-253.

Couper, M.P., 2000, "Web Surveys: A Review of Issues and Approaches", *Public Opinion Quarterly*, Vol. 64, No. 4, pp464-494.

De Heer, W.F. and Moritz, G. 1997, "*Data Quality Problems in Travel Surveys, An International Overview*", Workshop on Respondent Issues: Sampling, Weighting, *and Non-response*, Transportation Research Board Transportation Research Circular E-C008: Transport Surveys: Raising the Standard.

Dillman, D.A., Phelps, G., Tortora, R., Swift, K., Kohrell, J., and Berck, J. 2001, *"Response Rate and Measurement Differences in Mixed Mode Surveys; Using Mail, Telephone, Interactive Voice Response and the Internet", Research Papers*, Retrieved on 5/11/02, from http://survey.sesrc.wsu.edu/dillman/papers.htm.

Dillman, D.A., and Bowker, D.K, 1999, "The Web Questionnaire Challenge to Survey Methodologists", Retrieved on 5/12/03, from http://survey.sesrc.wsu.edu/dillman/papers.htm

Dillman, D.A., Tortora, R.D., and Bowker, D. 1998, "Principles for Conducting Web Surveys", Retrieved on 5/12/03, from http://survey.sesrc.wsu.edu/dillman/papers.htm

Dillman, D.A. 2000 (2nd ed), "*Mail and Internet Surveys: The Tailored Design Method*", John Wiley New York.

Dillman, D.A. 1998, "Mail and Other Self-Administered Surveys in the 21st Century: The Beginning of a New Era", Retrieved on 5/12/03, from http://survey.sesrc.wsu.edu/dillman/papers.htm

Dillman, D.A. 1978, "*Mail and Telephone Surveys: The Total Design Method*", Wiley, New York

Etterna, D, Timmermans, H., and van Veghel, L. 1996, "Effects of Data Collection Methods in Travel and Activity Research", European Institute of Retailing and Services Studies Report, Retrieved: 22 January, 2003, from www.bwk.tue.nl/urb/eirass/report.htm

Groves, R.M., and Couper, M.P. 1998, *Non-response in Household Interview Surveys*, John Wiley and Sons, INC.

Gunn, H., 2002, "Web-based Surveys: Changing the Survey Process", Retrieved 5th December, 2003, from http://www.firstmonday.dk/issues/issue7_12/gunn/

Illieva, J., Baron, S., and Healey, N.M., 2002, "Online Surveys in Marketing Research: Pros and Cons", *International Journal of Market Research*, Vol.44, No. 3, pp. 361-382.

Kalfs, N. and van Evert, H. (2003), "Non-Response and Travel Surveys" in *Transport Survey Quality and Innovation*, (eds) Stopher, P.R. and P.M. Jones.

Kam, H.B. and Morris, J. 1999, "Response Patterns in Travel Surveys: The VATS Experience", Retrieved: 10th February, 2003, from www.trc.rmit.edu.au/Publications/Papers/responsepatterns.pdf

Lazar, J. and Preece, J. 1999, "Designing and Implementing Web-Based Surveys", *The Journal of Computer Information Systems*, Vol. 39, No. 4, pp 63-67.

Melevin, P.T., Dillman, D.A., Baxter, R. and Lamiman, C.E. 1998, "*Personal Delivery of Mail Questionnaires for Household Surveys: A Test of Four Retrieval Methods*", Research Papers, Retrieved: 5th November, 2002, from http://survey.sesrc.wsu.edu/dillman/papers.htm

Miller, E.T., Neal, D.J, Roberts, L.J, Baer, J.S., Cressler, S.O., Metrik, J., and Marlatt, G.A. 2002, "Test-Test Reliability of Alcohol Measures: Is There a Difference Between Internet-Based Assessment and Traditional Methods?", *Psychology of Addictive Behaviors*, Vol. 16. No. 1, pp 56-63.

Myles, R. and Tibert, J., 1998, "Internet Surveys: Do They Work?", *Institute for Social Research Newsletter*, Winter, Vol.13, No. 1, Retrieved on 5/12/03, from http://www.math.yorku.ca/ISR/newsletter/internet_surveys.htm.

Richardson, A.J. 2000, "*Behavioral Mechanisms of Non-Response in Mailback Travel Surveys*", Paper Presented at 79th Annual Meeting, Transportation Research Board, Paper No. P00-2551.

Schaefer, D.R. and Dillman, D.A. 1998, "Development of a Standard E-Mail Methodology: Results of an Experiment", Retrieved on 5/12/03, from http://survey.sesrc.wsu.edu/dillman/papers.htm

Schneider, K.C. and Johnson, J.C. 1994, "Link Between Response-Inducing Strategies and Uninformed Response", *Marketing Intelligence and Planning*, Volume 12, No. 1. pp29-36.

Schonlau, M., Fricker Jr., R.D. and Elliot, M.N., 2001, "Conducting Research Surveys via E-mail and the Web", Retrieved on 29/01/04, from http://www.rand.org/publications/MR/MR1480/

Thompson, L.F., Surface, E.A., Martin, D.L., and Sanders, M.G., 2003, "From Paper to Pixels: Moving Personnel Surveys to the Web", *Personnel Psychology*, Vol. 56, No. 1, pp 197-227.

Woong Yun, G., and Trumbo, C.W., 2000, "Comparative Response to a Survey Executed by Post, E-mail and Web Form", Retrieved on 14/01/04, from http://www.ascusc.org/jcmc/vol16/issue1/yun.html

Zmud, J. 2003, "Designing Instruments to Improve Response", in *Transport Survey Quality and Innovation*, (eds) Stopher, P.R. and P.M. Jones.