





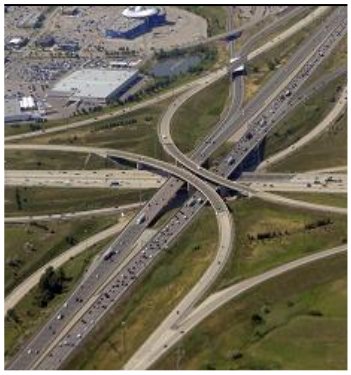

transportationtomorrow SURVEY 2016

TTS 2016 CHALLENGES AND LESSONS LEARNED

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ABBREVIATIONS

TAC – Technical Advisory Committee
TISC – Transportation Information Steering Committee
TTS – Transportation Tomorrow Survey
TTC – Toronto Transit Commission
GTHA – Greater Toronto and Hamilton Area
GGH – Greater Golden Horseshoe
DMG – Data Management Group, University of Toronto

Executive Summary

The 2016 Transportation Tomorrow Survey (TTS) was conducted in the fall of 2016 with over 162,700 households in the Greater Golden Horseshoe Area (GGHA). The TTS is a 24-hour recall household travel survey that has been conducted every five years since 1986. The 2016 TTS, the seventh cycle, was conducted on behalf of the various partner agencies and the Ministry of Transportation of Ontario (MTO) by independent research firm R.A. Malatest & Associates Ltd., with support and input from the University of Toronto's Data Management Group (DMG).

The 2016 TTS was marked by a number of key methodological changes. These changes included the move from landline telephone-based sampling to address-based sampling (to address the decline in the representativeness of landline-based samples, particularly amongst younger populations), as well as the move to completing a large proportion (64%) of the surveys online (compared to less than 12% in the 2011 cycle). In order to complete online surveys in both languages, a separate online data collection platform was implemented to be operated in parallel with the Direct Data Entry (DDE) telephone survey platform developed by the DMG for use in previous cycles. The surveys were administered in a single fall season, whereas recent previous cycles required two fall seasons to complete the required number of surveys. Conducting a household travel survey of this scale within a very short timeline (four months from project award start of full survey administration, and just over three months for to complete all surveys) was a complex logistical exercise. The conduct of the survey entailed ongoing collaboration with a steering committee over aspects of the research design, the set up of a call centre, development of survey tools, staffing large complements of survey/geocoding/data review staff, and considerable post-processing and data management, all while adhering as closely as possible to past processes, some of which had not been fully documented in previous survey cycles.

This report is intended to provide a broad view of challenges encountered and lessons learned in the administration of the 2016 TTS. Full details of the survey design, data, and data processing can be found in separate reports:

- the *Design and Conduct of the Survey* report documents aspects of the survey planning, conduct of the survey, and the results of survey administration;
- the *Data Expansion and Validation* report outlines the data weighting methods, with comparison to reference figures to assess the representativeness of the collected data;
- the *Data Guide* documents the survey data file, including details of the changes to survey data elements across different survey cycles, and top-line frequencies from selected cycles including the 2016 cycle; and
- a series of nine travel summary reports presents key household, demographic, and trip characteristics (for 24-hour and AM-peak trips) from the survey, aggregated for different levels of geography within the study area.

The current report is a companion document that is meant to provide a somewhat more qualitative and analytical discussion of challenges and lessons learned that goes beyond the factual accounting of processes and results presented in the other methodological reports. This report includes Malatest's observations, interpretations and recommendations.

Some of the key recommendations, which are presented in more detail in SECTION 4 of this report, include:

- Allow for additional time for front-end activities, pilot testing, and to develop the work flow processes and methodologies required to manage such a large survey.
- Allow for additional time for back-end activities and exploring the results with the committee
- Expand the trip definition to include walking trips (not just those made to and from work or school)
- If possible, use a single integrated CATI/CAWI platform.
- If data collection systems are to be provided to the data collection contractor for use, they should be adequately supported by useful documentation and technical staff resources.
- GIS files for the traffic zone and planning district boundaries should be refined well prior to the next cycle, and should match municipal and Statistics Canada boundaries where possible.
- For online surveys, use of Google Maps may be desirable, but some further work may be required to verify that traffic zones developed from the Land Information Ontario base jive well with the Google Maps results.
- General sampling targets and sampling methods should be determined well in advance of data collection.
- Address-based sampling is recommended to reach all types of household.
- The mix of address-only and address-and-phone samples should be considered carefully, and differentially balanced by geography according to their natural incidence.
- The target of a 5% sample may need to be reconsidered in light of the greater spread of weights required to address non-response bias in the data.
- Staff recruitment and retention should be an important focus in planning for data collection.
- The survey invitation letter should once again be printed on the letterhead of the Minister's office, and again with the logos of project partners.
- Plan for an even greater proportion of surveys being completed online in future studies. Future studies may consider re-allocating call centre resources to the online survey to meet demand.
- Pilot testing at an equivalent time of year (i.e., not the height of summer) would provide a better sense of responses rates to expect.
- Budget sufficient time and resources to support online data collection by: identifying and addressing causes of abandonment; supporting phone and emailed requests for assistance; phone follow-up on partial surveys; improvements to online tools.
- Develop templates for common questions and complaints from respondents.
- Requirements for the detailed processing and validation should be identified and detailed prior to survey administration.
- Develop a team with appropriate knowledge and abilities for review and correction of the more complex transit cases, and secure appropriate resources from key transit agencies to provide training and support quality control.
- Undertake multivariate data weighting that can address the household and demographic biases in the sample, but consider refining the methods (e.g., lower limits on extreme weights).
- When making historical comparisons, rely on longer-range comparisons (e.g. vs. 15 years ago), as trends may be difficult to separate from the effects of different biases in the data for short-range comparisons (e.g. vs. the last cycle).

- Allow for sufficient budget and time for preliminary analysis of both unweighted and weighted data so that the impacts of the chosen sampling and surveying methodologies can be better understood by the committee.

The remainder of this report is divided into the following sections:

SECTION 1: Changes implemented for the 2016 TTS
SECTION 2: Challenges
SECTION 3: Lessons Learned
SECTION 4: Summary of Key Recommendations

SECTION 1: Changes implemented for the 2016 TTS

The Transportation Tomorrow Survey (TTS) is a confidential and voluntary travel survey on how Ontarians in the Greater Toronto and Hamilton Area (GTHA) and Greater Golden Horseshoe (GGH) use the transportation system. The research helps local and regional governments, as well as the province and its agencies, make transportation planning and investment decisions. The 2016 TTS is one of the largest and most comprehensive travel surveys in North America, and the seventh in a series of surveys conducted every five years since 1986. The TTS collects three categories of information: household, person, and trip data.

In 2016, the TTS was awarded to Malatest, a Canadian market research firm that specializes in administering travel surveys. This marked the first cycle of the survey that was awarded to a private vendor since 1986. From 1991 until 2011, the survey was administered by the Data Management Group (DMG) of the University of Toronto.

In 2016, a more aggressive data collection schedule was implemented. By targeting 161,200 completions in a three-and-a-half month period, more than twice the number of completions per day were required than in any previous wave of the survey.

The following section outlines the changes Malatest made to the administration of the 2016 TTS in order to reach the target number of completions in the allotted time and provide data of the highest quality possible. Where possible, justification for these changes is provided.

In the discussion that follows, in the context of management of contact lists and survey administration activities, the term *'sample'* usually refers to the random sample of listings drawn from the contact list sources and to which survey invitations were extended. In the context of discussion of survey results, *'sample'* may refer to the set of households that completed the survey (and may be differentiated from the contact list sample by referring to it as the survey sample).

1.1 Sample Design

Previous cycles of the Transportation Tomorrow Survey had relied on the exclusive use of directly-listed (white pages) landline telephone sample, and all surveys were completed by telephone interview, except for a modest trial of online surveying in the 2011-12 data collection cycle. Further, for inclusion in the survey sample, the directory-listed sample required both a mailable address with postal code and a listed telephone number ('address-and-phone' sample). This approach yielded excellent results for many years during which most households had listed landline telephones, both in terms of high response rates and a representative sample.

However, over the past 15 years there has been a dramatic decline in the percentage of households with a listed landline and a substantial increase in the percentage of households relying exclusively on cell-phone service ('cell-phone-only' households). This is particularly true for households including only young adults and households in urban areas.

Two Statistics Canada surveys furnish statistics on the types of telephone services used by households in Canada: the *Residential Telephone Service Survey (RTSS)*, which ran from 2003 to 2013; and the *Survey of Household Spending (SHS)*, which has collected information on expenditures on telephone services from 2004 to 2016.

The available data on use of telephone services in Canada illustrate the dramatically declining trend in coverage of landline samples that would have had varying levels of impact on the different TTS over recent years. The trends are examined in the context of the 2001, 2006, 2011, and 2016 TTS below. Where available, data for Ontario are noted below; however, the publically available data releases do not always include Ontario data.

- TTS cycles for 2001 and earlier should not have been biased by reliance on landline samples. As of May 2003, only 1.9% of households in Canada (1.7% in Ontario) were cell-phone-only households, and only 1.2% of households in Canada had no telephone service at all.[1] This would suggest that approximately 97% of households would have had landlines, with the listed landlines providing excellent coverage of all types of household. The proportion was likely higher even when the survey was conducted in the fall of 2001 and May 2002.

- The 2006 TTS, conducted over the fall of 2006 and the fall of 2007, may have been somewhat affected by bias in the landline-based sampling. By the time of the 2006 TTS, the proportion of households with telephone landlines had declined to 90.5% in Canada, or 92.5% in Ontario.[2] While statistics by age group are not readily available specifically for 2006, the RTSS results reveal that by 2008, one third (34.4%) of households in Canada comprised solely of 18-34 year olds had only cell phones and no land line telephone, with the figure being slightly higher in Ontario, at 35.5%.[3] Following the trend backwards, in the area of one-fifth of younger households might have been excluded from the 2006 survey because they did not have a landline, suggesting that there may have been some bias in the results, assuming that people in cell-phone-only households had different household/family/employment/school characteristics and different travel characteristics compared to people of the same ages in households with landlines.

- The 2011 survey, conducted over the fall of 2011 and the fall of 2012, would have been subject to more pronounced sample coverage error associated with the use of landline samples, which would very likely have affected the representativeness of the survey sample. By 2010, the proportion of households in Canada with a traditional landline had declined to 67.0%, and, following the trend, by 2011, likely in the area of 63.3%. By this time, a number of households without a traditional landline would have converted to non-traditional 'wirelines', such as VOIP (voice over Internet protocol) and cable-based telephone services, with the total proportion of households with landlines/wirelines being in the area of 86.6%. While some non-traditional telephone services may get listed in the white pages directory, others may not be, so it is

[1] *Statistics Canada Residential Telephone Service Survey (RTSS), December 2005 data release (http://www.statcan.gc.ca/daily-quotidien/060405/dq060405b-eng.htm).*
[2] *Statistics Canada Residential Telephone Service Survey (RTSS), December 2006 data release (http://www.statcan.gc.ca/daily-quotidien/070504/dq070504a-eng.htm).*
[3] *Statistics Canada Residential Telephone Service Survey (RTSS), December 2008 data release (http://www.statcan.gc.ca/daily-quotidien/090615/t090615c1-eng.htm)*

difficult to estimate the coverage of directory-listed phone numbers (except to say that it would have likely been somewhere between, say, 65% and 80%).

Most concerning, by 2010, fully one-half (50.0%) of all Canadian households in the 18 to 34 year bracket relied exclusively on cell phones,[4] and, following the trend, 53.5% by 2011. Bias in the data was notably evident in the TTS samples collected for certain geographies with higher concentrations of younger, smaller, and frequent-move households, such as downtown Toronto. While data weighting by age group was introduced for the first time in 2011 to correct for disproportionate representation by age group, bias associated with the limitations of the sampling frame likely would have remained even after data weighting, which in turn would have affected the representativeness of the results.

- In 2016, the potential impacts of reliance on telephone-based samples would have been more severe. The Survey of Household Spending reveals that 66.8% of households in 2016 had a landline/wireline, with this figure being lower for Ontario, at 63.4%.[5] Although it is not clear how many of the wirelines might be listed in telephone directories, other information available to Malatest on the number of listed landlines in the area suggested that somewhere between 45% and 55% of households in the TTS region would have had directory-listed phone numbers at the time of the 2016 survey. With respect to younger households, 2013 was the last year of the Residential Telephone Service Survey, which was a reliable source for reporting on cell phone reliance in younger households. The 2013 data from this survey revealed that 60.6% of 18-34 year old households in Canada were cell-phone only households. Projecting the trend to 2016 suggests that at the time of the 2016 TTS, in the area of 71% of younger households may have relied exclusively on cell phones.

Given this context, continued use of directory-listed telephone sample would have risked obtaining a very biased, unrepresentative sample of the population. In particular, the data would not have been representative for younger households, frequent-movers and for smaller non-family households in areas with high urban density more likely to rely on cell phones only. What would likely have been significant biases in the 2016 data would have affected the accuracy of reporting even after data weighting and, in turn, would have likely severely affected the comparability of the data from cycle to cycle.

Research, as well as previous experience, has shown that a hybrid sampling approach including both phone-and-address and address-only sample is the best way to maximize the representativeness of the final dataset. For this reason, after exploration of alternative sampling plans and survey methodology at the start of the project, the 2016 TTS adopted the option to use a hybrid sampling design, including address-only and phone-only samples to cover households that would not have been possible to sample under the previous paradigm, which only sampled address-and-phone households. Phone-only samples were also trialed as an alternate method of reaching cell-phone-only and unlisted-landline households. The adoption of hybrid sampling also necessitated an alternative to telephone interviewing for survey completion, as only a small proportion of address-only households might be expected to call in to complete the survey over the phone.

[4] *Statistics Canada Residential Telephone Service Survey (RTSS), December 2010 data release (http://www.statcan.gc.ca/daily-quotidien/110405/dq110405a-eng.htm).*
[5] *Statistics Canada Survey of Household Spending (https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=1110022801).*

The options for completing the survey varied by sample type:

- **Address-and-phone:** Received a notification letter. Households could complete the survey online, phone the Toronto call centre using a toll-free number, or wait until they receive a call to complete the survey over the phone.
- **Address-only:** Received a notification letter. Households could complete the survey online or phone the Toronto call centre using a toll-free number to complete the survey. They did not receive calls as there was no telephone number associated with their address.
- **Phone-only:** Did not receive a notification letter. Households were 'cold-called' by the Toronto call centre. Those who did not have time were offered the option to complete the survey online and provided their secure web access code and the study webpage URL.

Table 1-1 outlines the distribution of sample by source, the expected and actual response rate, and percentage of final completions for each sample type. As the contact sample of each type that was drawn was adjusted based on actual response rates achieved, fewer invitations were mailed than originally planned for, and as noted elsewhere, use of phone-only sample was discontinued after only a fifth of it had been utilized.

Table 1-1: Expected and actual distribution of sample and completions by sample type

Sample Type	Planned Percentage of Total Contact Sample	Expected Response Rate	Expected Percentage of Final Completions	Actual Percentage of Total Contact Sample	Actual Response Rate	Actual Percentage of Final Completions*
Address-and-phone	13.9%	43.5%	46.5%	22.3%	36.9%	50.7%
Address-only	86.1%	7.0%	46.5%	76.3%	10.3%	48.7%
Phone-only	5.3%	17.0%	7.0%	1.4%	6.6%	0.6%
Total	**1,243,067**	**17.0%**	**161,200**	**1,004,840**	**16.2%**	**162,708**

*Final figures based on valid cleaned surveys in the final dataset after removal of excess/rejected surveys. Response rates are not listed for the 66 cases in the 'volunteer' sample, who were respondents who were not sampled but asked to do the survey (which was allowed in the interests of good relations with the public, as there were so few cases) or who were sampled but could not be matched up to their survey case when they called in to do the survey. Such cases are included in the total survey completions, however.

1.1.1 Address-based sampling

The advantage of the address-based sampling approach was more complete coverage of dwellings in the population universe. Sampling by address, rather than phone number, allowed households with cell phones or no phone at all to participate. For the 2016 TTS, sample was pulled primarily from the Canada Post mailing address database. The Canada Post address database included all mailable addresses in the area, with the exception of addressees who have registered with Canada Post to explicitly opt out of the database. The Canada Post database would also not provide coverage of households serviced by General Delivery or dwellings with mailing addresses for secondary suites in houses that do not get separate addressing, however, this would be a small percentage of total households.

Address-and-phone and address-only samples were drawn. The address-and-phone samples consisted of addresses that could be matched to a listed phone number, along with the phone number and the name of the resident the phone number was listed under. The address-only sample consisted of addresses that could not be matched to a listed phone number.

Address-based sampling requires a much greater volume of sample, as the address-only component sample could not be contacted beyond the initial notification letter, leading to a lower response rate. This increased the cost of both sample purchases and postage in comparison to that required to obtain an equivalent number of survey completions with address-and-phone sample. This cost increase was offset in part by using a form of postage for larger-volume mail-outs called Personalized Mail which is eligible for a discount compared to regular Lettermail (standard letter) rates, subject to approval by Canada Post, as long as it has a promotional message amongst other requirements (machine-readability, size, weight, etc.). The higher-than-expected online response rate for the survey also helped to offset the increased cost of the mail out, and reduced the volume of sample required to meet the target.

1.1.2 Supplemental phone-only sample

Phone-only samples were initially included to further increase the coverage of dwellings in the survey area. The phone-only samples included approximately equal thirds:

- White pages listings which could not be matched to an address;
- 'Random digit dial' (RDD) samples consisting of phone numbers for land line exchanges that are randomly generated from the available numbers that are not listed (in order to reach unlisted households); and
- Verified cell phone samples consisting of randomly generated phone numbers for cell phone exchanges that have been 'pinged' to verify that the number appears to be functional.

It may be noted that phone-only sample could be expected to overlap with address-only sample and the verified cell phone portion of the phone-only sample could be expected to overlap with the both address-only and address-and-phone samples. The phone-only sample was envisioned as an alternative way to achieve contact with address-only sample that might be better at surveying portions of this population who might be less likely to take the initiative to respond to the invitation letter.

The principle disadvantages of this approach was an increase in cost per survey with up to 2.5 times more dialling time owing to an increase number of call attempts required per survey completion (interviews took the same amount of time as other sample types). A small portion of this increased dialing time was offset by the lack of a notification letter, which saved printing and posting charges.

Phone-only samples were activated on September 28, 2016 and telephone surveying was attempted for nine batches of these samples. After initial assessment of response rates, refusal rates, and feedback from survey interviewers, the decision was made to discontinue use of phone only-samples. On October 6, 2016, introduction of additional phone-only cases was suspended, although phone-only cases already activated continued to be called until a minimum number of call attempts have been placed. Further details on the suspension of phone-only sample can be found later in the report (Section 2.9).

1.2 CallWeb survey development

A hybrid sampling approach (address-only sample included) required the option to complete the survey online. The previous wave of TTS (2011) did offer an online version of the survey, with 12% of surveys

completed entirely or in part online. However, it may be noted that 76% of those who at some point used the web interface version of DMG's Direct Data Entry (DDE) platform required phone contact (with the other 24% completing online without any phone contact),[6] and, furthermore, the web version of the DDE could not be used in the 2016 cycle due to prohibitive cost and time required to adapt it to be bilingual.

As a result, Malatest developed a new bilingual online survey for TTS 2016 using Malatest's Triptelligence™ system, which runs on a CallWeb-based CATI/CAWI platform.[7] It was not possible to examine the old web version of the DDE, so the new online version was developed based on the telephone interview version of the TTS instrument; i.e., an online version of the script was developed to be as identical as possible to the version programmed into the DMG's DDE platform. While there were some deviations from the telephone script (mainly with respect to additional questions to assist in clarifying contradictory responses or probing for missing trips), the online survey collected the same data as the DDE system and allowed data from the two streams to be merged into the final databases.

The online survey was programmed into Malatest's CallWeb platform, which improved online user experience through a responsive and easy-to-use survey tool. Data quality was maintained through Google search inputs for locations and automated probing questions using similar logic checks to those seen in the DMG survey software, DDE.

1.2.1 Online survey modifications

While there were challenges associated with administering the DDE survey online, Malatest introduced modifications to the online survey that made the survey easier to complete, ensured data were of the highest quality, and helped make the visual review process more efficient.

A question asking the type of phone service used by each household was added to the online questionnaire with the rationale that it might be used as a weighting variable; however, in the end this information was not used.

As households from the address-only sample did not have telephone numbers associated with their file, a question asking the participant's phone number was added to the online survey. There was also a field where the participant could provide an email address, though this was not mandatory. Collecting both phone numbers and email addresses proved invaluable, as Malatest was able to contact respondents with partially completed surveys to encourage them to complete, and a number of online respondents needed to be contacted to update or clarify their responses during the visual review process.

The final question added to the online survey asked participants if they were willing to be contacted for future transportation-related research. Those who indicated they were willing to join the panel were asked to confirm the phone number and email address they had provided. The DMG is the caretaker of this transportation panel sample. The panel sample was delivered separately from the main survey data file in order to protect the identities of the survey participants, and so that their TTS answers could not

[6] In 2011, of 28,863 respondents that touched the online survey at some point, only 6,400 (24%) completed online without follow-up contact, per Section 6.1 and Table 6.3 in the report *2011 TTS Design and Conduct of the Survey*. Data Management Group, Department of Civil Engineering, University of Toronto. (2014)

[7] CallWeb is a complete on-line data collection system. A license can be purchased independently of Malatest to allow for future use of the survey software.

be used for sampling (which would be using the TTS data for a purpose other than the stated purposes of the TTS).

The online survey embedded a Google Maps Application Programming Interface (API), which participants used to search locations or identify them by double-clicking on the map or via drag-and-drop of the location marker, which increased the efficiency of the online survey. Google Maps also returns the coordinates for locations selected, which meant locations from the online survey did not have to be geocoded during survey processing.

In some places, the online survey made deviations from the telephone script in order to represent the intentions behind the telephone survey instrument and ensure comparable data were collected between CallWeb and the DDE. The full list of deviations from the telephone script can be found in **Appendix A**.

1.2.2 Web portal

In order to foster awareness, recognition, and acceptance of the 2016 TTS, Malatest developed a project-specific website with information about the survey, available in both English and French. The 2011 survey had a similar informational website available in both English and French, although the 2011 online version of the survey was not available in French.

The 2016 website was designed to be visually appealing, with transportation-related pictures and strong graphic design to reinforce the communications messaging. The goal of the website was to provide information and confirm the legitimacy of the survey, provide a call to action to survey respondents to participate, and provide a portal to log in with the secure access code found on the advance letter.

1.2.3 Bridging database systems

As the online version of the survey was programmed as a parallel data collection system to the DDE system, Malatest explored developing software that would bridge the two systems and write survey responses from CallWeb surveys directly to the DDE database. This task was not feasible as the DDE software has little documentation and the architect of the system was no longer employed by DMG. There were concerns that due to the complexity of the DDE data structure and software, attempts to write CallWeb survey data to the DDE data tables might incorrectly populate or miss populating variables essential to subsequent functions such as data review. Therefore, a 'bot' (standalone program) was developed that updated the DDE with status codes from CallWeb surveys by reading from a file of CallWeb completions and sending keystrokes to the DDE system through the DDE interface. This prevented participants who had completed the survey online from being called to complete the survey over the phone.

1.2.4 Parallel post-survey data validation processes

Just as CallWeb and DDE systems collected survey data in parallel, surveys from these systems were validated separately.

Once telephone surveys were completed, they were printed out, reviewed for error flags generated by the DDE, as well as less severe data quality issues. Participants whose surveys contained errors were called back, their responses were clarified, and the survey was edited as necessary. After this process, the DDE reviewed the survey again. Surveys that did not have error flags were passed to geocoding. In cases where geocoding staff identified errors, the participant was called back. At the end of data

collection, surveys were passed through a second review, the post-processing component of the DDE system, which performed checks such as ensuring speed and distances travelled were realistic.

Malatest replicated the post-survey validations tests found in the DDE system. In some cases, post-survey data validation processes were programmed directly into the online survey to prevent participants from providing a response that would generate an error or prompting them to confirm a certain combination or responses. The remaining processes were generated as Microsoft Access queries, run on completed surveys, which were extracted daily from the CallWeb server. Malatest also adopted the DDE process of printing out surveys, editing responses on the paper copy, and entering the edits back into the survey databases. However, all post-survey validation checks were completed in a single step for online surveys. The Malatest system provided some flexibility in how surveys could be grouped and organized for review in daily printout bundles in PDF format.

1.3 Informed consent

In prior TTS waves, the approach to collecting data was to assume that those who had received the letter were fully informed. However, to meet with conditions of current privacy legislation,[8] meaningful, informed consent was obtained from each participant prior to collecting data. The requirement of informed consent ensures that participants understand the nature of the research and how the information will be used. Informed consent also protects the public from coercion, either implied or explicit. Under the current legislation, it is not sufficient to assume informed consent simply if the person interviewed indicated that they had recalled receiving the survey letter (the procedure in previous survey cycles). Each potential participant was informed of the purpose of the survey, who the survey is being conducted on behalf of, and how the data will be used before being asked if they wish to participate.

DMG was able to update the current DDE introduction to record informed consent without the need to add new variables or impact programming.

The inclusion of the scripts to obtain meaningful informed consent increased telephone survey interview time and also increased the likelihood of a potential respondent refusing to participate.

1.4 Income question

Early in the planning stages of the project, steering committee members suggested including an additional household demographics question asking for their 2015 total household income from all sources, before taxes. Household income is often correlated with dwelling type, household size, vehicle availability, and/or travel patterns, and is of interest to many transportation planners. This question may also be useful in the data validation process to check whether the income profile of respondents is similar to that obtained from reference data.

Due to time constraints, the income question was not able to be programmed as a new question in the DDE. Malatest and TISC discussed several different options for the proposed question. They included excluding the question (not recommended as the information was deemed important), asking the question only in the online survey (could create bias), or including results in the comments section (which could result in inconsistent results and incur additional cost to process).

[8] *Personal Information Protection and Electronic Documents Act (PIPEDA)*

The committee decided to include the question at the end of the CallWeb survey and to code the results for DDE completions in the comments section using two digit codes which were deemed unlikely to otherwise be included in comments. Malatest worked with the committee to develop six income bins that aligned with reporting from the 2011 National Household Survey.

1.5 Rideshare travel mode

In order to keep pace with recent developments in transportation choices, the option to select paid ride share as a travel method was added to the TTS survey. During discussions on how this option should be worded, it was agreed that specific services (i.e., Uber, Lyft, DriveHer, or other paid rideshare apps) would not be mentioned specifically in the category but were included in parenthesis after the more generic description. DMG was able to include this response option in the DDE and it was programmed into the CallWeb survey. There was no additional data collection cost associated with adding this response category.

1.6 Survey invitation letter

In the 2016 cycle, the design of the survey letter was changed. The 2011/12 cycle included the project logo at the top and the signatures of various officials of partner agencies (mayors, wardens, the Minister of Transportation). At the start of the project contract, the time remaining prior to when letters would need to be printed was determined to be insufficient time for TAC to obtain signatures for officials for all partner agencies. Instead, the letter was sent signed by the Minister of Transportation on Ministerial letterhead, with the relevant agency logos at the bottom of the letter. This reduced the logistics involved in soliciting signatures from partner agencies. The official letter from the Minister lent gravitas to the survey invitation and was a key driver of the positive response to the survey.

Figure 1-1 shows the overall layout of the letters for each cycle. For the full text of the letters, readers are referred to the appendices in the Survey Design and Conduct Reports for both the 2011 and 2016 TTSs.

Figure 1-1: Survey Invitation Letters – 2011 and 2016

2011 Letter - GTHA

transportationtomorrow
SURVEY 2012
City of Hamilton • City of Toronto • Metrolinx/GO Transit • Regional Municipality of Durham • Regional Municipality of Halton
Regional Municipality of Peel • Regional Municipality of York • Toronto Transit Commission • Ministry of Transportation Ontario

The Transportation Tomorrow Survey is an important travel survey, conducted on behalf of your municipality, other municipalities in central Ontario, and the Province of Ontario. Every five years for the past 25 years, this survey has collected travel information of persons in your community to keep pace with changing transportation needs.

Your household has been randomly selected to represent your community in the current survey. A professional interviewer will contact you in the next two weeks and ask you to spend about 10 minutes answering our questionnaire. However, if you prefer, you can complete the survey online at tts2012.ca using your secure access code or by calling in at 1-855-586-3800 or 416-586-3800. More details are provided overleaf.

It is important that your household take part in this survey to assist the planning of transportation services to meet your future needs as well as the needs of your community. Information collected in the past has been used to forecast future road usage and plan public transit services in your area.

All information collected will be kept strictly confidential. Your responses will be combined with other responses in your area and used to identify travel patterns. No information will be released in any way that could be traced to your household.

If you have any questions, please call the Ministry of Transportation at 1-800-268-4686, or visit our web site at tts2012.ca.

Your household's involvement in this project is critical to its overall success. Please advise other members of your household of this opportunity to participate in the development of transportation services in your area and throughout central Ontario, so they too will be prepared to take part.

Thank you for your assistance,

Mayor Bob Bratina
City of Hamilton

Mayor Rob Ford
City of Toronto

Chair and CEO Roger Anderson
Regional Municipality of Durham

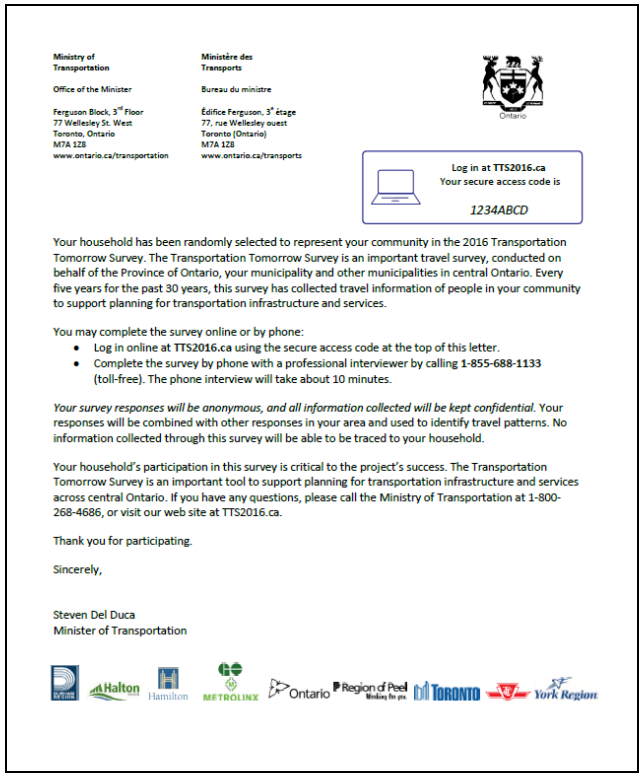
Chair Gary Carr
Regional Municipality of Halton

Chair Emil Kolb
Regional Municipality of Peel

Chair and CEO Bill Fisch
Regional Municipality of York

Minister Bob Chiarelli
Ministry of Transportation Ontario

2016 Letter- GTHA



Ministry of Transportation
Office of the Minister
Ferguson Block, 3rd Floor
77 Wellesley St. West
Toronto, Ontario
M7A 1Z8
www.ontario.ca/transportation

Ministère des Transports
Bureau du ministre
Édifice Ferguson, 3e étage
77, rue Wellesley ouest
Toronto (Ontario)
M7A 1Z8
www.ontario.ca/transports

Ontario

Log in at **TTS2016.ca**
Your secure access code is
1234ABCD

Your household has been randomly selected to represent your community in the 2016 Transportation Tomorrow Survey. The Transportation Tomorrow Survey is an important travel survey, conducted on behalf of the Province of Ontario, your municipality and other municipalities in central Ontario. Every five years for the past 30 years, this survey has collected travel information of people in your community to support planning for transportation infrastructure and services.

You may complete the survey online or by phone:

- Log in online at **TTS2016.ca** using the secure access code at the top of this letter.
- Complete the survey by phone with a professional interviewer by calling **1-855-688-1133** (toll-free). The phone interview will take about 10 minutes.

Your survey responses will be anonymous, and all information collected will be kept confidential. Your responses will be combined with other responses in your area and used to identify travel patterns. No information collected through this survey will be able to be traced to your household.

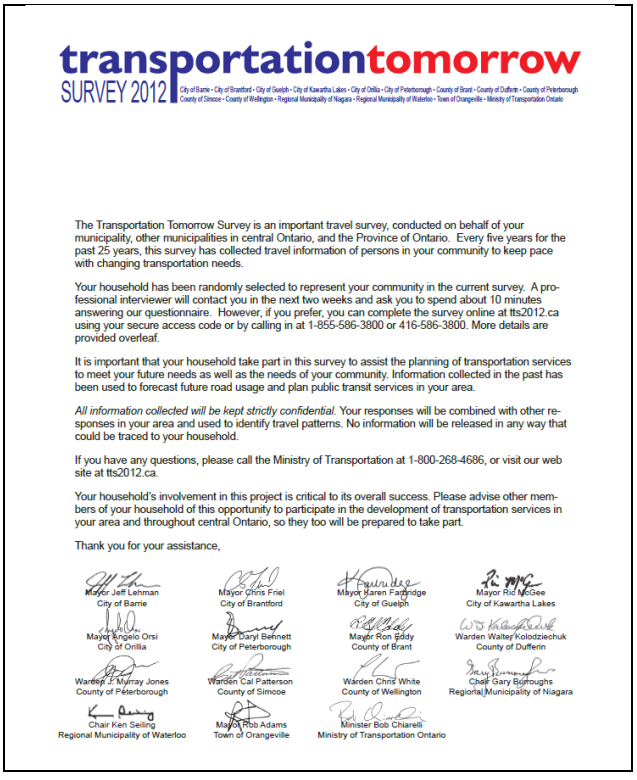
Your household's participation in this survey is critical to the project's success. The Transportation Tomorrow Survey is an important tool to support planning for transportation infrastructure and services across central Ontario. If you have any questions, please call the Ministry of Transportation at 1-800-268-4686, or visit our web site at TTS2016.ca.

Thank you for participating.

Sincerely,

Steven Del Duca
Minister of Transportation

2011 Letter - External to GTHA



transportationtomorrow
SURVEY 2012
City of Barrie • City of Brantford • City of Guelph • City of Kawartha Lakes • City of Orillia • City of Peterborough • County of Brant • County of Dufferin • County of Peterborough
County of Simcoe • County of Wellington • Regional Municipality of Niagara • Regional Municipality of Waterloo • Town of Orangeville • Ministry of Transportation Ontario

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If you have any questions, please call the Ministry of Transportation at 1-800-268-4686, or visit our web site at tts2012.ca.

Your household's involvement in this project is critical to its overall success. Please advise other members of your household of this opportunity to participate in the development of transportation services in your area and throughout central Ontario, so they too will be prepared to take part.

Thank you for your assistance,

Mayor Jeff Lehman
City of Barrie

Mayor Chris Friel
City of Brantford

Mayor Karen Farbridge
City of Guelph

Mayor Ric McGee
City of Kawartha Lakes

Mayor Angelo Orsi
City of Orillia

Mayor Daryl Bennett
City of Peterborough

Mayor Ron Eddy
County of Brant

Warden Walter Kolodziechuk
County of Dufferin

Warden J. Murray Jones
County of Peterborough

Warden Cal Patterson
County of Simcoe

Warden Chris White
County of Wellington

Chair Gary Burroughs
Regional Municipality of Niagara

Chair Ken Seiling
Regional Municipality of Waterloo

Mayor Rob Adams
Town of Orangeville

Minister Bob Chiarelli
Ministry of Transportation Ontario

2016 Letter - External to GTHA

Ministry of Transportation
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Ministère des Transports
Bureau du ministre
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www.ontario.ca/transports

Ontario

Log in at **TTS2016.ca**
Your secure access code is

Your household has been randomly selected to represent your community in the 2016 Transportation Tomorrow Survey. The Transportation Tomorrow Survey is an important travel survey, conducted on behalf of the Province of Ontario, your municipality and other municipalities in central Ontario. Every five years for the past 30 years, this survey has collected travel information of people in your community to support planning for transportation infrastructure and services.

You will be contacted by telephone next week and asked to spend about 10 minutes answering transportation-related questions. You can also complete the survey online at **TTS2016.ca** using your secure access code at the top of this letter or by calling

1-855-688-1133 (toll-free). It's important that one person complete the survey for the entire household (regarding the travel of household members 11 years of age and older).

Your survey responses will be anonymous, and all information collected will be kept confidential. Your responses will be combined with other responses in your area and used to identify travel patterns. No information collected through this survey will be able to be traced to your household.

Your household's participation in this survey is critical to the project's success. The Transportation Tomorrow Survey is an important tool to support planning for transportation infrastructure and services across central Ontario. If you have any questions, please call the Ministry of Transportation at 1-800-268-4686, or visit our web site at TTS2016.ca.

Thank you for your participation.

Sincerely,

Steven Del Duca
Minister of Transportation

1.7 Publicity and integration of social media

By using an address-based sampling methodology that included address-only sample, the total number of households sampled in the GTHA was more than three times larger than any previous iteration of the TTS survey. This made publicizing the study more important than ever before, as meeting the target number of surveys relied on households from the address-only sample to initiate survey completion based only on the advance letter they received.

The survey was publicised through traditional advertising as well as earned media. Malatest developed a poster, media release, and canned news article that were provided to the study partners to promote the survey in their region.

To promote survey acceptance, Malatest set up a project specific website (www.TTS2016.ca) which provided information about the project, types of questions asked, sponsoring agencies, and a portal through which the survey could be accessed using the secure access code included in their notification letter. Partners also promoted the survey on their own websites.

Malatest also set up a project specific Twitter account[9] which publicized the study and answered questions/addressed complaints in both official languages. MTO tweeted about the project from their official accounts and retweeted Malatest tweets. Partner agencies were encouraged to promote the study though their existing social media accounts (i.e., Facebook, Twitter, Instagram, Snapchat), as well as other platforms such as e-newsletter lists.

Malatest did not undertake to assess the extent to which the study was actively promoted by each client organization, or to assess the effectiveness of local promotion by each client. MTO undertook to request all partnering municipalities complete a form regarding the survey administration activities, and will have compiled this information separately.

1.8 Various survey metrics for quality control

Malatest monitored the total number of completions as well as the number completed via CallWeb and DDE on a daily basis. Malatest also reviewed the average household size and trips per person daily to ensure they were in line with expectations.

Malatest monitored the abandonment rate of the online survey to identify areas within the survey where users most frequently abandoned and other problems that could increase non-response and create bias, and some adjustments were made to the programming to help reduce abandonment.

1.9 Data weighting process

1.9.1 Summary of data weighting approaches in previous cycles

In previous cycles other than 2006, data expansion was undertaken for postal code (FSA)-based geographies (i.e. the first 3-digits of a postal code). In 2006, aggregated Census Tracts were used.

In cycles up to and including the 2006 TTS, the survey results had relied on high response rates and presumed low non-response bias to ensure relatively representative samples. Thus, geographic weights

[9] @tts2016_dot_ca

were applied at the household level only, and no adjustment was made for age distribution (the distribution in the survey sample was taken as is). The 2001 TTS introduced adjustments for apartments and non-apartments using Canada Post counts as the basis. The 2006 and 2011 cycles attempted to address imbalances in the representation of apartments by over-sampling listed phone numbers for apartments.

In the 2011 TTS, a two-step weighting process was employed. First, within each FSA, geographic weights were applied at the household level. After household weights were computed, within each municipality, the person-level data were weighted for six age ranges (0-17, 18-32, 33-47, 48-62, 63-77, and with 78+ divided into 78+female and 78+male). It may be noted that the 2011 survey cycle weighted to total population, including population living in collective dwellings (which were not part of the sampling frame), rather than the population living in total private households.

The initial 2011 household-level weights differed from the final person-level weights. Therefore, it was recommended that certain fields not be analysed at the household level. For example, 2011 statistics on the numbers of employed persons, persons with driver's licenses, etc. should be obtained from the person-level data table rather than from the summary counts for each household record. (In previous cycles there were no restrictions on which information should or should not be analysed at the household level.)

1.9.2 2016 expansion zone system

For the 2016 cycle of the TTS, postal-code based geographies were not recommended for geographic weighting, as the 2016 federal Census releases were initially only be available for Statistics Canada's standard geographies, and the release data for FSA-level data had not yet been set.

Malatest worked with the committee to develop suitable geographic expansion zones to be used for data weighting purposes. Geographies considered included standard Statistics Canada geographies, including Census Tract (CT), Aggregated Dissemination Area (ADA), and Census Subdivision (CSD), or some combination of these geographies. The final scheme developed was a hybrid of these geographies relying primarily on aggregations of ADAs. ADAs are generally based on aggregations of CTs in urban areas but also extend into rural area (which CTs do not), where they can either be portions of CSDs, have the same boundaries as CSDs, or contain multiple CSDs, depending on the CSD populations. Where ADAs straddled the boundaries of the TTS municipalities or planning districts, they were split by CT, CSD, and/or Dissemination Area (DA) in order to create expansion zones that conformed to the TTS geographies.

When aggregating the Statistics Canada geographies into an expansion zone, Malatest took into account the need to develop a sufficiently large sample with a good cross-section of all household types and demographics, but sufficiently small enough that variance in response rates by geography could be corrected for, as well as consideration of the geographic features of the area. For example, neighbouring ADAs that were split by a river or a major highway would not typically be combined, as their travel patterns might differ significantly. A draft expansion zone geography was developed by Malatest on the basis of ADAs and reviewed by the committee to refine the aggregations based on the committee member's understanding of the geographies of the area.

Appendix C includes a preliminary report prepared for TAC that explained the development of the expansion zones in more detail. The final expansion zone system, consisting of 568 individual expansion zones, was delivered in an Excel spreadsheet and as GIS files.

1.9.3 2016 weighting controls

To develop the control tables to use in 2016 data weighting, Statistics Canada Census data for CSDs, ADAs, CTs, and DAs was aggregated as appropriate to expansion zones. The various control tables were reviewed against the survey distributions by expansion zone to ensure that the great majority of cells had sample against which to apply weights. In some instances, cells may have been collapsed when one of the cells had no data (e.g., if in a specific small expansion zone, there was no data for 3-person households, 3- and 4-person households may have been combined in the weighting stratification, but only for that expansion zone).

For weighting the 2016 data and expanding it to represent all private households in the study area, the following controls were used:

Household Controls (2016 Census) – within each expansion zone

- **Total households:** private dwellings occupied by usual residents
- **Dwelling type**: stratified into single-detached, apartment, and townhouse
- **Household size:** (1-, 2-, 3-, 4-, and 5+ person households

Demographic Controls (2016 Census) – within each expansion zone

- **Age by sex**, stratified by sex (male, female) and 11 age ranges (0 to 4, 5 to 9, 10 to 14, 15 to 19, 20 to 24, 25 to 34, 35 to 44, 45 to 54, 55 to 64, 65 to 74, 75+)

GO Train Riders (Metrolinx, from Presto/ticket sale counts) - global adjustment across all expansion zones:

- **GO Train boardings:** weekday average for each of seven rail lines

The weighting for GO Train ridership by line was introduced to address significant over-representation of GO Train trips in the survey data after application of the other household and person-level weighting controls.

1.9.4 2016 weighting process

In order to solve the problem of the need to adjust the data for both household and demographic characteristics, an iterative proportional fitting (IPF) process was used. The method cycles through adjustments for each weighting control until the weights converge at a solution that satisfies both the household- and person-level weighting controls. For the demographic adjustments in each iteration, theoretical adjustments for each household member were computed, and an average adjustment was applied to each household. This method resulted in each member of the household having the same weight.

To mitigate the occurrence of extreme weights due to expansion zones with small samples / higher non-response bias for certain types of household or age groups, weights for households within a given expansion zone were generally limited to within a range of 0.2 to 5.0 times the base weight for the

expansion zone. Due to final calibrations to ensure that the total households in each expansion zone matched the control totals, this range is occasionally exceeded

More detail on the approaches in previous cycles, expansion zone geography, and data weighting process, can also be found in Section 3 of the report *TTS 2016: Data Expansion and Validation*.

SECTION 2: Challenges

Administering a survey on the scale of the TTS brings with it numerous challenges. The following sections present examples of the challenges that Malatest encountered when administering TTS 2016, as well as how issues that arose were mitigated, when possible. Significant challenges are bolded for emphasis.

2.1 Changes to sampling methodology

When Malatest proposed transitioning to a primarily address-based sampling methodology, the committee requested substantial information to make a decision on the sampling plan. This included a number of papers, in-depth exploration of different sampling scenarios (with different proportions of address-and-phone, address-only and phone-only survey samples), and pilot testing. Despite the provision of these materials supporting the address-based sampling plan, **the decision on the approach with target proportions of each sample type was deferred until the start of data collection, which made it difficult to make a definitive decision on staff resources, sample list requirements, and the quantities of materials required for mail outs.**

For future surveys, Malatest recommends making early decisions on the sampling approach and target proportions of different types of sample. It is expected that the information furnished by the 2016 TTS with respect to sample representativeness and response rates for different types of samples will assist in making early decisions for the next cycle (either at the RFP stage or shortly after the data collection contractor is engaged).

2.2 Survey site operations

Data collection for the 2016 TTS was undertaken across three separate sites: Toronto and Ottawa, ON, and Victoria, BC. Activities were spread across three sites for a number of reasons: after negotiation of the lease, the Toronto call centre had limits imposed on the number of staff allowed to work on site; the Ottawa and Victoria offices had survey staff with years of experience with CallWeb and online survey issues (whereas the Toronto call centre recruited telephone interview staff unfamiliar with CallWeb); and technical and professional expertise was readily available in the Ottawa and Victoria offices to support online surveying and other project activities. Table 2-1 outlines the distribution of tasks related to data collection undertaken by each office.

Prior to survey administration, Malatest acquired office space in Toronto and set up a call centre from which telephone interviews using the DDE would be conducted. With respect to the DDE portion of the survey, Toronto had responsibility over interviewer recruitment, training, telephone surveying, as well as transit and visual reviews, geocoding, survey validation and IT Support. In addition to the DDE component of the survey, Toronto call centre staff assisted in online survey support, transit and visual review, and survey validation.

Malatest's Ottawa office aided with DDE interviewer recruitment and IT support in addition to the online survey support for CallWeb (e.g., following up on partial surveys, assisting with aspects of technical support to survey respondents).

Malatest's Victoria, B.C office was responsible for the largest proportion of online survey tasks. These included: survey programming, online survey support, visual review of online surveys, survey validation

and database management. Malatest's dedicated human resources team based out of Victoria was responsible for planning for recruitment for telephone interviewer staff, as well as other Toronto call centre positions, and advising on human resources issues.

Table 2-1: Distribution of TTS 2016 tasks by Malatest office

		Toronto, ON	Ottawa, ON	Victoria, BC
DDE	Interviewer recruitment	✓	✓	✓
	Training	✓		
	Telephone surveying	✓		
	Visual review	✓		
	Transit review	✓		
	Geocoding	✓		
	Survey validation	✓		
	IT support	✓	✓	
CallWeb	Survey programming			✓
	Online survey support	✓	✓	✓
	Visual review	✓		✓
	Transit review	✓		✓
	Survey validation	✓		✓
	Database management			✓

Project work occurring across multiple sites and time zones required coordination of activities. As Malatest offices regularly collaborate on projects with geographically dispersed project teams, approaches and processes were easy to implement to ensure work was not duplicated and there was no confusion regarding roles and responsibilities. Staff regularly collaborates with offices in different time zones and staff in key positions with responsibilities such as project management, survey programming, sample management, and client liaison remained available outside regular business hours and when necessary adjusted their work schedules to meet project requirements.

A minor challenge associated with the call-back component of the visual review process for online surveys conducted out of the Victoria office was the small percentage of respondents who requested being called between 9:00 a.m. and 11:30 a.m. EST, before the Malatest's Victoria office was opened. These cases were transferred to other sites to ensure participants were called back at the time they requested.

2.2.1 Recruitment

The Toronto call centre required between 250 and 275 staff to operate regularly at the office space capacity of 150. **Hiring that number of part-time temporary employees within a short period of time proved to be a challenge. Adding to the challenge was the variety of positions for which Malatest was recruiting.** The positions were:

- Data Collection Clerk/ Telephone Interviewer;
- Geo-Coder;
- Geo-Coder Lead;
- Data Reviewer;
- IT Support Specialist;
- Web Developer;

- Admin/Reception;
- Call Centre Manager;
- Call Centre Supervisor; and
- Team Lead.

Malatest posted job ads for telephone interviewers, geocoders, and supervisors as widely as possible on internet job search sites, including Indeed, Monster, and the Job Bank websites. Newspaper ads were run in local newspapers. Malatest's Director of Human Resources, Toronto Call Centre Site Manager, and other Malatest staff attended the Canada Job Expo on July 21, 2016 in downtown Toronto, from which roughly 60 candidates were selected for the project. Malatest was also represented by staff at a job fair September 21, 2016 in North York, which resulted in many telephone interviewer and administrative hires of staff living in close proximity to the call centre, which increased shift flexibility for some of these staff.

From a Human Resources perspective the recruitment was challenging for the following reasons:

- **Volume of applications:** Malatest received roughly 5,500 applications.
- **Volume of interviews:** Over 1,000 pre-screening interviews were held over the phone as well as in-person interviews for each of the 432 staff hired over the course of the project.
- **Paperwork and reference checks:** The recruitment and hiring process generated large amounts of paperwork to be processed and references to be checked. TTS administrative staff was trained on the process and were able to take on some of this responsibility during the data collection phase, which allowed the site manager and other Malatest staff to focus more on site operations.
- **Job descriptions:** Because Malatest had to begin recruiting staff prior to the call centre being established, and before professional staff had the opportunity to work with the DDE software, job postings were refined throughout the hiring period based on Malatest's increased understanding of the requirements for each position.
- **Continuous hiring:** In order to maintain adequate staffing levels at both the Toronto Call Centre and in Victoria (CallWeb visual review), continuous hiring occurred from late July through early November.

Staff who had worked on previous cycles of TTS was subject to the same recruitment and interview process as other candidates. Malatest contacted 244 past TTS staff, 53 of whom were hired for TTS 2016. A total of 23 previous TTS staff members were retained to work on this wave of the study. These hires were often for more senior positions, based on their experience and performance on previous waves of TTS.

Malatest also expanded the online survey validation team. At the beginning of the survey, Malatest had a total of eight coders working on TTS. Malatest hired an additional 26 new employees in Victoria, BC to support the high volume on online completions for TTS 2016.

The process of validating online surveys required a greater level of effort than expected due to the volume of online surveys completed. This was due, in part to the delayed decision on the sampling plan used in the study, as well as the greater than anticipated response to the online survey, including amongst the address-and-phone samples. This presented the challenge of completing the work in a

timely fashion, while also continuously hiring and training additional staff to validate survey completions.

Recruiting and maintaining a suitably-sized staff is a key consideration for this large survey project. For future cycles of the survey, Malatest recommends that early decisions be made with respect to the sampling plan and estimated numbers of telephone and online completions, in order to facilitate the implementation of a strong recruitment strategy that will meet the needs of the project.

2.2.2 Training

Training on the DDE and the TTS survey instrument occurred from late-August until mid-November. Malatest helped to ensure consistency with previous waves of DDE surveying by hiring the training manager who filled this role in each of the previous waves of the TTS to conduct the training of 2016 telephone interviewers. His expertise with the DDE system as well as talent coaching staff helped to ensure that the telephone survey proceeded as efficiently as possible. Knowledge was transferred from the training manager to Malatest staff that documented the process and became trusted experts on the DDE survey as well. While recruiting and training new staff throughout the data collection period is not ideal, it did allow Malatest to prevent additional turnover by offering retraining to lower performing staff rather than terminating employment.

The former TTS site manager was also hired for this wave of the study to train DDE staff on the visual review process. In order to ensure good practices of DDE visual review were conserved in the CallWeb survey validation process, the site manager trained Malatest staff in the Victoria office on the process. This training occurred in person so hands-on components of training could be included. As was the case with DDE training, knowledge was transferred to Malatest staff, who documented the process and adapted it to the review of online surveys.

It may be noted that while some training material and documentation of processes was retained from previous cycles, other processes (e.g., visual review process) had documentation that was only retained in non-editable form (e.g., photocopy of instructions/guidelines) and other aspects of the process were not fully documented (e.g., criteria for acceptance of a completed survey). Involvement of the previous training manager and site manger facilitated reproduction of past processes and knowledge transfer. Malatest recommends the retention of key process documentation developed in the 2016 cycle.

2.2.3 Staffing

Planning appropriate staff contingents for the conduct of visual review for both online and DDE surveys was challenging for a number of reasons: as discussed elsewhere, decisions on the final survey targets by sample type were made fairly late; online vs. telephone response rates were not fully understood going into survey administration (with field test results from July not necessarily applicable to the fall season); in the previous cycle, staff did not maintain (or at least retain) metrics on the proportions of surveys that might require editing or follow-up calls, or be rejected as a result of visual review; nor were there useful metrics from previous cycle on the productivity and hours required specifically for the paper-based visual review process.

Maintaining a sufficient number of staff was a challenge throughout the project due to staff turnover. As the employment was short term and required shift work, some turnover is to be expected. In all, approximately 90 staff quit during the project of their own accord. Approximately two dozen had

employment terminated for performance or other reasons. In all cases, provincial and federal employment legislations and guidelines were followed.

The vast majority of staff was recruited for the data collection clerk/telephone interviewer position. Due to their experience, many returning TTS staff were able to take on positions of increased seniority with the team. To retain top performing staff, those who were exceptional on the phone were cross trained to data review in order to offer them more hours and daytime shifts. This approach also reduced the pressures on the number of new hires required.

Malatest experienced difficulty retaining geocoding staff during the delay while waiting for issues with the DDE post-processing console of the DDE to be resolved. While Malatest was able to temporarily keep these staff occupied with visual review of online surveys, there was attrition in staff due to the somewhat inconsistent working hours. There was also some inefficiency in that the geocoding staff were hired for a different skill set than that for visual review: some were not well suited to visual review tasks and were not as efficient. Steps should be taken in future waves to ensure all aspects of the DDE system are working as intended prior to survey administration to prevent similar periods of inactivity.

There was also a larger than expected number of inbound calls to the call centre. While some of these calls were initiated by respondents who received the survey letter or were in response to phone messages left during initial calling (for the address-and-phone sample), there was also a considerable volume of calls from online respondents (from both the address-and-phone and address-only samples) who sought to verify the legitimacy of the survey or requested help in completing the online survey. To meet this unexpected demand, Malatest increased reception staff from three staff per shift at the beginning of the project to nine in early October. As inbound call volumes continued to increase, Malatest expanded the team further. By Late October, Malatest had a team of 40 reception/inbound staff to keep up with the large volume of inbound calling, and to assist those who contacted the call centre with questions about the online survey.

2.2.4 Survey site hours

The Toronto call centre was open from 9:00 a.m. until 9:30 p.m. on weekdays and 10:00 a.m. to 5:00 p.m. on weekends. On weekdays, previously completed surveys were reviewed or geocoded from 9:00 a.m. until 5:00 p.m., when outbound dialing began, though this sometimes continued through the shift depending on the number of completions, staff absences, and other factors. Malatest made outbound calls from 10:00 am to 5:00 pm on Saturdays, and the call centre was open on Sundays to answer inbound calls.

For interviewers, interest in working on Sunday was high but the opportunity was limited as there was no outbound calling. Priority for these shifts was given to high performing interviewers. Daytime shifts for visual review were also coveted shifts for interviewers.

While Malatest followed CRTC guidelines and did not initiate outbound calls after 9:30 p.m., there were still **a number of complaints from households contacted that they felt they were being called too late**. However, the outbound calling schedule implemented was necessary to efficiently meet the target number of completions. Calling hours in previous TTS cycles extended to 9:30 p.m., and the period from 7:30 p.m. to 9:30 p.m. had been found to be very productive through analysis of response rates by hour. While the reasons for this are not clear, one may speculate that there may be number of different scenarios for which this timing provides a good window of opportunity after certain essential activities

are complete: workers who have longer commutes or longer work days who have finished late dinners; families with young children who have put their children to bed; families with older children who have returned from evening social or recreational activities; and other people who have completed evening errands such as grocery shopping and have returned home. Malatest recommends maintaining outbound calling hours to 9:30 p.m. in future cycles.

2.3 Data transfer between worksites and team members

Internal teams often had to share data between worksites and with project partners. Information exchanged with project partners included exchange of data with DMG (e.g., survey contact lists, survey data extracts, etc.) as well as transfer of PDF's individual survey printouts to the Toronto Transit Commission (TTC) so that a TTC staff member could conduct review of surveys with public transit-related responses off-site and return the surveys with annotated comments or corrections. This presented the challenge of ensuring that confidential survey response data were protected when transferred between locations.

This was addressed by requiring that all survey data transfer between sites and team members was done using SSH File Transfer Protocol (SFTP), which has a higher level of security than standard FTP transfers. Malatest set up the host and distributed the login information to the relevant parties, and ensured that all staff were informed of the appropriate methods of transferring survey data (i.e., never to be attached to an e-mail).

While the transferring of data between survey sites and to partners was a net positive for the smooth operation of TTS 2016, it did introduce additional administrative work to track surveys that had been transferred and ensure that all work had been completed as planned.

2.4 Public complaints

Over the course of survey administration, Malatest received roughly 2,000 complaints regarding various aspects of the project. Malatest tracked these complaints to identify any systemic issues with the survey process, particularly the online survey, as well as areas where the user experience could be improved. This represents a complaint rate of 0.2% relative to approximately 1,004,800 households invited to participate in the survey (about 990,400 households that were sent a letter and 14,400 in the phone-only sample who received only a phone call), or two out of a thousand.

During the data collection phase of the project, a complaint tracking report was distributed to MTO, outlining the complaints received by call centre staff, over email, and social media. This does not include complaints submitted directly to MTO, although many were forwarded to Malatest for resolution.

Table 2-2 details the complaints received by week throughout the data collection period.

Roughly one-quarter of complaints surrounded respondents' concerns over privacy. Respondents were typically concerned with how Malatest obtained their contact information, or how the data they provide would be used in the future and how their anonymity would be preserved. This was followed by complaints about receiving a phone call too late at night (18%) and the performance of the online survey (i.e., not knowing how to complete trips, the speed of the survey, and user experience) (12%).

Throughout the data collection phase of the TTS, Malatest fielded a large volume of email, calls, and other messages, which presented the challenge of responding to all feedback in a timely manner. In order to respond quickly and accurately to complaints, Malatest provided TTS front-line staff with templates for the more common complaints. All emails provided the URL for the study website, the toll-free number for the Toronto call centre and emphasized the importance of the study. The following templates were prepared:

Security or privacy concerns:

- Description of online security features (secure access code, encoding of data as it is being transmitted, all responses are stored securely on our servers which are housed within Canada – no cookies used);
- Security features on Malatest's servers;
- Link to the project privacy statement and Malatest's corporate privacy policy; and
- Authority for collecting information.

Prefer not to provide demographic characteristics:

- Explanation that these data are important to ensure the survey represents a good cross-section of the entire population;
- How travel patterns are influenced by these demographic characteristics; and
- Concrete examples of how these data will be used in practice.

Walking trips/recreational cycling:

- Importance and definition of 'walking trips' with respect to the survey methods; and
- Difficulty of capturing walking or recreational cycling routes when the origin and destination are the same location.

Slow Server:

- Apologize for technical issue;
- Explanation that the slow survey has been a result of higher than expected web traffic; and
- Provide an outline of mitigation strategies (e.g., splitting load across multiple surveys).

Table 2-2: TTS 2016 complaints received by Malatest tracked by category

Category	Total	Date Range													
		Sep 12-18	Sep 19-25	Sep 26-Oct 2	Oct 3-9	Oct 10-16	Oct 17-23	Oct 24-30	Oct 31 Nov 6	Nov 7-13	Nov 14-20	Nov 21-27	Nov 28-Dec 4	Dec 5-11	Dec 12-19
Privacy concerns	**484**	34	42	27	34	39	30	36	34	40	32	39	43	33	21
Calling too late	**370**	29	24	45	30	20	16	20	20	19	30	38	29	37	13
Online survey performance complaint (e.g. stuck on trips, page load was slow, unable to access survey)	**193**	9	11	10	8	45	104	27	13	11	9	5	5	7	1
Survey is too long	**249**	9	16	29	19	17	16	11	5	9	9	9	13	8	7
Felt they had been called too many times	**120**	0	12	11	12	14	7	10	8	12	8	8	10	5	3
Angry that we had called in general, no specific reason	**124**	8	14	13	7	4	8	8	10	13	11	5	11	8	4
Will complete online but doesn't want us to keep calling	**101**	6	6	6	4	5	10	15	15	10	4	5	10	4	1
Doesn't see the point in the survey	**102**	7	7	11	11	7	6	7	9	7	7	8	7	5	3
Online survey content complaint (e.g. poor design, doesn't ask about walking trips)	**95**	11	10	13	9	7	3	5	3	6	5	8	5	7	3
Other	**93**	8	4	5	6	8	4	7	3	10	8	8	12	6	4
Complaint about staff (e.g. accent, disconnected call)	**59**	4	2	7	3	4	6	5	4	4	4	6	5	4	1
Other complaint about government services not related to TTS	**40**	3	4	6	7	8	0	0	0	0	5	5	0	0	2
Bike rides should be included in the survey	**5**	0	0	0	0	0	0	0	5	0	0	0	0	0	0
Privacy concern and did not receive a letter	**6**	0	0	0	5	0	0	0	0	0	1	0	0	0	0
Concerned that the letter does not mention anything about the age or income questions	**4**	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Participated but have since changed their mind - remove all data provided	**8**	0	0	4	0	0	0	0	0	0	4	0	0	0	0
Total	**2,053**	**128**	**152**	**191**	**155**	**178**	**210**	**151**	**129**	**141**	**137**	**144**	**150**	**124**	**63**

The table below outlines the number of complaints received by MTO through various means (letters to the Minister, emails to the MTO information system, and calls received by Service Ontario agents) that were referred to MTO for response. There were only 82 such complaints over the course of survey administration.

Table 2-3: TTS 2016 complaints received by MTO

Week	# of Complaints requiring an MTO response
Sep 5-11	2
Sep 12-18	2
Sep 19-25	4
Sep 26-Oct 2	1
Oct 3-9	0
Oct 10-16	6
Oct 17-23	8
Oct 24-30	14
Oct 31-Nov 6	6
Nov 7-13	8
Nov 14-20	10
Nov 21-27	7
Nov 28-Dec 4	9
Dec 5-11	5
Dec 12-19	0
Total	**82**

2.5 Online survey

The option to complete the survey online was also offered in the 2011 TTS (as noted in Section 1.2) and, while the 2011 DDE online survey was accessed by a substantial number of participants, the abandonment rates were high and many participants had to be contacted over the phone to complete the survey. For 2016, Malatest programmed an entirely new online implementation of the TTS survey, which was designed as a more user friendly interface which, to the extent possible, replicated the DDE telephone survey both in content, and in internal validation. Online surveys were also visually reviewed using a similar process to the DDE telephone survey.

2.5.1 Development using CallWeb

Producing an online version of a telephone survey as complex as the TTS in a short period of time proved to be a challenge. As has been explained elsewhere, implementation of the online version of the survey was necessary to obtain a representative sample. However, from a project management perspective, making this methodological change in the short window before the start of data collection was a significant challenge. Programming of the online survey began shortly after the TTS kick-off meeting on May 12, 2016, and a prototype of the questionnaire was finished in time for the pilot test, which began on July 22, 2016.

Some of the challenge was associated with developing a survey questionnaire document outlining all skip patterns and requirements. The only existing documentation of the survey questionnaire was (1) a telephone interviewers training guide and (2) documentation of the DDE system that did not include a full detailing of the types of inline data checks present in the DDE system's phone interview module. Furthermore, there was no documentation available on the online version of the survey trialled in the 2011/12 cycle of the TTS, and, for technical reasons, it was not possible to access a working version of the 2011/12 online version. Time was also required to prepare, present the rationale for, and obtain approvals for any deviations from the telephone interview script that were required for the online survey.

Through the pilot test, Malatest identified programming errors and sections of the survey where the user experience could be improved. These were identified by comparing abandonment rates in various sections of the survey, as well as through a feedback survey at the end of the TTS module.

A link to the updated survey tool was provided to TAC for further testing and suggested changes were incorporated into the survey in time for the data collection period.

To meet timelines, programming of aspects of a given version of the survey instrument often had to be started prior to obtaining final feedback on the same version presented to subject matter experts (DMG, previous senior TTS staff) and the TAC committee. Arguably, this is not the most efficient approach to programming, requiring more rounds of revisions and modifications than might be required if all feedback on a version of the instrument had been obtained before the next round of programming.

Malatest continued to make minor improvements to the survey for the duration of the data collection period, based on abandonment rate metrics that were regularly reviewed, as well as feedback from participants, and those who abandoned and agreed to participate in a survey of why they were not able to complete the survey.

For future cycles of the survey Malatest recommends that timelines allow for the development and approval of online survey scripts well in advance of the start of data collection, to allow for timely completion of the programming and testing, including pilot testing. In addition, further improvements could be made to the online version of the survey instrument in order to obtain better data, and implement better checks. Malatest recommends that the survey timelines be planned to allow for the online survey to be programmed prior to a pilot test in the late spring (rather than in the height of summer). This would allow ample time to review the pilot test results with the committee, make any required changes prior to the commencement of staff training (which typically begins in mid to late August), and consider the response rates obtained in the pilot test to inform planning for full survey administration in the fall.

2.5.2 Deployment

While the online survey was ready for the beginning of data collection on September 7, 2016, Malatest mailed out smaller volumes of sample in the first three address-only and first six address-and-phone mail-outs as a contingency in the event of an unexpected failure of the online survey. **As there had been little time between the development and testing of the field test version of the survey and start of survey administration, certain processes associated with validating the online survey data had not yet been tested.** The slow initial launch also allowed for the visual review process for online surveys to be

further developed and quality controlled before deploying with a greater number of online surveys and a larger team of online reviewers. Protocols and guidelines for visual reviewers were modified and workflow processes were refined during these first few weeks of deployment of the online survey.

The decision to employ a slow start to the survey mitigated the risk of wasting significant amounts of address-only sample and creating unwanted publicity should the online survey have issues early on in data collection, and thus was well justified. However, **the slow launch did introduce the challenge of having to make up for the lower volume of online completions early in the project.**

Once it was confirmed that the online survey was functioning as intended, mail out volumes were increased. Between October 18 and December 6, 2016, Malatest collected an average of 1,650 online surveys per day (with a daily maximum of 3,226 surveys completed prior to data validation, on November 30), which was instrumental to Malatest's ability to reach the target number of completions.

In future cycles, Malatest recommends a more generous timeline during the front end of the project in order to allow for sufficient time after completion of a pilot test (with a finalized version of the survey instrument) to allow for the set up and refinement of processes associated with online survey data management and of the visual review process prior to launching of full survey administration.

2.5.3 Technical support and maintenance

The high response rate to the online survey generated greater-than-expected demand for online technical survey support. The most common technical issues that were brought to the attention of the TTS online support team were from participants who were having difficulty accessing the survey itself (i.e., unable to find the study website – typically because the participant was typing the study URL into a search engine), beginning and completing the trips section, and problems with their location information in Google Maps.

In rare cases, it was necessary for front-line staff to forward a technical issue to the team that programmed the online survey to resolve an issue. Once the issue was resolved, the TTS online support team would let the participant know the issue had been resolved and that they could resume the survey.

2.5.4 Administration of the Highway 407 question

The question as to whether the respondent used Highway 407 was initially a challenge to implement due to lack of documentation on the conditions for asking it, and its deployment in the online survey generated complaints from some respondents. The 2011 survey design included a question on whether or not driving trips used Highway 407, which was carried over to the 2016 TTS. The 2011 question was as follows:

(2) If "**D**" for drive and logical (computer) then -
" Did you/he/she use Highway 407 for any part of this trip?" (**Y**/**N**/**R**)

The DDE system was programmed to trigger this question only if logical to ask, however, the available documentation did not include any description of the conditions under which the question should be triggered. It was eventually clarified that the trigger for the question was based on examination of the combination of the origin municipality and destination municipality. For example, for a trip within a municipality completely north of Highway 407 or a trip between two municipalities completely north of Highway 407 (say, Newmarket to Aurora), the question was not triggered. For a trip between two municipalities separated by Highway 407 or if the origin or destination municipality contained a portion

of Highway 407, the question was asked. Under these conditions, the question may still have been asked when used of Highway 407 would not be a normal option, for example, between an origin and destination both well south of Highway 407 but within a municipality that contained a portion of Highway 407.

During the pilot test of the online survey, the Highway 407 question was asked of all respondents while the conditions for triggering the question were being explored. After the conditions for triggering the question were better understood, the online version of the survey was programmed with similar criteria for triggering the question, by examining the municipality in the location description captured in the survey. As there was no documentation from the DDE programming, Malatest initially implemented the same matrix of origin-destination municipality combinations that would trigger the question as used in the DDE system for this purpose. However, the way that locations were captured via the Google Maps API was not always conducive to assessing whether or not to trigger the question: the town recorded in the location description was often not standardized the same way as in the municipality cross-reference list from the DDE system, with Google Maps sometimes providing the expected municipality name, but other times providing the name of a village or historic municipality name that did not match the list. This was observed to lead to instances when the question should have been triggered but was not. The programming was subsequently changed to ask the question by default if the town names returned by the Google Maps API did not appear in the matrix of municipality combinations. As the question was sometimes triggered in DDE when it was not applicable, this was agreed to be acceptable.

However, during full survey administration, a few online survey respondents submitted complaints that they were asked the question unnecessarily even though all of their reported trips were miles away from Highway 407, which could be particularly irksome for respondents living outside the GTHA. When this came to light, the Highway 407 question was suspended in the online survey until a better solution could be developed.

DMG provided Malatest with an extract from the 2011 survey listing the origin and destination x-y coordinates for each trip and the responses to the Highway 407 question. Malatest conducted analysis of this information to develop a grid of origin-destination zones with an assessment of whether the route between a given zone pair might possibly cross the Highway 407 or be close enough to divert to the highway in order take advantage of highway speeds. In early October Malatest reprogrammed the question in the online survey with an algorithm to assess the origin-destination coordinates and trigger the question accordingly. This reduced the likelihood of unnecessarily asking the question, including in instances where the original DDE municipality-combination approach might have triggered the question (e.g., the instances when origin and destination were both well south of Highway 407 but within a municipality that contains Highway 407). In early November, after reviewing the results, the analysis was further refined to look at somewhat smaller blocks for the origin-destination matrix in order to eliminate some further unnecessary triggering of the questions.

It may be noted that the wording of the Highway 407 question was changed in early October to ask whether the respondent had made use of the Highway 407 ETR (express toll route). The Highway 407 ETR is a tolled segment of Highway 407 that runs between Burlington and Pickering. Previous to this, the question had simply asked about any use of Highway 407.

If it had been clear in advance that assessment of location latitudes/longitudes would be required, it would have been possible to initially set up the programming to evaluate the origin-destination

coordinates and/or spatially join the coordinates to a zoning system to better assess whether the question was relevant for any given trip. As it was, changes to the programming for this question occurred during survey administration, and there were periods when the question was not asked at all even when it could have been.

For future surveys, if there are to be questions triggered by complex logical conditions, particularly if they entail the assessment of geographic coordinates captured in the survey, Malatest recommends providing the contractor with documentation that clearly outlines those conditions sufficiently in advance to allow for programming of appropriate algorithms and testing. It is also suggested that, if it is necessary for the contractor to undertake complex geographic analysis to determine the conditions for triggering questions, the potential contractors should be advised of this in the project terms of reference.

2.5.5 The need for swift response to sever issues

The perception of data security was very important to some survey respondents, with a few raising detailed technical questions with respect to Internet security protocols and security certificates. Other respondents with older browsers may also have encountered warnings about certificates (which while valid, were raised as warnings due to high security settings on older browsers). It was an advantage for Malatest to own and maintain the servers used for online surveying and for the survey web portal, as it made it possible to respond quickly to any concerns or issues that might arise.

2.6 Web server issues

Throughout survey administration, there were minimal service disruptions to the online survey. However, shortly after the first large batches of sample were deployed, there were survey performance issues at peak traffic hours which were quickly identified and resolved.

Throughout the data collection phase of TTS, which lasted roughly three-and-a-half months, **there were two occasions where the online server was unavailable either due to generalized disruptions of the Internet or routine and scheduled maintenance by Malatest's internet service provider.** The first was on September 15 when the survey was offline from 3:00 a.m. to 12:00 p.m. and the second was on November 17 from 8:00 a.m. to 9:00 a.m. In each of these cases, a note was posted to the TTS 2016 website, noting that the survey would not be able to be accessed during those time periods.

The online survey was periodically unavailable on October 21, 2016, as a result of the distributed denial-of-service attacks that disrupted internet service across North America and parts of Europe, in particular, the Dynamic Host Configuration Protocol (DHCP) servers that route browsers to the appropriate IP addresses associated with web domain names. For this disruption, many users would not even have been directed by their Internet Service Provider to the web portal to view the notice that the web portal was not available. It is difficult to estimate the impact, but this issue may have cost the project in excess of 400 surveys with respondents who may have been discouraged and did not try again on another day.

Due to the higher than anticipated response to the online survey, shortly after the first large address-only batches of sample were deployed, there were survey performance issues at peak traffic hours that included slower than normal page loading times and, in rare cases, server timeout issues which caused participants to have to log back into the survey. Issues with web server overload were first identified on

October 12 and were resolved shortly thereafter. The overload was addressed by distributing the online survey demand across additional CallWeb servers. The strength of the online response was somewhat difficult to anticipate as it was not the case in 2011. The planning for future surveys will have the benefit of the knowledge that the online survey will be a very popular mode of response.

2.7 Online survey abandonment

Malatest monitored survey abandonment rates on a daily basis. **Throughout the course of the survey, 24% of households that logged into the survey did not complete the questionnaire.** In addition to measuring the gross abandonment rate daily, Malatest broke out the results by the page on which users stopped completing the survey.

To compliment this analysis, Malatest twice fielded a follow-up survey of users that abandoned the survey to understand why they chose not to complete the form. In each instance, a sample of at least 1,000 abandoners was identified and sent an email asking them to answer a few questions. Malatest reviewed the responses and identified common challenges that they reported or reasons for not finishing the survey. Malatest used this information to improve both the user experience (by adding additional instructions to clarify what was required or how to complete aspects of the survey) as well as the performance of the survey.

2.7.1 Causes

A number of survey respondents abandoned the survey after only answering a few questions. I.e., after discovering more about the content and types of questions, some respondents simply lost interest or were not prepared to give up the time required to complete the survey. Some respondents logged in but abandoned before answering even a single question.

In many cases, surveys were abandoned due to participant fatigue. This is particularly true of a travel survey like TTS, which has multiple sections and took roughly 20 minutes on average to complete online, depending on the size of the household (with larger households sometimes taking considerably longer). It is not possible to quantify the degree to which fatigue contributed to survey abandonment; however, Malatest did receive complaints that the survey was a significant time commitment, and that soliciting travel information from other household members was burdensome. This is supported by the representation of larger household sizes in the final data set, which is lower than in the general population (Section 3.8.1).

Based on abandonment statistics, as well as the surveys of users that abandoned the survey, **many users that did not finish the survey did so because they did not understand how to complete the form**. Of these, most abandoned the survey during the trips section, where users had particular difficulty entering trip information that included transit and understanding how to finalize the trips section.

Another less common cause of survey abandonment was an issue with Google Maps. The majority of households that reported difficulties using Google maps indicated that they could not find their address, or that the postal code associated with their address within Google maps was not correct. Such difficulties were more common with new developments that may not be fully mapped in Google databases; in rural areas; addresses on highways (as there may be are a number of ways or formats for describing a given highway); or addresses that have recently had postal code reassignments. Google may

also construct their own understanding of postal codes from available data that may not always match Canada Post's mapping of postal codes (and Canada Post closely guards access to GIS information on six digit postal codes, lest sharing the information should interfere with revenue streams that depend on the control of the GIS information). Malatest staff provided support to users experiencing issues with Google Maps via email and over the phone. It should be noted that this does not signal a serious problem with Google Maps. The vast majority of users successfully used Google maps to confirm their home address and report the locations of their workplaces, schools, and trip destinations. Even if the Google Map search was initially unable to locate the person's home or trip destination, the user had the option of clicking on the map or moving the marker to the correct location. Some users simply needed a little coaching to do this, or to accept that the Google description might differ slightly from the exact address even when the marker was clearly in the correct location.

Another reason respondents gave for not completing the survey was because they were not happy with the questions that the survey asked. In many cases, participants were displeased that the definition of a trip did not include recreational cycling without a destination (e.g., cycling from home to home) or walking trips other than those to/from school or work. Others noted that they did not understand why the survey needed certain demographic information and discontinued the survey. Such respondents often were uncomfortable answering questions on age, sex, information about children in the household, workplace locations, and/or school locations.

2.7.2 Abandonment reduction strategy

Throughout the survey, Malatest took a proactive approach to reducing the rate of abandonment, and used abandonment rate statistics and abandoner survey results to make programming changes to the survey.

To address sections, and in some cases specific questions, in the survey, that were identified as more difficult for users, Malatest increased the amount of information available within the online survey that helped participants complete the survey using both modal links (open in a new window with detailed instructions), and mouse-overs, also known as hover links, that defined key terms and response options.

Malatest also programmed additional instructions to the end of each section of the survey, indicating the information that would be requested in the next bank of questions, and providing instruction on how to complete.

To address difficulties that users were experiencing with the trips section of the survey, Malatest developed an introduction to trips section. Detailed information on what constituted a valid trip, as well as how to complete the section was provided at the beginning of data entry for the first household trip record. This information was subsequently provided using modal buttons, so that the text heavy introduction to completing trips did not have to be displayed each time entry of trips for a new household member was initiated.

2.7.3 Partial completion recovery strategy

In order to reach the target number of completions and reduce non-response bias, Malatest contacted users who abandoned the survey to provide technical assistance and encourage them to complete the survey.

Malatest considered surveys that had progressed to the following points (by sample type) eligible to be contacted as part of the partial completion recovery strategy:

- **Address-only sample** were eligible for follow-up upon provision of a phone number; and
- **Address-and-phone** sample were eligible for follow-up once they entered the number of vehicles in the household, which was considered the point at the survey at which the respondent had answered enough questions about the household that it warranted follow-up using the online CallWeb survey to complete the telephone interview. Those who had answered fewer questions than this were simply left in the calling queue for the DDE survey, as they would not be over-burdened by answering the same question again that they had already answered on the CallWeb platform.

Professional interviewers from Malatest's Ottawa call centre made up to five outbound telephone calls to users who abandoned survey to provide technical assistance. In many cases, surveyors completed the interview over the phone with the participant to ensure it was completed. Of all surveys completed online, 5,488 (4.6%) were started online by the participant and completed over the phone by Malatest staff.

On a weekly basis, Malatest also sent emails to users who recently abandoned the survey after completing at least the few initial questions capturing their contact information. The sample record for this email was cross referenced against the call statuses of these cases to eliminate emails to any respondents who had since completed the survey via DDE phone interview or via CallWeb or who had refused further participation upon call back.

Emails to partially completed cases were sent via CallWeb; typical at 3:00 a.m. on Saturday mornings, as the weekend proved to be the optimal time for participants to reengage with the survey. Emails were sent in the early morning, as there were typically few active surveys at this time and the email distribution required a significant percentage of the overall server capacity.

Emails were also sent to online respondents who had critical errors in their survey identified during visual review, and who staff was not able to reach during call-backs, in an effort to recover these completed surveys that would otherwise have been rejected.

Final statistics on follow-up emails:

- **Partial completes emailed:** 28,654
  - Of emailed cases, 14,502 (51%) were completed online or via telephone follow-up.
- **Completed cases in visual review call back emailed:** 17,218
  - Of emailed cases, 15,513 (90%) were resolved through email support and/or telephone follow-up.

Malatest recommends that follow-up with partial online completions be identified as one of the work activities resources should be allocated to in future cycles. Following up with partial completions is important not only to maximize survey response (and thus reduce non-response bias) but also to ensure as representative a sample as possible.

2.8 Sample procurement

The survey sample was pulled primarily from Canada Post mailing addresses. A portion of the sample was matched to listed phone numbers (address-and-phone sample), while a portion had the address only.

Acquiring the sample from Canada Post was more expensive than expected. Malatest was under the impression that it would save more through volume discounts and pare down the request to bare minimum requirements. Certain requirements (i.e. inclusion of names for use in telephone contacts, apartment flags, and programming costs for randomization) that were added and confirmed closer to survey launch, as well as other costs Malatest was previously not informed of by Canada Post sample brokers, resulted in higher costs than anticipated.

When considering the new sampling methodology for TTS, it seemed likely that Malatest would come close to or within the projected budget. In practice, even though there may not have been a need to draw as much sample, it was hard to predict final response rates far in advance to purchase the exact amount of the sample actually required. **Malatest also experienced significant delays beyond Canada Post's stated service standard of one week for processing sample request when procuring sample throughout the study**. These delays further complicated sampling purchase predictions. The result was that more sample than was eventually required had to be purchased in advance to ensure sufficient sample on hand to deal with various possible lower-than-expected response rate eventualities by geography.

Notwithstanding the challenges with the sample, Malatest recommends using the Canada Post address sample as a base in the next cycle, as it includes the most comprehensive enumeration of dwellings available, and is regularly updated. It should be noted however, that the Canada Post address frame does not provide complete coverage: it may not furnish addresses for rural dwellings that receive mail via 'General Delivery'; it does not furnish addresses for residents who have registered with Canada Post to opt out of having their address sold (although the proportion in the population is likely very small); and, finally, the Canada Post database may not include coverage of some secondary suites, particularly if they are illegal secondary suites that do not receive mail to a separate unit number. Caution should also be exercised if the incidence of apartments in the Canada Post address frame is to be considered for data weighting, as it may under-represent apartments, particularly in areas with a high incidence of informal secondary suites.

Earlier decisions on the sampling plan from the client would allow for better planning of the contact sample required, and would result in less over-purchase of sample. Completing thorough testing of the survey platform well in advance of the start of survey administration would also reduce or remove the risk of issues in the first weeks of surveying, which would allow for a more aggressive mailing schedule at the start of the project, in turn allowing for more time in the last weeks of survey administration to fine tune the targeting with smaller batches of contact sample, and less over-purchase.

2.9 Suspension of phone-only sample

Phone-only sample was comprised of verified cell phone numbers, random digit phone numbers, and white pages listings. Malatest included these samples in the study in an effort to ensure a good representation of the households in the study area, particularly in the event that there was low response to the online survey among the address-only sample.

Phone-only samples were introduced on September 28, 2016 and telephone surveying was attempted for a few batches of these samples. On October 6, 2016, introduction of additional phone-only cases was suspended, although phone-only cases already activated were called until the minimum number of call attempts had been placed, due to lower than expected response rates. **Cold calling (without the benefit of an introductory survey invitation letter), high proportions of not-in-service or non-residential numbers, and higher refusal rates in the phone-only calling significantly decreased production rates and negatively affected interviewer morale.**

On October 11, TAC approved the suspension of introduction of further phone-only samples, pending further information on phone only samples' response rates and characteristics for such surveys completed to date.

Malatest developed a report that compared the demographic profiles of phone-only sample to address-and-phone and address-only sample (**Appendix B**). Phone-only sample had age and household size profiles that more closely resembled address-and-phone sample, but did represent a similar proportion of apartment and townhouse dwellings as the address-only sample. Of note, the verified cell phone portion of the phone-only sample provided somewhat better representation of larger households than other samples. However, the report concluded that the **phone-only sample provided only minimal benefit towards providing a more robust representation of the study area, at a considerably greater cost than other sample types.**

Based on the poor performance of the phone-only samples in terms of response rates, productivity, interviewer morale, and the better than expected performance of the address-only samples, TISC accepted Malatest's recommendation to permanently discontinue use of the phone-only sample. Malatest would only recommend the use of phone-only samples for future cycles as a last resort in cases where other means are unable to achieve the desired response rate, and when sufficient budget is available to support this low-response method.

2.10 Online survey visual review and edit backlog

Given the delays in TISC's decision of the survey targets by sample type, it was difficult to plan for the initial online survey volumes. Under the final approved sampling plan for TTS 2016, Malatest projected an even split between surveys completed over the telephone and online. **In practice, there was a significantly higher than expected response to the online survey from both address-and-phone and address-only sample types. This increase volume created significantly more work than expected for the team tasked with validating online surveys.** As they were self-administered, online surveys had a higher incidence of flagged issues and required more follow-up to confirm or clarify information than did surveys completed by telephone interview (which afforded the opportunity to clarify information at the time of first completion). In addition, the online visual review reports and process differed in small ways from the DDE-based reports and process, so the work could not easily be shared between online and DDE visual reviewers without some cross-training.

In the beginning stages of the project, Malatest aimed to complete all call-backs within 2-3 days of online survey completion. However, as the volume of online surveys was higher than initially anticipated, Malatest did not initially have the capacity to meet this standard. As a result, Malatest began prioritizing call-backs in mid-October.

Priority 1 call-backs were for cases with error flags within the trip section of the survey (i.e., incomplete information, trips out of sequence, suspected missing trips) that required immediate attention due to the time sensitive nature of participants recalling their travel activity. Priority 2 call-backs were clarifications of stable characteristics at the household or demographic level (i.e. household address, work/school address, conflicting responses about valid household members) that were not urgent to correct.

At the conclusion of data collection, Malatest projected it would take until the end of January to complete this task. In practice, it took until the end of February to connect with all cases that required call-backs. It also took longer than expected to complete the corresponding edits to the survey database. Edits to trip information including a transit component were particularly time consuming, and these cases were of higher incidence in CallWeb surveys than those on the DDE.

Final validation of online surveys using standard tests was completed in May 2017 but it took a number of weeks afterwards to complete final custom data checks and review.

2.11 Transit review

In the previous wave of TTS, one TTC staff member reviewed completed surveys that had flagged errors for transit for between 2 to 2.5 hours each weekday. However, **because all surveys were completed in a single wave in 2016, TTC did not have the capacity to review all cases that involved transit.** It may also be noted that the shift to use of address-based sample appears to have reached more younger households, with an increase in the proportion of survey cases reporting transit trips, particularly amongst the online surveys, further increasing the transit review workload over previous cycles.

At the beginning of data collection, members of the geocoding team were trained by TTC staff to assist in transit review, and a TTC staff member visited the Toronto office to conduct the transit review on site for partial days a few days each week. TTC initially sent two staff members on Mondays due to the heavier caseload after the weekend (Friday and Saturday phone surveying, and online surveys from Friday through Sunday), and eventually fully deployed the second staff member to assist with clearing the CallWeb transit cases. Later, development of protocol to securely transfer the individual survey reports to TTC via SFTP saved TTC staff travel time and allowed for a greater volume of surveys to be reviewed by TTC staff.

Until November 16, Malatest and TTC reviewed both DDE and CallWeb completions. DDE surveys including transit were reviewed on site at the Toronto call centre. All cases flagged with a potential error were reviewed (1.5%) and 85% of all other transit cases were reviewed.

Based on the level of effort required from Malatest, and the associated cost to the contingency fund, a new transit review protocol was approved by TISC. TTC reviewed CallWeb completions exclusively and Malatest reviewed all cases flagged in DDE with 23.5% spot checking for the remaining (i.e. un-flagged) transit cases.

This change to the methodology of reviewing transit cases was justified as follows:

- There were more online completions than telephone completions, particularly in the final month of the survey. In addition, online respondents, who were generally somewhat younger on

average, were more likely to have transit trips. TTC staff was able to clear more cases per hour than Malatest staff, and would be able to complete this task in a reasonable timeframe.

- Each person completing the online survey was doing so without the benefit of an interviewer being able to probe. In addition, some of the early CallWeb surveys required more correction to transit information, until refinements were made to the instructions and interface to better enable respondents to enter correct transit route information. It was agreed that TTC's expertise was best used reviewing these cases, which in many cases were more complex.
- This scenario also freed up TTC staff to review more cases each day. CallWeb transit review cases could be identified and grouped together and even prioritized by date and/or complexity of issues when output as PDF documents, then securely transferred via SFTP so they could be completed at TTC offices (whereas the DDE-based process was designed around printing out all of the documents on paper, with considerable manual organization of the outputs). This saved the commuting time to and from the Toronto call centre in North York.
- Telephone cases that required call-backs were more time sensitive, as visual review was completed more quickly due to the lower daily volume of completions. These were able to be cleared by the early afternoon each day so cases that required call-backs could be done the following evening. TTC would only be able to come to the call centre three mornings a week, which would have sacrificed completions due to the delay. (It may be noted that TTC staff still supported the review of telephone cases and did travel to the call centre to provide guidance and troubleshooting to the transit review team).

Total cost for Malatest's contribution to transit review was $36,317.63 in staff time; however, the change in methodology resulted in a saving of roughly $33,500 in additional cost that would have been charged to the contingency if the status quo had been maintained.

For future cycles of the survey, Malatest recommends planning for sufficient transit review resources in advance. It would be ideal if a large portion of the review could be undertaken by TTC staff, as they have a deeper knowledge of the subway and transit routes, and can more quickly identify errors and make corrections that less knowledgeable staff would have to spend more time on to validate and correct. Malatest also recommends the use of protocols to allow the off-site review of transit cases by TTC staff. If it is not possible for TTC to allocate sufficient resources to conduct the transit review, then a dedicated transit review team should be hired, trained, and led by a team leader who is trained by the specialists from one or more transit agencies, and during the survey administration period, the review should be supported by specialists from TTC and/or other agencies who can help troubleshoot issues and provide ongoing guidance. The requirements for the specialized transit review team should be clearly specified up-front in the project terms of reference, so that bidders understand the level of effort that may be required.

2.12 Reduced telephone productivity

During TTS 2016, **Malatest experienced reduced productivity in completing surveys over the telephone compared to the previous wave (2011).** The decreased productivity was principally attributed to two changes in survey dynamics in 2016: ensuring participants provided informed consent to participate in the study, and the greater than anticipated response to the online survey from the address-and-phone sample. These factors are outlined in more detail below:

2.12.1 Informed consent

As discussed in Section 1.3 of this report, to conform to existing privacy legislation, it was necessary to obtain meaningful informed consent by first explaining the purpose of the survey, who the survey was being conducted on behalf of, how the data will be used, and then explicitly asking for permission to administer the survey. **The requirement that participants provide informed consent likely contributed to a reduced response through an increase in refusals[10] in this wave of the survey. It also introduced additional time required to explain the voluntary nature of survey participation for most calls where the phone is answered, which lowered productivity.[11]**

2.12.2 High online response from address-and-phone sample

In 2016, Malatest had an overall productivity rate of 1.7 completions per hour, compared to the 2.7 completions per hour realized in the previous wave of the survey. Prior to survey administration, Malatest expected an even split of telephone and online completions across all sample types. However, of the households in the address-and-phone sample that completed the survey, 40% completed online as compared to approximately 12% of the survey completions in the 2011/12 cycle (which relied entirely on address-and-phone sample drawn from white pages listings with mailable addresses). This may be the result of a number of factors, including: increased penetration of computers and mobile devices in Canadian households; increased computer literacy, including amongst older people; and perhaps the 2016 federal census—which encouraged online completion before more traditional methods—has increased the public's openness to completing online questionnaires (although the latter point is speculative).

While some of these address-and-phone households that completed the survey online may have been motivated to participate as a result of phone calls they received from the call centre, it is likely that most represented 'low hanging fruit' or motivated participants. With a lower online uptake, these households would have likely agreed to do the survey when eventually contacted by phone, improving the overall productivity of outbound telephone activity. (It may be noted that the overall response rate for the address-and-phone sample batches that had time to fully mature in the field was in line with previous survey cycles.)

In other words, because a large proportion of address-and-phone sample elected to do the survey online, phone staff conducting outbound dialling activity had to contend with a larger proportion of the sample available to them being unwilling households, difficult to reach households, or not-in-service phone numbers, and a smaller proportion being willing participants. For this reason, future surveys with similar options for completion cannot be expected to have telephone productivity rates as high as was possible in cycles previous to the 2016 TTS. This should be taken into consideration in the costing for future studies: on the one hand the dialling time for phone interviewing will have only modest productivity; on the other hand fewer survey interviews will need to be completed via phone, although resources for phone support surveys will still need to be allocated for incoming calls for requests for assistance with online surveys and outgoing calls to follow-up with abandoned partially-completed online surveys.

[10] Refusal rate in 2016 was 5.3% compared to 3.9% in 2011
[11] It took an average of 21 seconds to read the survey introduction, based on a review of 100 calls

2.13 Sample coordination between telephone and online surveys

Another challenge Malatest faced in the administration of the TTS was the sample management between telephone and online surveys. To ensure there was no barrier to completing the survey via the method of the participant's choice, all households were uploaded to both the DDE and CallWeb servers.

Of the address-only sample, 10% of those who completed the survey did so over the telephone through an inbound call to the call centre. Inbound calls were typically made by those in an older demographic, those who did not have access to the internet, and/or those who simply preferred to complete a survey over the phone. Similarly, a handful of participants from the phone-only sample indicated they preferred to complete the survey online, and were provided their secure access code and the URL for the study web page.

A challenge that presented itself in the final month of survey administration was a constraint of the DDE system, which only supported TTS identification (TTSID) codes of no more and no less than six digits, and the first digit could not be a zero (limiting the number of cases loaded on to the DDE system to no more than 900,000). As the address-based sampling plan was a total sample of more than a million records, Malatest had to create duplicate TTSIDs for 122,645 cases, which were placed on a separate instance of the DDE server. This considerably complicated some sample management, sample tracking and data reconciliation activities, particularly when working with data extracts from DDE which only include the numeric TTSID (such as the final data extract format)

This did not cause confusion for participants, who gave their seven character alphanumeric web access code on their notification letter when phoning the Toronto call centre. Reception staff used the web access code to look up the TTSID on the master sample spreadsheet and noted the server to which that case was assigned and transferred the call to the appropriate team.

While the duplication of TTSIDs on different servers introduced the risk of completing a survey with the wrong participant or confusion during the follow-up process, this did not occur in practice. The secure access codes given to respondents in their invitation letters were alphanumeric keys that were unique, even if the TTSID used by the DDE system was not, which helped prevent mix-ups with inbound phone calls. Reception staff were also trained to take care in determining the correct server when looking up the TTSIDs of respondents calling in who did not know their access code. When printing surveys from the server containing the duplicate TTSIDs, Malatest used yellow paper to avoid mix-ups with the surveys associated with the original instance of the same TTSIDs, which were printed on white paper.

For the next cycle, Malatest recommends ensuring that the data collection system is set up to handle samples in excess of 1,000,000 records. If sampling rate requirements will be similar, population continues to increase, and the proportion of address-and-phone households continues to decrease (thereby decreasing the overall response rate), it will be necessary to invite more than 1,000,000 households in future cycles.

2.13.1 Surveys completed on one system but started on another

Because the DDE and CallWeb questionnaires were parallel data collection streams, there was a challenge of participants beginning the survey using one channel (i.e., online or over the phone), and then wanting to complete the survey using the other.

For households that began the survey online and called the study toll-free number for assistance, professional interviewers would typically complete the online survey form over the phone with the participant. Those who began the survey over the phone and decided they wanted to switch to completing it online were advised that they would need to start the survey over, as there was no way to enter the responses they had already provided into the CallWeb form. These participants were advised that they could complete the survey in sections, and should make a record of their travel patterns for the day that they had been assigned to avoid forgetting trips made by household members.

For address-and-phone households that began the survey online and abandoned it before survey completion, if the respondent had substantively begun the survey, the case was blocked in DDE and outbound follow-up calls were undertaken to attempt to complete the survey with them via CallWeb. If, however, the respondent had only completed a few questions online, outbound calling via DDE was allowed to continue per the regular calling queue.

The 2016 cycle of the TTS was contractually constrained to use the DDE system for phone surveys, and a separate online survey system had to be set up to serve the need for an online survey mode that was available in both languages. For future cycles, Malatest recommends collecting the data using one integrated system, if possible, in order to simply sample management.

2.13.2 Partial surveys

There were conflicting instructions in the RFB as to what constituted a completed survey, which presented a challenge in assessing the total number of valid completions Malatest had toward the study target during data collection.

The RFB specified the following:

> "In order to be kept in the final database, each household shall meet the following specific criteria:
> - All information for all persons and all their trips in the database must be complete.
> - Each person record is complete without missing information, invalid work or school location, or unknown mobility for 50% (half) or more of his/her trips. Otherwise the person will be considered not interviewed and the person record shall be rejected from the household.
> - More than 50% (half) of the members in the household have complete information and remain in the database. For example if the information for two out of four people in the household is incomplete, the household record shall be rejected."

This is a definition of an acceptable survey that has been used in a number of household travel surveys in other jurisdictions but not before in the TTS. This definition allows for the acceptance of as much data as possible, keeping in mind that households with more household members and/or more trips are more likely to be rejected (as they have more data points in each survey) as compared to surveys with smaller households and with persons who did not travel. Retaining as many households as possible mitigates the risk of skewing travel patterns due to more high-complexity surveys being rejected, however, it does require correction factors in the data weighting to compensate for persons with incomplete or missing trip chains.

This guidance from the RFB was contradicted by clarification from the senior managers from previous cycles that a completed household must have a geocodable home address, have responses to all key

household questions, have a response as to employment and student status, have geocodable work and school locations (if applicable), and have key trip elements. The DDE system and DDE visual review processes were not configured to accept as complete surveys with less than 100% of all household members having good information for key fields. In consultation with DMG and the previous senior managers of the project, rules were further clarified (e.g., trip mode, time, purpose, and destination were required but an answer to the question on use of Highway 407 was not).

In October, when there was some uncertainty that Malatest would be able to reach the target number of completions using the first definition of a completed survey in the RFB, clarification was provided by MTO that surveys with complete information for greater than fifty percent of household members would be accepted. At that time, Malatest confirmed that this would add approximately 1,800 cases that were eligible for visual review.

However, based on the response rates in the final weeks of survey administration, these surveys were not required to meet the target of 161,200 completed surveys, and the more recent instruction stands with respect to all persons and all trips in the household being complete.

2.13.3 Development of a bot to coordinate sample management between CallWeb and DDE

Malatest originally proposed developing a bridge that would load data from CallWeb surveys directly into the DDE system, which would have had the advantage of being able to leverage the DDE system's visual review reports and processes, instead of having to develop a parallel version using CallWeb data extracts. After discussion with subcontractors as well as DMG, **it was determined that a bridge between the data collection systems was not a viable solution.**

DMG recommended against attempts to load DDE tables with survey responses, based on past attempts to do so. In previous cycles, attempts to load tables with survey data had resulted in complications due to not populating 'background variables' used for tracking and other purposes. The original developer of the DDE system had not left a clear guide to the relational database structure and content of background variables that would allow for us to determine which additional variables to populate with which values in order to ensure that subsequent processes (visual review, geocoding, etc.) would function as desired. Furthermore, the DDE system captures location information in a different format (using as its base a road segment file with some addition of landmarks and uncatalogued civic number ranges during data collection) than CallWeb (which used a Google Maps API that returned initial search terms, returned search results, and specific latitude/longitude coordinates), transforming the location data to an appropriate format may have required considerable up-front work.

DMG initially proposed an alternative solution that would require a bot to enter the data collected in CallWeb to the DDE via keystrokes in the correct sequence, which would ensure that the system automatically populated all background fields as required. However, it was felt that the DDE architecture was too complex to develop a bridge solution in time for survey administration that would take into account all the different permutations and DDE behaviours that would allow the bot to correctly transcribe survey responses (e.g., without direct feedback to the bot from the DDE system if the server was slow to respond and did not accept a single entry and refresh prior to the next entry from the bot, the data for an entire case might be compromised).

A simple bot was programmed to update DDE with status codes to reflect the completion of a survey online via CallWeb. The bot was developed by the former DMG computer systems manager working on

contract. This prevented interviewers from calling respondents who had completed the survey online, or who had progressed to the point where it would be more efficient for staff at the Ottawa call centre to dial partially completed cases and either complete the survey over the phone or provide technical assistance. An attempt was initially made to develop the bot to 'speak' directly to the DDE module and transfer call status cases by replicating the terminal inputs required. This system would have allowed for automation of the updates directly from CallWeb, however, it could not be developed prior to survey administration.

Instead, a simpler bot was developed that sent key strokes to the DDE module in order to update individual cases. **The bot developed had to be run manually once per day.** This involved extracting the TTSIDs for cases that had been completed the previous day and initiating the bot transfer.

In addition to the development of the bot, regular transfers of data were undertaken in the opposite direction, from DDE to CallWeb, in order to 'lock out' online survey cases that had been completed in DDE and prevent duplicate surveys being completed over the phone and online by the same household, should a household be so inclined.

For future cycles, Malatest recommends either using an integrated software platform capable of managing both the telephone and online surveys in one database, or, if two separate systems are to be used, more time in set-up phase of the project to allow for development of an appropriate bridging system. For the latter scenario, it would be useful if good system documentation and expertise with the data collection system were available.

2.14 Challenges in preparing the final data file and final reporting

The first extract of the DDE data in the deliverable format was provided to Malatest by DMG for the first time in May 2017, after which the x-y coordinates in the DDE data could be spatially joined to the traffic zone, planning district, historic municipality, and ward layers. After the DDE extract was delivered, the CallWeb dataset also needed to be prepared to extract to the same format, with the same category codes, and the same data transformations (with some fields in the final data file requiring population of no-response indicators, or transformation of response codes as collected into aggregated to split response codes as reported). Little documentation on required data transformations was available, beyond the 2011 data dictionary, which was found to have a few minor errors. The CallWeb extraction process took a number of weeks to program and test, before it could be merged with the deliverable version of the data from DDE. Some revisions were later required when issues were identified. Some of this effort could be reduced, and the provision of data files would be streamlined, if only one system were used to collect all of the survey data.

In addition, as mentioned elsewhere in this report, finalizing the data required a number of rounds of spatial joins to assign traffic zones and planning districts, sometimes to diagnose and address minor issues in the GIS shape files provided. In addition, during the DMG's review of the data, minor data issues were identified on a few different occasions, requiring correction of the data in the master data files, and re-extraction of the deliverable data format again. A number of further tests of the data were created and run on the data, with further adjustments to the data.

The delivery of an initial combined draft of the data file was only possible in early August of 2017, and the very final revisions and adjustments to the data were undertaken between August and November of 2017. In retrospect, the schedule for the delivery of the data was too aggressive considering the backlog

of online visual review after survey administration concluded, the challenges of managing data from two different systems, the geography issues, and the need for very close review of the data to identify any possible systemic or occasional data issues.

The schedule for developing the data weighting was impacted in part by the availability of 2016 Census data. Certain data critical to the data weighting were only made available in August 2017. Other data useful for validating the weighted data set (e.g., labour, journey-to-work data) was only available in November 2017. For the 2016 TTS, given the methodological changes, there was also considerable interest from TAC in reviewing the survey results by sample type (address-based vs. address-only) and survey method (phone, online), the weighted survey results relative to the previous cycle, and the validation of the weighted survey results relative to benchmark statistics.

For future survey cycles, Malatest recommends allowing sufficient time for back-end activities, including back-and-forth with the DMG to identify and address any data issues or data requirements, and to review preliminary unweighted and weighted results.

2.15 Technical support for TTS software

Per the RFB, DMG was responsible for supplying a computer system manager who was responsible for the setup, installation, and operation of the DDE, along with guidance and assistance to Malatest related to this computer system.

Unfortunately, prior to the installation of the DDE servers, the computer system manager employed by DMG accepted a different position at the University of Toronto. DMG negotiated that he would be able to provide up to 11 hours of support each week, which were quickly exhausted. The 11-hour limit was determined by the maximum amount of overtime he could work above and beyond his regular workweek for his new position. Malatest and DMG agreed that he should continue to provide technical support because any new hire would require a significant training by the former computer systems manager to be able to support the DDE system. In order for that continued support to be available, the former DMG computer system manager was contracted as an outside consultant at the rate of $100.00 per hour plus travel. A ceiling of 100 hours was set at the onset of this agreement; however, this was increased to 150 hours due to project demands. This cost ($15,000) was approved by TISC to be charged to the contingency.

Even with these special contractual arrangements, there were limits to the extent of the support that the former DMG computer system manager could provide. The architect / lead programmer of the DDE system had not worked for DMG for a few years, and had sometimes left limited documentation as to the functionality of the system. Some aspects were well documented, others not at all. For example, there was no clear documentation available of the relational data structure of the internal SQL working tables, and no complete lists of data fields and data dictionaries in those tables. While data dictionaries exist for the deliverable output tables, in the internal SQL tables, the working fields and values in those fields often differed from the final output tables. The DMG computer system manager often had to reverse engineer aspects of the programming before he could implement any changes. For example, while wording changes or changes to lists of response options were possible to implement, it was not possible to add new questions or make structural changes within the project timelines.

In some respects, the DDE module has several advantages for telephone interview data capture. The DDE system is configured for maximum efficiency: the ‘mainframe terminal’ style of interface allows for

quick keyboard entry of responses using single-character letter or number codes, it immediately jumps to the next question upon entry (after flashing the response entered for confirmation), and has very quick screen load times. This has advantages over web-based interfaces, which allow for less keyboarding and often require more (slower) interaction with a mouse to select response options via radio buttons or from drop down lists. While there is a learning curve, once phone interviewers become efficient with the DDE system and learn the response codes, they can achieve very fast interview times. However, the critical limitation of this system is the diminishing corporate knowledge with respect to the data structures and internal programming of the system. Malatest recommends that further use of the DDE system be carefully considered before adoption, especially in light of the fact that one might expect even fewer telephone and even more online survey completion in the future. However, the DDE has functionality and features which should be considered for any system that might replace it.

2.16 Envelope orders

For full survey administration, MTO had the responsibility of providing envelopes to Malatest for the mailing of notification letters to sampled households. The quantity of envelopes required was provided to MTO by Malatest, who had envelopes printed by a vendor of record. **This process required Malatest to submit envelope request six weeks in advance of the order being delivered, which proved to be a challenge as the sampling plan was updated with current responses rate assumptions roughly twice a week throughout the study, and the number of envelopes required changed with each update.** This resulted in unnecessary work for both Malatest and staff at MTO to ensure envelopes could be acquired in time for the scheduled mail outs. Given the late decision on the sampling plan options (survey targets by sample type), carefully planning was required to order enough envelopes for the start of data collection without over-ordering for sampling plan options with smaller mail-outs (higher address-and-phone targets) and without under-ordering for sampling plan options requiring larger mail-outs (options with higher address-only targets), while allowing for a sufficient window to order additional envelopes when response rates predictions could be refined based on actual performance.

In other transportation studies similar to TTS, Malatest typically assumes responsibility for envelope printing and passes the cost on to the client. Under these conditions, Malatest is able to have the bare minimum number of envelopes printed, with faster turnaround, based on the sample provided to the vendor, which allows for a flexible sampling plan without requiring overprinting of envelopes as a contingency.

While MTO may have obtained some savings by getting the envelopes printed by the Queen's Printer for Ontario, this savings was partially offset by project management costs associated with coordinating with multiple parties to clarify requirements, submit orders, coordinate with mail houses receiving orders, and related activities, in addition to the timeline pressures associated with the arrangements. For future cycles, Malatest recommends considering having the vendor take responsibility for the procurement and printing of all mail out materials.

2.17 Development of survey targets by region, municipality, and FSA

The 2016 TTS had a general objective of obtaining a uniform 5.0% sample of all households in all regions except Hamilton, which had a 3.0% sampling rate. **As the 2016 Census household counts were not yet available during survey planning stages, the final achieved sampling rates may differ.**

The survey targets by region were set based on the sampling rate applied to estimates of the number of households in each region. The household count estimates were projections to 2016 based on data from

the 2011 TTS data and earlier. In a few regions, the 2011 household counts used in the projections appeared to differ from the final 2011 Census figures by a few hundred, or in two cases, a few thousand households, possibly due to 2011 Census recounts or other issues with the way the 2011 data were aggregated by region. The regional survey targets were confirmed with the partner municipalities in order to secure funding prior to issuing the contract for data collection. The targets were later scaled slightly after the sampling plan options for a hybrid sampling methodology were approved, to a 4.94% sampling rate in regions other than Hamilton, and 2.96% in Hamilton.

Within each region, survey targets by FSA were set by distributing the regional target according to the Canada Post counts of addresses within each FSA. Survey targets by municipality or planning district were set by distributing the regional target according to the Canada Post counts of addresses within each municipality (which required apportioning the FSA level counts into 6-digit postal codes and/or delivery routes within the FSA).

After the 2016 Census results were released in early 2017, it was clear that, while they provided a fairly good basis for setting survey targets, the estimates of 2016 households used to set the targets differed somewhat from the Census figures. Some regions that were short of their survey target nevertheless achieved a sampling rate greater than their target 5.0% sampling rate, and others that met their targets were short of a 5.0% sampling rate. This is illustrated in Table 2-4 in the next section of this report.

For future cycles, to achieve a more balanced final sampling rate when setting targets and securing funding, Malatest recommends using more accurate methods of forecasting the household counts. Province of Ontario or Statistics Canada growth projections by Census Division could be used. Alternatively, Canada Post residential address counts available at the planning stages could be used (keeping in mind that there may be some differences from Census counts depending on the extent to which Canada Post's address database includes or excludes secondary suites in houses). Even with more accurate forecasts there may still need to be acceptance that, after eventual release of the Census data, the final sampling rates may vary slightly from those proposed in the planning stages.

2.18 Geographic boundaries

2.18.1 Challenges in reconciling Canada Post and TTS geographies

During survey administration, effort was required to set and monitor survey targets by both FSA and municipality/planning district. This is, to some degree, inevitable, as the adjustments to the Canada Post sample need to be undertaken using postal geographies, and the TTS data need to be organized by TTS geographies. Malatest addressed this by developing an accurate basis for assigning and apportioning FSAs, individual postal codes and/or local delivery routes in Canada Post reference data to the TTS geographies. Even so, some effort is required to maintain and monitor contact samples and survey completion tracking at multiple geographic levels (105 TTS municipalities/planning districts and 300 FSAs, which needed to be apportioned to about 500 sub-geographies).

2.18.2 Challenges in precisely monitoring survey targets by geography

Similar to the previous survey cycle, three-digit postal code (FSAs) and sometimes full six-digit postal codes in rural areas were used as the base unit for setting survey targets within regions and for tracking survey completions. The DDE system, FSAs and six-digit postal codes were used to manage sample and block further efforts once survey targets were met. However, postal code definitions do not always follow municipal and planning district boundaries, so four-, five-, and six-digit postal code definitions

were employed in order to assign appropriate amounts of sample and to track survey completions. Over 300 FSAs were fully or partially represented within the study area. However, even splitting FSAs could not match the municipal and planning district boundaries exactly. **This presented a challenge during survey administration as the actual number of completions assigned to each region was subject to a certain amount of error.** This resulted in some completions that were thought to be in-scope being rejected during the survey validation process, and others being attributed to different municipalities or regions than originally expected. Initially, it appeared that survey targets had been exceeded for all regions except one.

Table 2-4 presents a summary of completions on the basis of actual home coordinates mapped to the study geographies after the geocoding of completions was finalized. In the final data, four of the 24 regions were just slightly below target (between 99.5% and 99.9% of their target), and two of the regions were under target by a larger proportion (City of Peterborough at 95.7%, and Brantford at 98.1%). Many of the surveys that were rejected as outside the study area were extremely close to survey boundaries. While the idea of moving household coordinates close to the boundaries so that they fell within the boundaries was considered, very few locations were close enough (e.g., the other side of the street) to warrant moving them, and little work was put towards this. In addition, a number of surveys originally assigned to the City of Peterborough during survey administration based on their postal code were later determined to actually be located within Peterborough County. Of note, examining the final sampling rates referenced against the 2016 Census counts, 11 of the 24 regions achieved sampling rates greater than 4.9% and only three regions had sampling rates less than 4.9% (Waterloo and Guelph, at 4.8%, even though they had exceeded the target number of surveys, and Peterborough, at 4.6%).

Table 2-4: Final Validated Surveys as % of Target and Final Household Sampling Rates

	TTS Region	2016 Household Forecast*	Survey Targets**	Final Valid Survey Completions	% of Target	Difference from Target	2016 Census Hhs***	Final Sampling Rate
	SURVEY TOTAL	**3,345,811**	**161,200**	**162,730**	**100.9%**	**1,530**	**3,335,990**	**4.9%**
1	Toronto	1,083,285	53,512	54,359	101.6%	847	1,112,929	4.9%
2	Durham	233,850	11,559	11,702	101.2%	143	227,906	5.1%
3	York	372,178	18,397	18,380	99.9%	-17	357,084	5.1%
4	Peel	449,174	22,203	22,108	99.6%	-95	430,180	5.1%
5	Halton	198,294	9,802	9,770	99.7%	-32	192,977	5.1%
6	Hamilton****	211,580	6,275	6,426	102.4%	151	211,596	3.0%
11	Niagara	181,508	8,972	9,097	101.4%	125	183,828	4.9%
12	Waterloo	194,548	9,617	9,790	101.8%	173	203,832	4.8%
13	Guelph	49,884	2,466	2,483	100.7%	17	52,090	4.8%
14	Wellington	22,821	1,128	1,211	107.4%	83	22,121	5.5%
15	Orangeville	11,224	555	555	100.0%	0	10,565	5.3%
16	Barrie	59,611	2,947	2,957	100.4%	10	52,476	5.6%
17	Simcoe	116,025	5,735	5,820	101.5%	85	117,583	4.9%
18	City of Kawartha Lakes	31,541	1,559	1,553	99.6%	-6	31,106	5.0%
19	City of Peterborough	33,390	1,650	1,580	95.7%	-70	34,710	4.6%
20	Peterborough County	17,727	876	933	106.5%	57	17,455	5.3%
21	Orillia	13,380	661	665	100.5%	4	13,477	4.9%
22	Dufferin	11,881	587	636	108.3%	49	11,353	5.6%

	TTS Region	2016 Household Forecast*	Survey Targets**	Final Valid Survey Completions	% of Target	Difference from Target	2016 Census Hhs***	Final Sampling Rate
23	Brantford	39,406	1,948	1,911	98.1%	-37	39,215	4.9%
24	Brant	14,507	717	794	110.7%	77	13,507	5.9%

*Household forecast based on data from the time of the 2011 TTS projected to 2016, used as a basis for setting survey targets.
**Survey targets as adjusted after consideration of the sampling plan options and approval of the final sampling plan.
***Private dwellings occupied by usual residents.
****The target sampling rate for Hamilton was 3.0% rather than 5.0%.

2.18.3 Differences between TTS boundaries and Statistics Canada boundaries

One of the challenges encountered when applying the data weighting came from the need to reconcile the TTS geography files with the Statistics Canada standard geographies. The exercise in splitting ADAs that straddled planning districts / municipalities took some time but was relatively straightforward, and was necessary to ensure that the expansion zones reflected the TTS geographies. However, for some boundaries that should have been common to both geographic systems, the TTS planning district boundaries did not always follow the Statistic Canada geographies for boundary lines that should have been common. The Statistics Canada geographies are typically updated before each Census with recent municipal boundary files supplied by the municipalities, while the TTS boundary files were based on 2006 TTS boundaries, with some ad hoc adjustments over the years to reflect changes to municipal borders.

After the discrepancies were discovered, DMG made some adjustments to the TTS planning district boundary file to close gaps and to adjust the boundary lines to better fit the street network. Even so, the new TTS boundary lines did always follow exactly the boundary lines of the Statistics Canada geographies. As a result, some time was spent reconciling and investigating counts from the aggregation of expansion zones with counts obtained by aggregating the weighted TTS data from the planning district level. It was found that occasionally the coordinates for a household located very near the boundaries was spatially joined to an expansion zone associated with a planning district that was different from the actual planning district boundary the household fell into. In the end, because there were very few such instances, most discrepancies between the expansion zones used to assign the data weighting and the planning districts were left as is.

Some slight differences between the 2016 Census household or population counts and the sum of the expansion weights at the planning district/municipality level may be attributable to the small overlaps/discrepancies between the Statistics Canada based expansion zone boundaries and TTS planning district boundaries. The differences were very small relative to the populations represented. It should be noted that all analysis of the data is undertaken using the planning district geographies, not the expansion zone geographies. I.e., the expansion zones are artefacts of the data weighting process, and the discrepancies in aggregated totals should make very little difference to the results.

For the next cycle, it is recommended that the TTS boundaries be better adjusted to remove any gaps between boundaries, and, as much as possible, ensure that, for common boundaries, the municipal / planning district boundary lines follow as closely as possible the Statistics Canada CSD and other standard geography boundary lines (taking into account that the geographies will not all conform, as some ADAs will still need to be split across planning district boundaries).

2.18.4 Differences between TTS Planning District / Municipality boundaries and TTS Traffic Zone Boundaries

The GIS shape files that described the TTS regions, municipalities/planning districts, historic municipalities within Toronto, municipal wards, and traffic zones did not always jive. There were two main issues: boundary lines that differed for the different levels, and empty slivers (gaps) between shapes. In the discussion below, for shorthand, 'planning district' refers to the full municipality/planning district geography (not just the 16 planning districts in Toronto and the six planning districts in Hamilton).

When the final dataset was being prepared, the most recent planning district boundary file was provided to Malatest for the purpose of spatially joining the x-y coordinates of all locations to the TTS geographies. It was agreed that the planning district boundary file would be relied on when assigning planning districts to the locations captured in the survey (households, work locations, schools, trip origins and destinations), rather than the planning district associated with the expansion zone (discrepancies between which are discussed in the preceding section). As noted earlier, after initial runs at conducting the spatial joins, some issues were identified, and the DMG made adjustments to the planning district GIS layer to better respect the municipal boundaries and actual street locations. The traffic zone layer was not adjusted at this time.

The TTS traffic zone system has not undergone any substantial revisions since the 2006 traffic zone layer was produced. When the locations in the survey data were spatially joined to the traffic zone system, a number of locations within the study area were not coded to traffic zone due to empty slivers between traffic zones. There were also a few instances of locations on the Toronto waterfront that were not captured in the zone or planning district system. Efforts were undertaken to reconcile the data. Some of this work required manual review to identify locations with coordinates that fell between traffic zone boundaries, and then to manually determine which traffic zone to place the location in.

During testing of the final data, a number of discrepancies were identified between the planning district typically associated with the assigned traffic zone and the planning district assigned to the same location through the spatial join. There were three possible reasons for this: a very few traffic zones legitimately straddle planning district boundaries; the closest traffic zone assigned to a location falling in a gap between traffic zones may not have jived with the planning district; the planning district boundary may have extended beyond a traffic zone boundary into the edge of a traffic zone that it should border. A number of these issues were resolved with input from the DMG.

Similar issues were observed with discrepancies between planning districts and the municipal ward boundaries or with the historic municipal boundaries within Toronto that led to slight differences in the totals obtained for the sum of wards (or of the historical Toronto municipalities) vs. the total for the municipality obtained from the planning district/municipality layer.

As the final dataset was tested, some x-y coordinates within the data were adjusted (e.g., some school locations were updated, or destination geocoding issues were identified and resolved). Any changed locations could then be subjected to the same issues when the spatial joins were undertaken again, necessitating more testing and troubleshooting.

Both DMG and Malatest expended hours in testing for and reconciling geographic issues associated with issues with the GIS boundary files. In addition, every time revisions were made to the data file to address these issues, the revisions needed to be made in the master data tables (which included a number of working variables) and the deliverable data files needed to be extracted again from the master database into comma-separated-values format then transferred to DMG via secure FTP for further review. This added to the extra effort required in the data finalization.

Again, if work can be done in advance of the next survey cycle to create a geographic system of regions, planning districts, and traffic zones that follow basic topology rules (no gaps between features, no overlaps, higher levels follow the boundaries of lower levels). This would save considerable work for expensive resources such as GIS analysts, reduce the number of drafts data files that would need to be prepared, and reduce delays in producing the final data.

2.19 Google Maps/Land Information Ontario concordance

For the 2016 TTS, a large proportion of the surveys were completed online using CallWeb, which uses Google search functions and interactions with Google Maps to allow respondents to report home, work, school, and trip destination coordinates. Locations were stored as latitudes and longitudes with corresponding descriptions which usually included a street address and sometimes a place description (e.g., business name, transit station, etc.).

Telephone surveys were completed using the Direct Data Entry (DDE) module, which makes use of Land Information Ontario (LIO) street segment files as the basis of geocoding most street address locations to coordinates, although a portion of locations (e.g., specific places of interest, like an airport) were assigned coordinates manually by geocoders. The DDE LIO method uses matching of civic numbers and street names to street segments, and interpolating the location on the segment of the civic number within the civic number range, and offsetting 22 m to the side of the street the odd or even civic number belongs.

The use of Google-based map coordinates is new to the TTS. This raised questions as to whether there might be differences between how the same location might be coded in CallWeb via Google and in DDE using the LIO street segment base, and, if so, whether the any such differences might affect the analysis of the data.

At TAC's request, Malatest explored the extent of the concordance between LIO-based coordinates and Google-based coordinates, making use of a sample of over 299,000 trip destinations captured in online surveys in the first few weeks of data collection.

Due to the high concordance between Google and LIO-based coordinates, the steering committees accepted Malatest's recommendation that Google coordinates from online surveys be accepted 'as-is'. The full report on Google-LIO concordance may be found in **Appendix D**.

Some consideration may still need to be given to the consistency of the coordinates in relation to the LIO base, as the LIO street segments are the basis of the zone systems to which the data are eventually assigned. For example, it may simply be a matter of overlaying the traffic zones on top of Google Maps (which is possible to do in a number of GIS programs) and doing a visual review of the boundaries to confirm that the majority of traffic zone boundaries that follow street centre-lines in the LIO system, do so in Google Maps as well. Alternatively, the LIO street segment base could be overlaid on top of Google

Maps to verify that the LIO segments generally fall in the centre of the Google Maps representation of the streets. There was a high level of concordance in the traffic zone coding of the same address from Google Maps capture mapped via the LIO interpolation method, and the Google Maps base is likely developed from many of the same original sources that feed into the LIO base, nevertheless, it is possible that there could be some geographies where the alignment is off.

If it were to be established that the traffic zones do not align well with streets in the Google Maps base in certain areas or across the study area, it might then be of use to re-map coordinates from Google Maps to interpolate their given address descriptions via the DDE LIO interpolation method. Budget would need to be reserved for this exercise. Furthermore, this exercise would be undertaken at risk of diminishing the accuracy of some of the locations obtained via Google Maps (e.g., LIO's straight-line interpolation of addresses on crescents could change traffic zone assignments), and provisions would need to be made for handling addresses returned by Google with descriptions or formats that did not directly match the LIO (much as work undertaken in Malatest's testing of this issue). Nevertheless, the strengths of using Google Maps, including accuracy and interactivity (ability to view the result and move the marker on the map), are of considerable benefit, and thus use of Google Maps is recommended.

SECTION 3: Lessons Learned

The project team learned many lessons over the course of administering the 2016 TTS. These included operational issues, the dynamics of the study population, how the design of the survey could be optimized, the response to the survey by mode, non-response bias, and sources of error in data collection. These lessons have been documented and should be considered in the planning of future waves of the TTS as well as other similar travel studies. Significant lessons learned are bolded for emphasis.

3.1 Scheduling of project activities

3.1.1 Compressed schedule for front-end activities

The delay between the intended award of the TTS contract and the actual date that Malatest was confirmed as the vendor compressed the amount of time that Malatest had available to plan and execute the survey.

Furthermore, the original RFB did not consider the use of address-only sample nor the implementation of an online version of the survey, but was scoped out for telephone surveying only via the DDE system. Given the significant decrease in the number of households with listed land lines, particularly amongst younger and smaller households, this approach would have been undertaken at great risk to the representativeness of the survey sample and the usefulness of the collected data. The choice to collect surveys via address-based sampling with an online survey option was the best decision for the project but had consequences in terms of the amount of project management and preparation time required, and also introduced operational risks.

Malatest expended considerable time in the early stages of the project in order to present the reasons for incorporating address-based sampling and online surveying, with a number of papers prepared on the rationale for change, the sampling plan options, and expected impacts on scope and budget. TAC required time to consider these options before providing approval. This additional front-end work placed further demands on key staff resources and the TAC committee to consider options and make decisions. This further tended to compress the available time in which other front-end activities could be undertaken.

The compressed timelines did not allow sufficient time for Malatest to fully test the online survey tool. There were delays in the development of the online version of the survey tool, in part due to the time required to develop a comprehensive questionnaire with skip pattern instructions for programmers to work from (as the only documentation was an interviewer guide), to consult with internal subject matter experts (DMG and senior TTS staff from previous cycles) on necessary deviations from the telephone script, and to obtain approvals from the TAC committee for these deviations. This resulted in delays in finalizing the online version of the instrument. While the survey was prepared in time for the launch of the study, Malatest continued to identify minor bugs and make programming changes that would typically be identified prior to an online survey being fielded.

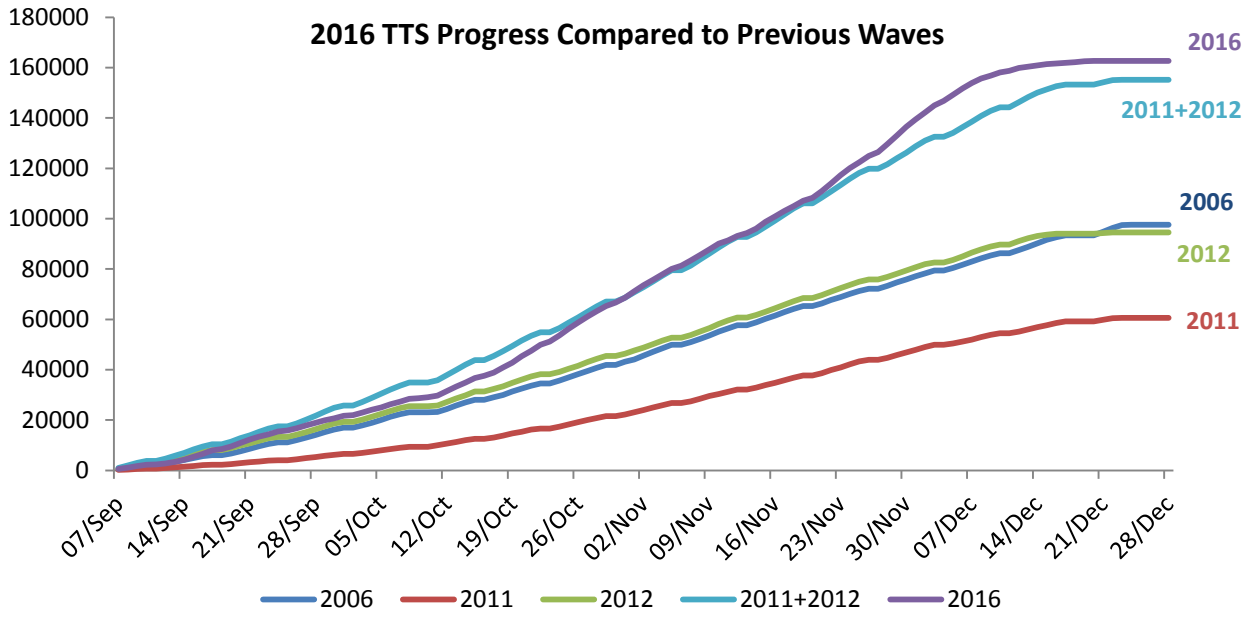
Nevertheless, despite the delays, compressed front-end timelines and additional pressures, the fact that the project successfully negotiated the methodological changes, started full survey administration on time, and met survey completion targets can be seen as a significant achievement. **Nevertheless, the**

challenges and extreme pressures encountered in achieving this underscore the desirability of deciding on an appropriate and viable survey methodology when scoping the project, of providing sufficient time in the front end to accommodate refinement of the survey methods and testing of survey instruments.

3.1.2 Compressed schedule for data collection

Collecting 161,200 surveys within a three-and-a-half month period represented more than twice the number of completions required per day compared to the 2011 TTS. Due to limitations of call centre capacity, the realization of survey targets within one cycle of data collection depended on high participation rates from the address-only sample, which could only be contacted via the notification letter they were sent inviting them to participate in the study. Figure 3-1 compares survey progress between the 2006, 2011/2012 and 2016 TTS. Only valid, accepted surveys in the final dataset are plotted. The figure shows dates until December 28, but is should be noted that all of the surveys ended in early or mid-December, with the exception that, in 2016, a very small number of online respondents was allowed to the end of December finish or edit their surveys for travel dates up to and including the last accepted travel date of December 17.

Figure 3-1: 2016 TTS progress compared to previous waves – valid surveys



The slow start launch of the online survey through reduced volumes of address-only sample put Malatest behind schedule in terms of the average number of completions required per day. However, **the slow start was worthwhile, as the consequence of failure of the online system with standard address-only batch sizes in the field would have put the completion of survey targets in the allotted time in jeopardy.** Furthermore, there was benefit to being able to refine the visual review process for online completions in the first few weeks of data collection before being overwhelmed by high volumes.

Predicting response rates was a challenge throughout survey administration. Pilot testing of the survey in July had yielded modest response rates, which were not entirely reliable as surveys conducted in July

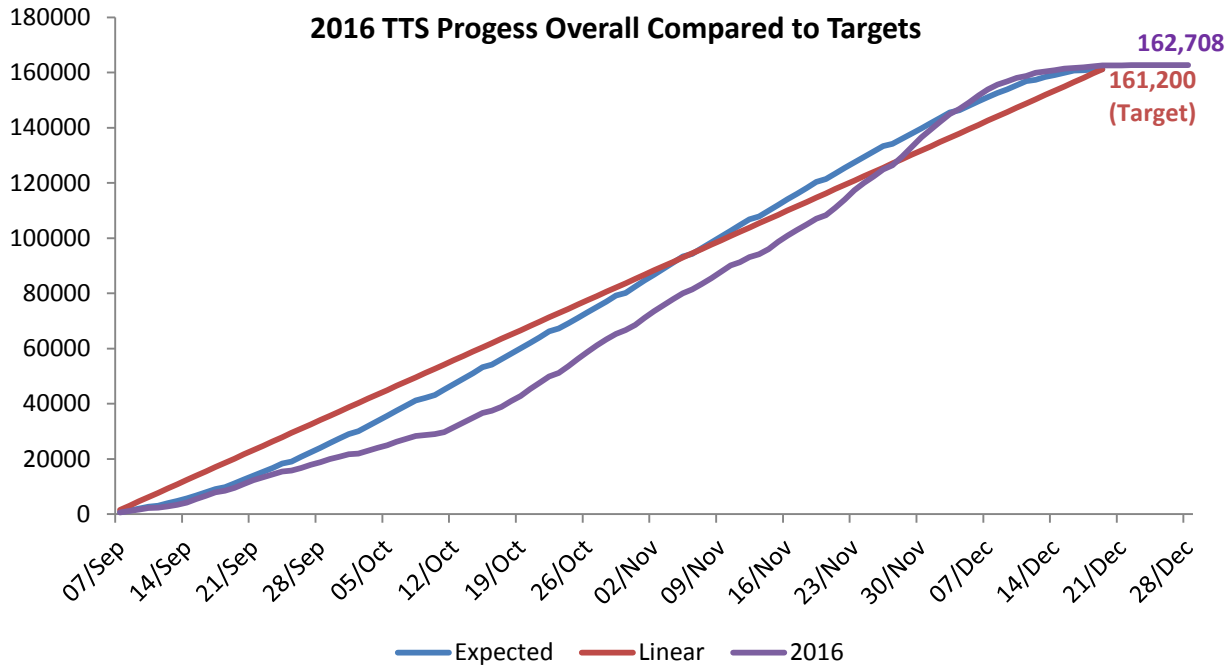
have atypical response rates compared to other times of year. During the early stages of data collection from the start of September through mid-October, survey response rates for the address-only considerably exceeded expectations, and as a result, the sizes of planned mail out batches were somewhat down-sized. However, in late October and through November of the data collection period, declines in the response rates of address-only samples, and delays from Canada Post in providing sample purchased raised concerns that the completion target would not be reached. As a result, Malatest deployed significant volumes of sample in the final month of data collection, in anticipation that the response rate to the survey would decline in the month of December. However, the **sample deployed in late-November and early-December performed as well, if not better than average.**

As a result of this unexpected late surge in survey completions, Malatest overshot the completion target. As the budget for data collection did not allow for visual review, follow-up, and validation of excess surveys, surveys obtained above 102% of the target for each region were put on hold and would only be visually reviewed if required after final visual review and further rejections resulted in any of the regions dropping below target.

In Figure 3-2, the slope of the purple line showing the actual valid/accepted survey completions obtained illustrates the slower start in survey completion volumes, with increasing volumes almost to the end of the project. It should be noted that the last travel date was December 17 and December 19 the last date for outgoing survey interview calls, but a few respondents were allowed until the end of December to edit or finish their online surveys.

In future cycles, it may be worthwhile to pilot test survey response rates during the fall preceding the data collection period, or at least in the spring prior to the end of post-secondary school exams, in order to get a better sense of achievable response rates. Given more time to develop and pilot test the survey, including both data collection as well as set up and refinement of visual review procedures, it would have been possible to begin the survey with a higher volume of address-only invitations and online surveys and better plan the survey volumes throughout the data collection period. If the final weeks can be planned to have lower volumes, notwithstanding the beneficial increase in response rates in late November through mid-December, there would be less risk of over- or under-shooting the survey target.

Figure 3-2: 2016 TTS progress overall compared to targets – valid surveys



3.1.3 Managing the volume of online visual review

While not a result of the compressed timelines, the greater than expected response to the online survey yielded many more online survey completions and with higher volumes earlier than expected. In addition to the volume of online surveys, the visual review process took longer than expected on a per survey basis, which also contributed to the backlog. For mixed-mode of similar scope and scale, Malatest would begin the data review process with a larger survey validation team to prevent such a backlog from occurring in the future. This would be facilitated by more time in the front-end phase of the project to allow for the set up and testing of the visual review procedures.

3.2 Locations captured in Google Maps vs. those geocoded in DDE

Some observations may also be made about differences between locations geocoded in DDE and via Google Maps. As discussed earlier in Section 2.19 of this report, Google Map locations and DDE LIO location interpolations had a high degree of concordance, but there were some differences. In many instances the Google coordinates were more accurate than the same coordinates obtained through the DDE LIO interpolation method. Many of the Google coordinates have 'rooftop' accuracy. For curved street segments and crescents, Google coordinates were notably more accurate than the interpolation method, which interpolates along a straight line between the start and end of the segment. Google coordinates were also often more precise for large school campuses, work campuses or industrial facilities. However, it may be noted that not all Google coordinates were more precise. Very occasionally, the coordinates might be for the midpoint of a street segment, and very occasionally they might be for located on the street centerline rather than to one side or another of the street. Of note, in the CallWeb survey data, locations were much less commonly coded to intersections than in the DDE data (although they were a minority for phone interviews as well, as capture of precise locations was encouraged). The uncommonness of intersections in the online surveys was likely due to the fact that

Google maps provided respondents with the opportunity to review the location on the map and adjust it my moving the location marker. It may be noted that the Google coordinates might also vary (with the general bounds of the property) for different respondents giving the same destination, depending on the location description given in the respondent's search and whether they manually moved the location marker, whereas 'same locations' captured in DDE would normally have the same standardized coordinates.

3.3 Useful modifications to the online survey

While Malatest made useful improvements to the online survey prior to, and throughout survey launch, there remained room for improvement.

3.3.1 Use of Google Maps

The use of Google Maps may allow for more accurate tracking of survey administration outcomes by geography. In 2016 as well as previous waves of the study, sample was acquired and survey progress by region was tracked by the FSA or postal code from the sample file. This resulted in a small number of unnecessary completions outside the study area that were rejected during survey validation. Extractions of the data were undertaken during survey administration to map actual confirmed household locations to planning districts and identify whether there were any mistakes in coverage (whether pockets of dwellings missed in the Canada Post data, or postal code geographies that yielded completions with households outside the survey borders). However, this was extra effort, and could not be done for each weekly report on survey progress. **Programming study area boundaries for the online survey to notify would-be participants that their household location is out of the study area would reduce the burden or participating for households whose survey would ultimately be rejected. Real-time spatial joins of confirmed household coordinates to the study area would also allow for more accurate tracking of results and increase the efficiency of the survey validation process.**

3.3.2 Improvements to user experience

Overall, the online TTS survey provided a user friendly experience; however, there are three general areas where the experience could be improved.

The TTS survey was a complex survey tool to program for three main reasons: the volume of information being collected across multiple relational tables, the complexity of the logic checks required to be implemented, and the load that up to 2,500 survey completions per day put on the web server. While Malatest optimized the web server conditions to support fast page loading speeds, **there is likely an opportunity to optimize the programming of the survey, which was constrained by development time.** There is also likely an opportunity to optimize the survey for mobile devices, although the survey performance, look, and feel on mobile devices was consistently improved throughout survey administration.

One section of the survey where the user experience could be improved was the trips section. Allowing users to copy trips from one household member to others who took the same trip and reversing trips when the same travel methods are used going to and returning from locations are two such improvements which Malatest identified early on as features in the DDE to replicate in CallWeb, but did not have sufficient time to implement this programming. These features would have significantly reduced the time to complete the online survey and in turn the abandonment rate.

Another aspect of the trips section experience that would be of considerable benefit to improve is the ease with which trips could be edited. Participants were able to easily make changes to the trip they were entering but then it was difficult delete or modify trips that were already submitted. As respondents gained familiarity with entering trips, they may realize that earlier trips need to be modified. The visual summary of the trips that had been entered could have been improved as well, to allow respondents to better review the trip information and navigate between trips.

Finally, once the household, demographic, and trips sections of the survey had been completed, the participant could not return to that section to edit the survey. This feature was a safeguard against participants creating fatal errors in their survey, but it is possible that this could have been accomplished in a way that allowed users to return to previous sections of the survey and amend responses that would create errors that would prevent them completing the survey.

3.3.3 Additional online validation checks

For the online TTS survey, there were a number of inline data integrity controls that ensured answers were given where expected, did not contradict other responses, and even probed for potential trip under-reporting (e.g., asking full-time workers why no work trips were reported). However, many validation checks were done after the survey had been completed through the survey validation process. Some validation checks can only be implemented post-survey.

The following validation checks in the survey would have helped improve the data quality of surveys and reduce the volume of work in the survey validation phase, and may be feasible to implement in future waves without sacrificing survey speed:

- Origin and destination very close to one another (and mode other than walked);
- Mismatch in time, purpose or locations between different people for shared trips;
- Inappropriate selection of “Other” (i.e.: selecting mode of transit “Other” and writing in a form of public transit, which caused the survey to skip transit route questions); and
- Transit routes that are incomplete or not possible by incorporating General Transit Feed Specification feeds which are also available via a Google API.

3.4 TTS trip definition

The definition of what constituted a valid trip in the TTS was the source of a number of complaints throughout the study period. By design, the TTS does not collect walking trips other than to work or school, and does not collect round-trip recreational bicycling trips that do not stop at a destination for any purpose before returning to the origin. The most common complaints from respondents were that recreational bicycling and walking trips (other than to school/work) were not included in data collection. The reasons for not including round-trip recreational jogging or bicycling trips have merit (in part due to the difficulty interpreting trip data when start and end point are the same location), although it may be noted that there is increasingly interest in active transportation habits including recreational outings that use sidewalks and bicycle trails even if they simply return to the point of origin. Excluding walking trips other than to/from work or school has been the standard for previous cycles of the TTS, and does reduce response burden. However, the exclusion of walking trips and round-trip recreational trips was a contentious issue throughout survey administration, particularly on social media.

It was challenging to provide online respondents with simple definitions of the types of trips to report on. The inclusion or exclusion of only certain kinds of walking trips was confusing to many online

respondents, though perhaps less of a problem for telephone surveys completed with trained interviewers. It may also be noted that there is likely more interest in walking trips amongst planners today than at the time the TTS scope was originally designed.

3.5 Pilot test

The online version for the TTS – adapted from the telephone script and programmed in CallWeb CATI/CAWI software – was pilot tested to ensure that skip patterns were functioning as intended and to assess the online response rate to survey invitations. To this end, the pilot survey also provided the opportunity to test various options for the advance letters being mailed to inform the full survey in the fall. The pilot mail out tested the types of sample being used, postage options, inclusion of a detailed instruction sheet, and the use of listed name in the address block.

Advance letters were sent out on Friday, July 22nd from Victoria, BC. Field test respondents who required support were provided a toll-free number and email address to contact the Transportation Tomorrow Project Team.

The sample for the pilot survey was purchased from Canada Post. The cases were randomly selected from the in-scope area, as defined by the forward sortation address (FSA) (i.e. first three characters in postal code). FSAs that included households that were both in and out of scope for the survey were excluded.

A total of 2,998 cases were randomly sampled. Of those, 1,499 cases had both address and phone number information (address-and-phone sample). The remaining 1,499 cases had an address but were not associated with a phone number (address-only sample). Two letters were directed to the Malatest research office in Toronto, to test whether there was a difference in transit time between Personalized Mail and Lettermail.

Sample was further stratified to test the impact of the following items on the online response rate to the survey:

- Postage (Lettermail versus Personalized Mail);
- Inclusion (or not) of a detailed instruction sheet; and
- Addressee in address block (listed name from Canada Post database [only available for address-plus-phone sample] versus Occupant versus Resident).

The following table outlines the response rates of each element of the mail out being tested.

Table 3-1: Pilot Test Survey Response Rate by Strata

Strata	Sample Size	Logon Rate	Response Rate
Address+phone sample	**1499**	**18.3% ***	**13.9% ***
Address-only sample	**1499**	**12.5% ***	**8.3% ***
Lettermail	**1499**	**16.7% ***	**12.1%** n/s
Personalized Mail	**1499**	**14.1% ***	**10.1%** n/s
With instructions page	**1498**	**14.0% ***	**10.5%** n/s
Without instructions page	**1500**	**16.8% ***	**11.7%** n/s
Address+phone sample with instructions	749	18.8% n/s	14.7% n/s
Address+phone sample - no instructions	750	17.8% n/s	13.1% n/s
Address-only sample with instructions	749	10.3% *	7.2% n/s
Address-only sample - no instructions	750	14.8% *	9.5% n/s
Addressed to Occupant	**1122**	**12.9%** n/s	**9.3%** n/s
Addressed to Resident	**1125**	**15.7%** n/s	**11.6%** n/s
Address+phone sample addressed to listed name	751	18.6% n/s	13.2% n/s
Address+phone sample addressed to Occupant	372	17.3% n/s	14.8% n/s
Address+phone sample addressed to Resident	376	18.5% n/s	14.4% n/s
Address-only sample addressed to Occupant	750	10.1% *	6.5% *
Address-only sample addressed to Resident	749	15.0% *	10.1% *

* = statistically significant differences[12] between figures in comparison group
n/s = differences between figures in comparison group are not statistically significant

3.5.1 Response rates in the pilot vs. full survey administration

The online response rates during the pilot test in July 2016 were more modest than those actually achieved during survey administration in the fall of 2016. The address-only pilot test sample achieved a 7.5% online response rate and 8.3% overall taking into account call-ins to the toll-free number, while the address-and-phone pilot test sample achieved a 12.1% online response and 13.9% taking into account call-ins. It may be noted that Malatest had originally proposed to offer prize incentives to encourage respondents to participate; however, the idea was rejected by MTO senior management, in part because the response rates in the pilot test were fairly positive.

The pilot response rates compare as somewhat less than the final online response rates achieved in full survey administration of 9.3% for address-only sample and 14.9% for address-and-phone sample (based on accepted surveys after data validation). It may be noted that one of the differences between the pilot test and full survey administration is that, in the pilot test, the survey letter was on Ontario letterhead, while in full survey administration, the letter was on the Minister's letterhead, which may have conveyed more of the importance of the survey. Other differences that could have affected response may have included the time of year, the ease of completing the online survey (with some improvements having been made to programming for full survey administration), and the availability of additional information about the survey through the web portal (which had not been available at the

[12] Two-tailed z-test (p<= 0.05)

time of the pilot), and the pilot sample sizes (with the modest random sample in the pilot being subject to more sampling variability with respect to response rate outcomes).

3.5.2 Use of Personalized Mail

Letters posted using personalized mail cost $0.24 less than those sent with regular Lettermail. **Although letters sent with Personalized Mail arrived two days later than those sent with Lettermail, there was no significant difference between the response rates of the two classes of postage.** It may be noted that the pilot letters were all sent from a mail house located in BC, but it is unknown whether this affected the differential letter travel times.

During full survey administration, the address-only letters were sent from the mail house in BC (as the supplier provided the most economical bid), while the address-and-phone letters were sent from a mail house in Ontario (as there could be more urgency in getting letters to mailboxes when available sample for telephone interviews was running low). All letters in full survey administration were sent via Personalized Mail. For each mail out batch, the dates on which online survey completions began were monitored in relation to the dates the mail houses reported dropping off the batches of letters with Canada Post. The letters sent from the mail house in BC typically took only one or two days longer to begin hitting mailboxes than the letters sent from the mail house in Ontario. On rare occasion, the letters from BC took less time to arrive than batches sent at the same time in Ontario, perhaps because of delays at local sortation facilities in Ontario. For future survey cycles, Malatest recommends that the contractor be given the freedom to source mailing services from the most reliable and economical mail houses, regardless of which province the mail houses may be located in, as long as the objectives of the survey can be met, as evidenced in the success of the 2016 survey.

3.5.3 Inclusion of instructions sheet

Overall, in the pilot test, there was no significant difference in the response rate of those who received instructions and those who did not. Malatest continued to test the use of an instruction sheet during full survey administration and determined that **response rates were significantly higher when the instructions were included**, enough to justify the extra printing cost.

3.5.4 Letter salutation

In previous cycles of the TTS, the names of occupants were included in the letter addressing. Approximately 10% of the population changes address over the course of a year, which is argument in favour of or a generic greeting (Occupant or Resident). However, identifying occupant by name increases likelihood that letter will be read/acted upon.

For address-and-phone sample, there was a slightly greater response rate when either Occupant or Resident was used in place of the listed name. The response rate when Resident was used in the address block was more than two percentage points higher than those addressed to Occupant. While this difference was not statistically significant for the entire sample as a whole, it seems to confirm the a priori hypothesis that Resident is a ‘warmer’ or less impersonal form of address, which may increase the likelihood that a household will respond to the survey.

3.5.5 Other lessons from the pilot test

Following the pilot test, Malatest compared key demographic indicators to previous waves of TTS and 2011 Census information, as appropriate. Two indicators that were predictive of the final unweighted

data set were the distribution of household size and the average trip rate for household members over the age of 11 (Table 3-2).

In the 2016 TTS, larger households were underrepresented in completed surveys due to the greater burden of collecting and entering trip information for other family members. This trend was also present in the pilot test. This demonstrates that attempts to recover partially-completed online surveys during full survey administration (an activity not undertaken in the pilot) did not necessarily produce a notably more robust distribution for this demographic marker.

Table 3-2: Comparison between household size in the TTS 2016 pilot study and full survey administration

Household Size	Pilot Test (n=333)	Full Survey (n=162,708)	2011 Census
1	19.8%	25.3%	24.7%
2	43.5%	37.7%	30.4%
3	13.5%	15.8%	17.0%
4	14.7%	13.9%	16.8%
5+	8.4%	7.2%	11.1%

The average number of trips per household members over the age of 11 in the unweighted data was also not appreciably that much different in the pilot test (2.29) than it was during full survey administration (2.25). It may be noted that the pilot test surveys were not validated, whereas the final surveys were subject to validations that included the removal of walking trips other than to or from school or work and commercial trips.

Malatest also discovered that the **online survey took approximately 20 minutes to complete**, as opposed to the 10 minutes it typically took to complete the survey over the phone. Communications materials were changed to reflect the actual time commitment required to complete the survey online.

3.6 Address-based sampling considerations

3.6.1 Address list issues

While address-based sampling provided greater coverage than sampling by listed phone number, there were some issues with this methodology that bear considering.

In rural areas, Canada Post appears to have a somewhat poorer success rate in matching mailing addresses from their database with white pages phone listings. Canada Post has standardized formats for rural route and PO Box addresses, whereas the white pages listings are not consistently formatted. In order to avoid localized bias, this can be addressed by adjusting the relative proportions of the address-and-phone and address-only survey targets to reflect the availability of address-and-phone and address-only sample, just as would be done in urban areas that naturally have less address-and-phone sample due to fewer households having listed landlines. For the 2016 TTS, Malatest set differential address-and-phone and address-only targets to reflect the relative distributions in the Canada Post universe, and response rates for the different types of sample were tracked separately, so that subsequent mail outs could be planned in order to better achieve the appropriate balance of the different sample types.

There was also a small degree of overlap between the phone-only sample and the address-only sample, which could not be avoided. Duplicate household samples were easily identified and removed during the survey processing, by looking for duplicate home addresses within the complete sample.

3.6.2 Online uptake for address-and-phone sample

The online response rate was higher than anticipated for the address-and-phone sample. Notwithstanding that a few days were allowed to elapse between delivery of the letter and the commencement of phone calls to batches of address-and-phone sample, precisely to allow for respondents to take the initiative to do the survey themselves, the online uptake was higher than expected. Of validated address-and-phone surveys in the final dataset, approximately 40% were completed via the online survey platform (with a small proportion of these being surveys started online but completed over the phone) and 60% were completed over the phone using the DDE platform. This compares to an expectation going into the project that 13% of surveys from this type of sample would be completed online and 87% would be completed via phone.

While more surveys have been completed online than originally projected, it may be noted that the balance of surveys completed from the address-and-phone (82,460) and address-only (79,226) sample groups[13] was in line with pre-data collection planning targets, which planned for an equal balance. This was achieved through careful tracking and management of the samples and mail outs throughout the survey administration period.

3.6.3 Support required for address-only sample

The address-only sample required considerable telephone and email support. While the address-only sample was recruited only by the survey invitation letter, 10% of survey completions from this sample were completed over the phone via the DDE system. It was often older individuals from this sample who called in to the project toll-free number to complete the survey over the telephone. In addition, there was considerable telephone-based and email-based activity associated with providing support to online respondents who sought technical help with the survey, asked for clarification as to how to answer questions, or wished to verify the legitimacy of the survey. There was also telephone follow-up with online respondents who abandoned their online surveys (using contact information captured in the first few questions on the online survey). In addition to telephone surveys completed by the DDE system, quite a few surveys were completed in the CallWeb system by a telephone interviewer following up on a survey started in CallWeb but abandoned before completion. Others contacted by telephone were convinced to complete the survey online. When this activity and the effort required for visual review and follow-up on problematic surveys is taken into account, the online surveys should not be considered zero-cost 'free surveys', as considerable person-hours were required to facilitate completion.

3.6.4 Balance of address-only and address-and-phone sample

Future surveys using the same hybrid sampling methodology as the 2016 TTS may wish to consider whether an equal balance of address-and-phone and address-only sample is desirable, or whether the balance should be adjusted to reflect the natural incidence of the two types of sample. The target of

[13] It may be noted that another 956 surveys were completed from phone-only sample and 66 from the volunteer sample. Volunteer sample includes respondents who were not sampled but asked to do the survey (which was allowed in the interests of good relations with the public, as there were so few cases) or who were sampled but could not be matched up to their survey case when they called in to do the survey.

an equal balance of address-only and address-and-phone sample was something of a compromise that balanced the desire to obtain a high number of surveys via telephone interview (the trusted method the DMG and TTS partner agencies had familiarity with) and providing a sample that was representative of the balance of address-only and address-and-phone sample in Canada Post's databases. As noted elsewhere, an equal balance of address-and-phone and address-only was not achieved uniformly across each sampling geography, nor was it desirable that it be so. Differential targets were set proportional to the distributions per Canada Post data. For example, Planning District 1, the Toronto core, the targets for address-and-phone and address-only were set to 20% address-and-phone and 80% address-only to reflect that there was proportionately less available address-and-phone sample in that area, whereas long-established suburban areas with older populations might be expected to have more landlines that match to addresses, and might target a majority of completions from the address-and-phone sample. As more households move to reliance on only cell phones, the incidence of address-and-phone sample in the address database may decline. This should be considered when setting expectations for the balance for the two types of samples in future surveys.

3.7 Managing survey response rates

Throughout the survey, a great deal of effort went into managing the response rate. This included detailed tracking of response rates by sample batch, frequently updating the TTS sampling plan to meet the completion target, and working to enhance the response rate to the survey.

3.7.1 Fluctuation in response rate during the survey

Address-based sample was divided into flights that were staggered across the data collection period. While there was variation in the performance of flights within each sample type, address-and-phone showed considerably more variation in response rate than address-only sample over the first four weeks the sample was in field (Table 3-3). However, there was much less variation in the response rate of address-and-phone sample in the field for five weeks or more. This may be due, in part, to the fact that, after the initial surge in online completions in the first few days after receipt of the letter, the pace of completion of address-and-phone samples could speed up or slow down based on the level of outbound calling effort applied to it, but after a certain length of time in the field, the sample batch would have achieved close to its maximum response.

Table 3-3: Standard deviation of overall response rate by day after letter was received

Day	Address-and-phone		Address-only	
	Number of flights	Standard deviation	Number of flights	Standard deviation
1	26	2%	22	0%
7	26	8%	22	1%
14	25	12%	20	1%
21	24	10%	19	1%
28	21	8%	16	1%
35	18	2%	14	1%
42	17	2%	13	1%
49	15	2%	11	1%
56	14	2%	9	1%

The standard deviation for online response rate of address-and-phone sample was not appreciably different from address-only sample, which confirms the notion that the variation in the response rate of address-and-phone sample is likely due in part to the amount of time it took call centre staff to make the maximum number of call attempts to each flight of sample (Table 3-4).

Table 3-4: Standard deviation of online response rate by day after letter was received

Day	Address-and-phone		Address-only	
	Number of flights	Standard deviation	Number of flights	Standard deviation
1	26	1%	22	0%
7	26	2%	22	1%
14	25	2%	20	1%
21	24	2%	19	1%
28	21	2%	16	1%
35	18	2%	14	1%
42	17	1%	13	1%
49	15	1%	11	1%
56	14	1%	9	1%

Notwithstanding the standard deviations in response rate over time, the fluctuation of online response rates amongst the address-only sample batches showed a pattern over time: early response in September through early October was quite strong, followed by decreased response rates for batches mailed between mid-October and mid-November, followed again by a surge in response rates in late November through mid-December.

Reasons for the fluctuation in address-only response rates over time may include:

- Seasonal variations (for example, respondents may have more time to respond to the survey in early September with the conclusion of summer holidays and the start of fall activity patterns, but less time later in the fall);
- Changes in the composition of mail-out batches (for example, targeting of under-performing FSAs within a planning district may have resulted in lower response rates for certain batches);
- Letters sent in the last few weeks of survey administration included a deadline for response, which may have motivated some respondents to complete the survey sooner than they would otherwise.

The administration of surveys with address-only samples is not as nimble as with address-and-phone samples, which are primarily completed online: there is a considerable lag between the random selection of the address sample, mail out, achievement of the maximum response rate, and reassessment of survey response predictions for the total sample. The results of decisions to increase or decrease mail-out sizes are not achieved for a number of weeks, and during the interim, response rates may have fluctuated as observed. For address-and-phone samples, by contrast, it is much easier to 'turn on' and 'turn off' telephone survey administration in order to more precisely meet targets.

As the mail-out and survey completion volumes were high in the last few weeks of survey administration, these fluctuations in response over time did not allow for finely-tuned management of survey response, resulting in the overshooting of a number of geographic targets. For future cycles of the survey, Malatest recommends ensuring a greater number of survey completions is obtained earlier with a tapering off near the end of survey administration to allow for finer control of the survey targets by region in the last few weeks.

3.7.2 Management of survey targets

Regional survey targets were set in the RFB based on DMG's projections of population growth (which used data from the 2001, 2006 and 2011 federal censuses) and uniform sampling rates (5% in all regions except Hamilton, which was set at 3%). Survey targets for planning districts and municipalities were set based on the distribution of address counts from Canada Post within each region. Survey targets at the level of postal code FSA (or four-, five-, or six-digit postal code when the FSA crossed planning district boundaries) were then determined, also based on the distribution of Canada Post address counts. The first sampling plan developed used predicted response rates based on Malatest's experience conducting similar travel surveys, the 2011 cycle of TTS, and results of the pilot test to determine the anticipated requirements for sample purchase and mail-outs.

Once the survey was underway, Malatest used the total number of completions for each region, as well as the response rate for that region in the past three weeks, to predict survey response for the sample recently sent to field and make changes to the estimated number of additional address listings to draw in order to achieve targets. The sampling plan was updated regularly during the survey administration period to ensure not only the overall target was reached, but also the targets for each region and municipality.

In areas where the number of completed surveys was expected to exceed target, Malatest blocked outbound calls to the corresponding FSAs. Cases from blocked FSAs that had already been accessed remained in the calling queue until they reached the minimum number of call attempts. FSAs were unblocked in the event they were no longer projected to reach target. No attempt was made to block

respondents from completing the survey online even if their region already had sufficient survey completions.

A challenge to predicting the final number of completed surveys was that the rejection rate of surveys over each platform could not be accurately projected. In the 2011/12 cycle, the rejection rate for DDE surveys was not reported, so it could not be used to plan for 2016. The visual review of the CallWeb system was undertaken using a database that allowed tracking, and so some rough predictions could be made, although predicting rejection rates was made more challenging by the backlog of TTC transit review and online visual review. The traditional DDE-based visual review process was conducted on paper, and the only way of estimating rejection rates during survey administration was to select a sample of paper visual review reports and manually tally the decisions made. In practice, in 2016, 5.1% of online surveys and 4.9% of DDE surveys were rejected during visual review and post-processing.

In addition to the overall completions target, there was a requirement to have at least 17% of surveys completed for each travel day. This was a challenge as there were two statutory holidays that fell on a Monday during the data collection period (Labour Day and Thanksgiving). In addition, while mail-outs were staggered twice per week, delivery of letters in mailboxes varied depending on Canada Post's workload in their processing centres, and days of delivery could not be predicted. Given the large volume of surveys which were completed online, this meant the possibility of uneven online completion by day of week with surges on the days that greater numbers of letters were delivered.

In order to ensure at least 17% or completed surveys had a Monday travel day, new sample was activated on Tuesdays, which resulted in fresh, more productive sample and more survey completions relative to the dialing hours on those days. Malatest also ensured that the survey house was at capacity on Tuesdays' and Wednesdays' to boost the number of completions early in the week. For online surveys, Malatest split the travel day for surveys completed on a Saturday or Sunday across the previous Thursday and Friday. However, all surveys completed on a Monday were assigned a Friday travel day, as there were doubts about participants' ability to accurately recall travel patterns for more than three days. The final distribution of valid surveys by travel day is presented in Table 3-5.

Table 3-5: Travel day representation by method of survey completion and overall

Travel day	CallWeb	DDE	Overall
Monday	16.0%	18.4%	16.8%
Tuesday	16.9%	16.8%	16.9%
Wednesday	15.9%	20.4%	17.5%
Thursday	25.7%	22.1%	24.4%
Friday	25.5%	22.4%	24.4%
Total	104,861	57,847	162,708

3.7.3 Response rate enhancement techniques

In addition to attempting to complete abandoned surveys and improving the speed of the survey and the user experience, Malatest implemented several other response rate enhancement techniques that ensure the target number of completions was reached.

In order to answer questions from sampled households, the general public, and the press, provide technical assistance, and resolve complaints Malatest established a project specific toll-free number and email account. These dedicated lines allowed staff to track all and resolve all issues promptly during the survey period, and was instrumental in removing barriers to completions among sampled households.

Malatest provided the option for households to complete the online survey in the official language of their choice. To ensure that households who were not fluent enough in English or French to complete the survey (either online or over the phone) **Malatest offered "on the fly" translation in 33 languages. This also helped to enhance the response rate to the survey among groups that are traditionally much more difficult to include in this type of research.** The language capabilities available included the following:

Arabic	Kannada	Sinhalese
Bengali	Latvian	Somali
Bosnian	Malayalam	Spanish
Cantonese	Mandarin	Tagalog
Croatian	Oriya	Tamil
Farsi	Polish	Telugu
German	Portuguese	Turkish
Gujrati	Punjabi	Twi
Hindi	Romanian	Urdu
Hungarian	Russian	Vietnamese
Italian	Serbian	Yoruba

While Malatest loaded sample to the DDE prior to letters being mailed, the DDE sample was not activated until one week after letters began to arrive, as shown by the day of first online completion for that batch of sample. **The activation of sample was staggered to allow participants the chance to complete the survey online or call in to the call centre before beginning active outbound dialing. While this contributed to the reduced performance of the telephone survey, it allowed Malatest to conserve outbound dialing resources for the households that were not motivated to complete the survey on their own.**

On December 5, 2016, **Malatest lowered the maximum call attempts from 8 to 5, in order to be able to progress through the sample more quickly.** Based on the volume of address-and-phone sample being deployed, interviewers – whose numbers were limited by the capacity of the call centre – were not able to clear the sample in the calling queue fast enough to activate the sample one week after letters began to arrive. After the reduction in the maximum call attempts, it was possible to clear batches of samples faster, without much diminishment in the achievable response rate for each batch.

To encourage those in the final batches of sample to complete the survey before the end of the data collection period, a respond-by date was prominently displayed on the notification letter. **The response rate for households that received these letters rose more quickly than typical, which suggests providing a date by which the survey should be completed can help motivate participation.** Because the data collection ended before these letters fully matured in the field, it is unknown whether this

would have increased the final response rate. It is possible that it may have only motivated earlier completion rather than more completions.

3.8 Mixed-mode surveying

The number of surveys completed online was greater than expected and in the end, made up 64% of all valid (accepted) surveys completed. This wave of the TTS demonstrated that residents expect to be able to complete surveys online. For a survey which required a great level of detail regarding the trips that other household members made, this also allows greater opportunity to consult with these individuals and ensures that the data collected are complete and accurate, particularly for larger households.

While telephone surveys require more telephone staff resources than those conducted online, telephone surveys tended to require less cleaning and follow-up with participants than those completed online (including having proportionately fewer transit trips than online survey, so less transit review), and required less sample per completed survey, which resulted in a lower mail out costs, offsetting the higher telephone dialling and interviewing costs. Also, in addition to the higher mail out costs and somewhat more intensive cleaning requirements for online surveys, the online surveys required considerable email and phone support, including phone follow-up with partial completers. **Overall, the cost per completed survey was not appreciably different between the two systems.**

One considerable drawback to the approach used was the level of effort required to manage two parallel data collection systems. This was not only through the daily reconciliation of CallWeb status codes to the DDE survey, but also a duplication of production and uploading of sample files, which had different formats in each of the two systems. This also created additional work in the preparation of the final survey databases, as data from CallWeb had to be aligned and merged to data from the DDE. **Future waves of TTS and other similar travel studies undertaken by the study partners would be well served to implement a single data collection tool that supports both telephone and online surveys.**

3.8.1 Sample representativeness

Tables 3-6 through 3-8 and Figures 3-5 through 3-7 compare key demographic information for the two primary sample types to 2016 Census data. The results for phone-only sample are presented for reference in the tables, but are not included in the charts, as the main comparison of interest is between address-and-phone and address-only samples (and in any case, the phone-only sample, which was abandoned after an initial trial due to low production rates, represents only 0.6% of the total sample. **Overall, results suggest that the use of address-only sample helped achieve a more balanced distribution than would have been achieved should we have relied exclusively on address-and-phone sample.**

The age ranges in Table 3-6 have been chosen to emphasize where there are differences or similarities between the address-and-phone and address-only samples. The address-and-phone sample by itself would have over-represented residents 65+ years of age by 13 percentage-points, under-represented those 25 to 39 years old by almost half, and also significantly under-represented those under four years of age, when compared with Census figures. The address-only sample much improves the representation of residents 25-39 years old, as well as those under four years of age. Of note, the 20-24 year age bracket appears to be difficult to target in both samples (4% in address-and-phone and 5% in address-only compared to 7% in the general population), which may be expected as non-response bias amongst youth is a well documented phenomenon. Overall, surveys completed from the address-only

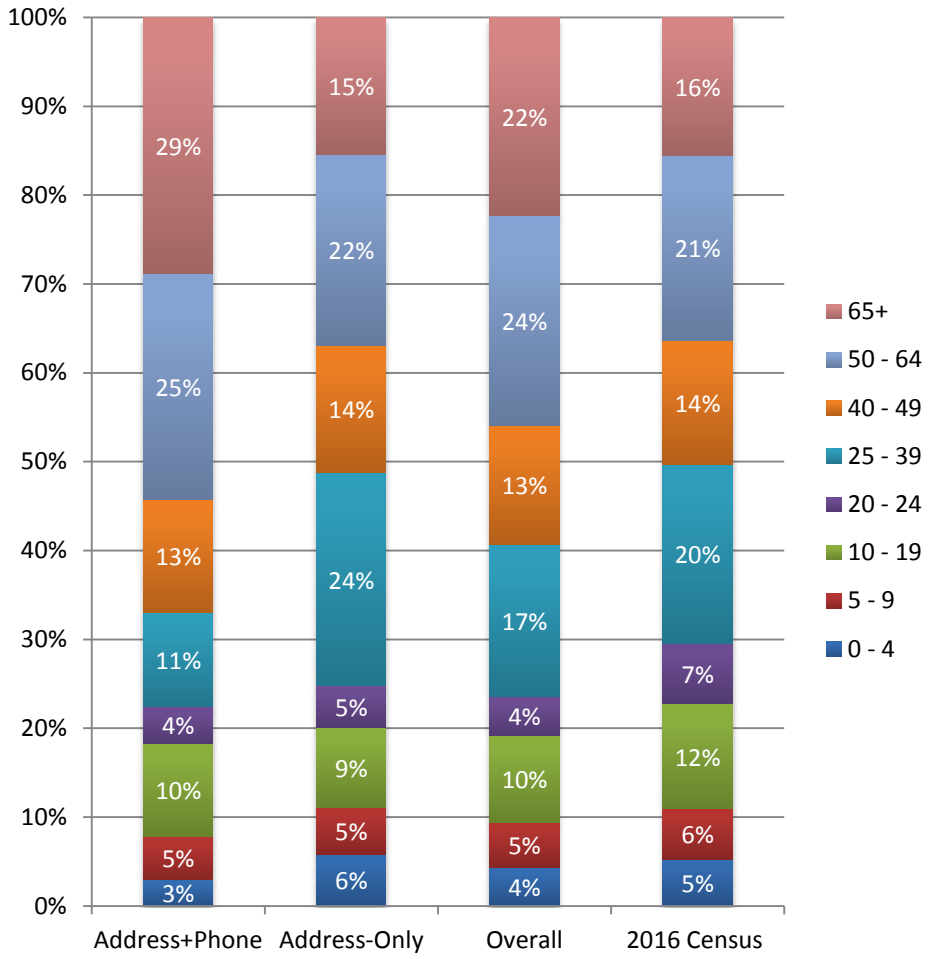
sample have helped to bring the age distribution of the total sample closer in line with 2016 Census proportions. The final combined sample still has modest imbalances towards older households, and under-representation of all age groups under 40 years of age, which was adjusted for by data weighting. **This suggests that the sampling methodology used provided results more in line with the demographics in the in-scope regions.**

Table 3-6: Age distribution by sample type

Age range	Address+Phone (n=191,840)	Address-Only (n=180,382)	Phone-Only	Overall (n=372,222)	2011 Census
0 - 4	3.0%	5.8%	4.2%	4.3%	5.2%
5 - 9	4.8%	5.3%	5.9%	5.1%	5.7%
10 - 19	10.5%	9.0%	12.1%	9.8%	11.8%
20 - 24	4.2%	4.7%	5.3%	4.5%	6.8%
25 - 39	10.6%	24.0%	14.5%	17.0%	20.1%
40 - 49	12.7%	14.3%	14.0%	13.5%	14.0%
50 - 64	25.4%	21.6%	24.0%	23.6%	20.8%
65+	28.8%	15.4%	20.0%	22.3%	15.6%

The 66 cases in the volunteer sample are not reported on individually, but are included in the overall total.

Figure 3-3: Age distribution by sample type



Phone-only and volunteer sample (which together comprise only 0.6% of total sample) are not presented individually in the chart, but are included in the overall total.

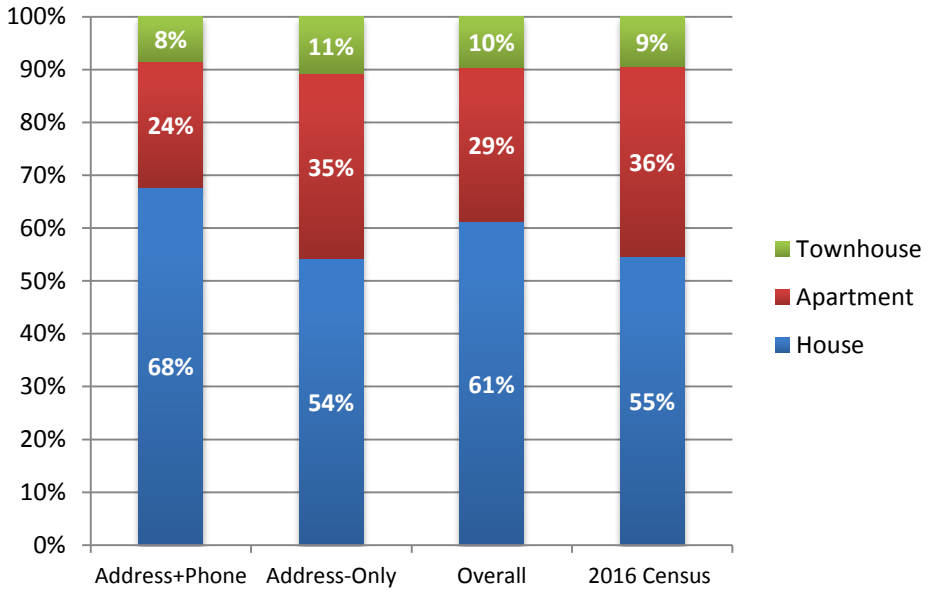
Surveys completed from the address-and-phone sample were more likely to be from those who live in a house, while the address-only sample represented a great many more households that live in apartments. **The improved distribution across dwelling types makes a strong case that using the sampling methodology used helped to ensure all dwelling types were well represented.**

Table 3-7: 2016 TTS dwelling type by sample type

Dwelling Type	Address+Phone (n=82,460)	Address-Only (n=79,226)	Phone-Only (n=956)	Overall (n=162,708)	2016 Census
House	67.7%	54.2%	73.2%	61.2%	54.7%
Apartment	23.8%	35.0%	18.6%	29.2%	35.8%
Townhouse	8.5%	10.8%	8.2%	9.6%	9.5%

The 66 cases in the volunteer sample are not reported on individually, but are included in the overall total.

Figure 3-4: 2016 TTS dwelling type by sample type



Phone-only and volunteer sample (which together comprise only 0.6% of total sample) are not presented individually in the chart, but are included in the overall total.

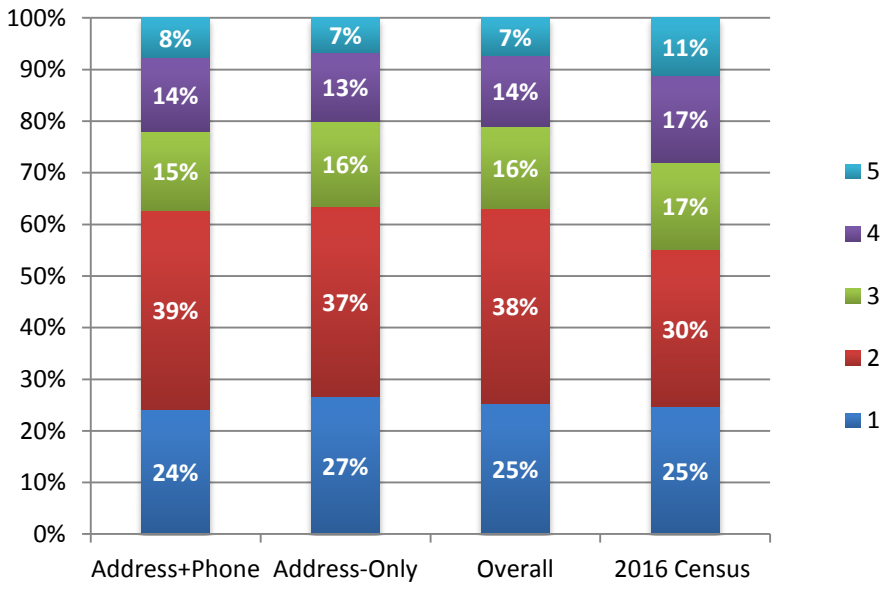
There was little difference in the proportion household size between of surveys completed from the address-and-phone sample and address-only sample groups, and both sample types somewhat over-represent two-person households and under-represent larger households. **The distribution of household size supports the previous assertion that the length of the survey may discourage larger households from completing the questionnaire.**

Table 3-8: Household size by sample type

Household Size	Address+Phone (n=78,103)	Address-Only (n=75,497)	Phone-Only (n=956)	Overall (n=153,600)	2011 Census
1	24.2%	26.6%	20.5%	25.3%	24.7%
2	38.6%	36.9%	37.6%	37.7%	30.4%
3	15.3%	16.3%	15.6%	15.8%	17.0%
4	14.3%	13.4%	16.8%	13.9%	16.8%
5	7.7%	6.7%	9.5%	7.2%	11.1%

The 66 cases in the volunteer sample are not reported on individually, but are included in the overall total.

Figure 3-5: Household size by sample type



Phone-only and volunteer sample (which together comprise only 0.6% of total sample) are not presented individually in the chart, but are included in the overall total.

Surveys completed from the address-only sample had slightly higher daily trip rates for individuals age 11 or older when compared to address-and-phone sample (Table 3-9). Of note, the transit trip rate for the address-only sample was 55% greater than for the address+phone sample. **This suggests that those with listed phone numbers – who also tend to be slightly older – have different travel behaviour from those who do not, and that the sampling methodology used helped to ensure the patterns of these different groups were represented, including providing more information on transit trips.**

Table 3-9: 2016 TTS trip rates by sample type

	Address+Phone	Address-Only	Phone-Only	Overall
Completions	82,460	79,226	956	162,708
People	203,134	190,085	2,505	395,885
People 11+	184,930	167,097	2,215	354,392
Trips	410,167	382,618	4,968	798,093
Trip Rate 11+	**2.218**	**2.290**	**2.243**	**2.252**
Transit Trips	37,996	52,895	489	91,437
Transit Trip Rate 11+	**0.205**	**0.317**	**0.221**	**0.258**

The 66 cases in the volunteer sample are not reported on individually, but are included in the overall total.

3.8.2 Survey non-completion

Table 3-10, Table 3-11, and Table 3-12 outline the differences between completed surveys, rejected surveys, and abandoned surveys for online survey completions

The comparison of household members for whom demographic information was provided (Table 3-10) reveals that rejected and abandoned surveys were more likely than validated survey completions to contain younger people, particularly for the 20-34 bracket. Older people were less likely to have rejected or abandoned online surveys, particularly those older than 65. Older households tend to be smaller and have less data to report overall (fewer people to report on, fewer work and school locations) and/or may be more available to receive follow-up calls for abandoned surveys and follow-up calls to clarify data issues identified during the data validation.

Compared to online surveys that cleared the data validation, rejected online surveys were more likely to be larger households (Table 3-11), which stands to reason given that larger households would have more data points that could have errors. Abandoned surveys had the same pattern, likely due to the burden of answering more questions and/or challenges with obtaining trip information for all household members. Both rejected and abandoned surveys were slightly more likely than survey completions to be for households living in houses rather than apartments (Table 3-12). This may tie in to the correlations between dwelling type and household size and between dwelling type and age of resident.

The differences between the complete and incomplete surveys suggest that survey non-completion would have contributed to bias in the survey sample. This further supports the rationale for the choice of weighting control variables (household size, dwelling type, and age/gender).

While data on rejected and abandoned surveys were not provided from the DDE system, there may be similar differences between them for similar reasons, although it may be noted that the overall profile

of those who completed the survey via telephone is different from that of those who completed online (as presented in the previous section of this report).

Table 3-10: 2016 Age distribution by survey disposition – online surveys

Age range	Completion (n=395,885)	Rejected (n=16,503)	Abandoned (n=65,541)
0-19	19%	22%	21%
20-34	15%	20%	20%
35-55	28%	31%	30%
55-64	16%	14%	14%
65-74	13%	8%	10%
75+	9%	5%	5%

Table 3-11: Household size by survey disposition – online surveys

Household Size	Completion (n=107,808)	Rejected (n=5,681)	Abandoned (n=26,493)
1	22%	14%	12%
2	38%	32%	33%
3	17%	20%	20%
4	15%	20%	21%
5+	7%	13%	14%

Table 3-12: Dwelling type by survey disposition – online surveys

Dwelling Type	Completion (n=107,808)	Rejected (n=5,513)	Abandoned (n=27,158)
House	60%	65%	65%
Apartment	29%	24%	25%
Townhouse	11%	11%	10%

Excludes responses of don't know and missing responses.

3.9 Sources of error

While Malatest developed a methodology that reduced the minimized error in the final TTS data set, the following possible sources of error have been identified.

3.9.1 Sample coverage error

While the Canada Post address database provided excellent coverage, it has minor limitations:

- As a rule, it will not provide coverage of collective dwellings (seniors' homes without separate apartments, prisons, military barracks, etc.).
- If the majority of households within a given postal code have refused to receive unsolicited mail, Canada Post may provide no address listings within a given area.
- Within certain very rural areas and on certain First Nations reserves, individual mailing addresses may not exist to be included in the database (e.g., residents receive their mail via 'general delivery').
- The Canada Post sample may also not include secondary suites in houses (such as basement apartments), particularly if the suite is not legally registered with the municipality and/or does not receive mail with separate unit addressing.

Nevertheless, Canada Post is considered to have the most comprehensive and up-to-date coverage of the dwelling universe available outside of the national Census.

3.9.2 Sampling error

Sampling error is associated with sampling only a portion of the population rather than surveying every member of the population. Given the robust survey sample, with over 161,000 survey completions, the theoretical margin of sampling error for the overall survey results is very low, at ±0.2% at a 95% confidence level (19 times out of 20). The application of data weights to compensate for over-/under-sampling of certain geographies or non-response bias amongst certain subpopulations will increase the effective margin of sampling error to ±0.3%. Within individual regions, municipalities or planning districts, and other subsamples, sampling errors are higher.

As noted, the application of data weighting to correct for bias increases the effective sampling error (by giving some individual surveys more impact on the results and diminishing the contributions of other surveys). As samples become less representative, more extreme weights must be applied to correct for disproportions in sample distributions, thereby increasing the design effect. The end result is that more surveys must be collected to achieve the same level of accuracy as if the survey sample was perfectly representative. This emphasizes the need to obtain as representative a sample as possible prior to data weighting. It also provides a strong rationale for limiting extreme weights to contain the design effect, even if it means allowing some bias due to disproportionate representation to not be fully corrected for by the data weighting.

Sampling error estimates are provided by region and municipality/planning district in the *Data Expansion and Validation* report. Users of the data should keep in mind that the margin of sampling error only describes one possible source of error.

3.9.3 Non-response bias

Non-response bias is another error of non-observation present in all surveys. Sample representativeness and attendant non-response bias in the unweighted data set are discussed in Section 3.8.1 above.

Non-response bias occurs when individuals who do not participate in a survey differ in relevant ways from individuals who do participate. For example, younger people are often less inclined to participate in surveys. Larger households are less likely due to the burden of completing a longer survey. Those living in apartments are also somewhat less likely to participate than those living in single-family dwellings.

It may be noted that given the lower response rates for address-only sample, the possibility for non-response bias may be considerably higher in this type of sample than for the address-and-phone sample with its higher response rates. Nevertheless, given the differences in the characteristics of address-and-phone and address-only households, inclusion of address-only sample is vastly preferable to excluding it for the reason that it has lower response rate. The combined address-and-phone and address-only samples provide a much more representative sample of the population than address-and-phone would alone.

Non-response bias may be corrected for, in large part, by data weighting. Nevertheless, validation of the weighted data against other benchmark reference data (e.g., employment estimates, school enrolments, transit usage) revealed some apparent differences that suggest that some aspects of non-response bias remain beyond that which could be corrected for via data weighting.

3.9.4 Possible under-reporting of trips

The length of the survey may have caused some households, particularly those completing the survey online, not to provide information on all trips. During survey administration, early comparison of data collected via DDE versus collected via CallWeb appeared to show a pattern of fewer trips per person 11+ years of age, and there was some concern that online respondents may be under-reporting trips. However, after data validation had been fully completed for CallWeb surveys, and poor surveys had been rejected, the trip rates in the final dataset were in fact equivalent. The differences observed when trip rates were monitored during survey administration may have been influenced by the fact that DDE surveys cleared visual review much sooner than CallWeb surveys, which had a backlog. Until a survey was cleared or rejected, it still counted to the preliminary figures on trip rates.

A caution may be added that, as with any comparisons of the survey results by survey method, the household characteristics and demographics for surveys completed by phone may differ from online surveys. **Even though the daily trip rates in the unweighted data appear to be equivalent, this does not rule out the possibility that online respondents may have under-reported trips more than those who completed the survey over the phone with an interviewer trained to elicit the correct trip information.** Further investigation would be required—such as regression analysis controlling for other factors (household and demographic characteristics, and even week of completion in the survey administration period)—in order to more conclusively verify equivalence or difference between the survey methods. Of note, the daily transit trip rates for the online portion of the sample differed from those in the DDE sample, which speaks to the different demographic characteristics of the respondents who participated by each method.

Table 3-13: Trip rate per person 11 years of age by method of survey completions

	DDE	CallWeb	Overall
Completions	57,847	104,861	162,708
People	133,321	262,564	395,885
People 11+	121,857	232,535	354,392
Trips	273,607	524,486	798,093
Trip Rate 11+	**2.245**	**2.256**	**2.252**
Transit Trips	25,270	66,167	91,437
Transit Trip Rate 11+	**0.207**	**0.285**	**0.258**

Whether or not online respondents under-reported trips more or less than telephone respondents, trips for other household members may often be under-reported by the primary respondent, as the primary respondent may know about other household members' key trips (e.g., to/from work and school) but may not be aware of all of the discretionary trips they made (e.g., stops along the way, whether they travelled outside the workplace at lunch time). This is an issue that could be equally present in previous cycles as in the 2016 cycle of the TTS.

3.9.5 Measurement and processing error

Errors of observation may also be present in the 2016 TTS. Respondents, survey interviewers, geocoders, and/or visual reviewers may have occasionally made mistakes in providing, entering, or coding survey responses.

While errors in data entry can occur for any question, the question that introduced the most risk in the DDE was the household income question, which was coded into the comments section of the survey. Coding the income question responses using a two-digit system section of the survey introduced the possibility of data entry errors being introduced as well as the possibility that either asking the question or transcribing the response could be forgotten when final comments were provided by the participant.

The occupation question asks respondents to self-classify their employment as one of the following: manufacturing / construction / trades; general office / clerical; professional / management / technical; retail sales and service; or other. When this question was first introduced in the 1996 TTS, field testing revealed that up to 30% of responses were misclassified in the opinion of those involved in the design and testing of the question. This is likely the same in 2016 as it was in 1996. In fact, in 2016, the online survey provided an 'other specify' category that allowed respondents who were not sure as to which category they belonged to provide a brief description. The review of these responses revealed a number of grey areas that even Malatest's coders with experience conducting coding for labour market surveys had difficulty classifying to one of the available categories. The shift to predominantly online surveying provides an opportunity to expand and improve the list of categories, including definitions available via mouse-overs or pop-up windows. Malatest recommends aligning the occupation categories with the National Occupational Classification (NOC) system, so that Census data can be used as a benchmark comparison.

Some online respondents may have erroneously confirmed destinations on Google Maps that were not their actual destinations. During geocoding, there was the possibility of incorrect manual geocoding of

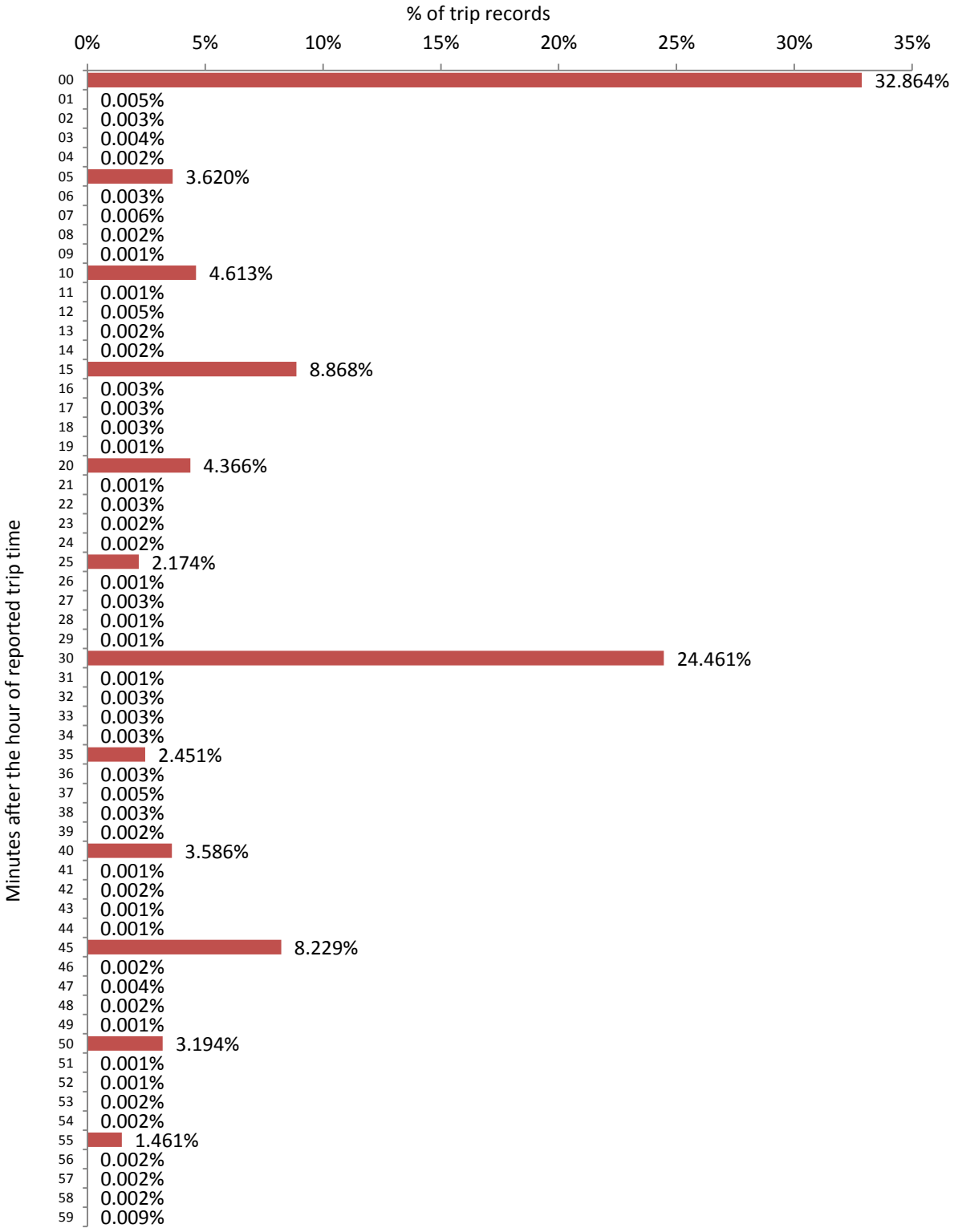
locations based on secondary research methods, particularly for duplicate street names in separate municipalities or multiple franchises or business branch locations.

A battery of validation tests was applied to the survey data in order to detect and correct errors, thereby minimizing the number of measurement errors that may pass through to survey acceptance.

Notwithstanding the testing undertaken, some sorts of respondent errors may have been difficult to identify and correct for. For example, if a respondent did not report trips taken by some householders, but did report them as passengers in trips the respondent took as a driver, there may be a discrepancy between the total number of people reported as vehicle occupants and the total number of passenger trips captured in the data. Future surveys could consider tests that would help identify such issues, although it should be noted that drivers may transport passengers other than other household members, so a discrepancy within a given household does not necessarily indicated that there was necessarily an error.

It may be noted that trip times should be considered approximate. The DDE system allowed interviewers to capture trip start times to the minute. The CallWeb system allowed online respondents to capture trip start times to the nearest five minutes, or if an abandoned survey was completed in CallWeb by an interviewer via phone follow-up, the system allowed online respondents to capture trip start times more precisely to the minute. Even when give the option to provide information accurate to the minute, respondents typically did not give exact times. As illustrated in Figure 3-6, survey respondents most commonly reported trip start times as rounded to the hour (33% of trips), half hour (24%), 15 or 45 minutes (17%), or nearest 10 minutes (other than the hour or half hour, 16%). In this context, care should be taken when aggregating the data so as not to obtain inflated counts. For example, querying the data for all trips between 0800 and 0900 would give an inflated count of trips over the course of one hour; instead, the data should be queried for 0800 through 0859. Some reporting for previous cycles had presented the AM Peak time period as 6:00 a.m. to 9:00 p.m. (even though the summary results in that cycle did not include data for trips reported as departing at 9:00 a.m.). The 2016 TTS summary reports clarify this as 6:00 a.m. to 8:59 a.m.

Figure 3-6: Frequency of reported trip start times – minutes after the hour



n=798,093

3.9.6 Question non-response

Online surveys can also have greater proportions of don't know/refused responses (Table 3-14). This was mitigated by the formatting of the survey response, such as graying out text for undesirable response options such as 'don't know' and 'refused', which helped reduce non-response to questions where response was not mandatory. Certain key questions did not allow for non-response. While age was refused for 4.1% of all CallWeb respondents, only 0.1% of such respondents refused to provide even an age range. For DDE surveys, if the respondent refused to provide age, the interviewer probed an approximate age to the nearest 5 or 10 years, and 0.5% refused to provide any kind of answer. Interestingly, while 22% of DDE respondents did not provide household income, somewhat fewer (18%) of CallWeb respondents did not provide an answer.

Table 3-14: Question non-response by method of survey completion

Survey question	DDE	CallWeb
Do you recall receiving a letter from the Ministry of Transportation regarding the Transportation Tomorrow Survey?	2.0%	3.0%
Is that a house, townhouse, or apartment?	none	none
How many vehicles does your household have available for personal use? Please include personal and business vehicles (including cars, light trucks, vans, and motorcycles).	<0.05%	<0.05%
How old [are you/is PERSON] ?	0.5%	4.1%
Would you identify which age range [you belong/PERSON belongs] to?	n/a	0.1%
[Are you/Is PERSON] male or female?	0.2%	0.8%
[Do you/does PERSON] have a valid driver's license?	<0.05%	2.1%
[Do you/does PERSON] have a transit pass? If so, what kind?	0.1%	1.2%
Are you employed? Full-time or part-time?	0.1%	<0.05%
What is [your/PERSON's] occupation?	0.1%	0.4%
Do [you/PERSON] have free parking available where [you/PERSON] works?	2.6%	11.7%
[Are you/Is PERSON] a full-time or part-time student?	<0.05%	<0.05%
What was the purpose of the trip?	<0.05%	0.1%
How did [you/PERSON] get there? Please select the main mode of travel.	None	none
How many persons were in the vehicle, including [yourself/PERSON]?	0.1%	0.2%
Which of the following ranges corresponds to your household's total income last year? Consider all sources of income before income taxes).	21.7%	17.9%

3.10 Data weighting and sampling considerations

3.10.1 Observations on the data weighting

It is Malatest's opinion that the introduction of the IPF weighting yields a survey sample that is a significantly better representation of the characteristics of the population.

Making all of the adjustments (with the exception of GO Train ridership) at the level of the expansion zone also has benefits in terms of the usability of the data for aggregations at less than the municipal level. By contrast, making age adjustments at the municipal level only, as was done in 2011, has the risk that the distribution of ages within sub-municipal geographies could be imbalanced. E.g., adjusting age

at the municipal level to compensate for non-response amongst young people in a downtown core might exaggerate the weights of young people in suburban areas.

Looking across expansion zones, there was a range of base expansion weights for the expansion zones. While the survey targeted uniform sampling rates by postal geography, and most postal geographies were within a reasonable range of their target, some areas were considerably short of target and others were considerably above target. Even within a given FSA that met targets, if the response was not uniform within the FSA, an expansion zone within that FSA might have had a lower sampling rate and thus a more extreme base weight.

Based on a 5% sampling rate target, the average base geographic expansion weight (before the application of adjustments for household and demographic characteristics) would have been about 20.0 in areas other than Hamilton and 33.3 in Hamilton. Examining the weighted data reveals a range of base weights from as low as 6.94 (in East Garafraxa which well exceeded its survey target, especially after reassignment based on actual coordinates rather than postal code) to a high of 108.5 (Tiny and Christian Island, which yielded much fewer completion than targeted). Nevertheless, in areas other than Hamilton, only 1% of cases had base weights of less than 10.0, while only 0.5% had base weights of greater than 30.0. Within Hamilton, the base weights by area ranged from 23.2 to 41.8. The range of these base weights could possibly have been somewhat better contained had there been a larger volume of survey completions earlier in the survey and more time to refine the targeting. However, given the imprecision of postal-code based targeting, especially in rural areas, and the difficulty obtaining a response in certain areas (in some areas all useable contact sample may have been mailed a letter) some variation in base weights should be expected.

There are some limitations to the iterative proportional fitting (IPF) approach as employed to adjust the weights for household and demographic characteristics after the base expansion weights were applied. A greater range of weights was produced compared to previous cycles, with more likelihood of occasional extremes. Even though the weights had limits applied, a small proportion of weights were at the extreme ends of the limits. Examining the weights relative to the base weight for each expansion zone:

- 6% of households had weights between 0.18 and 0.30 times the base expansion weight (typically older households in areas with high response from such households),
- 14% were between 0.3 and 0.4 times,
- 72% were in the relatively safe range of 0.5 to 2.0 times,
- 7% were between 2.0 and 4.0 times, and
- 1% were between 4.0 and 5.7 times the base expansion weight (typically younger households or larger households in areas with low response from such households).

Given these figures, and the range of base expansion weights, it is not surprising that across the entire study area, the weights in the 2016 TTS range from a low of 1.42 to a high of 198.1. The following table illustrates the standard deviations of the weights for different cycles of the TTS. As can be seen, the dispersion of weights was higher in 2011 than in previous cycles, and much higher in 2016 than in 2011. It should be noted that the weighting was necessary to address biases in the data file and develop a weighted data file that, overall, is more representative of the population. One could even argue that a more complex weighting approach might have been justifiable in 2011 and 2006 (and even other cycles) to correct for certain biases in the data and produce results that would have been even more reflective

of the trends in the general population (which would have led to higher standard deviations of the weights in those cycles as well). That said, some loss of precision should be expected – with more bias comes the need to weight the data to address disproportionate distributions, and survey efficiency is reduced: more surveys would be required to obtain the same margin of error as compared to an entirely representative sample.

Table 3-15: Standard deviation of data weights 1986-2016

TTS Cycle	Mean Expansion Factor	Standard Deviation
1986	23.86	3.14
1996	20.12	2.58
2001	17.73	3.95
2006	19.19	2.58
2011*	20.76	6.29
2016	20.50	15.96

*For 2011, final expansion factors were developed at the person-level (with household factors being the average of person expansion factors for householders within the same household), whereas in other cycles, they were developed at the household level (and each person in a household has the same expansion factor).

When conducting analysis of overall results for larger geographies (municipality or planning district) with large sample sizes, any more extreme weights should theoretically serve to make the overall result more accurate. However, when conducting analyses on smaller geographies or other subpopulations with small sample sizes, the more extreme weights could result in distortions or unusual results. For analyses that require small sample sizes, it may be useful to review the weights for the sample used, and consider possibly further limiting the weights with more extreme values just for that analysis (particularly if the cases with high weights have particularly unusual travel patterns).

For future survey cycles, if there have been reports from users of the 2016 data that the survey distributions for certain kinds of analyses have potentially be affected by the weights, in the next cycle, the weights could further be limited to a narrower range. It should be cautioned however, that such an approach may result in survey results that are less representative of the population universe if the IPF weighting cannot converge on a solution that satisfies all of the distributions in the weighting controls.

In summary, for future cycles, Malatest recommends employing IPF weighting (or similar multi-level multivariate weighting that can harmonize weights at the household and person level), but recommends considering whether to apply a narrower range of weights (at risk of not fully addressing bias in the data) if feedback from data users has indicated that they have challenges in working with the data.

3.10.2 Fundamental sampling considerations

As noted in Section 3.9.2, over- and under-sampling of different respondent sub-groups, whether by design (e.g., the lower sampling rate for Hamilton), due to different achieved response rates by geography (with some areas having exceeded or fallen short of target), or due to non-response bias (e.g., fewer completions with younger households and apartment dwellers) can lead to design effects when data weighting is used to correct for the over- and under-sampling, which in turn affect the accuracy of the weighted data.

Given the change in approach from previous surveys it may be appropriate to go back and review some of the more fundamental principles before the next survey. For example the 5% sample target was originally predicated on the availability of a representative sample frame and high response rate so that all records could carry approximately equal weight. As discussed elsewhere in this report, the decline in listed landlines and rise of cell-phone-only households over the last 15 years has made exactly representative, high-response rate survey samples impossible to obtain (outside the national Census, which is mandatory), and has necessitated changes to the sampling, data collection, and weighting methodologies. The greater spread in weighting factors noted in the preceding section (3.10.1) increases the amount of sample needed to obtain the same level of accuracy. Options that could be considered for future surveys might include:

- setting quotas by household type, and increasing the budget accordingly (considerable effort would be expended in screening out households that have met quotas and obtaining survey completions with less common / more-difficult-to-survey household types; given the level of effort in convincing households to participate, turning many households away after answering just a few screening questions is not a very efficient use of resources);
- increasing the overall sampling rates and obtaining a much larger sample overall;
- reconsidering the sample sizes by geography (e.g., over-sampling some areas of greater interest to planners, and under-sampling other areas with very high population that can obtain a good overall);
- refining the sampling and survey methods to increase participation and obtain incrementally more representative samples;
- adjusting expectations as to the level of analysis that can be undertaken with small sub-samples of the data.

3.11 Comparability with previous cycles

The 2016 TTS took a more complex approach to data weighting to address bias in the raw survey data. The final weighted distributions differ from previous cycles in certain respects (dwelling type, household size, demographics). Other cycles may have had different biases and were subject to different types of adjustment in the data weighting. Readers are referred to the TTS 2016 *Data Expansion and Validation Report* for more information on differences between the survey cycles.

As noted elsewhere there may be also different degrees of measurement and/or coding error in the different survey cycles and/or different degrees of under-reporting of trips by survey respondents. This should also be taken into consideration when making comparisons with previous cycles. Malatest recommends relying less on short-range comparisons (for which changes in methodology and differences in inherent biases in the data can confound comparisons) and relying more on long-range comparisons, e.g. comparing the most recent cycle to 10 or 15 years ago, for which actual trends may more clearly present themselves above the 'noise' associated with different biases in the data for different cycles.

SECTION 4: Summary of Key Recommendations

Project Timelines:

1. Additional time should be provided between the award of the contract and study launch, particularly when large-scale changes to the methodology are anticipated, or when refinements to the survey design may be required. The time required to develop materials and for committee approvals should be taken into consideration.
2. Sufficient time should be allowed for pilot testing, including the development of visual review and validation processes prior to the launch of survey administration.
3. Sufficient time should be allowed for back-end activities, including back-and-forth with the DMG to identify and address any data issues or data requirements, time to review the results of the data weighting, and time for TAC to review issues and provide decisions, particularly if methodological changes are to be undertaken.

Survey Instrument

4. While the core of the survey instrument is very similar to other household travel surveys conducted elsewhere, and can serve as a good foundation for the next cycle, the trip definition could be expanded to allow the capture of all walking trips. This would make the survey instructions simpler to understand, and provide useful data on active transportation.
5. Develop new occupational categories to be asked of workers aligned to the National Occupation Classification (NOC), so that results can be compared against the Census, with consideration of any splitting of categories that may be required to be of use to transportation models/planning.

Systems

6. If possible, a single integrated CATI/CAWI data collection platform should be used.
7. To avoid security issues with servers housed in other countries, and to allow swift response to any server issues, data servers for the online survey should be hosted in Canada and the contractor should have direct in-house control of the servers.
8. If a single data collection platform is not possible, the schedule should allow sufficient time to explore and set up linkages/bridges between systems (at least three to four months with working systems already in place if the systems are complex or if one system is to be loaded with complete data from the other system; less time would be required if the systems merely need to update each other with lists of completions to block further call attempts).
9. Any data collection systems developed by the client and provided to a subcontractor for use should be adequately supported by useful documentation and technical staff resources.
10. Given the challenges in making changes to and supporting the DDE system, continued use in future cycles may not be desirable. However, functions and features of the DDE system should be considered in the development of new systems, particularly with respect to the efficiency of data entry.
11. If the data collection system is to be developed by the client, it should be set up to handle contact samples in excess of 1,000,000 records.

Geography

12. Prior to the commencement of the project, the TTS traffic zone and planning district boundaries should be adjusted to reflect the latest municipal boundaries, align with standard statistics Canada CSD boundaries as best as possible, and conform to basic topographic rules (no gaps

between boundaries, extend boundaries to include waterfront areas with possible destinations, ensure that planning district and traffic zone boundaries align appropriately).

13. The use of Google Map APIs was quite successful, and in fact the Google coordinates often are more precise than the Land Information Ontario (LIO) street segment base. Accordingly, use of built-in map features for online surveys such as Google Map APIs is recommended. Given that the LIO street segments are the basis of the traffic zone boundaries, some further work may be advisable to confirm the traffic zones make sense with Google-based coordinates (notwithstanding the high level of concordance in traffic zones assigned in Malatest's testing).

Sampling:

14. In future cycles of the TTS, the overall targets for different sample types should be determined five to six months in advance, and the final sampling plan to be implemented should be approved three-months in advance of data collection to allow the vendor sufficient time to plan and implement the necessary processes as well as hire and train sufficient staff to complete the required tasks in the allotted time.
15. Address-based sampling should be used in future studies as it improved coverage and better represented the population universe.
16. If hybrid sampling is to be employed (mix of address-only and address-and-phone sample), consideration should be given to the appropriate mix of such samples relative to the natural incidence of the two types of sample in the Canada Post data. The mix should also be adjusted at sub-municipal geographies to reflect differential rates of listed land line / cell-phone-only households in each area.
17. Phone-only sample should not be used in future studies as it did not provide additional demographic coverage and was far less productive than expected.
18. To achieve a more balanced sampling rate, use more accurate methods of forecasting household counts (e.g., make use of municipal or regional forecasts) prior to securing funding from the partners.
19. Given the changes in approach from previous cycles and the greater spread of weights required to correct for non-response bias, it may be appropriate to review some of the fundamental principles in the design of the sampling (as the original 5% targets had been predicated on the availability of a representative sampling frame and an overall high response rate). This might include increasing the size of the overall sample.

Staffing:

20. Recruit locally to remove the barrier of a long commute for employees and decrease turnover. Location of the call centre near subway stations would facilitate recruiting suitable staff, however, it should be noted that commercial rents are typically much higher near transit hubs, and this may affect project cost.
21. Recruit staff with knowledge of the entire survey area, or, given the survey area's size, at least with the ability to become familiar with the survey area.
22. Staff should be cross trained to perform other duties whenever possible to reduce turnover in case of delays (such as the technical issues with the DDE geocoding).

Operations:

23. The survey invitation letter should once again be printed on the letterhead of the Minister's office, and again with the logos of project partners. The letter appeared quite official with

improved authenticity over the Ontario letterhead used in the field test and may have driven the higher online response observed in full survey administration.

24. To avoid delays and more fine-tuned planning of quantities of materials, for future cycles, Malatest recommends having the vendor take responsibility for the procurement and printing of all mail out materials, including the envelopes (which in 2016 were supplied by the Ministry), with sufficient budget allocated for this, and appropriate permissions obtained for printing the Ministry envelopes via a private print company.
25. Maintain outbound calling to 9:30 p.m. as the hours from 7:30 to 9:30 p.m. are typically most productive.
26. When deviating significantly from prior methodology, employ a slow start to data collection. Consider the implications on data collections later in the survey period to ensure that lower volume of completions obtained at the beginning of the survey can be made up in the middle, with tapering off of volumes at the backend to allow for fine tuning of survey targets.
27. Plan for an even greater proportion of surveys being completed online in future studies. Future studies may consider re-allocating call centre resources to the online survey to meet demand.
28. There was considerably more interest in the online survey than originally expected. Pilot testing at an equivalent time of year (i.e., not the height of summer) would provide a better sense of responses rates to expect.
29. When using an online data collection method for travel surveys, budget sufficient time and resources to: identify causes of abandonment and implement reduction strategies; recover partially completed surveys (including a telephone follow-up component); and to make improvements to the online survey tool on the basis of respondent feedback.
30. Consider further improvements to the online survey both in terms of programming and the user experience. These will further decrease abandonment rates, particularly in the trips section, where there were the greatest number of abandoned surveys.
31. For surveys on the scale of the TTS, templates for common questions and complaints should be developed to ensure timely response.
32. Envelopes should be printed by the vendor, with sufficient budget provided for this, to avoid unnecessary coordination work by both the client and vendor, and to reduce costs.

Survey processing:

33. Client requirements for the detailed processing and validation of the data should be developed prior to survey administration, rather than relying on the corporate knowledge of previous staff. As valuable as the involvement of the 2011/12 TTS training manager, site managers, and project lead was in ensuring continuity between cycles, these individuals' involvement is not necessarily guaranteed to continue into 2021, and some thought may need to be given as to what the work flow process requirements might be.
34. If it is up to the data collection contractor to develop work flow processes and rules using client-supplied technology, sufficient time should be provided in the project schedule to allow for this. If the data collection contractor provides the data collection systems, the contractor may already have work flow processes set up and less time may be required.
35. If TTC staff is to review surveys with transit trips, sufficient TTC resources and appropriate data access protocols should be planned for to handle the anticipated volume, and should be in place from the beginning. A separate transit review team should be set up, and hired, trained, and led by a team leader trained by the specialists from one or more transit agencies.
36. The proportion of surveys completed online and the greater level of effort required to validate online surveys should be considered when hiring and scheduling staff.

37. As possible, integrate more of the survey validation tests into the online survey to trigger corrections or clarifications by respondents. These tests could be integrated within the survey itself and/or at the end of the survey, prior to submission.
38. Data weighting via a method such as IPF should again address various biases in the raw data file at the household and demographic level, with some consideration of whether to further narrow the range of weights used to allow for analysis of smaller subsamples (although possibly at the expense of the representativeness of the data file), depending on feedback from users of the 2016 data.
39. Given that different biases may be present in the data from recent survey cycles (whether due to sample representativeness, methods, or data weighting), when making historical comparisons with previous survey cycles, Malatest recommends relying more on long-range comparisons (e.g., compare to 15 years ago) to identify trends.
40. For future cycles, if further changes are to be made to the methods, time and budget should be provided for the types of additional analysis that TAC may require to better the impacts of methods, review the data, and understand differences between cycles.

Appendix A – Deviations of the CallWeb survey from the DDE Script

2016 Transportation Tomorrow Survey

Deviations from TTS phone interview script for inclusion in CallWeb surveys

v3.0 August 18, 2016

The CallWeb version of the survey will be used for online surveys and for phone survey overflow work as required for surveys conducted in Malatest's other call centres. Outlined below are deviations from the past TTS survey scripts that will be programmed in CallWeb. Only three deviations will also be part of phone surveys conducted with the TTS direct data entry (DDE) telephone interview software: changes to the introduction; addition of rideshare app (Uber) to the modes; and the new income question. For other questions, any phone interview variations of scripts that are included below would only be used in the instance of a phone interview conducted via CallWeb (e.g., in the instance of follow-up with an online respondent to complete the survey with them over the phone).

Comments on the deviations from past TTS scripts have grey highlighting.

TELEPHONE INTRODUCTION

[In past TTS cycles, when respondents have received the letter, the process was to move without delay to the first question on the survey ("Are you still living at…?). However, to meet the requirements of current privacy legislation, we are now required to outline to all respondents who the data is collected for and the purpose of the survey. I.e., we are no longer allowed to assume that because they received the letter they read, understood, and remember the letter. We now also have to always ask for consent to collect their information. The below-noted deviations from the past TTS script should fulfill these requirements. Note that these changes to the introductory scripts will need to be implemented in both the TTS software and the CallWeb version, i.e., for all survey respondents.]

[If Sample Type = Address + Phone or Address-Only:]
By now you should have received a letter from the Ontario Ministry of Transportation explaining the purpose of the survey and telling you to expect my call.
Did you receive the letter?
1. Yes
2. No

[If (Sample Type = Address + Phone or Address-Only) and did not receive the letter:]
INTERVIEWER, IF DID NOT RECEIVE LETTER, READ THE FOLLOWING:
Since you did not receive the letter I'll explain the purpose of the survey. It is to help your Provincial and Municipal Governments make improvements to roads and public transport in your area. To do that they need to collect information on existing household travel patterns. All the information you give us is strictly confidential.

[If (Sample Type = Address + Phone or Address-Only) and received the letter:]
[This is the deviation from the previous TTS script. In past cycles, this explanation would be skipped.]
As explained in the letter, the purpose of the survey is to help your Provincial and Municipal Governments make improvements to roads and public transport in your

area. To do that they need to collect information on existing household travel patterns. All the information you give us is strictly confidential.

[If Sample Type = Phone Only, do not ask if received letter, but explain survey:]

The purpose of the survey is to collect information that will help your Provincial and Municipal Governments make improvements to roads and public transport in your area. To do that, they need to collect information on existing household travel patterns. Your survey will represent travel in your community.

[The following question to ask to start the survey is also new and was not part of previous TTS scripts. It has to be asked of all respondents whether they received the letter or not. For online survey, clicking the Continue button to begin the survey is taken as agreement to participate in the survey.]

Phone: **May I complete the survey with you now?**

1. Yes
2. No (persuade, reschedule, or ask to talk to appropriate person in household and restart introduction)
3. E-mail or mail new information [GO TO A3 ETC]
4. If prefer to do online, offer to email survey respondent with link to survey
5. Refuse to do the survey (close and code as refusal)

Web: **Click on the Continue button to begin the survey.**

This survey is entirely confidential and uses secure internet protocols. Survey responses will be combined for analysis and will be used only for transportation and municipal planning purposes. Once your travel information has been validated, your contact information will be deleted from your survey record.

HOUSEHOLD QUESTIONS

B1B. [If web survey, or if a new phone number recorded, or if sample is Phone-only or if sample is Address-Only]

What telephone service(s) do you have in your household? (select all that apply)

1. Landline: A regular landline telephone service

2. Cable phone: A phone service from a cable television provider

3. VOIP: A phone service over the Internet with a unique number (voice over internet protocol)

4. Cell: A cell phone or cell phones

5. Other, please specify: _____

9. Decline / don't know

[Note: Not a standard TTS question. This question is to determine whether the household is cell-phone-only or has a landline. This information may be important for data weighting address-based samples. It is not necessary to add this question to the regular TTS Software for the completion of phone interviews with address-and-phone samples.]

PERSON QUESTIONS

C4A. [if respondent indicated both f/t student and f/t worker, provide message to interviewer:]

From your answers, it appears that [you attend/PERSON attends] school full-time and also [work/works] full-time (more than 30 hours per week at [your/PERSON's] main job).

Is this correct?

1. Yes

2. No, I attend school part-time and work full-time (more than 30 hours/week)

3. No, I attend school full-time and work part-time (less than 30 hours/week)

4. Decline / don't know

[Note: TTS survey design does not allow students to be both full-time students and full-time workers. However, as this situation can arise (there are more f/t students with f/t jobs), we will not block online respondents from continuing or force them to change their answers. If they have confirmed that both school and work are full-time, in post processing we will make the required change to school = part-time to match the TTS standard. In the TTS software for phone interviews, the interviewer clarifies and changes values as necessary].

TRIP CAPTURE

IN TRIPS INTRODUCTION FOR ONLINE RESPONDENTS

[if person is employed:]

Phone, if necessary: **If [you/PERSON] are a commercial driver (bus driver, taxi driver, courier, travelling salesman): Only report your first trip to where you usually start your work (terminal, office). (If you don't usually start your work from the same place, then report your first trip to your first work location, but fill in the furthest destination you went to in the course of your work day, or the one you remember most accurately). Then report your final trip to wherever you went next when you finished work. You do not have to tell us about the all the work trips you made for commercial deliveries or while driving a taxi or bus for work purposes.**

Web: **If you (or a household member) are a commercial driver (bus driver, taxi driver, courier, traveling salesman): You do not have to tell us about the all the work trips you made for commercial deliveries, or while driving a taxi or bus. But please report the following:**

- **Your first trip to where you started your work day (terminal, office) or your first delivery or stopping point if you started your delivery/work schedule directly from home.**
- **Your final work-related stopping point if it is different from the one above.**
- **A return trip to your home or other non-work related location at the end of your work day.**
- **All personal trips made outside of working hours by any mode of travel other than walking.**

[Note: the treatment of commercial drivers trip in the usual TTS phone interview is to capture either the first trip to their usual starting place (terminal, office), or if they do not have a usual starting place, record the first trip when they left for work, but fill in the farthest location (or the one most accurately remembered). Then capture a final trip at the end of the work day to where they went next. (However, the TTS methodology does allow for the interviewer to capture up to five work-related trips in a row.) The instructions for online respondents above are somewhat simplified, and do not give instructions with respect to capturing 'the farthest trip or the one most accurately remembered' – however, the instructions for online respondents cannot be overly complicated. It may be noted that commercial drivers are estimated as being present in less than 1% of surveys.]

AT END OF TRIPS INTRODUCTION:

[if other member of household, PERSON's age>=11]

[WEB: present question if Online]

[PHONE: Interviewer: You do not need to read this question, however, if the respondent prefers to have another household member fill out their own trips on the survey, please record this choice here. Otherwise, select "Prefer to Answer for other householder" and continue.

This section is about the trips [PERSON] made during the 24-hour period between 4:00 AM [TRAVEL DAY] and 4:00 AM [TRAVEL DAY +1], whether for work, school, shopping or any other purpose.

If [PERSON] is at home, and over the age of 16 (or has the consent of a parent or legal guardian if they are younger) he or she could complete this section of the survey. Otherwise, you can provide their information on their behalf.

1. Prefer [PERSON] to respond on their own behalf

2. Prefer to answer for [PERSON]

[Note: this option is not part of the original TTS, but our experience has been that this can be an effective way to get better information for the travel of other householders. In another recent survey, about 3% of persons other than the main contact responded on their own behalf. This question will not be included in interviews conducted via the TTS software.]

E1C. [If no trips AND (did not work from home OR person is NOT employed)]

Why did [you/PERSON] not leave home or make any trips [yesterday/TRAVEL DAY]?

1. Out of town for entire day

2. Sick/ill or care for other sick/ill household member

3. Not scheduled for school classes or activities

4. Not scheduled for work or on extended leave from work (paternity/maternity, short-term disability)

7. Worked from home, and did not leave home for any reason

5. No need to leave home

6. Could not leave home, no transportation available

77. Other (specify): _____

79. Actually, [I/PERSON] did leave home to go to work or school (including walking trips to work or school) or to make at least one trip by a travel mode other than walking [GO BACK TO E1] [PROGRAMMER: bold this response option]

99. Decline / don't know [PHONE: INTERVIEWER: PROMPT FOR MORE INFO IF POSSIBLE, OTHERWISE CYCLE TO NEXT PERSON]

[Not a standard TTS question. Probe for online respondents, to assist in data review.]

E7. **How did [you/PERSON] get there? Please select the main mode of travel.** [PROGRAMMER: allow one response only]

If the trip involved both driving (or being driven) and Transit ('Park & Ride' or 'Kiss & Ride') please select 'Transit' as the primary mode.

1. Auto driver

2. Auto passenger

3. Transit (bus, subway, streetcar, trolley, GO Train, GO Bus, light rail, island ferry, WheelTrans, intercity bus, hotel shuttle bus, campus shuttle bus)

4. School Bus

5. Walked
[mouseover: **Walk trips should be only be recorded if they are to or from a work or school location, or if they are an essential link between two other trips by other modes.**]

6. Taxi or limousine

7. Paid rideshare / non-traditional taxi (via Uber, Lyft, DriveHer, or other paid rideshare app)

8. Motorcycle, moped, motor-scooter

9. Bicycle
[mouseover: **Include bicycles with electric motors if they still have pedals.**]

77. Other, please specify: _____

99. Decline / don't know

[rideshare option will be added to both the DDE phone interview script as well as online]

E19A. [((if E7 mode = auto driver OR motorcycle) OR (E8 Access mode = auto driver or motorcycle) OR)E10 Egress mode = auto driver or motorcycle)) and not licensed to drive]

[if auto driver:] **You reported that [you were/PERSON was] an automobile driver for this trip; however, you previously indicated that [you do/PERSON does] not have a driver's license. Which of the following best applies…?**

[if motorcycle:] **You reported that [you were/PERSON was] travelled by motorcycle on this trip; however, you previously indicated that [you**

do/PERSON does] not have a driver's license. Which of the following best applies…?

1. [YOU actually have/Person actually has] a driver's license

2. [YOU were/Person was] a [if motorcycle: motorcycle] passenger, not the driver

7. Other, please specify: _____

9. Decline / don't know

[In TTS software there is a warning message to prompt interviewer to confirm/clarify and continue. Above question is a formalized version of this meant to ensure correct data is captured for online respondents. For phone interviews, the question is a yes/no, but the interviewer has the opportunity to clarify and change other responses. For online respondents, we have proposed expanded options beyond yes/no to assist us in determining where the error lies (in the driver's license response, the mode response, or whether the respondent gave valid responses, i.e., drove without a license. Drive without a license, which is illegal, is not listed as an answer to the question, instead the respondent could indicate this in the "other, specify" category.]

E19B. [if auto driver and no vehicles available to the household]

You reported that [YOU were/PERSON was] an automobile driver for this trip; however, you previously indicated that your household has no vehicles available for your use. Which of the following applies…?

1. I drove a work vehicle, rental, or borrowed vehicle

2. Our household actually has vehicles. Please specify how many: ___

6. No, [I/PERSON] was a actually a passenger, not the driver

9. Decline / don't know

[In TTS software there is a warning message with a yes no response to prompt interviewer to confirm/clarify and continue. Above probe is a formalized version of this meant to ensure correct data is captured for online respondents. Rather than yes/no, we have response categories intended to help us address any data problems.]

E16. [if employed AND did not make a work-related trip AND no trip destination of 'usual workplace' AND no more trips]

You/PERSON] did not report going to work [yesterday/on TRAVEL DAY]. Were [you/PERSON] working at home?

1. Yes, worked from home (telecommuted)

2. No, away on business / working on the road

3. No, did not work [PHONE: interviewer: clarify answer to previous question]

4. No, actually [I/PERSON] worked and did take work-related trips [PHONE: interviewer: clarify answers or add trips to/from work]

[Based on the standard TTS question "You did not go to work yesterday, were you working at home?", which has a yes/no answer and the opportunity for interviewers to probe/clarify, but with additional response options to help better understand the data for online respondents.]

[if E16=4 actually did work)]

[PROGRAMMER: direct respondent to their trips summary, with the instruction to add the missing trips]

Please add your trips to and from work, whether you walked or used another mode of travel.

Please also record any other trips by modes other than walking that you may have missed.

E16A. [if a full-time student AND did not make a school-related trip AND no trip destination of 'school' AND No more trips]

You did not report [going to school / that PERSON went to school]. Did [you/PERSON] attend school [yesterday/on TRAVELDAY]?

1. Yes, did go to school [PHONE: (interviewer: clarify answers or add trips to/from school)]

2. No, did not have any schedule classes, stayed home sick, or did not attend school for another reason

3. No, away on a field trip or other travel

[Not a standard TTS question, but a probe for quality control / data validation purposes. TTS software does not have a 'missed school' probe, but both this question E16A and next question E17B are useful to prompt online respondents to report all trips, and collect information for follow-up purposes.]

[if went to school E16A=Yes and usual school location other than 'home']

[PROGRAMMER: direct respondent to their trips summary, with the instruction to add the missing trips]

Please add your trips to and from school, whether you walked or used another mode of travel.

Please also record any other trips by modes other than walking that you may have missed.

HOUSEHOLD INFORMATION – FINAL QUESTIONS

B9. Phone: **May I ask which of the following ranges corresponds to your household's total income last year? (Consider all sources of income, before income taxes)?**

Web: **Which of the following ranges corresponds to your household's total income last year? (Consider all sources of income, before taxes)**

This information is useful for transportation planning purposes, to get a better understanding of households and their travel patterns. Your answers will remain entirely confidential. Click here to see our Privacy Statement.

Phone: (Interviewer: read answers until confirmation)

1. $0 to $14,999

2. $15,000 to $39,999

3. $40,000 to $59,999

4. $60,000 to $99,999

5. $100,000 to $124,999

6. $125,000 and above

7. Decline / don't know

[New income question included in 2016 cycle, for both DDE phone interviews and CallWeb online. In DDE system, responses will be recorded in the open-ended comments field.]

B10. [Online version only]

Would you be willing to be contacted to participate in future transportation-related research?

Contact information you provide will only be used to contact you for future transportation-related research conducted by the Ministry of Transportation of Ontario, University of Toronto, or one of the agencies or municipalities which have partnered on this survey. Your contact information will never be sold or shared with any other agency, or used for any other purpose other than to invite you to participate in research in the future. Click here to see our Privacy Policy.

Personal information is collected on behalf of the Ministry of Transportation under the authority of section 205 of the Highway Traffic Act. If you have any questions, please contact Khandker M. Nurul Habib, PhD, PEng, Associate Professor (Transportation), Department of Civil Engineering, University of Toronto, Toronto, M5S1A4, Room: SF 3001F, Phone: 416-946-8027, Fax: 416-978-6813, Email: khandker.nurulhabib@utoronto.ca.

1. Yes

2. No

Pop-up if click on "agencies or municipalities" hyperlink above:

Agencies and municipalities that have partnered on this survey include:

City of Barrie	www.barrie.ca
City of Brantford	www.city.peterborough.on.ca
City of Guelph	www.guelph.ca
City of Hamilton	www.hamilton.ca
City of Kawartha Lakes	www.city.kawarthalakes.on.ca
City of Peterborough	www.city.peterborough.on.ca
City of Toronto	www.toronto.ca
County of Brant	www.brant.ca
County of Dufferin	www.dufferincounty.ca
County of Peterborough	www.county.peterborough.on.ca
County of Simcoe	www.simcoe.ca
County of Wellington	www.wellington.ca
Metrolinx/GO Transit	www.metrolinx.com
Ontario Ministry of Transportation	www.mto.gov.on.ca
Regional Municipality of Durham	www.durham.ca
Regional Municipality of Halton	www.halton.ca
Regional Municipality of Niagara	www.niagararegion.ca
Regional Municipality of Peel	www.peelregion.ca
Regional Municipality of Waterloo	www.regionofwaterloo.ca
Regional Municipality of York	www.york.ca
Toronto Transit Commission (TTC)	www.ttc.ca

Town of Orangeville **www.orangeville.ca**

Please visit www.tts2016.ca for further information about this research study.

B10A. [if B10=yes]

Please enter your name and the email address and phone number you can be contacted at:

Name: _____

Phone: _____

E-mail: _____

[PROGRAMMER: none of the fields are mandatory; initially recall name, phone and email from B1A for convenience but allow them to be edited or deleted]

Contact information you provide will only be used to contact you for future transportation-related research conducted by the Ministry of Transportation of Ontario, University of Toronto, or one of the agencies or municipalities which have partnered on this survey. Your contact information will never be sold or shared with any other agency, or used for any other purpose other than to invite you to participate in research in the future. Click here to see our Privacy Statement. [Privacy Script]

Personal information is collected on behalf of the Ministry of Transportation under the authority of section 205 of the Highway Traffic Act. If you have any questions, please contact Khandker M. Nurul Habib, PhD, PEng, Associate Professor (Transportation), Department of Civil Engineering, University of Toronto, Toronto, M5S1A4, Room: SF 3001F, Phone: 416-946-8027, Fax: 416-978-6813, Email: khandker.nurulhabib@utoronto.ca.

[PROGRAMMER: insert pop up window hyperlinked to 'agencies or municipalities' in B10A to open in separate window as above]:

Appendix B – Rationale for Discontinuing Use of Phone-Only Sample






TRANSPORTATION TOMORROW SURVEY

RATIONALE FOR DISCONTINUING USE OF PHONE-ONLY SAMPLE
OCTOBER 18, 2016



Background

Phone-only samples were initially included in the sample plan as another potential way to obtain the participation of households not represented in the address+phone samples, especially given the modest response rate expectations from the address-only samples (expected to be 7%).

The phone-only samples include approximately equal thirds:

- white pages listings with no address (i.e., could not have matched to an address in the Canada Post address+phone samples),
- 'random digit dial' (RDD) samples consisting of phone numbers for land line exchanges that are randomly generated from the available numbers that are not listed (in order to reach unlisted households), and
- verified cell phone samples consisting of randomly generated phone numbers for cell phone exchanges that have been 'pinged' to verify that the number appears to be functional.

The target for sampling plan Option 4A was to obtain approximately 7% of all surveys via phone-only samples, with the planning assumption that a 17% response rate would be achievable across all phone-only sample types.

Phone-only samples were introduced on September 28, 2016 and telephone surveying was attempted for a few batches of these samples. On October 6, 2016, introduction of additional phone-only cases was suspended, although phone-only cases already activated will continue to be called until a minimum number of call attempts have been placed. Calling was suspended due to lower than expected response rates. It may be noted that with cold calling, high proportions of not-in-service or non-residential numbers, and higher refusal rates, phone-only calling significantly decreased production rates and negatively affected interviewer morale.

On October 11, TAC has approved the suspension of introduction of further phone-only samples, pending further information on phone only samples' response rates and characteristics for such surveys completed to date.

Response Rates from Phone-Only Samples

The table below illustrates response rates for different types of phone-only samples. Samples 301 to 303 are illustrated as they have received the most calling effort of all such samples. The samples are not fully depleted (still have some cases active which have not received the minimum number of call attempts), so do not necessarily represent the full yield of the samples, however, very few cases remain as still active.

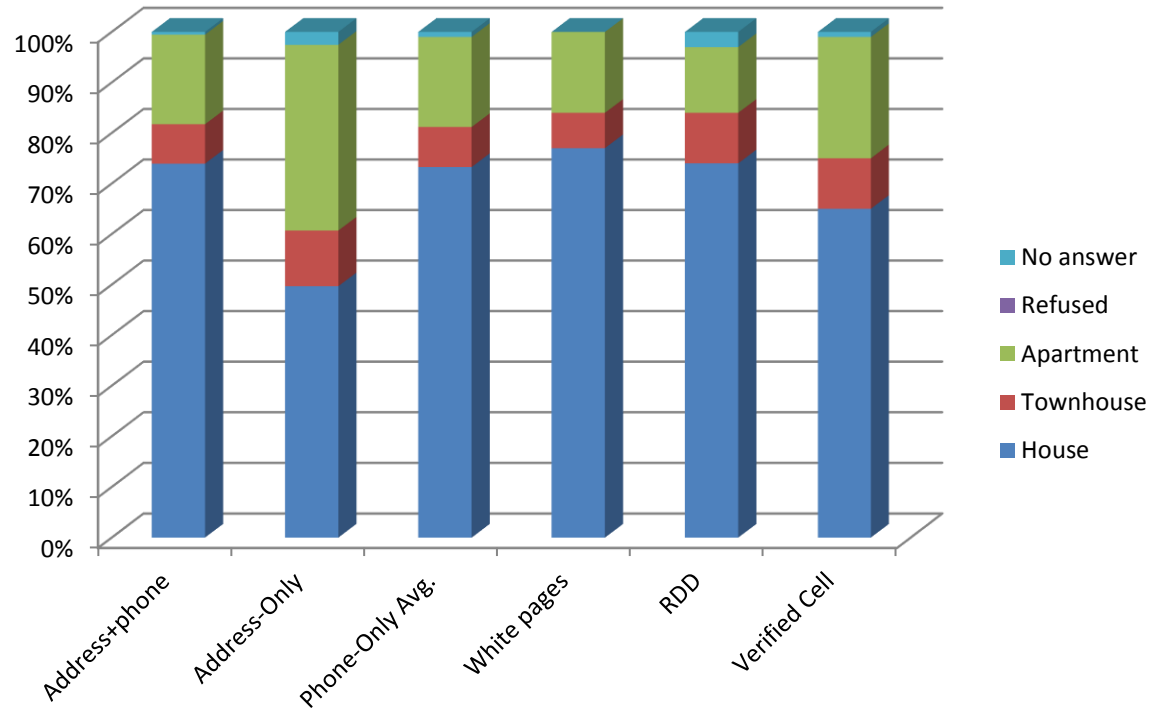
As indicated, response rates are considerably lower than the 17% response rate originally hoped for from this type of sample, with RDD and verified cell phones having much lower response than the listed white pages samples without addresses.

Sample Batch	Sample Type	Phone Numbers Accessed	Complete	Active	Refusal	Invalid	Rejected/ Retired (minimum # of call attempts made)
301	White pages	2,341	12%	4%	31%	28%	25%
302	RDD	2,285	3%	1%	6%	79%	12%
303	Verified Cell	1,857	6%	6%	31%	17%	39%
304	White pages	2,235	7%	4%	22%	43%	24%
305	RDD	1,522	13%	7%	28%	30%	22%
306	Verified Cell	1,238	2%	1%	6%	77%	14%
307	White pages	779	6%	7%	30%	17%	39%
308	RDD	762	11%	7%	34%	27%	21%
309	Verified Cell	940	2%	4%	6%	77%	11%
Total	-	13,959	7%	5%	22%	42%	24%

Comparisons of Key Characteristics of Households for Different Sample Types

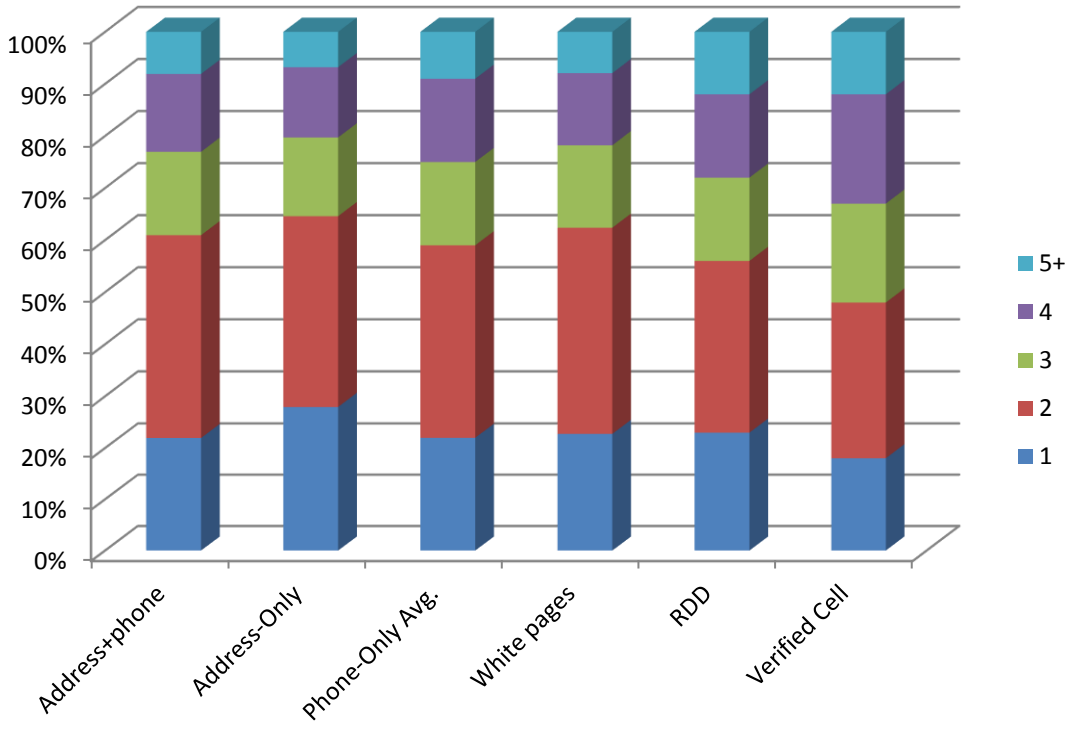
Dwelling type. In terms of dwelling types, the phone-only samples resemble the address+phone samples more so than the address-only samples, as illustrated below. Of the phone-only types, the verified cell sample types do have somewhat more representation of apartments and townhouses – although as noted earlier, these types of samples have much lower sample sizes due to much lower response rates than the white pages phone-only samples.

				Phone-Only		
Dwelling type	**Address+phone**	**Address-Only**	**Phone-Only**	**White pages (no address listed)**	**RDD**	**Verified Cell**
House	74%	50%	74%	77%	74%	65%
Townhouse	8%	11%	8%	7%	10%	10%
Apartment	18%	37%	18%	16%	13%	24%
Refused	0%	0%	0%	0%	0%	0%
No answer	1%	3%	1%	0%	3%	1%
Sample (n)	21,348	8,666	696	473	69	154



Household Size. In terms of household size, a similar pattern emerges, with household size distributions for phone-only samples resembling more closely those for address+phone samples, with some variation amongst the types of phone-only sample. Interestingly, verified cell samples appear to have more 3-, 4- and 5+ person households than the other sample types; however, as noted earlier, the very low response rates for these samples mean that considerable effort much be expended to obtain the few survey completions that are obtained from this type of sample.

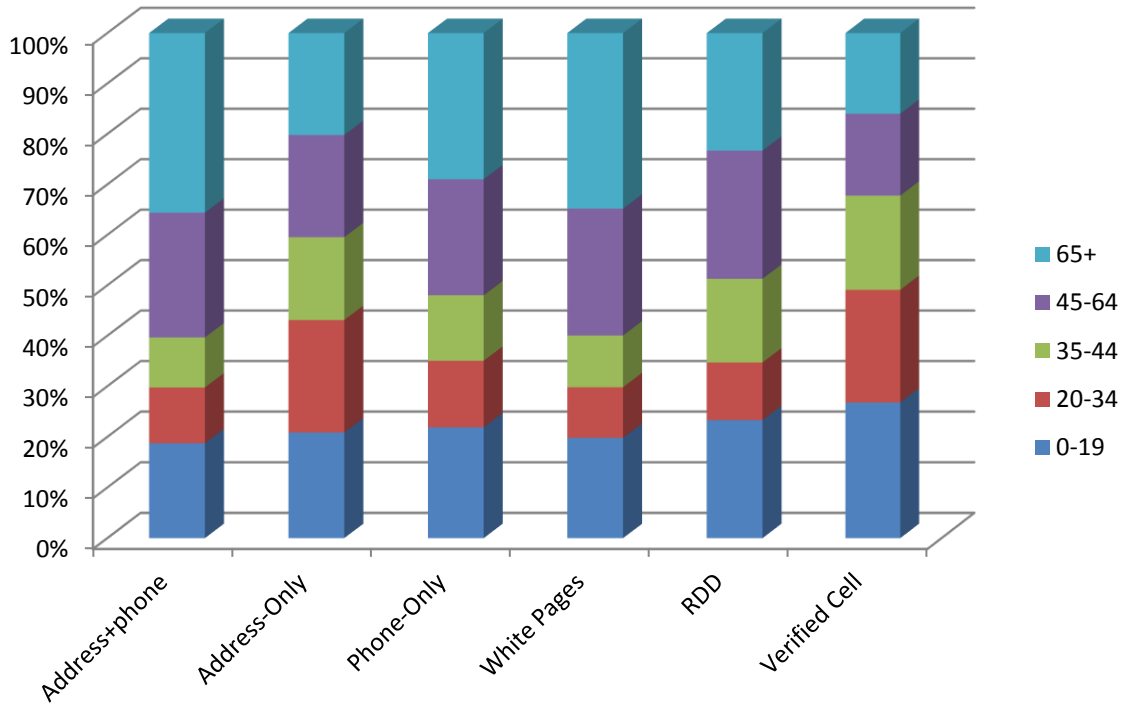
				Phone-Only		
Household Size	Address+phone	Address-Only	Phone-Only	White pages	RDD	Verified Cell
1	22%	28%	22%	23%	23%	18%
2	39%	37%	37%	40%	33%	30%
3	16%	15%	16%	16%	16%	19%
4	15%	13%	16%	14%	16%	21%
5+	8%	7%	9%	8%	12%	12%
Sample (n)	21,617	8,689	696	473	69	154



Age Profile. In terms of age profile, once again the age distribution for phone-only samples resembles that of address+phone samples, although it does skew slightly younger with 8%-pts greater representation for those under 44. This deviation is driven by the verified cell sample, which skews younger. This helps to explain the greater frequency of 3+ resident households in this sample, as observed in the previous table and figure.

Of note, the address-only sample as a whole skews even younger than the phone-only sample, with 11%-pts greater representation for those under 44, compared with the address+phone samples.

				Phone-Only		
Age Bins	**Address+phone**	**Address-Only**	**Phone-Only**	**White Pages**	**RDD**	**Verified Cell**
0-19	19%	21%	22%	20%	23%	27%
20-34	11%	22%	13%	10%	11%	22%
35-44	10%	16%	13%	10%	17%	19%
45-64	25%	20%	23%	25%	25%	16%
65+	36%	20%	29%	35%	23%	16%
Sample	43,245	18,874	1,818	1,181	193	444



Trip Rates. Interestingly, the trip rates per householder for phone-only samples are slightly lower than for both address+phone and address-only samples. However, for all phone-only sample trips the average trip rate per person eleven years or older is similar to the address-based samples – due to a greater representation of children ten and under in the phone-only samples.

Sample Type	People	People 11+	Trips	Trips/person	Trips/person 11+
Address+phone	43,757	39,882	86,905	1.99	2.18
Address-Only	19,049	16,539	36,447	1.91	2.20
Phone-Only Avg	1,845	1,642	3,466	1.88	2.11
White pages	1,204	1,096	2,329	1.93	2.13
RDD	193	159	327	1.69	2.06
Verified Cell	448	387	810	1.81	2.09

Recommendations

It may be noted that the rationale for inclusion of phone-only samples—being concerns over low response rate for address-only samples—is considerably less compelling given that address-only samples introduced to date are yielding response rates in the area of 11% (compared with the expected 7%).

Based on the poor performance of the phone-only samples in terms of response rates (x% compared with the expected 17%) and productivity (and with associated impacts on call centre morale and commitment), and the higher-than-expected performance of the address-only samples, we recommend discontinuing any further introduction of phone-only sample.

Appendix C – Preliminary Report on Data Weighting Hybrid Geographies

2017 Transportation Tomorrow Survey
Development of Hybrid Geography For Data Weighting

Report on Preliminary Work

Date: July 26, 2017
Prepared by: R.A. Malatest & Associates Ltd.

Table of Contents

Important Note:

This report was a preliminary report included to illustrate the process of developing the expansion zone geographies. Figures and expansion zone boundaries discussed in this preliminary report do not necessarily reflect final figures and expansion zone boundaries.

The final expansion zone definitions were delivered as spreadsheets and GIS files, after review by the committee.

1. Introduction

As the release of 2016 Census data by Forward Sortation Address (FSA) will not likely occur until 2018, we will not be able to weight and validate data collected at the FSA level of geography as had been done in the past.

We will instead use a hybrid of Census geographies to complete these tasks. These geographies will include:

- Census Subdivisions (CSDs). These usually follow municipal boundaries.
- Aggregated Dissemination Areas (ADAs). In census-tracted areas, these usually contain multiple census tracts. In more urban areas, there are usually multiple ADAs within each CSD. However, in more rural areas, there may be multiple small-population CSDs contained within an ADA.
- Census Tracts (CTs). These exist in most urban areas, but do not exist in more rural areas within the TTS study area. They are usually smaller than the ADAs.

Following the May 30 TAC meeting, the following general plan was approved.

- Within the more urbanized areas we will explore using aggregations of ADAs for the weighting geographies as they respect almost all CSD boundaries. For ADAs that straddle Planning District boundaries, they could be split into the planning districts by aggregating Census Tracts (CT). It may be noted that the CTs should respect the ADA boundaries.
- In the urban fringe and more rural areas, we will explore using either CSDs as the base, or for some larger CSDs containing multiple ADAs, ADAs might be used. For the occasional sets of very small CSDs with very small survey samples, we might combine small CSDs up into the larger ADAs they nest within.

After an initial review of the ADA geographies by Malatest, some issues were identified with certain TTS Planning District boundaries being out of date. Since then, DMG has revised the planning district boundaries to better match the municipal partners' actual municipal boundaries (which are usually the same as Statistics Canada's Census Subdivision boundaries from the 2016 Census, with some occasional exceptions).

Following the June 27 TAC meeting, budget to develop hybrid geography was approved.

This document provides a report on preliminary work undertaken to develop the hybrid weighting geography.

2. Review of ADAs to Determine Base Geographical Units

A review of Statistics Canada's Aggregated Dissemination Area (ADA) geography has been undertaken for its appropriateness in using as the base for data weighting, and to identify ADAs that would need to be disaggregated into smaller component geographies in order to respect TTS Planning District (PD) boundaries.

The exercise produced the following observations:

1. In urbanized areas (most of the study area) ADA boundaries are usually aggregations of Census Tracts, with the ADA boundaries respecting the CT boundaries, with one rare exception to this.

2. Within the City of Toronto, there are 10 ADAs that include portions of two Planning Districts. These ADAs can easily be split by Census Tract. An example is provided later in Annex 1 of this document (***Example A***).

3. Within the City of Hamilton, there are 8 ADAs that include portions of two Planning Districts. These ADAs can easily be split by Census Tract.

4. ADA boundaries usually respect CSD boundaries, however, there are occasional exceptions. These are illustrated later in this document.
    - ADA 3510001 contains both Asphodel-Norwood within the study area and other CSDs outside the study area. (***Example B****)*
    - ADA 3515009 contains both a portion of Selwyn and a portion of Peterborough City. (***Example C***)

5. In rural or urban fringe areas, ADAs may include multiple CSDs / Planning Districts. There are two such ADAs within the study area. These are illustrated later in this document (***Example D***).
    - ADA 35220001 contains both Melancthon and Mulmur.
    - ADA 35220004 contains Amaranth, Easter Luther Grand Valley, and East Garafraxa.

Each of the two ADAs would need to be split into component CSDs if data weighting is to be undertaken to respect the municipal level of the Planning Districts. However, it may be noted that the number of survey completions for each of the component CSDs is quite small. Whether these CSDs should be grouped for weighting is still an open question.

6. There are a few instances of PDs not respecting CT or CSD boundaries. These are illustrated later in this document.
    - Most of ADA 35200037 is in PD 13, but a small portion is in PD 15. PD 15 does not respect the CT boundaries, but this portion of the CT in PD 15 is mostly green space and commercial area, so it should not make a difference to the residential counts used in data weighting. (***Example E***)

- ADA 35430049 is the entire CSD of Adjala-Tosorontio. However, the PD boundary for Essa intrudes into the CSD boundary for Adjala-Tosorontio. Fortunately, this portion of the ADA does not include private residences. (***Example D***)

7. The individual ADA geographies typically have survey sample sizes that are somewhat smaller than would be preferred for weighting purposes. Only a small portion of the ADAs have sample sizes greater than 250 households.

3. Weighting Geographies

The final weighting geography will be a hybrid geography including the following type of geography as weighting units, depending on the area:

- Individual ADA with sufficient survey sample sizes for weighting purposes
- Two or more ADAs with smaller survey samples that will be aggregated together for weighting purposes
- Individual CTs aggregated with other CTs or ADAs, in order to split selected ADAs by Planning District boundaries
- Individual CSDs, in order to split selected ADAs by municipal boundaries

The hybrid geography will include two 'layers':

1. The first layer, or the 'base layer', will include the individual ADAs for most of the study area (except where those ADAs are to be split by CT or CSD), selected individual Census Tracts, and selected individual Census Subdivisions. Statistics Canada 2016 Census data will be drawn at these geographies.
2. The second layer, or the 'weighting layer', will aggregate geographies from the first layer into the final 'geographical weighting units' as appropriate to ensure sufficient sample sizes for effective data weighting. Some ADAs may have sufficient sample sizes already and may not require aggregating with other ADAs or CTs in order to achieve a reasonable sample size for use in weighting.

The ADAs, CTs, and CSDs for the first layer have been identified. The second layer has not yet been fully developed. Once the data weighting scheme has been approved, Census data files with data for household size, dwelling type, and age/gender will be matched to the base geographical units used in the system. These will then be aggregated for the final geographical weighting units.

4. Outstanding Issues

There are two outstanding issues to consider when finalizing the system of geographical weighting units:

- Appropriate sample size thresholds for weighting units.
- Appropriate aggregation of neighbouring ADAs, CTs, and/or CSDs

Sample size thresholds: Our experience with multivariate weighting for household travel surveys, including the Iterative Proportional Fitting (IPF) weighting method, has been that geographies with sample sizes of from 250 to 500 surveyed households are ideal.

Minimum threshold: The minimum target of 250 households is to ensure sufficient representation of all household types, household sizes, and age/gender groups. However, in past projects, we have successfully included occasional geographies with from 80 to 250 surveyed households. Nevertheless, it may be noted that this increases the risk of empty cells in the weighting stratification for other controls (e.g., age/gender distribution within the geography, household size, dwelling type) and increases the risk of extreme weights for cells with lower response / higher non-response bias.

Upper threshold: Given that the data may be recombined into different geographies for analysis later, the weighting units should also not be overly large, to mitigate the potential skewing that could occur when data weighted using one geographical system is recombined into a different geographical system.

For this reason do not usually recommend geographical weighting units of more than 500 or 600 households, unless they naturally occur within a small geography.

Considerations: One the one hand, using smaller geographical units and smaller sample sizes increases the flexibility with which alternate geographies can be drawn for analysis and modelling purposes (and confidence in doing so). On the other hand, it may lead to more extreme weights (although this can be addressed by limiting extreme weights) or may lead to slightly less success in converging to a solution in terms of balancing all demographic and household weighting controls.

For rural areas, for very small CSDs, there may be an argument for keeping these CSDs separate, if there is a need to provide reporting at the CSD level. We would expect TAC to advise if this is necessary.

The following table outlines the number of geographical units in the base layer, and the number with in different sample size ranges. A summary of the number of geographic base units with different sample sizes is presented by Planning District and Region in Annex 2 in this document. A full accounting of the geographies within the survey areas is provided separately in an Excel spreadsheet. An interactive map illustrating the Planning Districts, ADA boundaries, and ADA sample sizes is available at: http://arcg.is/0jX4DL

We will seek direction from TAC on their comfort level with using different sample size thresholds.

Total Survey Sample (n)	**163,046**
Total Base Geo Units (ADAs, CTs, and/or CSDs)	**1,064**
Average Sample Size per Geo Unit	**153**
# of Base Geo Units with…	
0 to 24 surveys	17
25 to 49 surveys	32
50 to 74 surveys	77
75 to 99 surveys	130
100 to 124 surveys	183
Subtotal <125 surveys	**439**
125 to 149 surveys	154
150 to 174 surveys	134
175 to 199 surveys	111
200 to 224 surveys	71
225 to 249 surveys	48
Subtotal 125 to 249 surveys	**518**
Subtotal 250 to 800 surveys (above ideal threshold for weighting)	**107**

Aggregation of neighbouring ADAs, CTs, and/or CSDs: Which ADAs, CTs, or CSDs to aggregate is an interesting question. Without intimate knowledge of each of the geographies and transportation networks, this may present something of a challenge.

There is a considerable number of ADAs with sample sizes of less than 250 households surveyed. The approximate number of ADAs below this threshold is 957 (with 439 having fewer than 125 surveys in each ADA, and 518 having between 125 and 249). These may need to be manually reviewed to determine appropriate aggregations that 'work' in terms of transportation-related analysis.

It may be possible develop general rules that will make faster work of aggregating ADAs, e.g., the first cut of joins being to the closest adjacent neighbour (in terms of the shape centroid), which tends to result in joins with either the smallest of the neighbours or the 'narrowest' of the neighbours. TAC members or DMG may have other suggestions for how to aggregate the ADAs.

We will seek direction from TAC on an appropriate approach to aggregating neighbouring geographies.

5. Next Steps

- Consult with TAC on sample size thresholds for weighting units
- Consult with TAC on approach to aggregating ADAs
- Prepare base GIS layer with base geographical units (combination of ADA, CT, and CSD geographies)
- Develop appropriate aggregations of base geographical units into geographical weighting units
- Aggregate Census data for demographic/household weighting controls
- Apply data weighting to the survey data and validate weighted data

The Annexes on the following pages present maps illustrating some of the types of geographic issues encountered (Annex 1) and a table summarizing the sample sizes for the base geographic units for PDs and Regions in the study area.

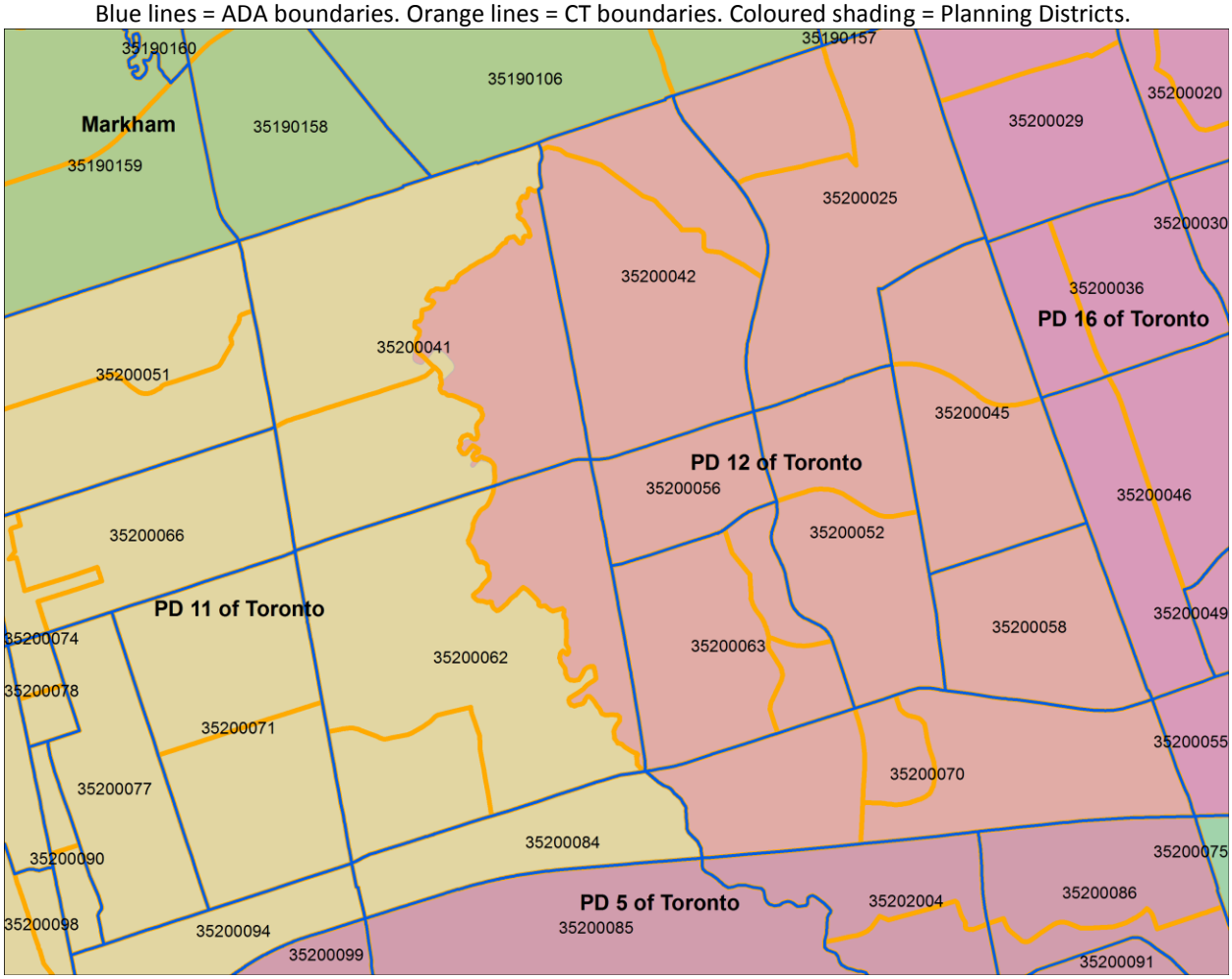
Annex 1: Illustrations of Geographical Issues

A. ADAs split by PDs.

The illustration below shows two ADAs which each contain more than Planning District

- ADA 35200041 is partly within PD 11 and partly within PD 12. Fortunately, the Planning Districts very closely follow CT boundaries, so it is possible to use the three CTs to split the ADA across PD 11 and PD 12.
- ADA 35200062 is also partly within PD 11 and PD 12, and its three CTs can also be use to split this ADA.

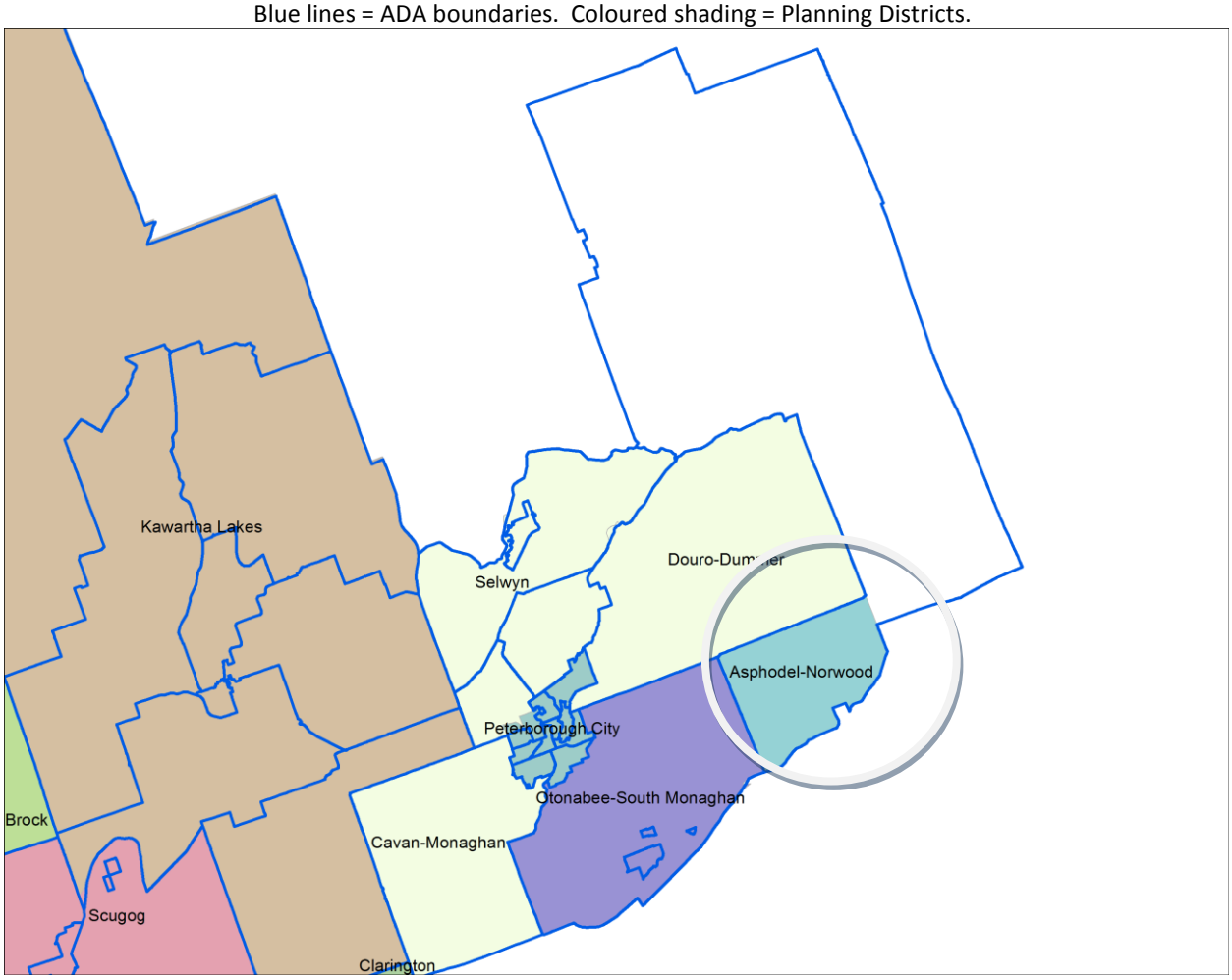
Blue lines = ADA boundaries. Orange lines = CT boundaries. Coloured shading = Planning Districts.



B. ADA that does not respect CSD boundary.

In the illustration below, the municipality of Asphodel-Norwood is only one part of a larger ADA. This is easy to resolve by ignoring the ADA boundary, and relying on the CSD to define the geographical unit to use in the weighting base layer.

Blue lines = ADA boundaries. Coloured shading = Planning Districts.



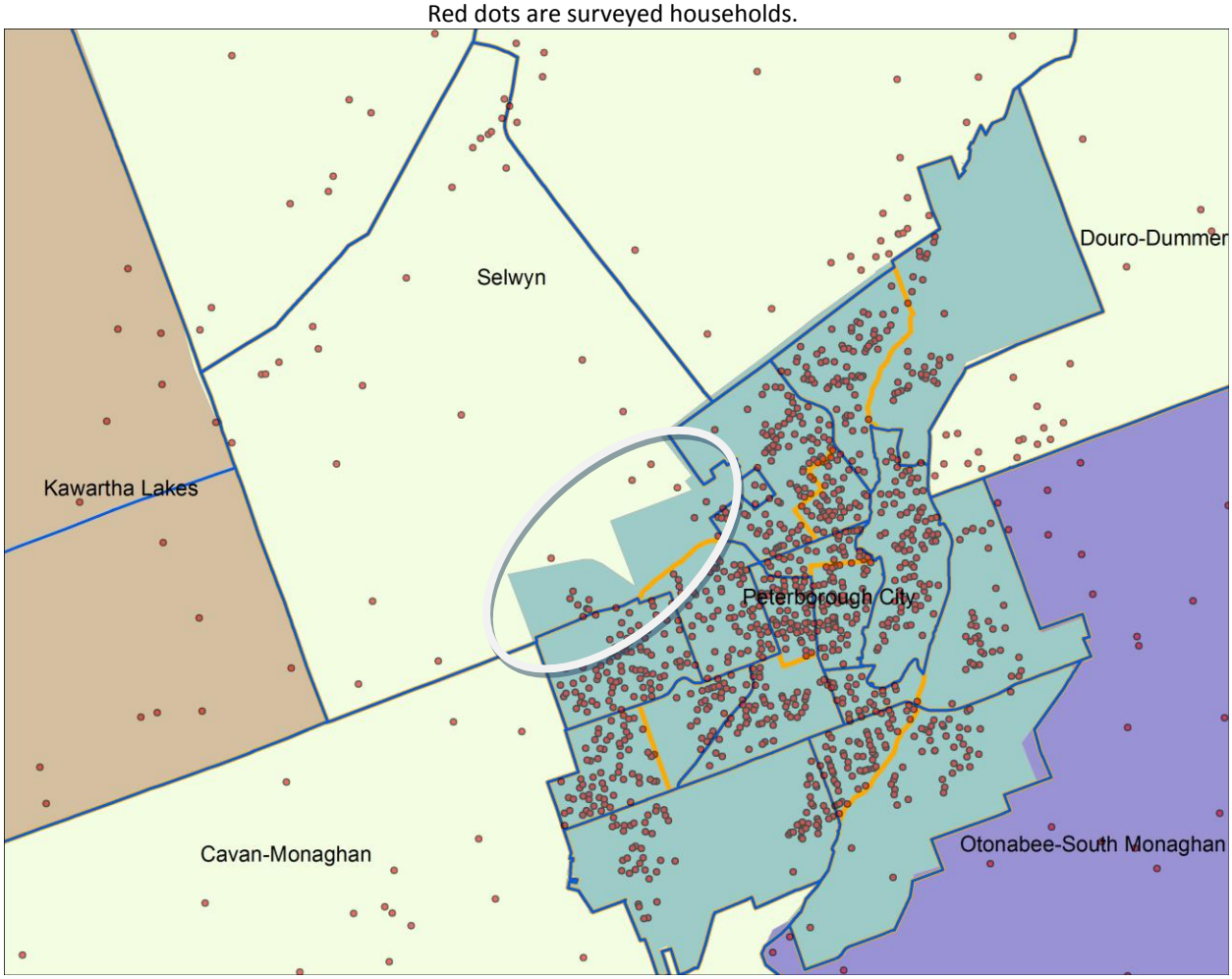
C. ADA and CT do not respect PD and CSD boundaries.

In the illustration below, one ADA contains both part of Selwyn and part of Peterborough.

The ADA can be split by CTs to isolate a portion of the ADA that is within the city of Peterborough. However, there is a portion of Peterborough City with habitation and survey completions that cannot be separated out using CTs. One of the CTs includes both part of Selwyn and the part of Peterborough City circled below.

We may need to explore whether the geography can be broken down further (e.g., into Dissemination Areas) in order to properly split the ADA into Selwyn and Peterborough.

Blue lines = ADA boundaries. Orange lines = CT boundaries. Coloured shading = Planning Districts.
Red dots are surveyed households.



D. ADAs split by CSDs; PD not respect CSD. In the illustration below, there are issues:

1. Mulmur and Melancthon are separate CSDs but fall under one ADA.

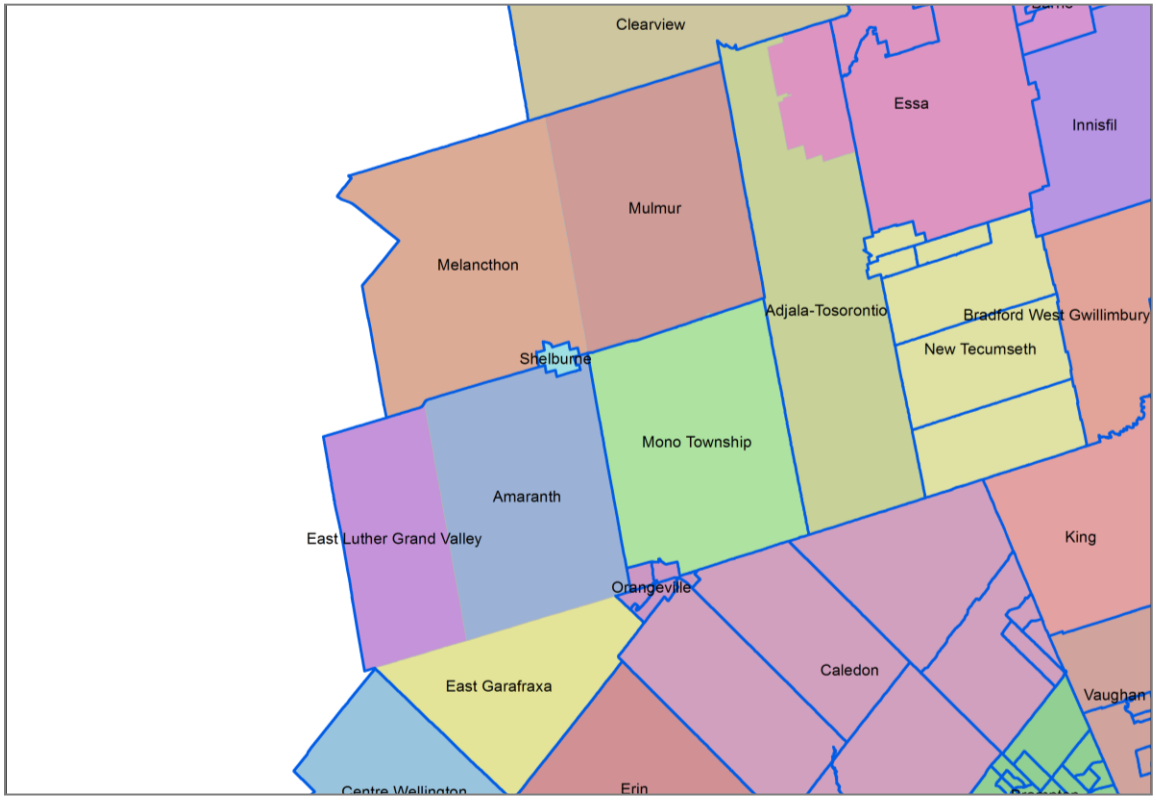
2. East Garafraxa, Amaranth, and East Luther Grand Valley fall under one ADA

In both instances, the individual municipal sample sizes are small.

ADA	Planning District / Municipality	Households	Sample size (n)
35220001	Mulmur	1,315	85
	Melancthon	1,037	37
35220004	East Garafraxa	8,54	123
	Amaranth	1,335	74
	East Luther Grand Valley	1,106	24

3. Finally, the TTS Planning District geography for the Township of Essa does not follow Statistics Canada CSD boundaries. As a result, a small portion of the Essa Planning District intrudes into the ADA which is the same as the CSD for the Adjala-Tosorontio. This small area is not Census-Tracted so cannot be split using the Statistics Canada geographies considered in this exercise. This small area appears to be part of a Canadian Forces Base (including barracks). However, since no surveys were obtained for the army barracks (which would fall outside of the residential address sampling frame), this may be a non-issue.

Blue lines = ADA boundaries. Coloured shading = Planning Districts.

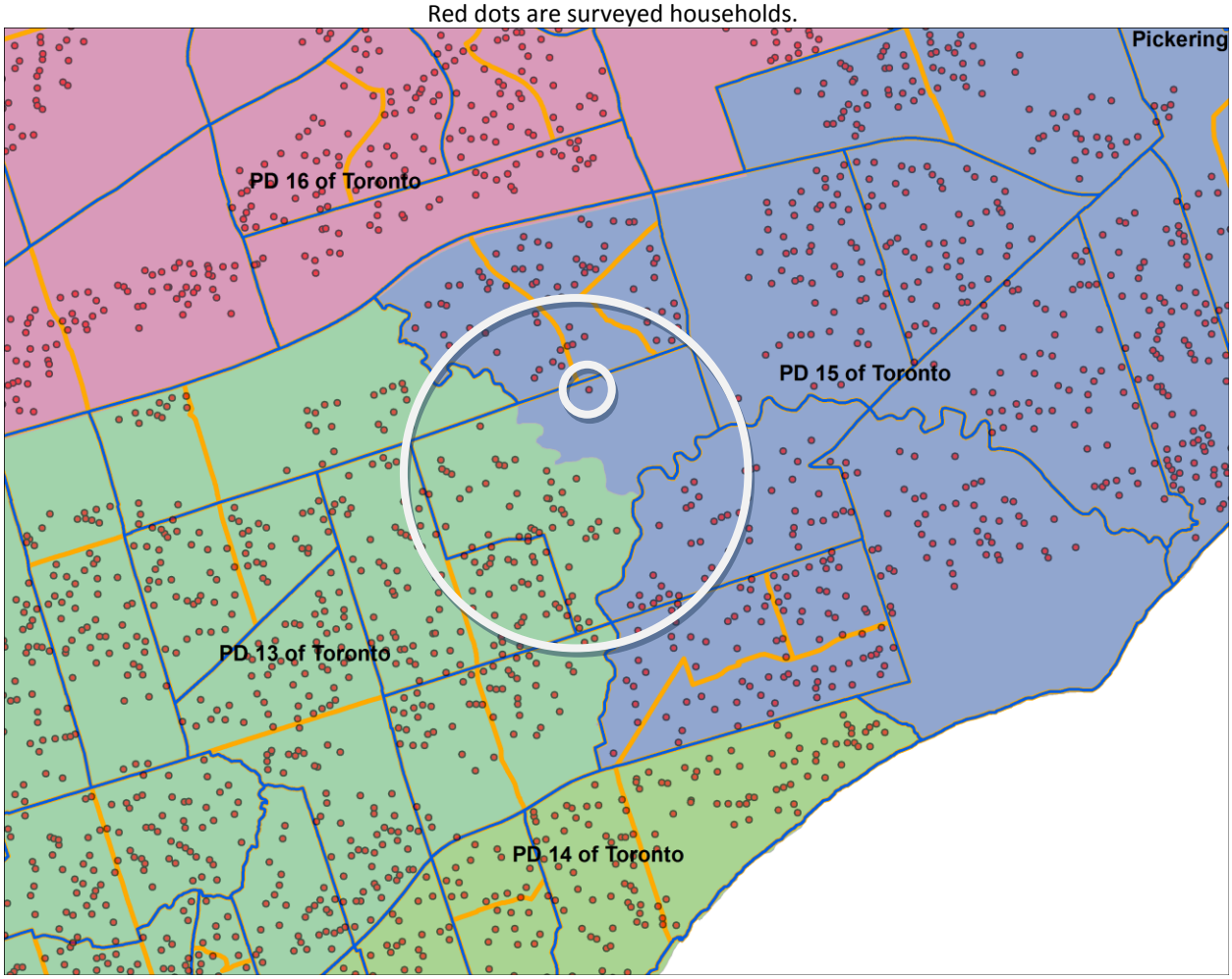


E. PD boundary does not follow ADA/CT boundary.

In the illustration below, one ADA in the centre is split by PD 13 and PD15. However, the PD boundaries do not respect the CT boundaries, and there is one household that falls in the PD 15. Closer inspection revealed that this is probably a non-issue:

- Google maps reveals that most of the PD15 (blue shaded) portion of the ADA at issue are either green space or commercial space
- The solitary household coded to this area probably has an error in geocoding, as the location appears to fall in a commercial area (unless the respondent is a building caretaker). This survey will be investigated and may be removed or regeocoded.

Blue lines = ADA boundaries. Orange lines = CT boundaries. Coloured shading = Planning Districts. Red dots are surveyed households.



Annex 2: Detailed Breakdown of Sample Sizes for Base Geographical Units

PD / Region Total	Total Survey Sample (n)	# Base Geo Units (ADAs, CTs, and/or CSDs)	Avg. Sample per Geo Unit	Size of survey sample within base geo unit (n)												
				0 to 24	25 to 49	50 to 74	75 to 99	100 to 124	Subtotal <125 surveys	125 to 149	150 to 174	175 to 199	200 to 224	225 to 249	Subtotal 125 to 249 surveys	Subtotal 250 to 800 surveys
Grand Total	**163,046**	**1,064**	**153**	**17**	**32**	**77**	**130**	**183**	**439**	**154**	**134**	**111**	**71**	**48**	**518**	**107**
PD 1 of Toronto	8,260	27	306				2	1	3	2	1		2	1	6	18
PD 10 of Toronto	2,664	17	157			1	3	2	6	2	2	3	2	1	10	1
PD 11 of Toronto	4,426	23	192				1	6	7	3	1	4	1	1	10	6
PD 12 of Toronto	1,589	10	159			2		1	3	2	1	2			5	2
PD 13 of Toronto	3,717	24	155				5	5	10	3	4	3		1	11	3
PD 14 of Toronto	1,313	8	164				1	1	2	1	2	1	1		5	1
PD 15 of Toronto	1,421	10	142				3	2	5	1		2	1	1	5	0
PD 16 of Toronto	3,925	26	151		2	1	3	3	9	4	2	7	2		15	2
PD 2 of Toronto	4,111	27	152		2	3	2	6	13	4	1	2	2	1	10	4
PD 3 of Toronto	4,352	26	167		1	2	2	4	9	6	3	1	3		13	4
PD 4 of Toronto	5,108	28	182		3	1		5	9	2	4	3		2	11	8
PD 5 of Toronto	2,398	14	171		1	1		2	4	1	3	3	1	1	9	1
PD 6 of Toronto	4,027	23	175		1		1	2	4	3	4	5	2	2	16	3
PD 7 of Toronto	1,663	7	238					2	2	1				1	2	3
PD 8 of Toronto	4,149	21	198				1	1	2	2	3	5	2	4	16	3
PD 9 of Toronto	1,232	10	123			3	1	1	5	2	1	1		1	5	0
1 ADA with a CT split by PD 13/PD 15	107	1	107					1	1						0	0
Toronto Total	**54,462**	**302**	**180**		**10**	**14**	**25**	**45**	**94**	**39**	**32**	**42**	**19**	**17**	**149**	**59**
Ajax	1,863	15	124			1	5	3	9	2	1	3			6	0
Brock	238	1	238						0					1	1	0
Clarington	1,662	10	166					2	2	2	3		2	1	8	0
Oshawa	3,285	20	164			1	1	3	5	5		5	3		13	2
Pickering	1,539	12	128				5	3	8	1	1			2	4	0
Scugog	468	4	117	1				1	2		1	1			2	0
Uxbridge	438	3	146				1		1	1		1			2	0
Whitby	2,240	14	160			1		2	3	4	3	2		1	10	1
Durham Total	**11,733**	**79**	**149**	**1**		**3**	**12**	**14**	**30**	**15**	**9**	**12**	**5**	**5**	**46**	**3**
Aurora	969	7	138				1	1	2	3	1			1	5	0
East Gwillimbury	439	3	146					2	2				1		1	0

PD / Region Total	Total Survey Sample (n)	# Base Geo Units (ADAs, CTs, and/or CSDs)	Avg. Sample per Geo Unit	Size of survey sample within base geo unit (n)												
				0 to 24	25 to 49	50 to 74	75 to 99	100 to 124	Subtotal <125 surveys	125 to 149	150 to 174	175 to 199	200 to 224	225 to 249	Subtotal 125 to 249 surveys	Subtotal 250 to 800 surveys
Georgina	877	7	125	1				2	3	1	1	2			4	0
King	379	2	190						0			2			2	0
Markham	5,404	39	139			8	2	6	16	8	8	2	3		21	2
Newmarket	1,489	9	165			1		1	2		5			1	6	1
Richmond Hill	3,311	24	138				5	6	11	3	5	2	2	1	13	0
Vaughan	4,864	39	125		1	3	10	10	24	3	5	3	3	1	15	0
Whitchurch-Stouffville	697	5	139					2	2	1	1	1			3	0
York Total	**18,429**	**135**	**137**	**1**	**1**	**12**	**18**	**30**	**62**	**19**	**26**	**12**	**9**	**4**	**70**	**3**
Brampton	8,486	62	137		4	11	12	11	38	7	3	5	2	1	18	6
Caledon	1,177	8	147				2	2	4	1	1			1	3	1
Mississauga	12,484	95	131			11	16	21	48	18	15	4	4	4	45	2
Peel Total	**22,147**	**165**	**134**		**4**	**22**	**30**	**34**	**90**	**26**	**19**	**9**	**6**	**6**	**66**	**9**
Burlington	3,560	22	162				3	2	5	4	6	4	1	1	16	1
Halton Hills	1,101	6	184						0	1	2		3		6	0
Milton	1,784	10	178				1	2	3	1	3		1		5	2
Oakville	3,356	23	146			1	7	3	11	4	2		1	4	11	1
Halton Total	**9,801**	**61**	**161**			**1**	**11**	**7**	**19**	**10**	**13**	**4**	**6**	**5**	**38**	**4**
Ancaster PD	437	7	62	2		3	1	1	7						0	0
Dundas PD	322	5	64		3	1			4	1					1	0
Flamborough PD	617	5	123			1		2	3	1		1			2	0
Glanbrook PD	332	4	83		1		2		3	1					1	0
Hamilton PD	3,898	48	81	4	7	11	11	9	42	2	3	1			6	0
Stoney Creek PD	829	12	69	1	2	5	1	3	12						0	0
Hamilton Total	**6,435**	**81**	**79**	**7**	**13**	**21**	**15**	**15**	**71**	**5**	**3**	**2**			**10**	**0**
Fort Erie	645	3	215						0			1	1		2	1
Grimsby	513	3	171					1	1			1	1		2	0
Lincoln	442	2	221						0				1	1	2	0
Niagara Falls	1,743	9	194						0	3	1	2	1		7	2
Niagara-on-the-Lake	372	1	372						0						0	1
Pelham	336	2	168					1	1				1		1	0
Port Colborne	425	2	213						0	1					1	1
St. Catharines	2,786	12	232						0		2	1	3	1	7	5
Thorold	405	2	203				1		1						0	1
Wainfleet	108	1	108					1	1						0	0

PD / Region Total	Total Survey Sample (n)	# Base Geo Units (ADAs, CTs, and/or CSDs)	Avg. Sample per Geo Unit	Size of survey sample within base geo unit (n)												
				0 to 24	25 to 49	50 to 74	75 to 99	100 to 124	Subtotal <125 surveys	125 to 149	150 to 174	175 to 199	200 to 224	225 to 249	Subtotal 125 to 249 surveys	Subtotal 250 to 800 surveys
Welland	1,102	5	220						0		2	1			3	2
West Lincoln	242	1	242						0					1	1	0
Niagara Total	**9,119**	**43**	**212**				**1**	**3**	**4**	**4**	**5**	**6**	**8**	**3**	**26**	**13**
Cambridge	2,228	15	149				4	1	5	4	2	2	1		9	1
Kitchener	4,324	29	149			1	3	7	11	8	4	1	2	2	17	1
North Dumfries	182	1	182						0			1			1	0
Waterloo	2,158	8	270				1	1	2	1				1	2	4
Wellesley	171	1	171						0		1				1	0
Wilmot	333	3	111				1	1	2	1					1	0
Woolwich	405	3	135				1		1	1		1			2	0
Waterloo Total	**9,801**	**60**	**163**			**1**	**10**	**10**	**21**	**15**	**7**	**5**	**3**	**3**	**33**	**6**
Guelph City	2,488	14	178				1	2	3	3	2	3	1	1	10	1
Guelph Total	**2,488**	**14**	**178**				**1**	**2**	**3**	**3**	**2**	**3**	**1**	**1**	**10**	**1**
Centre Wellington	625	4	156					1	1	1	1		1		3	0
Erin	211	1	211						0				1		1	0
Guelph/Eramosa	248	1	248						0					1	1	0
Puslinch	137	1	137						0	1					1	0
Wellington Total	**1,221**	**7**	**174**					**1**	**1**	**2**	**1**		**2**	**1**	**6**	**0**
Orangeville	558	4	140					1	1	2		1			3	0
Orangeville Total	**558**	**4**	**140**					**1**	**1**	**2**		**1**			**3**	**0**
Barrie	2,958	18	164			1	1	5	7	2	1	2	4		9	2
Barrie Total	**2,958**	**18**	**164**			**1**	**1**	**5**	**7**	**2**	**1**	**2**	**4**		**9**	**2**
Adjala-Tosorontio/Essa	187	1	187						0			1			1	0
Bradford W. Gwillimbury	536	4	134					2	2	1		1			2	0
Clearview	262	1	262						0						0	1
Collingwood	484	2	242						0		1				1	1
Essa	383	2	192						0			1	1		2	0
Innisfil	654	3	218						0		1			1	2	1
Midland	359	2	180						0		1	1			2	0
New Tecumseth	631	6	105	1				3	4	2					2	0
Oro-Medonte	380	3	127				1	1	2			1			1	0
Penetangushene	210	1	210						0				1		1	0
Ramara	224	2	112	1					1				1		1	0
Severn	252	1	252						0						0	1

PD / Region Total	Total Survey Sample (n)	# Base Geo Units (ADAs, CTs, and/or CSDs)	Avg. Sample per Geo Unit	Size of survey sample within base geo unit (n)												
				0 to 24	25 to 49	50 to 74	75 to 99	100 to 124	Subtotal <125 surveys	125 to 149	150 to 174	175 to 199	200 to 224	225 to 249	Subtotal 125 to 249 surveys	Subtotal 250 to 800 surveys
Springwater	278	3	93		2				2				1		1	0
Tay	193	1	193						0			1			1	0
Tiny & Christian Island	235	3	78	2					2					1	1	0
Wasaga Beach	532	2	266						0	1					1	1
Simcoe Total	**5,800**	**37**	**157**	**4**	**2**		**1**	**6**	**13**	**4**	**3**	**6**	**4**	**2**	**19**	**5**
Kawartha Lakes	1,555	8	194						0	2	2	2			6	2
Kawartha Lakes Total	**1,555**	**8**	**194**						**0**	**2**	**2**	**2**			**6**	**2**
Peterborough City	1,566	11	142				1	4	5	2	2	1	1		6	0
City of Peterborough Total	**1,566**	**11**	**142**				**1**	**4**	**5**	**2**	**2**	**1**	**1**		**6**	**0**
Asphodel-Norwood	72	1	72			1			1						0	0
Cavan-Monaghan	190	1	190						0			1			1	0
Douro-Dummer	147	1	147						0	1					1	0
Otonabee-S. Monaghan	163	2	82	1					1		1				1	0
Selwyn	309	3	103	1					1	1	1				2	0
Peterborough Total	**881**	**8**	**110**	**2**		**1**			**3**	**2**	**2**	**1**			**5**	**0**
Orillia	668	4	167						0	1	2	1			4	0
Orillia Total	**668**	**4**	**167**						**0**	**1**	**2**	**1**			**4**	**0**
Amaranth	75	1	75				1		1						0	0
East Garafraxa	124	1	124					1	1						0	0
East Luther Grand Valley	32	1	32		1				1						0	0
Melancthon	42	1	42		1				1						0	0
Mono Township	162	1	162						0		1				1	0
Mulmur	93	1	93				1		1						0	0
Shelburne	107	1	107					1	1						0	0
Dufferin Total	**635**	**7**	**91**		**2**		**2**	**2**	**6**		**1**				**1**	**0**
Brantford	2,130	13	164				2	1	3	1	4	2	2	1	10	0
Brantford Total	**2,130**	**13**	**164**				**2**	**1**	**3**	**1**	**4**	**2**	**2**	**1**	**10**	**0**
Brant	588	6	98	2				3	5				1		1	0
Brant Total	**588**	**6**	**98**	**2**				**3**	**5**				**1**		**1**	**0**
1 CT split by region/PD Selwyn / Peterborough City	71	1	71			1			1						0	0

Appendix D – Exploration of the Concordance between Google-Geocoded Destinations in Online Surveys and the Land Information Ontario Geographic Base





TRANSPORTATION TOMORROW SURVEY

Exploration of the Concordance between Google-Geocoded Destinations in Online Surveys and the Land Information Ontario Geographic Base

FEBRUARY 24, 2017



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Transportation Tomorrow Survey

Exploration of the Concordance between Google-Geocoded Destinations in Online Surveys and the Land Information Ontario Geographic Base

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1 Background

1.1 Land Information Ontario

The Transportation Tomorrow Survey has traditionally made use of street segment files as the basis of geocoding the great majority of all locations, most recently using the Land Information Ontario (LIO) street segment file. The LIO file includes street segments with civic number ranges on each side of the street ('From Left' to 'To Left'; 'From Right' to 'To Right').

1.2 DDE use of LIO

For telephone surveys completed via the Direct Data Entry (DDE) system, the DDE allows interviewers to enter and match to a list of LIO-based standardized addresses and allows geocoders to geocode new place descriptions to LIO-based addresses. As the street segment only defines the ends of the street segment, when a specific civic number and street name are entered for a given city, the DDE uses an algorithm to interpolate the location of the specific address along the street segment. For example, within a given municipality, "175 Main Street" may match to an LIO street segment that, on the left side, has civic numbers ranging from 101 Main Street to 199 Main Street; the DDE would place the x,y coordinates at 76% of the way along the street segment, with an offset 22m to the left.

1.3 Google Maps Locations

The CallWeb online surveys use Google Maps APIs to allow online respondents to search for and confirm locations. The Google utilities yield locations found either through 'auto-complete' suggestions (offered as the respondent starts to type the description of a location), through best matches of location description text to a places database (when there are no correct auto-complete suggestions), or via interaction with a map (drag-and-drop, double-click). The user is asked to review the location on the map and confirm that it is correct or revise the location, before continuing in the survey. If the result returned is too imprecise (e.g., just a city name and latitude and longitude of the centre of the city), the online survey does not allow the respondent to proceed. Typically, the CallWeb surveys are self-completed by the respondent, although some that have been started in CallWeb may be completed over the telephone with interview staff (e.g., respondent partially completed the survey before calling the toll-free line or receiving a follow-up call).

The Google locations are recorded with latitude and longitude, a description from Google's places databases, and the type or types of location represented, and some information about the search history. Depending on the type of location and/or match to the Google database, there may be varying levels of 'precision' in the resulting coordinates. For example, the location may have rooftop precision for a business or place of interest, interpolation of a civic number along a street segment (much as with how DDE uses the LIO segment file), a location identified as being within a limited civic address range (e.g., the centre point of somewhere between civic numbers 35 and 85), a street centre point (if only the street is known), an intersection, a specific transit stop, etc.

Post-survey, a small portion of online surveys may also have geocodes (latitude, longitude) manually entered by data review staff in order to correct locations online respondents had mistakenly confirmed as correct.

2 Rationale for Exploring the Concordance between LIO and Google

Differences may exist in how a given location might be geocoded via the LIO base and how the same location might be geocoded via Google Maps. For example, locations coded via the LIO base will always be offset 22 metres from the street centre line, and civic addresses are presumed to be equally spaced between the 'from' and 'to' end points of the street segment. Google Maps may sometimes furnish results that are similarly interpolated along street segments, but with a different offset from the centre line, but other times will furnish results that more precisely identify the specific location along the street segment, and sometimes will even identify the location as the centroid of the actual building (i.e., with a much greater offset from the street centre line in the case of a shopping centre or other large building).

Some questions have been raised as whether the location coordinates captured via online surveys in CallWeb should be recoded to match the LIO base or whether the Google-returned coordinates can stand alone and coexist with LIO-based coordinates. The objective of the current exercise is to explore the extent to which online trip destination coordinates would differ if they were coded via the DDE/LIO approach and the extent to which those differences might matter to the eventual analysis of the data.

3 Steps in Exploring Concordance

In order to explore the concordance between LIO and Google, the following steps were planned:

1. Undertake textual matches of location descriptions captured by online surveys to the LIO street segments file, as possible given the text descriptions of addresses recorded in the online surveys
    a. Report on the overall match success rate;
    b. Report on the match success rate for different Google-based location types;
2. For locations that can be text-matched, explore the extent to which the coordinates returned by Google differ from the coordinates returned by the LIO street segment interpolation.
    a. Discard cases that are obvious poor matches (which may occur if the same street name exists in different parts of the same city);
    b. For locations considered to be good matches, determine the distance between the Google-based and LIO-based coordinates, and the proportion of cases that are very close, moderately close, etc.;
3. For the locations that cannot be matched according to the description, undertake matching of the latitude/longitude returned by Google to the closest LIO street segment, and determine the civic number range corresponding to the closest point on the LIO street segment.
    a. For these locations, randomly check results and review against the Google-based location description first to confirm that the matches are generally good.
    b. Discard cases that are obviously poorly geocoded in one system or the other (and flag for follow-up geocoding review if necessary).
    c. Determine the distance between the Google-based and LIO-based coordinates, and the proportion of cases that are very close, moderately close, etc.
4. Once the preceding steps have been undertaken, plot both the Google-based coordinates and the corresponding LIO-based coordinates, and undertake spatial joins to the TTS Traffic Zone

system to determine the extent to which they systems might return similar or different kinds of results for zone-based analysis. This task would exclude locations coded to intersections, which have yet to be offset away from where the street centre-lines meet.

5. Collaborate with the UofT DMG to undertake an overall assessment of the concordance between Google-based coordinates and LIO-based coordinates, and the likely impact it may have on analysis, in order to make recommendations as to how Google-based geocodes should be treated in the final dataset. Options may include:
    a. take no action, i.e., accept Google-based geocodes as reasonably precise (and sometimes even more precise than LIO coordinates);
    b. match Google locations to LIO via textual matches as possible;
    c. re-geocode Google locations that do not have addresses (e.g., a park; a transit stop; or that have addresses which do not match to the LIO via textual matches) to addresses that can match to the LIO segments file via spatial matches to the closest LIO street segment; and
    d. re-geocode Google locations that do not have addresses (e.g., a park; a transit stop; etc.) to addresses that match to the LIO segments file via matches to the closest segment via manual review.

    Of the options, the latter is to be avoided, if possible, as manually re-geocoding locations would consume resources and delay the project.

4 Matching Google Locations to LIO Street Segments

4.1 Text Matching Google Address Descriptions to LIO Street Segments

The first step undertaken was to match address descriptions in Google against the street names and civic number ranges in the LIO street segments file. Good matches would then used to explore how closely or far apart the Google-based coordinates would be compared to the LIO-based coordinates for the same address.

It may be noted that Google returns descriptions that often include the names of villages, small towns, and historic municipality names (e.g., Etobicoke, North York). By contrast, the LIO street segment file only includes the same city/town name for each Census Subdivision (e.g., streets in Etobicoke and North York are all identified as being in Toronto), but it does include the Planning District (PD) for each location. In order to maximize the match potential, as a precursor to the textual matches, the Google-based coordinates were first spatially joined to the TTS municipality/PD system, and the municipality or Toronto planning district was substituted in for the city/town name in the Google-based description of the location. A number of operations were also undertaken to parse the Google-based address descriptions to break out the component parts of each address description and better match against the LIO street names, e.g. standardizing “Ave” and “Avenue” to match how the street types are described in the LIO.

In total, 88.5% matched: 86.3% had a good text match to a unique LIO street segment within the same municipality or planning district (Type 1 matches); a further 2.2% could be matched to more than one LIO street segment with the same street name and civic number range (Type 2).

Possible reasons for Google descriptions not matching an address in LIO might include:

- possible errors or issues in the automated algorithms to parse the address descriptions in Google into their component parts for matching;
- differences in how roads are described in Google compared to the LIO. For example, Google might return “14TH LINE” as a street name, where as LIO may have the street listed as “14 LINE”; or, Google might return the number of a highway passing through an urban area, whereas LIO may have the street segment listed under the local street name of the highway;
- areas of more complete coverage in Google than in LIO or vice versa;
- imprecise address descriptions in Google (e.g., very occasionally if a user double-clicks on, or drags the marker to, a location on the Google Map, Google will return an address with a civic number range within which the clicked point on the map might be found); or
- location description in Google does not contain a specific address (e.g., a place of interest like a park, or a transit stop) even though it is accurately geocoded.

4.2 Spatially Matching Google Coordinates to the Closest LIO Street Segment

For the remaining 11.5% of locations for which no textual match was found, the Google coordinates were mapped to the closest street segment within a radius of 500m.

In the text matching exercise, a small portion of all cases (1,365 or 0.5%) had been found to have a street name from Google that matched identically to one or more segments in LIO, but the civic number provided by Google could not be found within any of the civic number ranges of the LIO street segments. For these cases, the Google coordinates were matched with the closest LIO street segment with the same name (Type 3 matches). In a number of cases, the closest LIO street segment did not have civic number ranges on either side of the street (e.g., left from = 0, left to = 0, right from = 0, right to = 0).

The remaining 33,000 cases were spatially matched to the closest LIO street segment within 500m (Type 4 matches). For this match type, a sample of 336 cases was visually reviewed. In total, 68% of the matched LIO street segments have the same street name as the address given by Google, but a different format, different spelling, and/or differing information (e.g., missing street direction on one side of the join). Exhibit 1 shows an example for “Seventh Concession Road” in Google description vs. “7th Concession Road” in the LIO base.

Exhibit 1 - Google address mapped to the closest LIO Street Segment. Same street name.

The following figure (Exhibit 2)shows examples of spatial matches to street segments of different names. In the figures, the red dots identify the Google-based coordinates, the black lines illustrate the LIO street segments, and the green lines illustrate the distance between the Google-based coordinates and the LIO-derived coordinates. In the example below, for most of the locations noted at the top of the map, the locations are identified by Google as being addresses on Highway 2, but have been matched to the LIO segment for the cross-street of Boswell Drive, as it is closer to the Google coordinates. It is worth noting that even if LIO-based coordinates had been assigned for the civic address on Highway 2 street segment with just a 22-m offset from Highway 2, it is likely that the LIO-derived coordinates would fall within the same traffic zone as the Google coordinates.

Only 116 cases could not be mapped to a LIO street segment (i.e., no street segment was found within 500m of the Google coordinates).

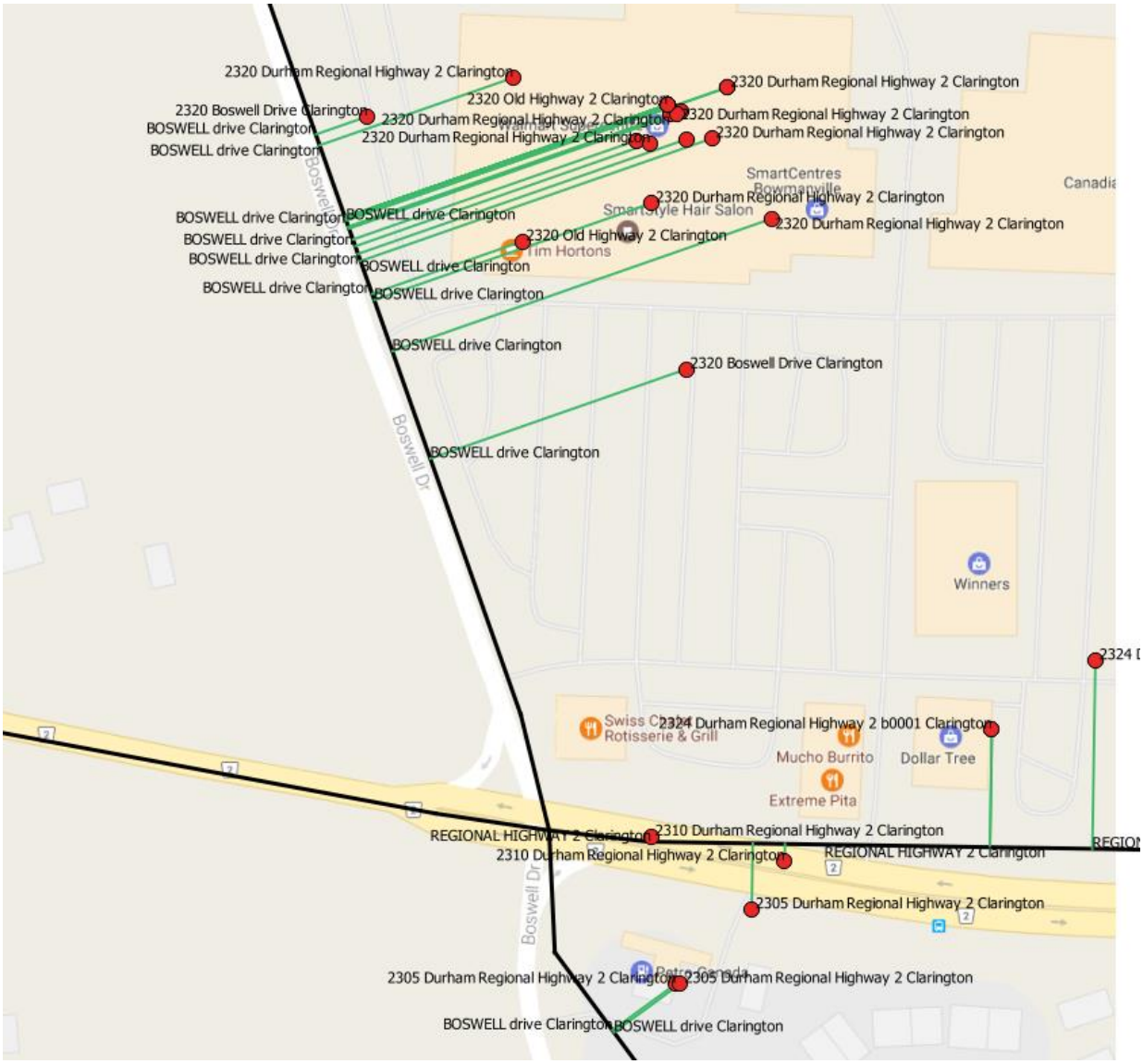

Exhibit 2 - Google address mapped to the closest LIO Street Segment. Different street name.

4.3 Assessing the Spatial Concordance between Google and LIO Coordinates

The next step undertaken was to assess the spatial concordance between latitude/longitude coordinates as assigned by Google and the coordinates as assigned with the match to the LIO segments file. For this exercise, for the text-based matches, the LIO-based coordinates were generated using a similar algorithm used by the DDE software (interpolating the location of the civic number along the street segment and offsetting by 22m from the segment). For the 11.5% with spatial matches, we chose the LIO-based coordinates the latitude/longitude of the closest point on the segment to the Google-based coordinates; we did not offset the corresponding LIO-based coordinate the usual 22m from the street centre line, for convenience in the calculations.

Exhibit 3 presents distance concordance for the sample of over 299,000 trip destinations located within the study area, by Google-to-LIO match type. As indicated in the table, a large majority (93%) of the text-based matches had Google-based coordinates within 200m, 78% within 100m and 33% within 25m.

The text based matches (Type 1 and Type 2) can be taken as the best indicators of the indicators of the concordance between Google locations and LIO street segments (i.e., if the exact same civic address is represented in both Google and LIO, what are the differences or similarities in how they are mapped?). As review of the Type 4 spatially-based matches suggested that over two-thirds of such matches were for the same street but with different spelling or formats, the spatially-based matches can nevertheless be viewed with a good deal of confidence as being appropriate matches for the most part

Exhibit 3 - Distance Concordance by Google-to-LIO Match Type

MATCH TYPE		Total cases matching to LIO segments		Distance Concordance (% of group)		
		Count	% of total	<=25 m	<=100 m	<=200 m
TOTAL SAMPLE		**299,175**	**100%**			
No textual match, no spatial match within 500m		116	0.04%	n/a	n/a	n/a
TOTAL MATCHED TO LIO SEGMENT		**299,059**	**99.96%**	**33%**	**78%**	**93%**
1	Textual matches	258,170	86.3%	33%	78%	93%
2	Textual matches with duplicate matches for the same civic number (chose closest one)	6,675	2.2%	13%	57%	97%
3	Google coordinates mapped to the closest LIO street segment with identical street names (search radius of 500 m)	1,365	0.5%	37%	86%	99%
4	Google mapped to the closest LIO street segment (search radius of 500 m)	32,849	11.0%	40%	84%	97%

As noted, 7% of textual matches are for Google-based coordinates that are more than 200 m away from the matching LIO street segment. This does not mean that the Google-based information incorrectly assigns coordinates 7% of the time. Data were reviewed to determine possible reasons for such large differences between the Google coordinates and matched LIO-based coordinates. These include:

- **LIO-derived street address coordinates are close to the edge of the property, whereas coordinates assigned by Google are the centre of a very large building** (e.g., shopping mall, recreation centre), complex (e.g., university campus) or other large property (e.g., park, parking lot). Exhibit 4 shows an example of large differences in the Google and LIO versions of the coordinates caused by a large university complex (University of Waterloo). Red points show address coordinates from Google. Black lines are LIO street segments. Blue lines represent distances greater than 500m between Google and the matched LIO coordinates. The Google-based coordinates for the eight locations to the north of Columbia St. W all have the same street address of "200 Columbia St. W", even though they are different buildings on campus (user might have double-clicked on their building on the map or dragged the marker to their building). The LIO street segment to which these match (to the west of the map on Columbia St W) has a civic number range of 200 to 350. For Columbia St W, LIO also has a number of street segments to the northeast of this segment which have no civic numbers (from = 0, to = 0). A similar pattern is present for the two locations on campus both returned from Google with street address of "200 University Dr." that match to the LIO street segment to the east of the map.

Exhibit 4 - Large university campus causing difference in geocoding, Waterloo

Similarly, in the map below (Exhibit 5), the Google locations all match to a street segment with civic number range from 123 to 123 Garratt Blvd. The Google locations are all between 200m to 500m from the LIO street segment. The Google locations appear to be a more accurate positioning for where their activities would take place at the destination (Bombardier Aerospace complex with address of 123 Garratt Blvd). The LIO version of the location appears to be on the incorrect side of the street for the Bombardier complex.

Exhibit 5 - Large complex causing difference in geocoding, North York

- **The DDE algorithm, which interpolates the civic number location between the street segment endpoints, yields inaccurate results for curved street segments.** By contrast, Google often has accuracy to the actual property location for the civic number. The illustration below (Exhibit 6) shows three different street addresses for a crescent. The Google coordinates in red dots appear to be the correct house locations for the civic addresses, whereas the LIO-based coordinates have been interpolated along the line between end points of the crescent. For one address, the LIO-derived coordinate is on the incorrect side of the cross street the crescent intersects with.

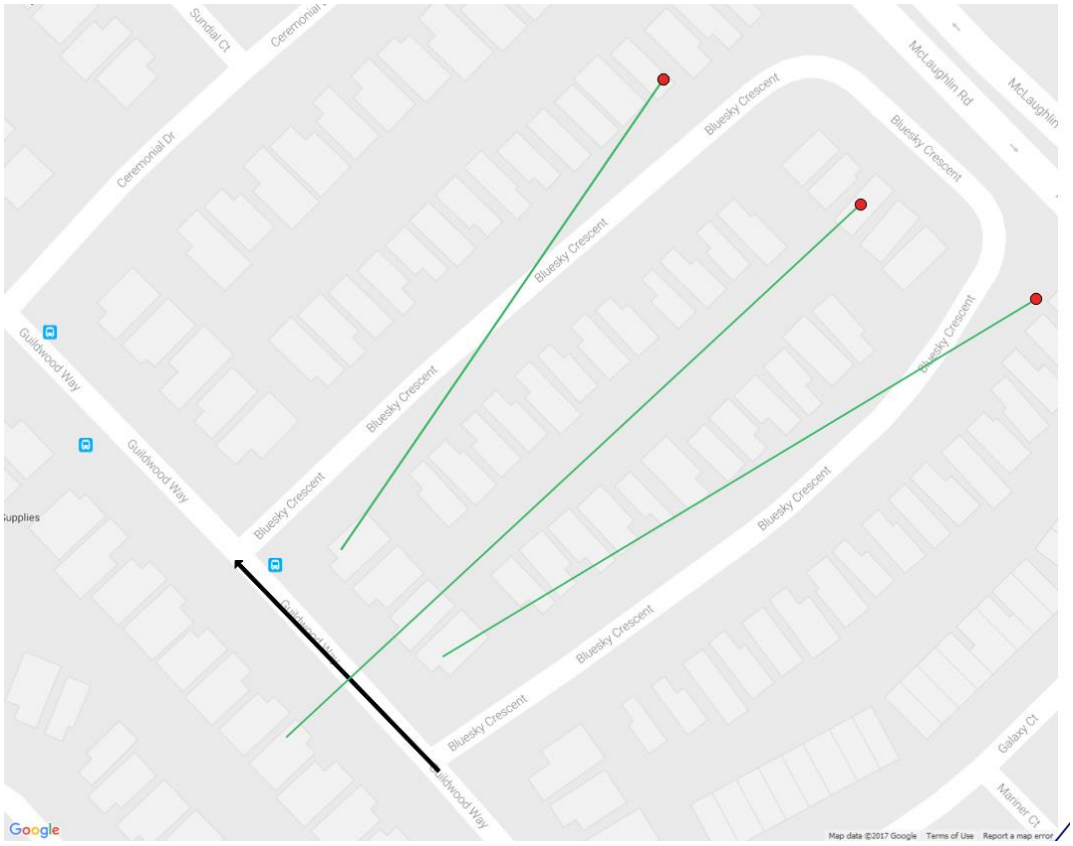

Exhibit 6 - Crescent street causing difference in geocoding, Mississauga

- **LIO street segments and Google street segments may not always be perfectly aligned all through the study area.** Overlaying the LIO street segments on top of a Google Map of the study area reveals that for many portions of the study area the LIO street segments align very closely to the Google Maps road network (Exhibit 7), whereas in certain areas, the LIO street segments are slightly offset from the roads in Google Maps (Exhibit 8). For the most part, these offsets appear to be modest in distance

Exhibit 7 - Good Alignment between Google and LIO, City of Hamilton

Exhibit 8 - Poor Alignment between Google and LIO. Google road network has slight offsets from LIO.

4.4 Assessing Traffic Zone Concordance between Google and LIO Coordinates

Setting aside for the moment the reasons for differences in distances between Google-based coordinates and LIO coordinates, and the relative accuracy of the two geocoding methods, the question remains as to whether the introduction of Google-based coordinates to the TTS will affect the results of data analysis. For example, given that 22% of coordinates furnished by Google are more than 100m away from the coordinates that would have been obtained if the same address was geocoded using the LIO-based street segment civic number interpolation, how much of a difference would this make to a typical analysis of the data using the 2006 TTS traffic zone system? Therefore, after the matches were completed, the next step was to determine the extent to which the use of Google-based coordinates may result in changes in the distribution by traffic zone. The results are presented in Exhibit 9, below.

In 95% of the cases, the destination coordinates fall in the same traffic zones. This high level of concordance is encouraging and suggests that most analyses would provide similar results regardless of whether the coordinates were coded via Google or via the LIO-based algorithm. This would be even more true for analyses that aggregated traffic zones, given that in many instances the Google-based coordinates were in a neighbouring traffic zone to that of the LIO-based coordinates.

Exhibit 9 - Traffic Zone Concordance by Google-to-LIO Match Type

	MATCH TYPE	Total cases matching to LIO segments		Traffic Zone Concordance
		Count	% of sample	% within same traffic zone
	TOTAL SAMPLE	**299,175**	**100%**	
	No textual match, no spatial match within 500m	116	0.04%	n/a
	TOTAL MATCHED TO LIO SEGMENT	**299,059**	**99.96%**	**95%**
1	Textual matches	258,170	86.3%	96%
2	Textual matches with duplicate matches for the same civic number (chose closest one)	6,675	2.2%	83%
3	Google coordinates mapped to the closest LIO street segment with identical street names (search radius of 500 m)	1,365	0.5%	92%
4	Google mapped to the closest LIO street segment (search radius of 500 m)	32,849	11.0%	86%

4.5 Concordance for Different Google Geocoding Methods

When locations were captured in the online surveys, the type of Google-based geocoding method was recorded for reference, e.g., whether the search yielded a location that matched to a specific street address, intersection description, point of interest such as a business, postal code, etc. If the respondent interacted in the map (12.3% of all geocoded locations) by double clicking or dragging the marker, this was recorded as the geocoding method. A very small proportion of all locations were re-geocoded by data reviewers post-survey. The geocoding method was not returned by the Google search function or the map for another small proportion of all locations.

The sample was explored to determine whether there were differences by geocoding method in terms of the degree of concordance. The results are presented in the table on the following page.

Amongst the more common types of geocoding results in the survey data, Google street addresses (being 71% of all locations) had a concordance rate matching the average (97%), places of interest (office buildings, business establishments, shopping centres, parks, etc.) concorded 94% of the time, and locations geocoded via the respondent interacting with the map concorded only slightly less often (double-click, 93%; drag and drop, 94%). Of the common methods used to geocode the vast majority of locations, there does not appear to be a geocoding method that yielded poor levels of concordance. I.e., there should be no need to have to troubleshoot pockets of data for specific geocoding methods.

Exhibit 10 - Concordance by Google Geocoding Method

ID	Accuracy	Total number of cases matching to LIO segments	Distance Concordance (% within distance)			Traffic Zone Concordance % within same traffic zone
			<=25m	<=100m	<=200m	
	Total n	299,059	99,733	232,878	278,035	
	%	100%	33%	78%	93%	95%
Location Geocoded via Google Places Autocomplete / Geocode						
11	Street Address (Google)	213,288	39%	83%	95%	96%
12	Intersection (Google)	6	50%	83%	83%	100%
13	POI (Google)	39,453	16%	59%	85%	92%
14	Postal Code (Google)	6	0%	50%	100%	100%
15	Neighborhood (Google)	1	0%	0%	0%	100%
16	Route/Street Name (Google)	17	0%	100%	100%	76%
17	Locality (Google)	5	60%	100%	100%	100%
18	Transit Station	1,051	6%	47%	68%	89%
Location Geocoded via Google Map Interaction						
96	Double Click	19,850	21%	67%	88%	91%
97	Drag and Drop	17,055	27%	72%	91%	92%
Assigned manually during visual review / follow up						
1	Full Address	1,057	27%	68%	87%	90%
2	Intersection				100%	
3	Landmark	5	20%	40%	100%	80%
6	Address Range					
7	Street Name	9	56%	89%	100%	100%
8	FSA	4	0%	75%	100%	0%
	Unknown	7,247	25%	70%	89%	93%

4.6 Concordance for Different Study Geographies

Concordance was explored by municipality and planning district to determine whether there were any systematic differences in concordance by geography. Exhibit 11 illustrates average distances between the Google and LIO coordinates for all match types, while Exhibit 12 presents this for only the textual matches. Exhibit 13 details the distance and travel zone concordances by municipality/planning district.

Selected geographies were explored to determine potential reasons for higher averages . For example, it was found that the results for parts of Waterloo were influenced by a sizable number of locations being mapped to university campuses differently via Google than via LIO street segment, as illustrated in Exhibit 4 earlier in this report.

While there is some variance by planning district, there are only six planning districts for which more than 10% percent of samples fall in different traffic zones. All are small municipalities (Brock, East Garafraxa, Amaranth, Puslinch, Guelph/Eramosa), with the exception of PD 10 of Toronto.

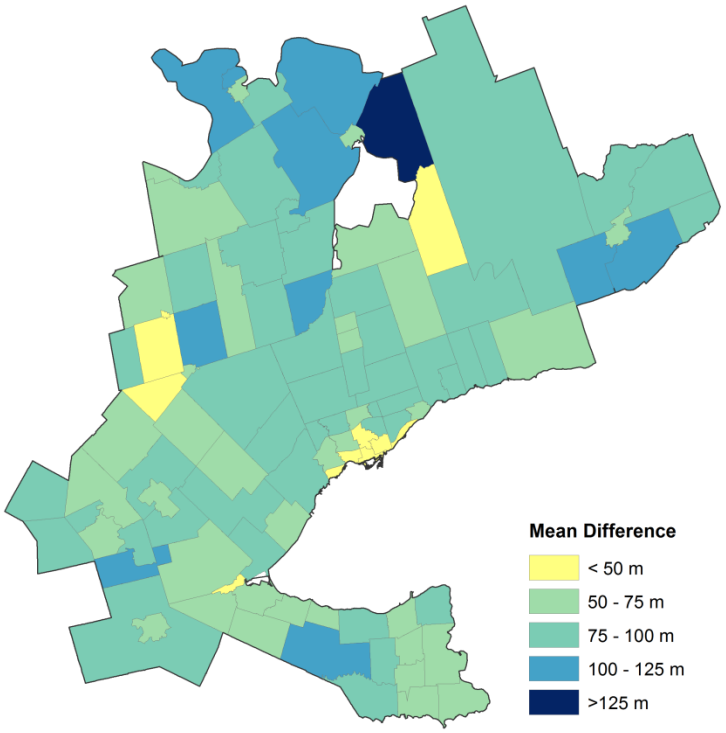

Exhibit 11 - Average Difference in Distance per Planning District for all match types

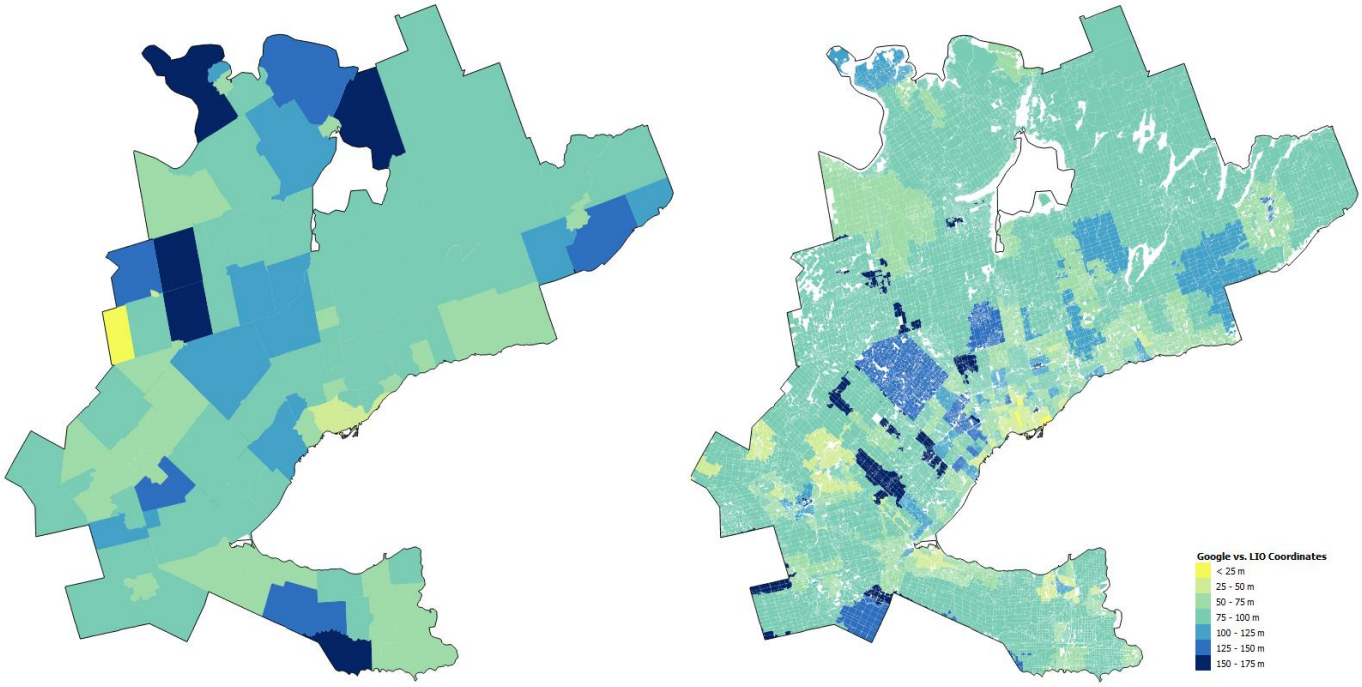

Exhibit 12 - Average Difference in Distance per Planning District and per FSA – Textual Matches Only

Exhibit 13 - Concordance by Municipality / Planning District

Region	Municipality / Planning District	Total number of cases matching to LIO segments	Distance Concordance			Traffic Zone Concordance % within same traffic zone
			<=25	<=100	<=200	
Barrie	Barrie	4,570	29%	74%	93%	97%
Brant	Brant	1,184	34%	72%	85%	98%
Brantford	Brantford	3,051	34%	80%	95%	96%
Kawartha Lakes	Kawartha Lakes	2,016	29%	70%	92%	98%
Dufferin	Amaranth	90	57%	81%	93%	**87%**
Dufferin	East Garafraxa	65	54%	95%	95%	**88%**
Dufferin	East Luther Grand Valley	23	48%	70%	91%	100%
Dufferin	Melancthon	50	50%	90%	90%	90%
Dufferin	Mono Township	212	26%	71%	79%	94%
Dufferin	Mulmur	54	48%	61%	76%	96%
Dufferin	Shelburne	84	56%	90%	96%	99%
Durham	Ajax	2,663	26%	74%	91%	97%
Durham	Brock	240	71%	88%	93%	**88%**
Durham	Clarington	2,080	39%	82%	95%	96%
Durham	Oshawa	4,403	35%	73%	90%	99%
Durham	Pickering	2,441	25%	71%	91%	97%
Durham	Scugog	707	32%	75%	91%	93%
Durham	Uxbridge	664	41%	76%	90%	95%

Region	Municipality / Planning District	Total number of cases matching to LIO segments	Distance Concordance			Traffic Zone Concordance % within same traffic zone
			<=25	<=100	<=200	
Durham	Whitby	3,856	27%	71%	91%	98%
Guelph	Guelph City	5,990	31%	78%	94%	92%
Halton	Burlington	7,572	26%	71%	88%	96%
Halton	Halton Hills	1,942	36%	75%	91%	96%
Halton	Milton	3,054	30%	69%	89%	96%
Halton	Oakville	7,536	30%	76%	94%	97%
Hamilton	Ancaster	1,264	28%	76%	96%	94%
Hamilton	Dundas	747	47%	89%	95%	93%
Hamilton	Flamborough	1,590	38%	76%	91%	90%
Hamilton	Glanbrook	767	48%	82%	95%	94%
Hamilton	Hamilton	7,843	41%	84%	95%	95%
Hamilton	Stoney Creek	1,623	42%	86%	96%	93%
Niagara	Fort Erie	866	35%	82%	96%	98%
Niagara	Grimsby	971	27%	76%	92%	99%
Niagara	Lincoln	826	32%	77%	90%	98%
Niagara	Niagara Falls	2,666	29%	81%	94%	97%
Niagara	Niagara-on-the-Lake	900	36%	78%	88%	97%
Niagara	Pelham	596	25%	72%	89%	92%
Niagara	Port Colbourne	493	37%	87%	94%	92%
Niagara	St. Catharines	5,118	38%	80%	92%	96%
Niagara	Thorold	577	44%	82%	92%	95%
Niagara	Wainfleet	93	49%	76%	83%	100%
Niagara	Welland	1,705	37%	80%	92%	94%
Niagara	West Lincoln	322	33%	71%	81%	94%
Orangeville	Orangeville	941	32%	76%	93%	97%
Orillia	Orillia	1,455	38%	80%	94%	98%
Peel	Brampton	10,396	27%	72%	92%	94%
Peel	Caledon	1,549	28%	67%	85%	93%
Peel	Mississauga	23,956	22%	67%	88%	94%
Peterborough	Peterborough City	3,122	33%	80%	95%	93%
Peterborough Cty	Asphodel-Norwood	66	33%	79%	86%	100%
Peterborough Cty	Cavan-Monaghan	284	30%	71%	83%	93%
Peterborough Cty	Dummer-Douro	173	28%	69%	94%	96%
Peterborough Cty	Selwyn	543	29%	79%	91%	99%
Peterborough Cty	Otonabee-S. Monaghan	212	31%	67%	82%	94%
Simcoe	Adjala-Tosorontio	207	56%	79%	91%	98%
Simcoe	Bradford W. Gwillimbury	646	35%	68%	81%	93%
Simcoe	Clearview	298	54%	85%	90%	97%
Simcoe	Collingwood	880	30%	78%	97%	96%
Simcoe	Essa	357	45%	77%	91%	96%
Simcoe	Innisfil	765	35%	73%	90%	96%
Simcoe	Midland	771	42%	74%	96%	98%

Region	Municipality / Planning District	Total number of cases matching to LIO segments	Distance Concordance			Traffic Zone Concordance % within same traffic zone
			<=25	<=100	<=200	
Simcoe	New Tecumseth	871	35%	71%	83%	94%
Simcoe	Oro-Medonte	587	25%	66%	84%	97%
Simcoe	Penetangushene	276	35%	79%	89%	99%
Simcoe	Ramara	220	24%	66%	76%	100%
Simcoe	Severn	312	26%	57%	76%	95%
Simcoe	Springwater	249	35%	76%	88%	96%
Simcoe	Tay	180	34%	76%	88%	99%
Simcoe	Tiny	225	28%	69%	79%	99%
Simcoe	Wasaga Beach	559	30%	73%	93%	97%
Toronto	PD 1 of Toronto	27,442	42%	93%	99%	93%
Toronto	PD 10 of Toronto	3,338	22%	67%	90%	**87%**
Toronto	PD 11 of Toronto	7,038	27%	83%	96%	93%
Toronto	PD 12 of Toronto	3,230	23%	72%	94%	97%
Toronto	PD 13 of Toronto	6,411	27%	73%	92%	95%
Toronto	PD 14 of Toronto	1,577	45%	90%	97%	95%
Toronto	PD 15 of Toronto	1,716	34%	79%	93%	96%
Toronto	PD 16 of Toronto	6,202	23%	72%	93%	94%
Toronto	PD 2 of Toronto	7,647	63%	94%	99%	97%
Toronto	PD 3 of Toronto	5,399	46%	85%	95%	91%
Toronto	PD 4 of Toronto	10,125	48%	88%	95%	95%
Toronto	PD 5 of Toronto	4,683	21%	78%	93%	96%
Toronto	PD 6 of Toronto	7,613	65%	95%	99%	97%
Toronto	PD 7 of Toronto	2,230	43%	87%	98%	94%
Toronto	PD 8 of Toronto	7,209	32%	77%	93%	95%
Toronto	PD 9 of Toronto	2,308	20%	69%	87%	96%
Waterloo	Cambridge	4,512	30%	72%	87%	93%
Waterloo	Kitchener	9,017	30%	77%	94%	93%
Waterloo	North Dumfries	338	22%	62%	85%	92%
Waterloo	Waterloo	5,779	24%	74%	94%	91%
Waterloo	Wellesley	259	35%	73%	88%	98%
Waterloo	Wilmot	627	30%	77%	92%	93%
Waterloo	Woolwich	1,069	35%	80%	93%	97%
Wellington	Centre Wellington	937	36%	76%	92%	95%
Wellington	Erin	373	50%	82%	95%	91%
Wellington	Guelph/Eramosa	570	39%	71%	92%	**78%**
Wellington	Puslinch	277	47%	73%	85%	**84%**
York	Aurora	1,943	30%	76%	94%	95%
York	East Gwillimbury	722	28%	69%	89%	95%
York	Georgina	904	33%	78%	93%	94%
York	King	659	24%	69%	85%	94%
York	Markham	13,344	29%	72%	92%	95%
York	Newmarket	2,839	30%	76%	94%	93%

Region	Municipality / Planning District	Total number of cases matching to LIO segments	Distance Concordance			Traffic Zone Concordance % within same traffic zone
			<=25	<=100	<=200	
York	Richmond Hill	6,607	24%	69%	91%	94%
York	Vaughan	9,225	28%	73%	92%	94%
York	Whitchurch-Stouffville	1,276	30%	76%	90%	97%

5 Recommendations

Based on the high degree of concordance between Google-based coordinates and corresponding LIO-based coordinates, Malatest recommends the use the Google coordinates from online surveys completed via CallWeb 'as-is' in the final data file along with the LIO-derived coordinates from DDE. We do not recommend further post-processing of either the CallWeb or DDE data.

There does not appear to be a need to translate the Google coordinates to LIO-based coordinates or apply systemic corrections. In fact, in many cases the Google coordinates are more precise than those derived via the LIO-based interpolation method. Google appears to have more street segments with civic number information, often has rooftop-precision coding, and allows user interaction with maps to refine locations.

Similarly, the high degree of concordance both in terms of the proximity of the coordinates determined by each method and in terms of traffic analysis zone coding suggests that it is not necessary to translate locations that were captured in DDE and assigned coordinates via the LIO interpolation method into Google-based coordinates to improve their accuracy.

The occasional differences between Google- and LIO-based coordinates do not appear to be widespread enough to have a major impact on most forms of data analysis. It may be noted that some differences might be apparent in the case of microanalysis that look at specific areas containing university campuses or industrial sites – nevertheless, it appears that in most cases the Google-based coordinates are more precise representations of where people travelled.