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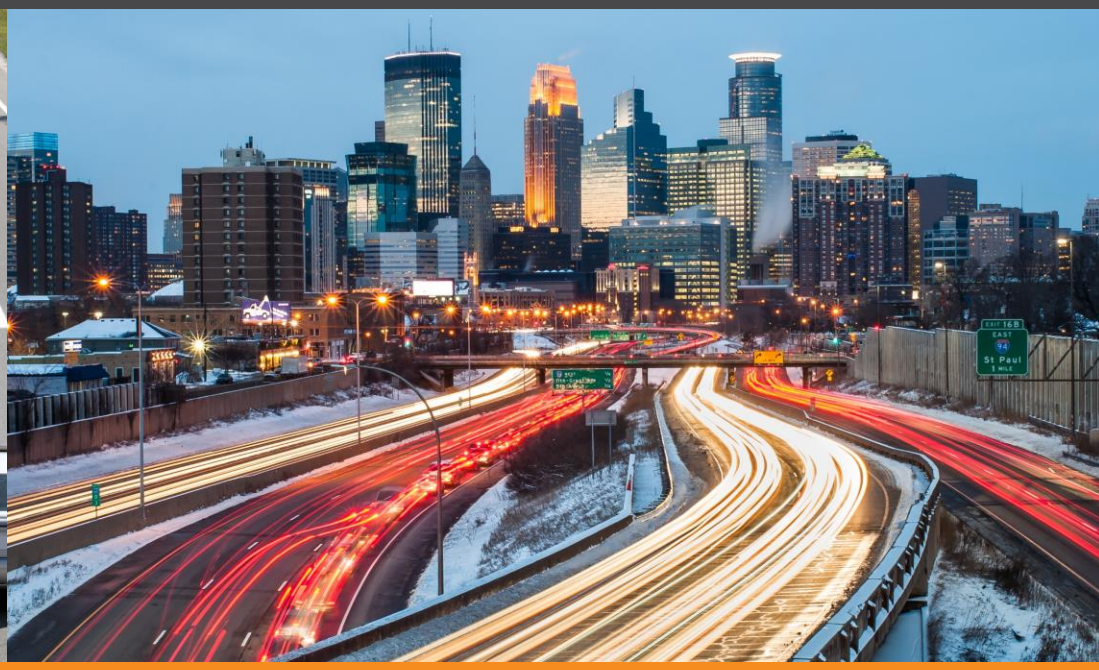
2021 TBI QA/QC PLAN

Task 3 | May 18, 2021



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1.0 INTRODUCTION

In 2018, the Travel Behavior Inventory (TBI) transitioned to a recurrent household travel survey (HTS) design collecting data every other year. This recurrent design introduced efficiencies and operational improvements for data collection in the Twin Cities metropolitan region helping the Metropolitan Council ("the Council") to have more current, detailed data for use in their travel modelling and planning practices. After each wave of data collection, the project team will analyze the results and evaluate the methodology to identify aspects of the study that can be improved upon in the subsequent wave of data collection. The project team will then decide where revisions should be made given the Council's priorities while working within the program's constraints (e.g., budget, scope, schedule). Each wave will leverage previous work and industry best-practices.

In a recurrent HTS program, a philosophy of transparency in design, data preparation, scripting, and quality control is essential to ensure the Council can modify future waves—regardless of approach or selected consultant. This philosophy of transparency will be coupled with an adherence to quality assurance and quality control (QA/QC) protocols throughout the entire project. We note the inherent close relationship between good project planning and management and effective, steady quality control. Moreover, it is RSG's experience that outlining QA/QC protocols in the quality control plan itself is only the first step, the implementation of the plan at every step of the project is the key to success. Protocols for the 2021 TBI QA/QC plan are organized in the following categories:

- Study design protocols
- Sampling and response protocols
- Data collection protocols
- Risk assessment
- Dataset preparation procedures
- Expansion and weighting procedures

2.0 TBI QUALITY ASSURANCE & CONTROL

2.1 STUDY DESIGN PROTOCOLS

Survey Instrument Design

A smartphone-based GPS travel survey app will be the primary means of data collection for the 2021 Wave 2 TBI. However, the survey will maintain mixed mode participation options with the opportunity to participate via a smartphone travel survey app, an online survey, and/or a call center. This methodology is efficient, cost-effective, less burdensome on survey respondents, and yields a robust dataset ideal for model updates and transportation planning. Even though over 85% of US adults are smartphone owners[1], smartphone ownership is not yet universal. Near-term, it is important to continue offering online and call center response options to reduce survey bias, with most adults providing travel data via a smartphone app and the remaining share of participants providing their responses through traditional online or call center methods. RSG has designed, developed, and optimized integrated HTS platforms, rMove™ and rMove for Web™, that streamline the participant experience in a mixed mode HTS while collecting the highest quality data. These survey instruments will be utilized for Wave 2 of the TBI program.

rMove

RSG's proprietary smartphone travel survey app, rMove, passively collects users' trips while they go about their daily life. Users are prompted to answer daily surveys about their travel habits as well as trip surveys after each trip they make resulting in far more accurate trip rates and trip information. Due to the lower overall burden of passive trip collection, rMove users are willing to participate for multiple days at a time increasing the "effective sample size" of a study by providing more travel days, more trip data, and insight into day-to-day travel variability (e.g., commuting and telework patterns). RSG continually improves rMove in each new version of the app with structured, regular software development periods, testing cycles, and bug reporting. Each new version aims to improve data quality, battery life, and user experience in rMove. rMove is available in the Google Play (Android) and iOS (Apple) app stores and it runs natively on Apple iOS (version 13.0 or later) and Android (5.1 or later) operating systems.

rMove for Web

RSG's proprietary survey technology, rMove for Web, serves as the online equivalent to rMove. Call center interviewers also use rMove for Web to collect responses over the telephone to ensure consistent real-time data validation and dataset quality. RSG created rMove for Web to ensure survey alignment regardless of participation mode. By using integrated survey platforms (rMove and rMove for Web) survey responses from all three participation modes (smartphone, online, call center) undergo identical logic, validation, and real-time checks. Survey responses are stored in a single database to ensure that data collected are consistent regardless of participation mode.

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[1] According to the Pew Research Center's mobile fact sheet which was last updated in April 2021. https://www.pewresearch.org/internet/fact-sheet/mobile/

Survey Participation

Households participating by smartphone will be asked to complete a seven-day travel diary in rMove and those participating online or by call center will complete a one-day travel diary on a Tuesday, Wednesday, or Thursday. Travel data will be collected for all household members, regardless of age or participation method. Many children typically accompany adult household members on trips and thus that data is already reported by the adult participant (i.e., each trip survey asks which household members are on a given trip). For a single weekday, one adult household member will also be asked to report the trips any members under age 18 make without an adult present (e.g., child walked home from soccer practice with friends), as well as provide summary level data for the day (e.g., if the child went to school). This approach ensures a complete single day diary for all household members (including children) across all participation methods without overly burdening the reporting adult.

2.2 SAMPLING AND RESPONSE PROTOCOLS

The sample planning methodologies employed in the TBI will include a combination of industry best practices and innovative sampling methods aimed at mitigating survey bias and meeting study targets. Sampling methods have evolved in recent years to address the decline in survey response rates observed nationally, to decrease survey costs, and to increase participation from historically underrepresented groups.

Sampling and Response Frameworks

There is a great deal of publicly available information that documents the challenges of participation for historically underrepresented populations (e.g., low- income households, people who are recent immigrants, new Americans, and People of Color). The higher costs for obtaining this participation have also been well documented (i.e., by the Census Bureau). Throughout each stage of a HTS, there are methods that can be applied and actions that can be taken to address the representativeness of a survey within its timeline and budget. RSG will employ both our experience and industry research when tackling these challenges. We primarily use two frameworks in our approach to obtaining a representative sample including the total survey error (TSE) framework and the hard-to-survey framework.

Total survey error framework

The TSE framework is defined as the set or combination of errors that can occur in a survey[2]. The TSE framework identifies five primary types of errors that survey researchers should account for including coverage error, sampling error, nonresponse error, measurement error, and processing error. We consider each of these in survey design:

- **Coverage error** – Coverage error occurs when members of a population of interest are not included in the sampling frame – the list from which the survey sample is selected. We have proposed an address-based sampling (ABS) methodology selecting households from the U.S. postal service list of all household addresses. Therefore, we largely avoid

[2] Total Survey Error framework definition: https://link.springer.com/referenceworkentry/10.1007%2F978-94-007-0753-5_3034

coverage error for a HTS by using this sampling method. For instance, the segment of the population noted in this question will be included in our proposed sampling frame because the majority of our sample will be a probability sample randomly invited via ABS.

- **Sampling error** – Sampling error is the error caused by surveying a sample of a population instead of the whole population, as that sample will always vary in some way from the characteristics of the entire population. The primary survey stage where we aim to address and reduce sampling error is during sample planning. We also adjust for sampling error during weighting.
- **Nonresponse error** – Nonresponse error occurs when survey respondents are somehow systematically different than those who were not invited or did not respond to the survey. We address nonresponse error at each stage of an HTS during sample planning, survey instrument design, public outreach, data processing, and weighting. In sum, we invite more households from groups who historically have responded at lower rates to increase their share in the sample. We then design our surveys to provide multiple modes of participation reducing barriers to participation. During survey administration, we employ public outreach to further supplement our ABS and boost response from underrepresented groups. Finally, during data processing and weighting we correct for nonresponse bias in the final dataset.
- **Measurement error** – Measurement error occurs in HTS when the survey instrument or questionnaire affects the recorded value, often resulting from poor instrument or questionnaire design. RSG has collaboratively developed and refined our survey instruments as well as an industry-standard questionnaire with our clients over the course of many HTS projects. Over time, RSG has honed each of these to decrease measurement errors to the extent possible.
- **Processing error** – Processing errors arise during data cleaning, processing, and weighting. We address this by employing a highly experienced team that employs stringent QA/QC practices throughout each of these survey stages.

We aim to reduce TSE at each stage of an HTS by employing survey best-practices and implementing new creative solutions based on project constraints (e.g., timeline, budget).

Hard-to-survey framework

Some segments of the population face particular challenges that make them harder to survey than the other segments. We use the hard-to-survey framework[3] to identify the sources of those challenges or difficulties in survey participation and what survey operation they affect. Hard-to-survey populations can be classified into the following subcategories based on survey operation including:

- Hard to sample
- Hard to identify
- Hard to find or contact
- Hard to persuade to take part
- Hard to interview

[3] Hard-to-survey framework definition: https://doi.org/10.1017/CBO9781139381635.003

Identifying the survey operation that a hard-to-survey population impacts enables us to take more targeted actions to address their participation challenges. For instance, if a segment is hard to persuade to take part, we may target our invitation messaging to their concern and/or target our outreach efforts to that segment to increase their recruitment rate. The hard-to-survey framework provides a method of directly addressing sampling and nonresponse errors for specific population segments.

Addressing representation in the TBI

The 2018-2019 TBI underrepresented Black, Indigenous, and People of Color (BIPOC) residents, Hispanic residents, recent immigrants, New Americans, and to a lesser degree low-income households in the region. These segments of the population fit within the hard-to-survey framework as hard to persuade to take part because they may be untrusting of government/public institutions and/or may face more barriers to participating in the survey (e.g., less time in their day to use for completing the survey, limited English proficiency). To better represent these segments of the population, we must aim to reduce survey nonresponse bias (when invited residents do not respond to our invitation to complete the survey).

It is generally considered that nonresponse has increased in recent decades, with more attention to it in recent years. RSG utilizes the Census Bureau's American Community Survey data and other available data to measure this bias. During the sample planning stage of the project, RSG will work with the Council to determine sampling priorities. We will prioritize how the survey should address nonresponse from a number of hard-to-survey segments given the study's timeline and budget. There are of course always tradeoffs during this stage, and we will discuss those with the Council to identify the best sampling plan for the region.

In addition to addressing nonresponse through survey sampling, we can also address this error through public outreach efforts. Knowing that this segment is hard to persuade to take part in the survey, aids the development of our outreach messaging and influences the types of outreach we employ (i.e., purchasing an advertisement in a local paper versus working with a local community center). To improve representation in the final survey sample, RSG recommends a multi-pronged approach:

- Provide the survey instrument in English, Hmong, Karen, Oromo, Somali, and Spanish.
- Perform compensatory and targeted oversampling.
- Implement a targeted outreach campaign partnering with community-based organizations (CBOs) that are primarily composed of underrepresented populations.

A multi-pronged approach will be more effective than any measure on its own. There will always be tradeoffs when determining how to best utilize the outreach budget, and the project team will discuss these to identify the best outreach plan based on the Council's priorities and data needs.

The sampling and response challenges we face are continually evolving and are unique to each survey region. However, COVID-19 and the political climate have rapidly and universally impacted survey research in both positive and negative ways. These external factors are forcing survey researchers to find new and creative solutions to conduct successful surveys, but these

factors have also led to greater uncertainty on survey response. It is rare for any HTS to have infinite resources. Therefore, we must reduce TSE as best possible within the timeline, budget, and unique regional needs of each survey program. That will be true for this project as well underpinning the importance of transparent communication with the project team throughout each stage of the survey effort.

In the sample plan for Wave 2, RSG and the Council will determine how often sample should be ordered during the data collection period. RSG recommends ordering sample addresses two to four times for Wave 2 of data collection. The Council and RSG should finalize the sample reorder plan when the data collection period/timeline is finalized. Real-time transparency during data collection will also allow for close tracking of progress toward sample targets and help to identify problems and correct them early and rapidly. For example, ordering sample in stages will allow the study team to adjust sampling rates during data collection to best meet sample targets.

2.3 DATA COLLECTION PROTOCOLS

Participant Engagement and Communication

Communications with participants are guided by data privacy and security protocols, by behavioral science “nudging” best practices, and by the belief that daily, frequently repeated tasks should be automated as much as possible to reduce error and ensure timeliness. Outbound communication to households sampled through ABS will be initiated by mailed invitations and all participating households’ invitations will be complemented by reminders via email, telephone, and/or within the smartphone app itself. Reminder emails are thoughtfully scheduled throughout the survey period with the intent of maximizing response. Inbound communication from participants is typically incentive-related questions and/or requests for technical help. Project staff respond to the participant inquiries within one business day.

Survey Monitoring and QA/QC

During survey fielding, RSG will continuously monitor the survey database and perform regular QA/QC. Below are response monitoring tools that RSG will provide to the Council:

- Provision of a real-time online dashboard that provides the Council with results such as response rates, progress toward quotas, or comparison to control data (such as ACS) in real-time. This dashboard can include a set of custom analyses based on the Council’s needs and requests.
- Provision of the final survey response forecast during project calls throughout survey fielding.

Survey Completion Criteria

A household record will be considered complete and will be included in the data deliverable when it meets the following conditions:

- The household completed the signup survey by answering all required questions.

- All household members completed at least one concurrent 24-hour travel diary regardless of survey participation mode (smartphone, online, or call center).

For smartphone participants that complete at least one, but not all seven days – data from partially complete days (i.e., some, but not all, household members completed their surveys on a given day) will also be delivered and will be flagged as incomplete.

2.4 RISK ASSESSMENT

Risk management is a key component to the success of any project. RSG and the Council should identify and evaluate the risks at the start of each study wave and update the QA/QC plan for that year with expected risks and proposed mitigation strategies. RSG has found that conservative planning and identifying contingency plans for foreseeable challenges early on can help in achieving project success. While prompt communication and pragmatic innovative methods can help in overcoming unforeseeable challenges. Our philosophy when facing challenges in survey administration is prompt and frequent communication with our clients. RSG discussed potential risks for the 2021 Wave 2 TBI with the Council at the kickoff for Wave 2 and will continue this conversation throughout the project lifecycle.

Risks due to COVID-19

Since early 2020, RSG has actively been working with the Council to address and overcome the challenges COVID-19 has presented for their data collection efforts. Prior to the COVID-19 outbreak, travel behavior was changing rapidly due to many factors in the transportation industry such as: new modes (e.g., ride-hailing (Uber, Lyft), scooter share, bikeshare); trip substitution or shifting due to eCommerce (e.g., goods delivery, food/meal delivery, Amazon lockers); new types of vehicles (EVs); and the early, evolving stages of vehicle automation. Undoubtedly, these behaviors were evolving in different ways across demographics such as income, race/ethnicity, and age. Now, the COVID-19 outbreak has introduced further catalysts for change in travel behavior and the “new normal” is not yet fully understood or realized. Similarly, ABS response rates for surveys have been negatively impacted by COVID-19 and delays in United States Postal Service (USPS) mail delivery during COVID-19 outbreak have introduced greater uncertainty for survey researchers. RSG has quickly adapted our methods and survey designs to help the Council collect data to prepare for and understand these forthcoming trends to the extent possible.

Typical HTS Risks

In addition to addressing the heightened risk that COVID-19 has imparted on the survey data collection, RSG will also help the Council address typical HTS risks which include:

- **External factors** that influence response such as political perceptions or elections, and increased barriers to participation for hard-to-survey populations; or factors that disrupt typical travel patterns such as natural disasters (or even a major snowstorm). These external factors have the potential to negatively impact study outcomes and thus the approach is to start with conservative estimates on response.

- **Technology related risks** that can affect survey protocols, data security or instruments. RSG has worked to minimize technological risks to the extent possible by adhering to General Data Protection Regulation (GDPR)[4] standards and employing the Microsoft Azure cloud-based platform that provides enterprise-grade data storage, security, management services, and continuous uptime. Similarly, all data are encrypted when passing between the smartphone and servers. Notably RSG has also carefully reviewed the specific Minnesota and Wisconsin data privacy requirements to have a process in place in the event study participants request deletion of their data, etc.
- **Participant response rates** that could lead to the study being notably over or under target. RSG closely monitors response during study fielding and to the extent possible aims to forecast final response rates for the study to ensure positive study outcomes. If it appears that response is under target, additional outreach measures can be taken, participant reminders (both electronic, printed, or by telephone) can be edited or increased, and the number of mailed invitations can be increased. If it appears that response is over target, the number of mailed invitations be dialed back, participant reminders can be removed, or survey outreach could be decreased.
- **In-flight design and planning changes** can be a risk to both study budget and quality. Examples of these risks include delays do to re-work of deliverables if households are removed from the dataset after weighting has occurred, delays to launching surveys if edits are made to mailings too close to printing dates or breaks in survey logic resulting in last minute changes after testing. To mitigate these risks, RSG employees rigorous project management to ensure necessary required lead-times are planned for, and also employs a philosophy of repeatability to minimize risk of errors in any re-work by creating a data audit trail through scripting and automating our data processing and weighting work. All data processing and weighting procedures are also carefully documented and will be provided to the Council upon delivery of final datasets in the dataset guide and weighting memo.

2.5 DATASET PREPARATION PROCEDURES

Once survey fielding has concluded, RSG will begin cleaning, processing, and performing initial descriptive analysis of the dataset. RSG performs a combination of human-driven and automated tool-driven data cleaning processes to provide a high-quality dataset that has been through rigorous QA/QC. Our methods leverage data science and software engineering best practices, as well as a blended utilization of survey and passive data QA/QC techniques. Our data processing philosophy is transparency with the project team combined with scripted repeatability.

[4] The General Data Protection Regulation 2016/679 is a regulation in EU law on data protection and privacy in the European Union and the European Economic Area. More information can be found here: https://gdpr.eu/

Smartphone Data Cleaning

While data cleaning and QA/QC is necessary for online, call center, and smartphone survey data, RSG takes extra steps to rigorously clean and review our smartphone GPS data with the goal of providing a user-friendly dataset. RSG overlays the smartphone trip path data collected onto maps to ensure the trip segments, paths, and times all appear to be correct. RSG has developed proprietary machine-learning algorithms to assist in this process, helping to identify the trips most likely to require splitting into two trips (e.g., passenger drop-offs with a short stop period), merging with adjacent trips (e.g., trip split at long light in traffic), cleaning (e.g., spurious location jumps from urban canyon effect), or dropping from the dataset (e.g., spurious trips resulting from movement in a building). Our analysts carefully review many of the actions recommended by our algorithms to add a secondary level of quality control to the process.

Dataset Imputation

As part of the dataset cleaning process, RSG imputes a number of data variables including departure time, trip purpose, mode, and travel party size. The purpose of these imputations is two-fold. First, the imputed data can serve as a consistency check against what the respondent reported for this trip to reduce respondents' errors. This takes full advantage of the data collected from the smartphone (e.g., the trip traces) to improve the overall quality of the data. Second, the imputed data improves the number of records that can be used in analysis and modeling by increasing the number of records with complete data. For more technical details on variable imputation, see the Wave 1 Technical Methodology report.

Unweighted Data Deliverable Review

RSG will deliver the unweighted, cleaned, and processed dataset to the Council for review. The Council will then have one month to review the data, ask questions, and request updates prior to delivery of the final weighted and expanded dataset.

2.6 EXPANSION AND WEIGHTING PROCEDURES

Once, the survey dataset has been processed and thoroughly reviewed, RSG will begin the weighting process. RSG will weight the dataset using innovative-yet-proven methods that have been used in other regions as part of RSG's industry-leading work on smartphone-based HTS projects. We continue to incorporate our research and client feedback, along with repeatable scripts on our projects to tackle new approaches for weighting across seven days of data.

Weighting the survey data to represent the broader population is important for descriptive analyses and for providing model calibration targets. The weighting methodology applied will adjust for survey non-response, survey participation mode (smartphone, online, call center), as well as geographic bias due to oversampling and other factors. In addition, trip rates will be adjusted between the three participation methods offered for the survey. Data collected through convenience (non-probability) sampling will be compared with those data collected through ABS (probability) to identify and correct for any bias. RSG will discuss the overall weighting approach with the Council and obtain approval before beginning the weighting process. RSG's weighting process for mixed mode HTS data includes four primary steps:

1. **Initial Expansion**: Calculating an 'initial weight' based on the probability of selection. This essentially 'reverses' the sample plan, providing higher initial weights to areas where less sampling occurred.
2. **Reweighting to account for non-response bias**: Performing an iterative proportional fit (IPF) routine to several key household and person dimensions to ensure the weighted data accurately represent the entire survey region (and reduce sampling biases).
3. **Creating day-level weights to account for multi-day survey data:** Adjusting the day-level and trip-level data to account for the fact that smartphone respondents provided multi-day travel diaries, while online and call center respondents provided a single day travel diary (this is the "multi-day adjustment"). These relatively simple adjustments ensure that travel analyses accurately reflect the entire survey region and do not over-represent smartphone respondents with multiple travel days.
4. **Adjusting for non-response bias in day pattern and trip rates**: Adjusting the trip-level weights by participation mode to account for reporting biases. These adjustments help make the day and trip-level data more consistent and increase the accuracy of trip rates across survey participation methods.

Overall, the goal of the weighting process is to make the survey sample representative of the survey region across a number of key dimensions (e.g., age, income) related to travel behavior. RSG will discuss the variables (and combinations of variables) that will be used as targets in the weighting process with the Council prior to beginning the process. The team will agree on a list of variables that will be reliable targets (while also avoiding extreme weights). After determining the weighting variables, the marginal distributions will be based on the most recent ACS data.

Weighted Data Deliverable Review

RSG will deliver the final weighted dataset to the Council for review. The Council will then have one month to review the dataset, ask questions, and request updates. RSG will provide the Council with the weighting scripts as part of the final weighted data deliverable, so that the Council has the ability to re-weight the dataset at any point in the future (e.g., a few households are pulled out of the dataset at a later date).

2.7 CONSIDERATIONS FOR A RECURRENT DATA COLLECTION PROGRAM

In recent years, the transportation industry has, and is, embracing software best practices. RSG is no exception. We believe that quality and quality-control are closely related to software and data science best practices such as ensuring that all work is scripted, scalable, repeatable, and reproducible. For example, we actively use GitHub in-house to maintain and update scripts over the course of a project. This is closely related to quality because of the efficiency and ability to reproduce results over the course of a recurrent study program.

RSG's experience is that the quality assurance and control plan itself is only the first step, the implementation of the plan at every step of the project is the real key to success. Therefore, we note that it can be challenging for the QA/QC plan to be fully written and implemented in

advance of later tasks such as Task 6: Survey Management Plan and Task 7: Survey Administration. We acknowledge that elements will change and evolve over time. Incremental updates are essential to adhere to industry best practices and ensure the continued success of the TBI. We will continue to document the evolution of this plan over the course of the project and ensure any such changes are recorded and shared with final documentation.

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