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Canadian Guidelines for the Measurement of Transportation Demand Management Initiatives

User's Guide

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Canada

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1. INTRODUCTION

This is the *User's Guide* for *the Canadian Guidelines for the Measurement of Transportation Demand Management Initiatives*. These guidelines are based on an examination of international best practices and consultation with Canadian TDM Stakeholder organizations. Supporting information can be found in the *Guidelines for the Measurement of the Impact of Transportation Demand Management Initiatives – Technical Report*, which is available separately.

1.1 About TDM

Transportation demand management (TDM) policies and programs influence the demand for travel in the private automobile in three ways: by shifting private automobile use to other modes, dispersing travel from times of peak demand, or eliminating travel all together.

There are two main categories of TDM initiatives:

1. Education, promotion, and outreach that change personal attitudes and awareness:
    a) Branding and positioning (shape perceptions and remove biases against more sustainable choices)
    b) Information and education (enhance understanding of different travel choices)
    c) Targeted marketing (e.g. individualized marketing programs)
    d) Special events (e.g. commuter challenges, transportation fairs, bike-to work weeks, or two-for-one transit fare days)
    e) Recognition and rewards (encourage use of alternative modes through rewards for participation or behaviour changes)

2. Travel incentives and disincentives that make a travel option more attractive (i.e. easier, faster, less expensive or more attractive):
    a) Ridematching
    b) Guaranteed ride home programs
    c) Traveller information services
    d) Road or motor vehicle use pricing (e.g. parking levies, road tolls, mileage-based auto registration fees, pay-as-you-go auto insurance)
    e) Transit pricing (e.g. discounted monthly passes, time-based transfers, free transit in downtown core)
    f) Workplace-based (e.g. payroll-deduction transit passes, preferential carpool parking, flexible working hours, telework)
    g) School-based (e.g. universal transit passes for post-secondary students, school travel plans, active and safe routes to school programs, walking school buses)
    h) Site specific TDM supportive facilities (e.g. preferential car pool parking, bicycle parking, trip end facilities, enhanced transit shelters at a workplace, signage, information kiosks)

A TDM program may include any number of initiatives that are targeted at specific traveller groups, geographic areas, or types of travel behaviour.

1.2 About Measurement

This document provides guidelines for measuring the impact of individual or collective TDM initiatives. This measurement can be expensive and time-consuming. While organizations may question the benefits of measurement in view of the cost and effort, those benefits are very real. Effective measurement enables organizations to:

- Prepare a business case for securing funding
- Evaluate progress toward goals
- Explain the benefit of investment
- Improve the design of new or expanded programs

- Develop forecasting and business case techniques
- Remain accountable to the public, elected officials and funding agencies
- Benchmark results against programs in other areas

One challenge in measuring the effect of TDM initiatives is that impacts are not always readily tangible values like cost, time or distance (although it is always preferable to strive for tangible impact measurements). Another is that the cause-and-effect relationship between an initiative and the resulting change in travel behaviour may be complicated by a number of other factors. For example, TDM initiatives that build awareness of travel options are important – but they impact personal attitudes (which are difficult to measure) and compete with many other factors that shape how individuals think (such as economic or environmental crises).

Many organizations are interested in measuring the ability of TDM to reduce the emission of greenhouse gases (GHG) and Criteria Air Contaminants (CAC) from transportation. However, emissions are linked to fuel consumption and must be estimated rather than directly measured. This estimation process involves extrapolation based on intermediary TDM impacts that can be measured more directly, such as the number of people travelling by car or transit, or the total number of vehicle-kilometres travelled (VKT), which is a measure of vehicle activity.

1.3 About These Guidelines

1.3.1 Purpose

These guidelines will help organizations that are conducting TDM initiatives to measure the impacts of those initiatives and, over time, effectively evaluate progress toward established goals. They address a variety of topics including *indicators* (what should be measured), *variables* (the types of data upon which indicators are based), *data collection methods* (how to measure the indicators), and *calculations* (mathematical processes). The guidelines are applicable to a range of TDM initiatives, application contexts, and organizational capacities. They offer a step-by-step framework that encourages the consistent application of core principles, but in a manner that is flexible rather than prescriptive: in other words, it is not possible to identify specific data requirements for each and every initiative in each and every application. Rather, the guidelines provide the practitioner with the information from which to choose the impact measurement technique that suits the specific application, local conditions, target group, etc.

These guidelines are intended for use by municipal authorities, non-governmental organizations or private businesses that are using TDM initiatives to influence travel behaviours. As measurement guidelines, they provide users with a standardized method to realize the benefits of measurement as listed in the previous section. Specifically, their use may help in the following ways:

- To fulfill reporting requirements of funding agencies.
- To develop a measurement strategy for inclusion in a funding application.
- To enable a defensible methodology for reporting to the public or elected officials.
- To enable reporting on progress toward specific goals or targets.
- To maximize the value of test or pilot initiatives in helping to shape the design or business case of a more extensive program.
- To inform policy-making and the design of established programs.
- To develop dependable results that provide a value proposition for engaging the private sector in TDM initiatives.
- To work towards the establishment of a Canadian database of the results of TDM initiatives.

Note that these guidelines do not advise on TDM program design (i.e. the setting of goals or the selection of appropriate TDM initiatives). **Rather, they provide advice on the design and implementation of a measurement strategy.** There may be overlaps and synergies between the information needed for overall program design and the information needed to conduct a measurement strategy; however, they are two distinct and separate processes.

1.4 Organization

The remainder of the *User's Guide* includes the following sections:

- **Section 2** describes the evaluation framework and outlines a step-by-step approach to measurement.
- **Section 3** describes different types of data collection.
- **Section 4** describes the calculation of results for more complex indicators.
- **Section 5 includes a glossary of important terms.**

Two appendices relate directly to the guidelines. **Appendix A** contains a TDM Evaluation Framework planning sheet that should be used to record actions that are required and undertaken at each step; and **Appendix B** provides guidance on sampling for an appropriate level statistical accuracy and precision for surveys.

2. EVALUATION FRAMEWORK

This chapter outlines an evaluation framework for TDM initiatives that begins at the project planning stage. It allows practitioners to define the meaning of success for their program, choose appropriate indicators, conduct an effective data collection program, and evaluate outcomes meaningfully. This framework is based on two best-of-breed European frameworks for TDM impact measurement, namely the European Union's MOST MET[1] program and Sweden's SUMO[2] program. In the absence of any such framework in this country, the Canadian Guideline has adapted these two European frameworks as the basis for Canadian practice.[3], [4]

The evaluation framework guides practitioners to measure the impact of initiatives against the program's goals using carefully chosen indicators. An indicator is the "what" to measure. Indicators are grouped into assessment levels. An assessment level describes the purpose of the assessment.

The process is divided into nine steps, as shown in **Exhibit 1**. Each step in the process is described further in the following sections. The reader also will find several sidebars that provide background information, such as sources and logic, for further reference.

After the evaluation period is complete, the results should be used to refine the TDM program. At this point, the process can be re-started at any of the previous steps, depending on the results and needs of the program.

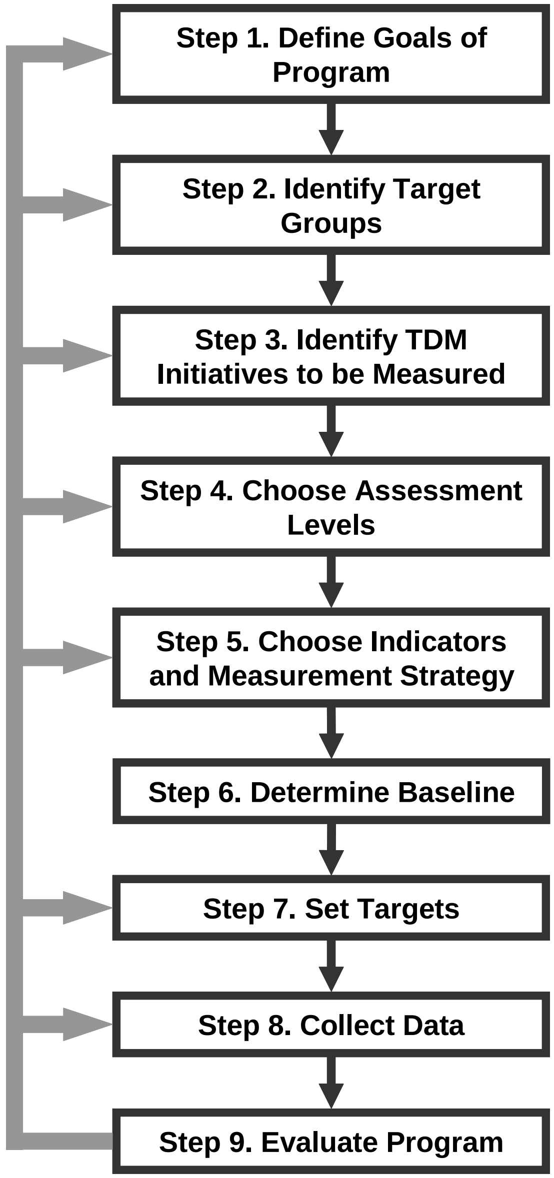
[1] Finke, T. et al (2001). MOST MET: MOST Monitoring and Evaluation Toolkit, MOST Consortium: Aachen, Germany.

[2] Hyllenius, P., Ljungberg, C., Smidfelt Rosqvist, L. (2004) *SUMO: System for Evaluation of Mobility Projects,* trans. Intelligent Energey Europe, Swedish Road Authority: Borlänge

[3] See iTRANS Consulting Inc., *Best Practices Summary,* March 2009.

[4] Note that the European term, "mobility management," has been replaced by its North American equivalent, "TDM."

Exhibit 1: Evaluation Process



2.1 Step 1 – Define Goals of Program

Program goals are normally prescribed by municipal or regional council, the funding body, or the community at large, and should answer the question, "Why are we doing this TDM program?" Not all TDM programs have the same goals – some may aim to reduce congestion, while others try to improve health through more active transportation. Funding agencies may place a priority on reductions in GHG and/or CAC emissions. Regardless, a clear understanding of program goals is critical to designing an effective measurement strategy. Although the definition of goals must reflect local, program-specific considerations, the evaluation framework discussed in the *Technical Report* can help practitioners formulate this definition.

2.2 Step 2 – Identify Target Groups

The target group(s) for a TDM program are those whose behaviour the program is attempting to influence. Initiatives may target a single group or multiple groups, one workplace or an entire business park, a single neighbourhood or an entire community. Some initiatives may target individuals of a certain age. School-based initiatives may target students (e.g. walking school bus), teachers (e.g. employee transit pass program) or both (e.g. bike to school week for students and staff).

In the project planning stages, identifying the target group(s) allows TDM practitioners to design better, more focused programs and to measure results more effectively. It is easier to collect data and calculate impacts for target groups that have clear parameters.

2.3 Step 3 – Identify TDM Initiatives to be Measured

The planning stages of a TDM program will identify one or more TDM initiatives to be delivered. Larger initiatives may, in turn, contain smaller initiatives. From a measurement perspective, initiatives to be evaluated should be identified at a level that is detailed enough to provide an appropriate degree of "resolution" or understanding, while ensuring that excessive detail does not create an unbearable burden of data collection and calculation.

Once a list of TDM initiatives to be measured is in hand, the next step is to identify the expected effects of each initiative on its target group(s). For example, the goal of a workplace TDM program may be to reduce emissions from employee commuting, and the initiative to be measured may be a carpool ridematching service; in this case, the expected effects would be a reduction in the number of employee vehicle trips and an increase in the number of employee carpool trips. The choice of indicator, in other words, is dependent upon the expected outcomes; although – as discussed in **Section 4.3** - 'activity' is a basic and important indicator that is widely applicable.

2.4 Step 4 – Choose Assessment Levels

2.4.1 Types of assessment levels

A TDM initiative can be evaluated on a number of different levels, each of which involves its own indicators and measurements. There are 11 assessment levels presented in **Table 1**. The assessment levels are divided into two overall types: **context assessment** and **performance assessment**.

The Context assessment levels provide a picture of the external factors that may influence the program's results, and also measure Baseline information that will be needed to calculate more complex indicators. There are two context assessment levels:

1. *Level S-System Conditions* addresses the transportation, land use, and policy environment of the TDM initiative – conditions that lie outside the control of the TDM practitioner, but that may impact the effectiveness of the TDM program or skew the measurement results.

2. *Level P-Personal Information* identifies appropriate sub-groups and measurement levels to allow for statistically significant surveys. The choice of sub-groups and measurement levels depends on the data that are gathered when the program is actually implemented. This will be discussed further in **Section 3**. For communities, some of this information may be available from Statistics Canada. *Level P* also provides baseline data for individuals' existing travel patterns, which will be used to calculate changes in behaviour after the program is in place.

Some of the context assessment data will already have been collected as part of the program design. For example, parking supply and price will influence how a workplace TDM program is designed, but will also have implications for program measurement and evaluation if parking conditions change during the project (e.g. if supply is added or prices go up). In another example, existing mode split information may be gathered for program design, but it will also be required as a baseline for the calculation of modal shift results. It is important not to duplicate efforts, but to collect data in enough detail during the program design phase that it can be used later as baseline data.

Performance assessment levels describe the progress of the initiative against the goal. Where context initiatives examined external factors, performance assessment levels examine the impacts of the initiatives themselves. The performance assessment levels are further divided into three groups:

1. **Outputs:** *Level A-Activities Undertaken* and *Level B-Customer Satisfaction* assess the activities and processes of the program itself, rather than its impacts. For example, outputs might include the number of events organized or brochures distributed. Measuring outputs allows us to compare programs based on different levels of effort, such as examining whether placing twice the number of advertisements for an event will yield twice the number of participants. Of course, these relationships cannot be analyzed without the sufficient baseline information: there are always "other factors" at play.
2. **Outcomes:** *Level C-Awareness* through *Level H-System Impact* are used to assess program effects on the target group(s), transportation network, community and the environment. These outcomes may involve attitudinal changes, participation rates, shifts in travel patterns, or other personal or environmental impacts, and range from least complex (*Level C*) to most complex (*Level H*). The progression of complexity is dependent upon the measurements at previous levels – i.e., in some cases, one cannot skip a level. The linkages and dependencies are further discussed in **Section 2.5** and in **Table 2** and **Table 3**.
3. **Effectiveness:** *Level I-Financial Effectiveness* assesses outcomes as a function of investment. By doing so, it enables "apples-to-apples" comparisons with alternative strategies. Most often, investors like government bodies are interested in the economic value of investment strategies. Expressing benefits in terms of dollars and cents is highly meaningful to the public and elected officials. One way to do so is to determine the cost per unit of change for a specific indicator – e.g. tonnes of GHG emissions reduced per dollar invested. This allows comparison between two TDM initiatives, or between TDM and infrastructure investments. A second approach is a business case analysis that assesses an initiative's full economic benefits and costs, thus reducing impacts to a simple benefit-cost ratio (e.g. 2:1) that is readily understandable. However, caution must be used due to the difficulty of accounting for and quantify all benefits (see further discussion in **Section 3**).

Table 1 provides further detail on each context and performance assessment level.

2.4.2 Choosing assessment levels

Consider the following factors when choosing assessment levels:

- **Goals:** The assessment levels should allow for evaluation of the initiative against the program's goals.
    - A bike to work challenge may have the goal of having residents try cycling to work. This initiative may be evaluated at *Level D*-Participation (number of participants for the event) and/or by *Level E*-Short-term Change (number of people who tried cycling as a mode of transport to work).

- If the program's overall goal is to reduce long term parking demand, the project should not be assessed at *Level E-Short-term Change* (e.g. the number of people who try sustainable modes). It should be assessed at *Level F-Long-term Change* (e.g. number of people who make a more permanent change) and *Level H-System Impact* (e.g. parking demand).
- The goal of another program may be GHG reduction. In this case, the program should be assessed at Level H-System Impact. GHG changes cannot be directly measured, but must be calculated using indicators from other assessment levels. Because of this, a program with a GHG reduction goal should also assess *Level F-Long Term Change*.

- **Type of initiative:** Different initiatives require different measurements. It is extremely difficult to identify travel behaviour change due to a marketing campaign when other incentives or disincentives are being offered. It may be more suitable to assess *Level A-Activities Undertaken* (e.g. number of posters distributed, radio time purchased) and/or *Level C-Awareness* (e.g. percentage of population that can recall seeing campaign information).
- **Complexity:** The level of complexity must be suitable for the budget and scope of the TDM initiative.
- **Funding requirements:** Funding bodies (including Transport Canada) may require a certain assessment level to receive funding (i.e. GHG measurements at the *Level H-System Impact*. Municipal and regional councils may be interested in assessing participation or customer satisfaction for a bike to work event or walking school bus program.

Each assessment may have any number of levels, but will always include *Level S* - *System conditions*) and *Level P-Personal Information*). Other combinations of levels from *Level A* through *Level I* may also be used; some initiatives may require one level only, while others require most (or even all) levels. When choosing assessment levels, remember the following:

- *Level F* and *Level H* must be used if the intention of the TDM impact measurement program is to reduce GHG emissions.
- More detailed levels of assessment, such as *Level H*, may not be practical or appropriate for every project or initiative.
- Assessment at one level may require data or calculations from another level; for example,
  - *Level G* and *Level H* are dependent on information from *Level E* and *Level F*
  - *Level I* is dependent on *Level G* and *Level H*.

Table 1: Assessment Levels			
Assessment Level			**Description**
CONTEXT ASSESSMENT			
Context	S	System Conditions	Background conditions surrounding the implementation of the TDM program.
	P	Personal Information	Information about individual survey respondents that will allow them to be grouped. Also, information about the respondents' personal situation that may impact their response to TDM.
PERFORMANCE ASSESSMENT			
Outputs	A	Activities Undertaken	Activities undertaken by the TDM program team to accomplish the goals of the program.
	B	Customer Satisfaction	Customer reports of satisfaction concerning the TDM program or program activities.
Outcomes	C	Awareness	Level of awareness of the program among members of the target group.
	D	Participation	Level of participation among the target group.
	E	Short-term Change	The short-term impact of the initiatives, i.e. number of people who have tried an sustainable mode. This is equivalent to "experimental use" in other programs.
	F	Long-term Change	The long term (one year or greater) change to participants travel behaviour.
	G	Personal Impact	The direct impact to participants who have made a long-term or short-term change. This includes indicators such as time savings, mobility level, affordability, vehicle operating cost savings, personal health benefits, or other impacts for individuals. Can typically be represented as averages for population sub-groups, as individual impacts for all participants may be difficult or impossible to determine.
	H	System Impact	The aggregate impact of travel behaviour changes on the system. This could be impacts to transit ridership, congestion, GHG or CAC emissions, public health or some other goal for the system as a whole.
Effectiveness	I	Financial Effectiveness	The benefit of the system for the investment. This can be measured holistically as cost/ benefit or it could be a more finite cost per unit of change. Cost per unit of change reflects progress for investment for a certain goal, but neglects side benefits of the program. Full cost/benefit can encompass more impacts but can be more difficult to calculate.

2.5 Step 5 – Choose Indicators and Data Collection Strategy

Each assessment level may have several different indicators (or things that are the subject of measurement). **Table 2** shows possible indicators for the Context Assessment Levels (i.e. *Level S* and *Level P*), and **Table 3** shows possible indicators for Performance Assessment Level (i.e. *Level A* through *Level H*), and some specific measures for each. At each level, the indicators selected will vary by project. Some projects may require additional indicators to reflect the "full picture". Regardless, it is important to include two types of indicators: those that pertain directly to the assessment level in question (either context or performance), and those that are needed to subsequently calculate indicators at other levels (note that the arithmetic relationships among indicators are described in more detail in the data collection and evaluation techniques sections).

2.5.1 Choosing Indicators

Like assessment levels, the selection of appropriate indicators will reflect several key factors:

- **Goals:** The indicators should relate directly to the program's goals.
- **Type of initiative:** Indicators must relate to the type of initiative. A good indicator of *Level D-Participation* for a cycling promotion event is the number of people in attendance. A less suitable indicator would be hits to the event's website.
- **Complexity:** Some indicators are more complex than others. For example, both benefit-cost ratio and cost per tonne of GHG reductions are valid indicators for *Level I-Financial Effectiveness*. However, benefit-cost ratio is much more data intensive and may not be suitable for use in projects with smaller budgets.
- **Funding requirements:** Funding agencies may request a specific indicator, such as GHG reductions.
- **Measurability:** Measurability is critical for indicators, each of which must be measurable in a practical fashion using available data and calculation techniques.
- **Calculation requirements:** Some indicators are not directly measurable, but are calculated based on other indicators, assumptions or standard factors. For example, CAC reductions are not directly measurable but can be calculated by multiplying vehicle-kilometres reduced by a "CAC factor" (in grams per vehicle-kilometre). Therefore, if CAC reductions are a desired indicator then VKT must also be chosen.[5]

[5] Other indicators may be used in the calculation of CAC emissions. VKT is used in this example because it is the most commonly used parameter for TDM professionals. In most cases, it is easier to determine VKT reduced by TDM than it is to determine other possible parameters, such as fuel consumed.

Table 2: Indicators and Measures for Context Assessment

Possible Indicator	Measure
Level S-System Conditions Background conditions surrounding the implementation of the TDM program	
Population statistics (target/other groups)	Number of people
Parking data (on-site, off-site, availability, utilization, cost)	Number of spots, peak utilization (% used at peak time)
Existing travel subsidies	$ available and used, target population, target population size
Details of work times	Number of shifts, start time, end time, number of hours
Existing telework, flex time, compressed workweek	Days available per week, number of people participating, days participated per week for average participant
Carpool, carshare, company car information	Number of carpools, number of carpoolers, preferential parking availability, number of company cars or carshare, utilization, % used at peak time
Public transit - mode to transit, frequency, connectivity, pricing, special offers	Walk distance, transit type, vehicles per hour, price
Cycling facilities	Distance (km), directness of route, pavement quality, safety, km of routes, showers per person (employees / students / etc), secure bicycle parking per person (site users)
HOV network	Km of HOV lane
Sidewalk coverage	% of given roadway classification (one side or two sides)
Average travel time (by mode)	Minutes (convert to hours for calculations)
Average travel distance (by mode)	Km
Average travel speed (by mode)	km/h
Level P-Personal Information Information about individual survey respondents that will allow them to be grouped and information about the respondents' personal situation that may impact their response to TDM	
Age	Years of age
Gender	M/F
Job type	Hours worked per week, job descriptor (office-based, off-site, shift, manufacturing, retail)
Place of residence	Postal code / GIS
Place of work/school/etc	Postal code / GIS
Travel days per week	Days traveled to / from site per week
Trips per week	Trips to / from site per week
Time of travel	Start / end time of trips to site
Travel time	Total travel time for one trip
Travel distance	Total travel distance for one trip
Transport mode	Mode (or combination of modes) used to travel
For carpool - Number of people sharing mode and same/different household	For carpool – number of people in carpool, household, origin location (postal code)
Travel route	NA
Public transit pass	Pass type, usage in days
Car availability	% of time that a car is available for this trip

Table 3: Performance Indicators and Measures for Each Assessment Level

Possible Indicator	Measure
Level A-Activities Undertaken Activities undertaken by the TDM program team to accomplish the goals of the program	
Related jobs completed by staff / volunteers / etc.	Flyers distributed, calls made, calls answered, requests filled, events organized, promotional materials distributed
Level B-Customer Satisfaction Customer reports of satisfaction concerning the TDM program or program activities	
Participant satisfaction	% of participants satisfied with service
Administration satisfaction	Satisfaction rating of site administration with services provided
Level C-Awareness Level of awareness of the program among members of the target group	
Awareness of program / initiative existence	% of target group aware of initiative
Knowledge of role / purpose	% of target group able to describe role / purpose
Ability to contact / get information (if applicable)	% of target group able to describe how to get information (website location, phone number) or contact office / coordinator, number of website hits
Level D-Participation Level of participation among the target group	
Number of people using the service / initiative / participating in event	Number of calls, number of requests, number of participants at event, number of people registered, number of people using system
Level E-Short-term Change The short-term impact of the initiatives, i.e. number of people who have tried an sustainable mode. This is equivalent to “experimental use” in other programs	
One time try of alternative / new mode / reduced travel	Number of people who attempted
Experimental changes in travel patterns	Change type, number of people who made change, duration of change, days per week of change
Satisfaction with short-term change	% of people who made change that are satisfied with change
Level F-Long-term Change The long term (one year or greater) change to participants travel behaviour	
Aggregate mode share change type	% mode shift from each mode to each mode
Average duration	Average length of change at time of measurement
Average frequency	Average days of week used for each mode
Level G-Personal Impact The direct impact to participants who have made a long-term or short-term change. This includes indicators such as time savings, mobility level, affordability, vehicle operating cost savings, personal health benefits, or other impacts for individuals. Can typically be represented as averages for population sub-groups, as individual impacts for all participants may be difficult or impossible to determine	
Fuel consumption	Litres
Active time	Active minutes per day
Active kilometres travelled (AKT)	Km
Personal cost of travel (user cost)	Cost $ per km
Time savings (or cost)	Minutes per trip, or $ per trip

Table 3: Performance Indicators and Measures for Each Assessment Level

Possible Indicator	Measure
Level H-System Impact The aggregate impact of travel behaviour changes on the system. This could be impacts to transit ridership, congestion, GHG or CAC emissions, public health or some other goal for the system as a whole.	
Trip generation – transit	Number of transit users
Trip generation – private car	Number of auto users
Trip generation – car pool	Number of car pool participants
Trip generation – cyclist	Number of cyclists
Trip generation – pedestrian	Number of pedestrians
Mode shift	Change in number and % of auto users to sustainable modes, decrease in auto mode share
VKT reduced	Total decrease in kilometres traveled by users as result of mode shift
Transit kilometres travelled (TKT)	Km
GHG/CAC reduced	Tonnes or tonnes per person (target group or total population
Health care cost	Cost savings resulting from GHG reduction
Lost time due to congestion	Vehicle hours travelled (VHT) under congestion.
Number accidents	Number / year
Number of accidents per capita	Number of accidents per person (target group or entire population)
Number of accidents per VKT	Number of accidents / km
Economic cost of accidents	Cost of accidents
Average fuel usage	Litres
Relative growth (decline) in traffic volumes	% change in volumes / % change in population
Level I-Financial Effectiveness The benefit of the system for the investment. This can be measured holistically as cost/ benefit or it could be a more finite cost per unit of change. Cost per unit of change reflects progress for investment for a certain goal, but neglects side benefits of the program. Full cost/benefit can encompass more impacts but can be more difficult to calculate	
Investment per tonne CO_2 reduced	Dollars / tonne
Cost-benefit	Ratio (dollars (cost) / dollars (benefit))

2.5.2 Designing a Data Collection Strategy

The data collection strategy specifies when and how data collection will occur. For each indicator:

- Choose the data source or calculation strategy (see **Section 3**).
- Determine the timing of baseline data collection. This is the **"before"** condition – that is, the current or recent situation prior to the implementation of the TDM initiative.
- Determine the timing and frequency of follow-up data collection to ensure consistency with target timelines (e.g. annual surveys for three years would be required to measure progress toward a goal that includes interim targets such as a 10% reduction after one year, a 15% reduction after two years, and a 20% reduction after three years). This is the **"after"** situation – that is, after the TDM initiative has been implemented.
- Determine the required sample size, question types, and other details for the baseline and follow-up surveys. Information about choosing sample sizes is provided in **Appendix B**.

Questions for practitioners to consider when developing their data strategy are listed below:

Data collection for regional/municipal initiatives:

- How do you decide what portion of the population to survey? There are tools online that suggest minimum sample sizes for different levels of statistical significance.
- Which sub groups should you survey? Whole population, only the people who have changed? How does this change the sample size?
- Can you survey only program users and estimate a minimum?
- How can you supplement surveying with Tier 1 data?

Data collection for neighbourhoods:

- How can you supplement surveying with Tier 1 data?
- Can you only survey program users?

Data collection for sites – employers (workplaces)

- How do you sample within a site?
- Can you survey a limited number of sites extensively and then extrapolate that information over many sites?

Data collection for sites – schools (i.e., for students)

- How do you group representative samples for schools?

2.6 Step 6 – Determine Baseline

A baseline is a full **"before"** picture that describes not only the travel behaviours that exist prior to initiative implementation, but also the contextual factors that might influence the behaviour of target audiences (e.g. transportation network or economic conditions). Baseline data collection must be in sufficient detail to allow for comparison to the "after" situation and to distinguish between behaviour change that arises from the TDM initiative and behaviour change that arises due to contextual factors. A full "before" picture for both context indicators and performance indicators should therefore be collected.

Travel surveys, travel time surveys, and similar data collection should be done at this time. Baseline surveys may be more intensive and detailed than follow-up surveys, because gathering extra levels of detail early in the process can enable efficiencies later on (e.g. be allowing practitioner to identify smaller sub-groups that can be targeted for surveys instead of simply repeating surveys of a larger population). If the measurement strategy includes repeated consultations with focus groups, those groups should be assembled at this time.

2.7 Step 7 – Set Targets

The baseline data, once assembled, will help the practitioner to understand the existing travel patterns and to set ambitious but reachable targets. For each of the indicators, set a target and a time frame to meet it. The targets and time frame must be supported by a data collection plan that allows for consistent, timely measurement of the chosen indicators (as defined in Step 5).

2.8 Step 8 – Collect Data

More information about data is provided in **Section 3**, including the types of data that should be used for the analysis and alternate methods and sources for collecting these data.

2.9 Step 9 – Evaluate

Evaluation can be done by simple calculation, more complex spreadsheets, or using full transportation models. The method of evaluation will depend on the resources available and the required detail of the analysis. More information about evaluation is provided in **Section 4**.

2.10 Recording Actions at Each Step

Appendix A contains a TDM Evaluation Framework planning sheet that should be used to record actions that are required and undertaken at each step. While some steps may seem to be simple or to duplicate planning and decision-making steps, recording them will simplify the measurement process.

3. DATA COLLECTION TECHNIQUES

3.1 Categorization of Data (Tiers)

Step 8 of the Evaluation Framework is 'Collect Data.' Data are required to evaluate each of the chosen indicators (either directly or through calculation). This section provides detailed information about data collection methods and techniques.

For the purposes of this report, we have divided data into three types:

- **Tier 1: Direct Data** are data that are collected through direct observation. This reduces the risk of bias, but does not provide any information about motivation or how different indicators are related.
- **Tier 2: Reported Information** is data that are reported by another party – they are not directly observed. More detailed information can be collected this way, but it may be subject to bias. Tier 2 data are divided into two subgroups:
  - **Tier 2a: Surveys** includes surveys of whole populations, target populations, or participants.
  - **Tier 2b: Databases and Outside Sources** includes information that can be provided by regional, provincial or national sources, and information from other communities that can be used as a supplement to local information
- **Tier 3: Model Outputs** are data that can be derived from local or regional transportation models. Unlike the Tier 1 and 2 data, these are not observed data; rather, they are synthesized through a modelling process. However, they can be used to fill gaps or expand upon existing observations – synthetically – where the information does not otherwise exist.

Tier 1 and Tier 2a data are used to describe changes in travel patterns surrounding the TDM initiative; they measure the less complex indicators that represent local changes in travel patterns. Tier 2b and Tier 3 data cannot be used to measure these kinds of indicators. Instead, Tier 2b and Tier 3 data provide standard values or assumptions to be used in calculations. Tier 2b and Tier 3 data answer questions about the baseline situation (i.e. mode split in the general population) and variables that are not expected to change (i.e. average trip distance by mode for most TDM initiatives).

This section serves as a "primer" on data collection for TDM impact measurement. Not all information is applicable for all measurement projects. Of importance, practitioners should seek to focus their data collection activities so as to identify the travel patterns of their target groups. Practitioners may wish to read only the introductory information for each subsection in detail and then focus on only those techniques that apply to their project. Specific techniques have been indexed in the following section, for reference.

3.2 Principles of Data Collection

This section outlines some key principles of data collection. The specific use of these principles must be assessed for each individual application.

1. **Consistent and Representative Data** – The survey data should be collected during a representative period(s) for monitoring. Often, the data are referred to as a snapshot of typical conditions. Depending on the sensitivity of the data collected, efforts should be made to avoid data collection during statutory holidays, examination periods for the local universities and colleges, and scheduled construction; during all of which times travel patterns are expected to be atypical. Training and orientation of data surveyors are encouraged to ensure consistent data collection and results.
2. **Regular Monitoring** – The periodic collection of direct data at fixed intervals, using a fixed method to allow for regular direct comparison (thus stressing the importance of the previous two points). If the data are to be compared from year to year as part of a greater monitoring program, consistency in the way the data are collected will be essential. Since this will rely on a fixed set of

parameters, it is important that the time of year and/or time of day selected at the survey design stage represent the design period both currently and in the future. Inconsistencies can be related to differences in method in both data collection and data distillation and analysis. In the case of a cordon count program, the survey locations should remain the same from year to year wherever possible. Any changes that are required due to a change in survey scope or change in the transportation system should consider the compatibility of the data with historical datasets and should be fully documented.

3. **Sample size** – This can be an issue depending on the potential for variance over time. Each location should be assessed on a case by case basis.
4. **Value-Added Opportunities** – Many data collection programs present opportunities for other types of data to be collected concurrently. The survey or data collection program design should weigh the opportunities that are present (data that are required by various parties) against the degree of data degradation (the potential for decrease in accuracy) and attempt to achieve an acceptable balance. For data collection efforts requiring a larger level of effort, it is often prudent and essential to find opportunities for collaboration. Multiple organizations can sometimes coordinate cost savings efforts and design the data collection program to address more than one set of needs. For example, larger origin-destination surveys (or trip diary surveys) can be carefully crafted to address questions regarding trip-making characteristics as well as attitudinal and opinion-based responses. Consideration does need to be made regarding reduced sample size and accuracy due to increased time per survey and compliance due to survey fatigue if the number of questions in the survey becomes too large.

3.3 Index of Data Collection Techniques

For convenience, **Table 4** lists several types of data that are relevant to TDM impact measurement. The table lists the Tier to which each type of data can be found, and it also indicates the page number at which detailed descriptions can be found.

Table 4: Index of Data Collection Techniques

Data Type	Tier Number	Page Number
Attitudinal Surveys	2a	29
Behaviour Surveys	2a	30
Focus Groups	2a	31
Panel Surveys	2a	32
Conjoint Analysis (Stated Preference Surveys)	2a	32
Mode Choice	1	21
O/D Surveys/Trip Diary (All Modes)	2a	28
Parking Surveys	1	25
Roll Surveys	2a	31
Survey Response Rates	2a	33
Transit Surveys	1	24
Travel Mode Surveys	2a	30
Travel Time Surveys	1	26
Vehicle Classification	1	22
Vehicle Occupancy	1	23

3.4 Tier 1 variables: Direct Data

Direct data (or counted data) are data that are observed. Data collection programs for direct data must be designed so that these data represent the typical condition at the time of the data collection. This section will address the collection of standard transportation data that are directly measurable.

Direct data should be collected inconspicuously without greatly disrupting the transportation system. This will ensure that the survey does not influence the subject (i.e. traffic flow), and that results represented in the data collected reflect typical conditions. The presence of data collection personnel and equipment can often affect the behaviour of the traveller, resulting in skewed results. For example, traffic flow may slow due to the presence of the surveyor and reduce the number of vehicles counted. If the surveyor is mistaken for enforcement personnel, often compliance related behaviour will be corrected such as usage of HOV lanes, operating speeds and uncontrolled pedestrian crossings. Where applicable (in interview surveys, for example), random and regular sampling should be used.

The hours of collection for direct data should correspond with the travel hours of the target group.

3.4.1 Types of Direct Data

The following section describes the types of data used as TDM measures and the typical method for their collection.

3.4.1.1 Mode Choice

A mode choice survey is a count of person trips entering and exiting the study area, where the trips are categorized by the travel mode. Due to the detailed nature of the study, these surveys are undertaken manually. A typical mode choice survey ideally captures the activity continuously from 6:00 to 18:00 on a weekday. If the objective is to target only the peak periods, then the survey can be modified to suit the specific needs. Standard modes include:

- Private auto – single occupant (i.e., the driver).
- Private auto – more than one occupant (i.e., the driver plus at least one passenger).
- Public transit.
- Bicycle.
- Walking (including wheelchairs and strollers).
- Other (active transport).
- Other (non-active transport).

Data usually are collected in 15-minute increments to permit detailed analysis by time period. It should be noted that there may be opportunities for combining vehicle classification and/or vehicle occupancy with mode choice into the same survey, depending on the overall data collection needs and amount of anticipated traffic.

Applicable Initiatives: All initiatives that have mode shift as an objective.

Measure: Change in the share of a particular mode for a specific period of time, reduction of mode share for the private automobile during the peak periods, increase in mode share for active transport modes, increase in minutes of physical activity per day, increase in mode share for transit.

For example, baseline volume for a university is measured to be 50,000 person trips between 7:00 and 17:00. Of the total person trips, 5,000 trips (or 10%) were made via public transit. After the implementation of a university-wide transit pass, the proportion of person trips made on public transit increased to 20% , equivalent to a 10% mode shift towards public transit (or increase in mode share by 10%) from all other modes.

3.4.1.2 Vehicle Classification

Vehicle classification counts provide vehicle volume information by vehicle type entering and exiting the study area. Generally, the vehicle categories are:

- Passenger cars (which includes minivans, sport-utility vehicles and pickup trucks of all sizes).
- Light trucks (includes moving trucks/cube vans, ambulances, and single unit trucks) and
- Heavy trucks (includes fire trucks, tractor-trailers and container trucks).
- Buses.
- Other.

Depending on the specific data requirements of the monitoring program, the vehicle classes can be tailored. Automated traffic recorders (ATRs) are a reliable means of obtaining vehicle classification data. However, if the vehicle classes required are similar in size, manual methods are needed to ensure accuracy. Permanent count station data are often available and can be an inexpensive data source if the study area encompasses part of the Provincial road or highway network. Data are usually obtained for one week (if using automated methods) in 15- or 60-minute intervals. There may be opportunities for combining mode choice and/or vehicle occupancy with vehicle classification into the same survey, depending on the overall data collection needs and amount of anticipated traffic.

Applicable Initiatives: Demand dispersal and displacement through telecommute / telework, off-peak work start and end times, and off-peak goods and services movements.

Measure: change in distribution of passenger cars away from peak periods, change in proportion of trucks during the work day.

For example, baseline volume for a service road into an industrial park is measured to be 40,000 (or 40%) during the six busiest hours of a typical weekday (i.e. 6:00-9:00, 15:00-18:00) of the 100,000 daily vehicles observed. After the implementation of employee-based TDM initiatives targeting peak demand dispersal, the proportion of traffic within the 6 busiest hours has now dropped from 40% to 35%, or a 5% shift from the peak demand. The same approach can be undertaken for initiatives aimed at shifting goods movement away from peak daytime business hours (i.e. 6:00-18:00).

3.4.1.3 Vehicle Occupancy

Applicable Initiatives: Increase carpooling and ridesharing, ridematching

Measure: Reduction in single occupant vehicles (SOV), increase in overall vehicle occupancy rate, increase use of HOV lane(s)

Vehicle occupancy (VO) counts provide vehicle volume information by the number of occupants entering and exiting the study area. Both the driver and the passengers are considered vehicle occupants. Due to the detailed nature of the study, vehicle occupancy surveys are undertaken manually. A VO survey ideally captures the activity continuously throughout the day but is often adjusted to address only the peak period(s) of a survey day –e.g., the 3-4 hours that bracket the morning and afternoon commuter peak periods. Typically, the vehicle categories are:

- Single occupant vehicle (driver only).
- Auto with two occupants (driver plus one occupant).
- Auto with three occupants (driver plus two occupants).
- Auto with four occupants (driver plus three occupants).
- Auto with five or more occupants (driver plus four or more occupants).

The vehicles monitored in VO surveys can be exclusive to private auto, or include cars for hire such as taxis and limousines and commercial vehicles as well, depending on the objective of the TDM initiative(s) measured. Some VO surveys include transit buses, school buses, paratransit buses and intercity buses. Both the occupants and their vehicles typically are counted in a VO survey, so vehicles also can be classified by type. Counts are usually disaggregated by direction and by lane, where necessary (i.e. HOV lane). Combination of mode choice and/or vehicle classification (i.e. marked carpools and vanpools) and buses with vehicle occupancy parameters into the same survey is possible, depending on the overall data needed and amount of anticipated traffic.

Many municipalities, regional governments and Provincial / Territorial governments have developed standardized VO forms. Organizations such as Metrolinx's Smart Commute Initiative, have their own forms, tailored to site-specific VO counts.[6]

[6] See http://www.smartcommute.ca/tma_toolkit, for guidelines on VO and the conduct of other surveys.

3.4.1.4 Transit Surveys

Transit surveys provide useful information about how transit facilities are used. This includes ridership (the number of trips on a transit route or system), boardings and alightings (the number of people who get on and off the service) at specific locations, and origin/destination pairings of boardings. Point check surveys (monitors all passengers onboard all transit vehicles by direction at a fixed location) are conducted regularly by the local transit authority or agency for their own service monitoring purposes. Conventionally, the point check surveys are conducted using surveyors at cordon station locations, where they are required to track the following basic information:

- Time of observation.
- Direction of travel.
- Route number and destination (or route description).
- Type of transit vehicle (regular service, community shuttle, paratransit, etc.).
- Number of passengers onboard (approximate).
- Bike rack availability (yes/no).
- Number of bicycles on board.

Applicable Initiatives:

- Special events (Bike to work/school week, Commuter Challenge)
- Workplace-based incentives (payroll-deduction transit passes)
- School-based incentives (universal transit passes)
- Transit pricing

Measure: Increase transit ridership percentage or transit mode share, increase usage of bike racks, increase usage of workplace and school issued transit passes

Since the surveyors will be required to count the number of passengers on a moving vehicle, the stations should be selected at existing bus stops wherever possible to increase potential for accuracy. The speed of the vehicle is also a major factor affecting the accuracy so coordination with and cooperation from the vehicle operators will greatly benefit the quality of the data. At busier locations, it may be necessary to assign two (one per direction) or more surveyors to maintain survey integrity. An alternative source for transit ridership data is fare box data, which may be available through the local transit authority or agency. However, these data will be limited to a total number of passengers boarded for a specific vehicle and route, without any geographical context and how many passengers actually arrived or departed the study area (departures are not tracked by the vehicle operator). Depending on the TDM initiative(s) measured, fare box information may be sufficient. The number of bicycles and bicycle racks on transit vehicles will provide a utilization measure (i.e. bikes on board during a peak hour, bikes to bike rack ratio, etc.) which can be used as a site specific proxy measure of TDM impact.

Boarding and alighting data can be collected through automatic passenger counters that many transit agencies have installed on their buses and rail vehicles. Manual counts also can be conducted. More detailed information can be collected using electronic fare cards; some of these systems allow transit agencies to pair boardings and alightings to estimate O/D pairs.

3.4.1.5 Parking Surveys

Applicable Initiatives:

- Special events (Bike to Work/School Week, Commuter Challenge)
- Workplace-based incentives (payroll-deduction transit passes)
- Commuter Car-pool program
- Parking pay structure (i.e. unbundling)

Measure: Change in parking utilization and demand, overall and by category (i.e. preferred parking for carpools)

Parking surveys is a generic term that encompasses several types of parking counts. Generally, they are all site specific counts and are conducted for shorter durations and targeted time periods. For the purposes of TDM impact monitoring, utilization is the most appropriate parking-related input and/or indicator.

Parking utilization surveys attempt to quantify the parking demand versus the parking supply. Parking utilization surveys have also been coined parking occupancy surveys and should not be confused with vehicle occupancy surveys at parking facilities.

Demand is determined by counting the number of parked vehicles within a study area at regular intervals. Depending on the intended use of the data, the interval size may vary. To establish the supply, the number of parking stalls within the study area must be defined. Depending on the focus of the TDM initiative being measured, finer detail may be required and the type of parking (or parking inventory) may need to be identified:

- On-street versus off-street.
- Public versus private.
- Paid versus free.
- Unrestricted versus restricted (by time of day, duration, day of week, etc.).
- Non-preferential versus preferential (reserved for employees, persons with disabilities, car- and van-pools, alternative fuel vehicles, etc.).

Utilization surveys and parking inventories can be conducted on foot with either a pencil and paper method using customized data forms, or by using a portable digital assistant (PDA) or tablet computer that is set up to capture time-stamped data. Optional elaborations may include integration of geo-referenced data using GIS technology.

Parking revenue records (usually from automated payboxes) are an alternate source for off-street parking data. However, there can be limitations to the data (i.e. assumes that the full duration paid for is used – no more, no less; and does not usually provide information based on parking type) depending on the desired level of detail.

Other types of parking surveys exist, such as parking duration (how long a vehicle is parked) and turnover (how many vehicles are serviced by a stall) surveys. Duration can be used to identify patterns of different target groups (i.e. it can distinguish between short term parkers [visitors] and long term parkers [employees]). While, in some cases, duration and turnover may not be as applicable as a TDM indicator, they may be a separate interest that can be incorporated into a greater survey and may provide specific information of interest.

3.4.1.6 Travel Time Surveys

> **Applicable Initiatives:**
> - Staggered work/school start times (away from rush hour periods)
> - Condensed work weeks
> - Telecommute/telework
> - Virtual classrooms
>
> **Measure:** Change in travel time, personal cost savings, reduction in non-productive time

Travel time surveys are conducted to measure the actual time it takes to travel from an origin to a destination via a predetermined route. Because travel time is a key determinant of modal choice, travel time surveys can profile current conditions among competing modes: by conducting before-and-after travel time surveys, we can understand the effectiveness of a TDM initiative against its competitors. While travel time surveys can be conducted across various modes, their most common application is the auto mode. The survey usually requires two surveyors to complete: one driver and one recorder. The recommended driving technique is called the floating car method, whereby the vehicle is driven to permit as many cars to pass as it has passed itself. In theory, the vehicle should travel at the average running speed of the traffic platoon. The recorder is equipped with a stopwatch or digital time piece. Times are recorded on either data forms or other inputting device, such as a laptop. Recent GPS innovations allow for the passive recording of more precise travel time information, without the need for manual record-taking: the data are uploaded via satellite to software that process the information and provide summary tabulations (including, for example, estimates of greenhouse gas and Criteria Air Contaminant emissions).

Typically, several types of data are recorded in a standard travel time survey. These include
- Date, time period, weather and any other environmental factors of interest.
- Route description (if varying and applicable).
- Start and end time, recorded to the nearest second.
- Start location (or direction of travel) and end location.
- Times and locations of intermediate points (e.g., intersections, points at which the vehicle is stopped due to congestion or at a traffic signal, etc.).
- Notes and comments (i.e. causes and durations of delay).

The travel time is then calculated for each trial as the difference between the start and end times. The same calculation for times between two nodes will yield travel times for each trial for the individual segments of the route. The number of trials required for a time period is at the discretion of the practitioner. Strategies to complete the desired number of trials may include increasing the number of survey vehicles per study period, conducting the survey for the same period over several days or some combination of the two.

A transit variation on the standard floating car travel time survey can be conducted onboard public transit vehicles and times are recorded at bus stops. Since the number of vehicles and potential routes can be significant, this type of survey is usually conducted in conjunction with ridecheck surveys to determine transit ridership.

3.4.2 How to Collect Volume Counts (Automated versus Manual)

Many types of volume data are collected in transportation studies. Typically, the term “volume” refers to motorized vehicles, but count program components focusing on alternate modes, such as cyclist and pedestrian volumes, are becoming increasingly common input in transportation planning. This type of data generally is aimed at determining sheer quantity, with little to no discriminating information regarding the composition of the volume. As such, both automated and manual counting methods are used.

Automated counting methods use electronic equipment designed specifically for counting various types of traffic. The main advantage for using automated counting methods is that they are consistent and can count continuously over long periods of time (long duration counts) in many types of weather conditions. They are limited in different ways in terms of what can be counted, and depending on the number of locations that need to be counted concurrently, a substantial number of counters would need to be purchased, maintained and stored. Different equipment options include:

- Pneumatic hose counters and other portable traffic recorders.
- Permanent count stations – access to data may be available through municipal, regional or Provincial / Territorial transportation authorities.
- Short count stations – access to data and equipment may be available through municipal, regional or Provincial / Territorial transportation authorities.
- Intersection loop detection counts – access to data may be available through municipal, regional or Provincial / Territorial transportation authorities.
- Video detection count stations – requires special set-up for specific projects.
- Automated detection counters for hallways and pathways used to count cyclists and pedestrians in low- to medium-volume areas.

Because of the specific nature of the data required, many of the data requirements will be best addressed through manual counting methods. Manual counts are conducted by personnel situated in the field at the survey station using electronic count boards (also known as tally boards) or other recording devices. This tends to be for shorter duration counts at selected time periods or commuter or facility peak periods, when the traffic is at its highest.

Manual surveys tend to be more versatile, since they can monitor and distinguish among individual modes and vehicle types; and they are responsive to changes in the traffic conditions. However, manual counts are prone to inconsistency due to differing method and human error. To minimize the chance for error, it is recommended that the survey method be designed for simplicity, and the survey protocol documented and provided to the data surveyor. If the nature of the data collection is complex, a training session or field orientation is suggested. Data collection must be planned to minimize counter error and provide sufficient rest time to data surveyors. Complicated and/or high volume locations require more data surveyors and more frequent breaks. Provincial labour laws should be consulted for minimum break times. Data surveyors should not typically work for more than four consecutive hours to avoid errors resulting from fatigue.

Whatever the means for collecting the required data, consistency is recommended. Generally, this means using the same method, same technology (wherever possible), and same survey periods and locations for each survey. To determine the locations of your survey stations:

- **Step 1: Identify the study area** by drawing an imaginary line (or cordon line) around the entire study area. The study area size can range from a one specific site to an entire metropolitan region. In many cases the cordon line may end up evolving into a series of screenlines after Step 3 (see below).
- **Step 2: Identify all entry points on the network** by marking every point on the network where the volume for the mode(s) in question cross the cordon line and enter the study area.
- **Step 3: Look for efficiencies** by eliminating minor route entry points and consolidating entry points. If the number of access points is extensive, then it will be prudent to assess all the entry points and retain only those that carry the majority of the traffic. Typically, this is relegated to the arterial and major collector roadways which provide significant linkages throughout the area. Remember to assess the entry points in terms of all modes. Depending on the volume type(s) and focus, it may be necessary to assess the entry points in terms of routing designated for trucks, bicycles and pedestrians (greenways). Entry points which converge (either inside or outside the study area) can be replaced by a survey station at the conversion point, depending on the intended use(s) of the dataset.

Specific count (or volume count) types that can be used either directly or indirectly as TDM measures are described in the previous sections.

3.5 Tier 2a variables: Surveys

There are several types of surveys. In contrast to Tier 1 data collection, which generally is inconspicuous, surveys actually engage the traveller. They also provide further insight into actual or intended behaviour (why an action has been taken, in addition to recording the actual action); and they can record both quantitative and qualitative information.

Past action surveys ask respondents to describe their actions over a stated period of time. In contrast to direct data which records observed actions as they occur, past action surveys rely on stated personal recollections of actions of the past. Past action surveys can be executed using passive methods (achieved en masse through questionnaires, postcard surveys, web polls, etc.), interactive methods (personal interviews, telephone surveys) or some hybrid of the two (trip diary surveys).

The sections below provide an introduction to the types and applications of surveys for TDM impact measurement. The reader is referred to the many available texts on survey design for further details.[7]

3.5.1 Survey Types

3.5.1.1 Origin-Destination Surveys / Trip Diary (All Modes)

> **Applicable Initiatives:** All
>
> **Measure:** Mode share / mode shift, travel time, average trip distance, number of trips, personal information, other (can be defined as needed)

An origin-destination (OD) or trip diary survey is a questionnaire survey in the form of a diary, intended to log the details associated with the trips made by every member of a household. Typically, these surveys are conducted in confidence for a single day but can span multiple days depending on the data requirements.

In most such surveys, households are sampled randomly in a defined community, or a group, and travel is recorded for all members above a minimum age (commonly of the order of 10 or 11 years).[8] (Surveys also can be conducted at the workplace, or at specific locations – e.g., pulling over travellers on the side of a road to interview them.) If surveys are conducted for one day, the participants are distributed evenly across the date range and assigned a day. For simplicity, a reference system can be used to establish what day is to be assigned to a household (i.e. households with a primary phone number ending in 1 or 2 is assigned Monday for a trip diary day, 3 or 4 to Tuesday, and so on).
The survey typically asks about the respondent's trips made at a particular time (e.g., all trips made the day before) and/or location (e.g., how the respondent got to work today [i.e., one trip]). Survey questions generally ask about:

- Origin of the trip (where the trip started).
- Destination of the trip (where it ended).
- Purpose of the trip (e.g., going to work, taking a child to daycare, going shopping, returning home)
- Mode(s) used (e.g., transit, walked all the way, park-and-ride [auto and transit]).
- Start time of the trip
- End time of the trip

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[7] One recent publication is de Leeuw, E.D., Hox, J. and Dillman, D., editors, *International Handbook of Survey Methodology*. Psychology Press, New York, 2008. 506 pages. See also Rea, L. M. and Parker, R. A., *Designing and Conducting Survey Research: A Comprehensive Guide*, Second Edition. Jossey-Bass, 1997 (cited elsewhere in this report).

[8] The cut-off respects parents' reluctance to discuss their children's travel behaviour, and also reflects the fact that young children generally do not travel independently.

The tendency is for most region-wide surveys to be geo-coded, given the ubiquity of geographic information systems; and this provides the ability to depict accurately a traveller's origin, destination, mode and route choice.

The survey typically also will ask about the respondent's characteristics (e.g., whether or not he or she has a driver's licence) and his/her household characteristics (e.g., the number of autos available to the household).

These surveys cover all of the sampled household's trips, including cycling, walking and ridesharing. Accordingly, the total travel 'picture' is provided; however, the portion of TDM-like activities reflects the actual modal shares in the general population – in other words, the TDM activity is relatively small. On the other hand, this broad base allows analysis of TDM's characteristics relative to those of other modes, so that the appropriate 'markets' for TDM can be identified, in terms of trip distance (what distance auto trips would most likely switch to walking or cycling) and trip purpose (e.g., the proportion of work or school commute trips). This can be used to identify appropriate targets for TDM programs. Some surveys have asked about the frequency of telecommuting, but this is difficult to relate to the actual observed travel patterns.

Participants can be randomly sampled or screened to ensure that they comply with the criteria of a focus group (i.e. full-time post-secondary students, for example). Since the survey can be long and can require a time investment both in training and diary entries, some agencies and organizations have offered prizes and/or some equivalent (e.g., a chance to win a transit pass) in order to further entice people to participate and complete the survey.

Design of the survey will vary depending on the specific objectives one is striving to achieve with the data. Protocol regarding missed days or atypical days, or days without travel will need to be established and communicated to the surveyed. The definition of a trip and the trip's start and end point will also need to be considered and determined. The level of data regarding modes used and trip purpose will also need to be considered.

Finally, we note the importance of including work and school trips, because both focus on the 'compulsory' trips that people must make every day, and because both workers and students represent key target 'markets' for TDM programs. These can be measured by the aforementioned traditional surveys and counts. However, there are two related critical issues: first, it is well known that many such commuters adhere to their regular patterns for only 4 or sometimes 3 days of the week (of the order of 1/4 to 1/5 of people), due to other associated trip needs – e.g., soccer after school every Wednesday. Therefore, the *frequency* and *regularity* of use is important, in addition to actual surveyed or counted behaviour (which commonly measure a snapshot – one day – in time). Second, it is well documented that an individual's travel choices are linked to those of other members of the household: thus, an understanding of the full household's travel patterns is important. Both these needs can be addressed by multi-day surveys and by panel surveys (long-term annual surveys of the same households). Moreover, many TDM measures are targeted to the workplace or school; meaning that an individual's travel choices must now be linked to those people who are *not* members of his/her household. However, the available data and surveys do not capture the choice dynamics and tradeoffs: one approach is to engage a group of individual travellers for surveys over a multi-year period (i.e., a panel), to complement workplace or school O/D surveys and counts.

3.5.1.2 Attitudinal Surveys

Attitudinal surveys are interview surveys designed to gauge perception, outlook and awareness. These surveys can be administered either passively or interactively. Attitudinal surveys may provide adequate measurements to gauge initiatives related to public awareness, marketing and branding.

3.5.1.3 Behaviour Surveys

Behavioural surveys are interview surveys designed to determine the actions of those surveyed. The distinction between attitudinal surveys and behavioural surveys is that what we think and say (attitude) may not be reflected in what we do (behavioural). Some agencies have combined these surveys together in order to save costs. However, the combination of the two survey types can be confusing to the respondent, leading to poor results for both surveys; and so in order to achieve good data quality it is best to separate the two surveys. (One possible alternative is to ask respondents for their comments regarding programs, TDM in general, etc., at the end of a behavioural survey. That way, at least some 'high-level' input on attitudes can be gathered, without compromising the behavioural survey.) These surveys can also be administered either passively or interactively.

3.5.1.4 Travel Mode Surveys

Travel mode surveys are typically taken on site as interview surveys. They tend to be targeted to a particular group (i.e. employees) or site (i.e. shopping mall patron).

3.5.2 Survey Tools/Strategies

3.5.2.1 Common Types of Survey Tools

Surveys can be conducted with a number of tools, or 'instruments.' The choice of survey depends on the target group, the size of that group, the accessibility of that group, the issues that are to be surveyed and cost. Commonly used instruments include:

- Computer-aided telephone interview (CATI) is used to gather quantitative data, such as an origin-destination survey, or qualitative information, such as an attitudinal survey. Respondents are selected randomly, and typically are notified by letter in advance. Data recorded in a CATI session are typed directly into a computer which, using specially-coded software, immediately identifies errors and gaps, thus allowing the interviewer to probe and address the issue immediately. (For example, people sometimes forget the bus route number that they took: the software, if set up properly, can indicate that this particular route does not run between the place of origin and place of destination for this particular trip). CATI surveys are commonly used in most cities to capture one-day travel data: recent region-wide surveys include Montréal (2008), Ottawa-Gatineau (2005), the Greater Toronto Area – Hamilton (and beyond; 2006) and Winnipeg (2007). One problem with CATI surveys, whose sampling requires knowledge of a home telephone number, is that younger respondents, who use a cell phone rather than a land line, may be under-represented. A web survey can alleviate this, to some degree; however, as discussed below, web surveys may have too much of a bias towards younger users. Some surveyors now have made special effort to include cell phone numbers in their sampling, as another way to address the growing use of cell phones.
- Mail-back surveys cover the same questions as a CATI survey. The forms are mailed to randomly-selected households. Respondents are asked to complete the form, and then mail it back (normally, in a pre-paid envelope). Mail-back surveys typically are less expensive than CATI surveys: on the one hand, the sample size can be much higher than that of a CATI survey (for the same cost), but the response rate typically is lower. Mail-back surveys also place a greater burden on the respondent to fill out the questionnaire (as opposed to having the CATI interviewer 'writing' the answers). Also, errors and gaps are more difficult to rectify, because these must be addressed only after the form is returned (as opposed to an immediate rectification in a CATI survey). Trip diary surveys typically use the mail-back format, and cover travel on multiple days. The trip diary has been used in the 2008 Vancouver and 2006 Victoria region-wide origin-destination surveys.
- Personal or face-to-face interviews allow for direct interaction and probing between the interviewer and the respondent. These work well when the target group is concentrated at a particular location – e.g., an office building where a ridesharing program is proposed, or at a park-and-ride lot. They also capture the activity while it is in progress – e.g., an origin-destination

survey of people arriving at work. However, on a unit basis (i.e., cost per completed survey), they can be more expensive than a CATI or mail-back survey.

- Web-based surveys are becoming increasingly widespread as use of the Internet grows. They have the advantage of convenience and reduced costs; and they can be set up so as to minimize the response burden (amount of time needed to complete the surveys) on the part of the respondent. However, the lack of interaction with the respondent means that it can be difficult to rectify errors or gaps; and there remains a bias that corresponds to computer usage rates in the general population (i.e., higher among younger people, and lower among older people).
- Newspaper ads can be used to solicit comments and attitudes on a wide basis. Readers are encouraged either to clip, complete and mail in the form, or they are directed to a web address or, perhaps, a telephone number to submit their responses.

3.5.2.2 Roll Surveys

Roll surveys are taken in elementary, middle and secondary schools by the staff. Its name indicates that the survey is conducted at the beginning of class when attendance is taken. The intent is to gauge the mode used to get to and from school. While this is not widely practised in North America, it is being used in New Zealand by the Auckland Regional Transportation Authority, as a means of tabulating travel behaviour (mode use) before and after the introduction of school-based TDM programs. The advantage is that virtually all students can be captured; however, a roll survey does not capture average distance or route information. Average distance can be calculated based on origin if the school (and parents) consent to the release of postal code information paired with mode of travel.

A roll survey can be taken at any interval required by the study and supported by the school. The survey could be conducted on one day, one week, one day per month for a number of months, one week per month, etc. Like all surveys, gathering information for only one day may not provide a full picture of travel patterns – i.e. children may be driven four days but walk every Friday; a Wednesday survey will not capture this information. On the other hand, the survey does capture an accurate profile of what people actually did on that particular day, which also is important to know.

Incentives to the school may increase compliance and accuracy from an administrative level.

3.5.2.3 Focus Groups

In a traditional interview, the questioner takes the lead and sets the structure for the information that is collected. The very act of asking specific question can serve to guide the participant in a direction where they might possibly miss information related to some of the most important factors. In an interview, the tone, pace, and responses desired are controlled by the interviewer. Notice for example on TV how the setting of the interview and the style of interviewer is the dominant factor in how the interview is perceived. In general, participants in the interview become aware of the types of responses that are being requested and may adapt their behaviour and responses to meet the expectations of the interviewer. Thus one potentially significant limitation of the interview is that any responses obtained through the interview may be influenced with the personal biases and agenda of the interviewer: accordingly, careful training and selection of the interviewer is important to offset these possibilities.

Focus groups came out of the need by social scientists who were looking for a nondirective approach that "allowed individuals respond without setting boundaries or providing clues for potential response categories." A focus group, as described by Krueger,[9] usually consists of 7 to 10 participants who are randomly selected, but who represent the target group based on some common characteristics. The focus group is led by a skilled interviewer who creates a permissive and non-threatening environment in which participants discuss openly with each other the topic being investigated.

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[9] R. A. Krueger, Focus Groups: A Practical Guide for Applied Research, Second Edition, SAGE Publications, Inc., 1994

Focus groups provide an opportunity to identify within a target population not just the response to a question, but the reasoning and thinking behind the response. Focus groups are appropriate when there is a need to understand attitudes, preferences, and perceptions of people when they are interacting with others. This interaction serves to allow participants to respond to others and it stimulates ideas and memories that otherwise might not have been brought out. Focus groups have been used successfully in the areas of marketing, identifying trends, assessing customer relations, assessing quality, and providing detailed feedback on products.

One main disadvantage of focus groups is because of their reduced structure, there is a less than efficient use of time. Focus groups also require a highly trained interviewer to help keep the groups focused on topic. In addition, focus groups are relatively expensive to conduct and the data obtained is not necessarily representative of the larger population. Focus groups can be used at different phases of the program planning and implementation, depending on the need and on the specific issues at hand (e.g., acceptance of the concept in general, or getting information about a specific input or concept).

3.5.2.4 Panel Surveys

Panel surveys follow a small group, or panel, of respondents in order to measure changes over time in that group's behaviour. The respondents represent the target groups. The same respondents are surveyed in the "before" and "after", allowing the analyst to pair changes in behaviour and make assumptions about the population as a whole. Some panels – for example, in Puget Sound, Washington – have been conducted annually for the same individuals over 10 years. Methods were developed to introduce new respondents to the group, in order to replace those who had moved or who no longer could participate. The Puget Sound panels conducted an origin-destination survey, and also collected information about the ways in which the respondent households' travel-related behaviour had changed (e.g., regarding the purchase of a new vehicle). Thus, they focus on measuring changes over time. Panel surveys have the advantage of being less expensive than larger area-wide surveys; however, they must be seen as a complement to, rather than a substitute for, a larger origin-destination survey. The number of participants can vary according to the circumstances: however, a reasonable minimum number of, say, 10 individuals or households is required in order to maintain some consistency from year to year.

3.5.2.5 Conjoint Analysis (Stated Preference Surveys)

Conjoint analysis is used widely in consumer research, to help quantify how would-be consumers evaluate different types of products and the associated attributes. The analysis is based upon stated preference surveys, which use respondents' responses to a number of questions to quantify how they value different types of products or improvements. Whereas origin-destination (or so-called revealed preference) surveys capture how a 'consumer' – i.e., a traveller – *has* behaved in an actual situation, stated preference surveys are intended to describe how a traveller *would* behave in a situation with which s/he has no prior experience. They also can quantify *why* a traveller is not using an existing service (i.e., with which s/he thus has no prior experience), and what it would take for her/him to use it. It is important to note that stated preference surveys are not the same as attitudinal surveys (the latter by design being qualitative, open-ended and often subjective).
In transportation planning, stated preference surveys have had wide use in two applications: assessing the monetary value that travellers will pay in order to save travel time by using a tolled highway (how much time is the monetary value of the toll worth); and, assessing the value of the 'penalty' imposed on transit riders who currently take one bus all the way to their destination, when a new, better rapid transit system is implemented (which is more comfortable and faster, but requires them now to make a transfer and thus lose their seat, wait outside, and so on).

To date, stated preference surveys have had limited use in TDM. However, they could be used to:

- Fill a "predictive" role by ranking packages of initiatives, determining the value of initiatives to users, or by providing equivalent cost values.

- Quantify attitudes and awareness by measuring the change in the value of time (on transit, walking, etc.) before and after an advertising campaign. Stated preference surveys offer a more concrete way of quantifying attitudes.

3.5.3 Survey Response Rates

Today there are many software packages and online resources which make it very easy, compared to the past, to create surveys. This has not been entirely a good thing. Today, surveys are being conducted everywhere one looks, especially on the internet. Surveys are distributed through email on regular basis. If you visit for example an auto manufacturer's website you may be asked to complete a driver preferences survey. If you make a purchase online you may be asked to complete a customer satisfaction survey. Surveys have become so commonplace and frequent that people in general are reluctant to participate in any way. Therefore, one should expect and plan for relatively low participation rates, especially for online surveys.

In order to engage participants and to reduce the 'respondent burden," surveys should be:

- Worded clearly, in jargon-free terms, with the intended meaning clearly understood.
- Organized such that questions are asked in a logical, common-sense sequence. Clearly-defined instructions should be provided at every step, including explanations of the questions.
- As 'closed-ended' as possible – meaning that questions should be given finite response choices (e.g., 'yes/no,' multiple choice, ranking) and 'open-ended' questions (i.e., questions that ask respondents to write in their comments or opinions) should be used selectively.
- Illustrated with examples, where applicable. The examples should be realistic, but also hypothetical, so as not to bias possible responses.
- Complete and exhaustive in terms of the response choices for a given question (for example, mode of travel: all possible choices should be listed). Allow for "other" as a final response, and ask the respondent to explain (this allows the coder to back afterward and either assign the response to another choice, or other categorize the response).
- Subjected to a pilot test in all its aspects (i.e., the wording of the survey questions may appear to function well; however, the 'weak point' might be the order in which the questions are presented).

Other ways to increase survey response rates include providing a rational, direct, immediate and unambiguous answer to the question "What's in it for me?" or "Why is this important?" to the potential participant.

Finally, some agencies have offered a prize or recognition to those who participate. The prize could build on a relevant theme – e.g., a chance to win next month's transit pass. An alternative approach may be to offer to share the findings of the survey with those who participate.

3.6 Tier 2b variables: Databases and Outside Sources

3.6.1 Data from Regional, Provincial and National Sources

A number of data sources are available that contain aggregate data from different communities. Canada's key nation-wide data source is Statistics Canada; a number of useful Census statistics are available. The Census Place of Work / Place of Residence linkages indicate where workers "normally" work in relation to where they live (i.e., where they worked in the week prior to the Census). Since 1996, the mode choice also is indicated. These provide a robust source of data, given that every fifth household throughout the country is sampled. However, these are not necessarily 'true' trips (since they do not indicate stops along the way, e.g. to take a child to daycare, which may preclude the use of anything but the family auto); the data are collected in May, when the weather is warm; and, the May time period means that post-secondary classes have finished for the year (meaning that travel profiles of working students and institutional workers are improperly captured).[10] As well, confidentiality regulations mean that data for very small areas (or for small communities) may not be available, and so only data aggregated for larger areas might be available (and could mask what really is happening).

The Censuses of several countries have a similar variable. The American Census also captures the number of occupants in the vehicle (if the respondent indicates that s/he was in a private vehicle). The U.S. National Household Transportation Survey, which is conducted periodically, is a national origin-destination survey, which – although it has a very small sample size – provides a complement to urban origin-destination surveys (since it captures travel outside the urban area) and to the Census residence-home linkages.

3.6.2 Transferable Data from Other Communities

With improved technology and electronic data transfer techniques, there is increasing opportunity for communities, municipalities, and regions with similar socio-economic and/or geographic characteristics to share data. Where two communities have very similar infrastructure and socio-economic make-ups, overall travel patterns may be similar and cross applicable. Average distance travelled and number of days worked, for example, may be very similar in two different communities. Data from one community may be used as a proxy for data from another community. Note that when transferring data, it is equally important to ensure that the TDM applications are similar.

3.7 Tier 3 variables: Model Outputs

Travel demand forecasting models are used widely in transportation planning to estimate travel under future socio-economic and demographic (land use) growth and transportation network configurations and services. Most medium-sized and large communities have such models in place, and these generally cover the entire urban area. Walk and cycling trips are captured in some of the larger models, although to differing degrees of accuracy (and some models only consider these trips in the urban core). However, newer techniques are enabling a more profound treatment of these modes; and several models now also capture the ‘access’ mode to transit (i.e., park- / kiss-and-ride as well as walk to transit).

Models can output, essentially, the same types of data as may be collected or gathered in Tiers 1 and 2 – for example, counts on individual streets, ridership on a transit line, and – depending on the model – cycling and walk trips (note that capabilities vary among models). The difference is that the model outputs are synthesized (i.e., calculated with a mathematical, computerized model), rather than observed. On the one hand, model data can be used to address gaps in the observed data (e.g., if counts are available only for certain facilities, then the model can allow a broader coverage of the network, by outputting synthetic counts throughout the transportation network). However, the quality of data that are model outputs is dependent on the quality of the Tier 1 and Tier 2 data that are input into the model. Issues of precision and scale also arise (meaning that using outputs from a model that covers an entire urban region may not have sufficient precision to capture properly conditions at a specific individual site). For this reason, indicators calculated based on Tier 3 variables can be more uncertain than indicators based on Tier 1 and Tier 2 data. Model output is one of the only tools available to quantify the future impact of TDM.

As a final point, it is important to note that travel demand forecasting models are not intended to replace before-and-after measurement of TDM impacts. Rather, the application described here is to fill in gaps in observed data. At the same time, models have an important role in *predicting* TDM impacts; and the state-of-the-practice is described in the *Technical Report.*

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[10] In contrast, origin-destination surveys typically are conducted during the autumn, when students are in school, summer vacations are over, travel behaviour is stable, and it is still warm enough to capture pedestrians and cyclists.

4. CALCULATION, MODELLING, AND EVALUATION

Indicators can be measured three main ways: directly – through data collection; through calculation; or using outputs from a model. The focus of this chapter is to present guidance on how to evaluate key indicators.

Direct data (i.e. transit ridership) can be indicators in their own right, but are often combined with other data to calculate another more complex indicator (i.e. mode shift). Indicators that can be calculated directly from data are shown in blue in the exhibit. The accuracy of the indicator is directly dependent on the accuracy of the data collection and the ability to distinguish changes due to TDM from those due to other influences.

Some important indicators that can be evaluated directly from data include:
- Transit trips (ridership).
- Transit pass sales.
- Vehicle occupancy.
- Vehicle trips (generated, or past a set point).
- Pedestrian trips (generated, or past a set point).
- Awareness.
- Acceptance.
- Participation.
- Parking utilization.
- Productivity.
- Employee retention.

Some of the most important indicators for funding bodies and municipalities cannot be calculated directly from data. These indicators must be calculated using a combination of data, other indicators and “factors.” Drawing the path from data to a complex indicator can look like a tree; a very complex indicator may be calculated based on a number of simpler indicators, which may in turn be based on simpler indicators.

The remainder of this section is divided into five parts. **Section 4.1** talks about the different levels of impact assessment. **Section 4.2** explains the evaluation of modal share. **Section 4.3:** discusses the evaluation of KT indicators, and **Section 4.4** discusses the use of these indicators. Finally, **Section 4.5** presents examples, for reference.

4.1 Key Levels of Impact Assessment

There are three key levels in calculating the impacts of TDM initiatives:
- Data – all of the branches end at a data source.
- Calculated indicators, especially KT indicators.
- Financial effectiveness.

Of all the data sources, “OD Surveys” can supply the most complete set of information, although the information may be more difficult or expensive to collect with a high level of precision.

Readers may be familiar with the term “vehicle kilometres-travelled” (VKT), which describes activity by different types of vehicles (typically, the personal vehicle). These guidelines introduce two other KT Indicators: Transit Kilometres Travelled (TKT) and Active Kilometres Travelled (AKT), which describe transit and active transportation, respectively. Many of the most complex types of indicators (and those most requested by funding bodies) are dependent on these three key indicators that quantify changes in travel patterns: VKT, transit kilometres travelled (TKT), and active kilometres travelled (AKT). These are referred to as “KT Indicators.” Most of this section of the guidelines is dedicated to illustrating different ways to evaluate and use these indicators.

VKT, AKT, and TKT are calculated using some combination of the same basic indicators. They, in turn, can be used to calculate many more complex indicators.

“Overall Cost-Benefit” reflects the financial effectiveness of the initiative. It is the most complex indicator and also the most all-encompassing. A complete cost-benefit analysis should include all costs and.

Finally, remember that indicators measure the change over a given length of time; the indicator measures the change between the before case – before the TDM initiative was in place, and the after case – after the TDM initiative has been in place for some length of time.

All indicators can be approached two ways:

1. Find the before; find the after; calculate the difference
2. Find the difference directly – applicable in two situations:
   a) When you have already calculated the difference for one of the input indicators
   b) When the difference is more easily available than the before and after values.

This concept is explored further in subsequent sections.

4.2 Evaluating Mode Share

Several related terms define the evaluation of modal use. To start, mode share refers to the percentage of all travellers within a study area or study group who are using a particular mode. Mode share can be used to describe the share of any mode or combinations of modes for which data are available. Typically, these include auto (which in turn can be broken out according to auto driver or auto passenger; again depending on the availability of data), transit, cycling and walking.

The equation for mode share (MSh) is as follows, where *x* represents the mode:

MShx = number of users in mode x / number of total users in all modes

When referring to the relationship among multiple mode shares, mode split is inferred. Mode split is the ratio of travellers among two or more modes (often auto and transit alone; although this also can be applied to other modal combinations) rather than among all possible travel modes. Mode split (MSp) is expressed as follows, where *x*, *y* and *z* represent the different modes in question. The proportions of all modes examined should sum to 100%.

MSp expressed as MShx / MShy / MShz

Mode shift is the change in mode share for a particular mode over a regular period of time. Ideally, this should be specific and qualified, stating the modes involved in the mode shift before and after the initiative. Generally, it is acceptable to refer to either the ‘before’ mode (a shift *from* mode *x*) or ‘after’ mode (a shift *to* mode *y*) in cases where detailed data are not available. The equation for mode shift (ΔMSh)[11] is shown as:

ΔMShx = (MShx# in year B) - (MShx# in year A)

[11] The Greek letter Δ (delta) is commonly used to denote ‘change’ or ‘difference’ in mathematical equations.

4.3 Evaluating KT Indicators

The term “KT Indicators” describes the change in the travel *activity* made by different modes of travel – specifically, the private auto, transit or active transportation (cycling and walking). The concept of KT measures both the *number* of trips made by a given mode and the *distance* of trips made by this mode. TDM programs can influence both the number of trips and the distance of these trips. Thus, KT indicators are important to measure what the TDM initiative is actually doing in its own right, as well as being the basis of the calculation of environmental and other impacts.

This subsection provides an overview of *how* to evaluate KT indicators. Examples showing how to use this process follow in the final subsection (see **Section 4.5**).

4.3.1 Basic Components

The basic components of KT indicators never change. They are trips and trip distance. Multiplying the number of trips by the average distance of those trips is the most fundamental way to calculate KT.

TRIPS X TRIP DISTANCE

There are two ways to do this calculation: either as an *aggregate/average*, or for each *individual trip*. As an *aggregate/average*, trips would be the total number of trips; the trip distance would be the average distance of all of those trips. The KT can also be calculated for *individual trips* and then added together to determine the total KT: when looking at an individual trip, the KT is equal to the Trip Distance, because the number of trips is one.

4.3.1.1 KT by Mode or Groups of Modes

The approach to calculating the change in KT for each mode is essentially the same.

TRIPS by MODE X AVERAGE TRIP DISTANCE

- The total TKT is the number of transit trips multiplied by the average distance of a transit trip.
- The total AKT is the number of cycling and walking trips multiplied by the average distance of cycling and walking trips.
- The total VKT is the number of vehicle trips multiplied by the average distance of a vehicle trip.

Note that VKT can capture the activity of all types of vehicle, but it usually refers to trips made by the private automobile (i.e., by the personal vehicle, regardless of whether it is an automobile, or a light truck, minivan or motorcycle).

This calculation is simple when looking at conditions at a single point in time. It becomes more complex, however, when a mode shift occurs: that is, measuring the changes that occur over time when trips are diverted from one mode to another (a common goal of TDM).

4.3.1.2 Calculating Changes in KT

There are two ways to approach the evaluation of *average trip distance for trips that have shifted from the personal vehicle to other modes*. These are:

1. Find the trip distance for each trip that has shifted modes (i.e., for the relevant trips made by each individual who participates in the TDM program). Average those distances.

2. Calculate a standard average trip distance for each mode. This is based on the assumption that trips that are new to a mode travel approximately the same distance as trips that were already in that mode (i.e. the TDM initiative has not encouraged people to walk further, it has encouraged more people to walk about the same distance).

These same principles apply to the other KT Indicators. **Section 4.3.2** describes how these distances can be sourced.

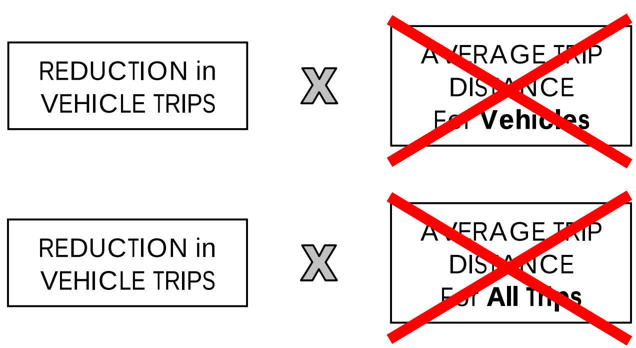
4.3.1.3 KT When the Mode is Changing

Every mode can have a different trip length. Vehicles and pedestrians have very different trip lengths. Even cyclists and pedestrians have trip lengths. A cyclist may travel a long distance, especially for a commute trip. Pedestrians are limited in the distance they can travel practically in a given amount of time (i.e. few people will walk for four hours to get to work in the morning).

If the measurement is taken at a single point in time, using an average trip distance will provide accurate results – even if all modes are averaged. It will not provide accurate results if there is a change (mode shift) between two modes with different average trip distances (i.e. auto to walk).

For example, VKT reduced is one of the most common indicators; it can be used to calculate GHG reduced or CAC reduced because private vehicles produce emissions with every kilometre travelled. The total VKT is equal to the reduction in *Vehicle Trips* multiplied by the *Average Trip Distance for Vehicles*. However, when examining the reduction in VKT, the average trip distance of the ***new*** mode must be used, because the average trip distance for ***all*** vehicles trips may not be the same as the average trip distance for the ***trips that used to be vehicle trips*** (trips that shifted modes). The relationship looks like this:

By comparison, the two relationships shown below (using the average distance for ***vehicles*** or the average distance for ***all trips***) will **not** provide accurate results:



This distinction is important because different trip distances may be more amenable to diversion to other modes: for example, long distance trips are more likely to stay with auto (or possibly switch to transit) than they are to cycling or walking, while very short distance trips are those that are most conducive to switching to the walk mode.

Note also that VKT is measured in terms of *vehicle*-trips, whereas TKT and AKT are measured in terms of *person*-trips. VKT can be converted to *person*-trips by applying a vehicle occupancy factor (typically, the average number of persons – including the driver – in a vehicle). This conversion (person-trips to vehicle-trips, or vice versa) ensures that modal shift comparisons use a common basis.

4.3.2 Determining Average Trip Distance

Average Trip Distance can be determined using a number of sources:

- The Census of Canada collects place of work and place of residence information for the workers in 20% of all households across Canada. The linkages can yield an approximate indication of trip distance by mode, again if geocoded distances are available. This information cannot be filtered online, but full data sets are available for purchase. Although the sample size is quite large and covers the entire country, confidentiality restrictions may limit the level of detail for specific applications. Contact Statistics Canada for more information.
- Some regional or municipal travel demand forecasting models can estimate the average distance by mode for the existing (base) case.
- The information can be collected through some type origin-destination O/D survey or trip diary.
  - Random sample of the population at large (typically conducted in major urban areas across the country)
  - Random sample of the target population for a proposed TDM program
  - Random sample or even a census (100% sample) of the participants in an actual TDM program

  Here again, however, a GIS may be needed to accurately reconstruct the distances, because survey respondents typically can supply information about the location of the origin and of the destination of the trip, but very few individuals are able to recall, even approximately, the actual distance travelled.

Many municipal, regional and Provincial / Territorial governments and other public agencies use geographic information systems (GIS) to store, manage and analyze planning and other data, and to present these data graphically on a map. GIS is an extremely useful tool that can be paired with O/D survey or other data to calculate the distance between an individual's place of residence and place of work / school. The distance can be calculated according to the shortest route. However, note that 'as the crow flies' distances are not useful, because they do not reflect the actual routing taken by the trip. Rather, we are interested in following the actual path or route taken by the mode of interest: for example, if one is travelling by auto, then the route must account for one-way streets; or if travelling by transit, then the path must account for the transit route as well as the walk to the boarding transit stop and from the alighting transit stop. Depending on the capabilities of the individual GIS, routing by different modes and under specific local conditions may be calculated – for example, one-way traffic prohibitions generally do not apply to pedestrians; and cyclists, pedestrians and autos may be able to take advantage of a more direct route than that offered by public transit.

The average trip distance should be determined for each mode. Differences between alternate sub-modes that cover the same origin and destination should be taken into account: one way is to average the distances among the competing sub-modes. For example, an origin and destination could be served by a surface bus that serves local streets, by an express bus that is more expensive but which uses the main road network, and by a commuter rail serves that is reached via a local bus.

4.3.3 Determining the Number of Trips

4.3.3.1 Determining Trips per Length of Time

The indicator should describe a change per some unit length of time – i.e. KT per day, KT per month, or KT per year. For the KT indicators, this is done by defining the time period for the trips per mode.

Normally, data collection provides trips over a short time period; common measurements are trips per day or trips per hour. It is also important to understand which day or which hour – the number of trips on a Saturday may be very different than the number of trips on a Tuesday. Similarly, the number of trips between 8:00 am and 9:00 am may be very different than the number of trips between 1:00 pm and 2:00 pm. Whatever data are used, they must be factored to reflect the time period needed for the indicator. Typically, VKT is reported in VKT reduced per year. Alternatively, one could report VKT reduced over the whole life of the initiative. The same basic logic is needed: Trips per year is the number of trips per day times the number of days.

TRIPS per DAY	X	NUMBER OF DAYS

For a commuter program (or, similarly, a school program) this calculation must be more specific. To determine the VKT reduced per year, estimate the number of trips per workday and the number of workdays per year.

TRIPS per WORK-DAY	X	Number of WORKDAYS per YEAR

Determining the number of days is very similar to determining the average trip distance: it must be done through surveys, or using an estimation based on some other data. The number of days is very important in the measurement of TDM.

Many regional O/D and Trip Diary surveys ask respondents about their travel activity on the "past day" (typically, this is 'yesterday,' to get the most recent data for a complete day, while the information still can be recalled easily). However, many TDM initiatives encourage travellers to change their behaviour only once or twice a week (i.e. telework programs), so it is important to ensure that the correct frequency of the activity is taken into account. Accordingly, O/D and Trip Diary surveys for TDM should ask about activities over the "past week" to get a more accurate description of travel behaviour – i.e., they should ensure that the frequency and day-by-day variation is taken into account.

4.3.3.2 Determining the Number of Trips

The number of trips per day or hour is normally a data indicator – it is not calculated, it is derived directly from the data collection. The following methods can be used to determine the number of trips by mode:

- Count trips by each mode
  - At a fixed point or a number of fixed points (cordon)
  - Entering or exiting a site (trip generation)
- Use an O/D or Trip Diary survey and determine how many trips the respondents made and what modes they used.

In order to determine the change in trips by a certain mode and to pair that change with an average trip distance, mode shift is required.

4.3.3.3 Determining Mode Shift

In some cases, it is important to understand the mode shift. This is especially important when the change in the number of trips by mode will be used to calculate a VKT, because of the challenges with average trip distance. It is also important when a program has very specific goals, i.e. to shift trips from auto to cycling. Mode shift can be determined using two general strategies:

1. Determine the "before" mode share (i.e. % vehicle driver, % vehicle passenger, % transit, % cycle, % walk) ; determine the "after" mode split (i.e. % vehicle driver, % vehicle passenger, %

transit, % cycle, % walk); calculate the difference in before and after for each mode; estimate the percentage that shifted FROM each mode TO each mode.
2. Using a panel survey or another similar technique, pair each individual's "before" behaviour with his/her "after" behaviour, and then directly calculate the difference.

Remember that there may be other factors (not TDM) that cause mode shift. It is important to be as clear as possible about what portion of the mode shift is due to TDM and what portion is due to some other factor. Making this distinction is not always simple. However, several techniques can be used:

1. Depending on the number of respondents to the survey, it may be possible to partition the O/D survey data into sub-groups, according to the 'after' mode choices – for example, groups of former auto users who now used transit, and former auto users who now walked. A comparative analysis of the characteristics of each sub-group would help to provide an understanding of the different characteristics associated with each type of modal shift: for example, from our O/D survey we might determine that the average transit trip has a distance of 7.0 km, and the average walk trip has a distance of 1.5 km. So, an employer transit pass program *likely* would not generate much of an impact on very short trips (meaning, in other words, that shifts from the auto to walk trips likely had nothing to do with the employer transit pass program).

2. When conducting before and after O/D surveys, whether for a panel or for a larger group, ensure that very precise details are gathered regarding mode choice (before and after) and the reasons for the choice. For example, it is common in O/D surveys to ask transit users (or cyclists or walkers) whether or not they had an auto available for this trip (i.e., whether or not they had a choice in modes). People who did not have an auto available to them for the trip (either because they do not own an auto or because someone else in the household needed the auto) are considered as 'captive' to transit (or cycling or walking) – i.e., they did not have a choice. This information is very important. However, we also need other information: for example, if the person did not have a choice for this trip, did the availability of the TDM program change the *frequency* of trips (meaning s/he might have made more trips than before, even without the availability of the auto); or were other people in the household affected by the availability of the TDM program. We also want to know whether the availability of the alternative to driving has affected households' ownership of vehicles – for example, were people able to defer or avoid the purchase of a second auto as a result of the program.

3. Stated preference surveys, described in **Section 3.5.2.5**, quantify the factors behind different choices – i.e., they quantify how people value different choices. Although stated preference surveys require much smaller sample sizes than O/D surveys (to cover the same-sized study area or study group), the former can be much more expensive on a per-unit cost; and so they may be practical only for more comprehensive TDM applications.

4.4 Using KT Indicators

4.4.1 Calculating GHG using VKT

For most practitioners, the impact of TDM measured in terms of GHG emissions will be of great interest because of the requirements of funding bodies and public interest in air quality and climate change. The level of emissions is directly related to the volume of fuel consumed. However, fuel consumption is dependent on factors such as travel speed, resistance from wind and grade, acceleration rate, and the distance travelled for each vehicle, which can be very difficult and arduous to calculate at a disaggregated level. In practical terms, the simplest way to reliably derive the GHG measure is by using the appropriate factors for fuel efficiency[12], and GHG[13] and CAC[14] emissions

[12] http://wwwapps.tc.gc.ca/prog/2/UTEC-CETU/FuelEfficiency.aspx?lang=eng
[13] http://wwwapps.tc.gc.ca/prog/2/UTEC-CETU/GhgEmissionFactors.aspx?lang=eng
[14] http://wwwapps.tc.gc.ca/prog/2/UTEC-CETU/CacEmissionFactors.aspx?lang=eng

from Transport Canada's website for the Urban Transportation Emissions Calculator (UTEC). These factors will require the VKT as a direct input:

FUEL CONSUMED (litres) = VKT (km) X FUEL EFFICIENCY (1itres /100km)

GHG(kg) = FUEL CONSUMED (litres) X UTEC GHG Factor / 1000

4.4.2 Calculating Criteria Air Contaminants using VKT

Calculating CAC emissions is important both for funding and for understanding air quality impacts on health care costs. Note that the choice of CACs depends on the specific application of interest – i.e., different factors may apply for HC, NOx, particulate matter, etc.

CAC(kg) = VKT (km) X UTEC CAC Factor / 1000

CAC (kg) = VKT (km) * UTEC CAC Factor / 1000

4.4.3 Calculating Health Care Costs using KT Indicators

Health care cost savings due to TDM can also be estimated. TDM can impact health care costs in a number of ways. These can include:

- Reduced number of injuries and fatalities due to a reduction in vehicle travel
- Reduced health problems (and costs) associated with obesity and inactivity due to mode shift from auto or transit to an active mode
- Decrease in air pollution (CAC) leading to reduction in air quality related health costs.

TDM can impact health care costs in other ways that are more difficult to quantify, including reduced stress from driving.

The three indicators described above (health care costs – collisions, health care costs – inactivity, health care costs – air pollution) can all be calculated using KT indicators.

4.4.3.1 Health Care Costs – Collisions

The basic components of Health Care Costs due to collisions are the number of collisions and the health care cost per collision.

HEALTH CARE COST (COLLISIONS) = NUMBER of COLLISIONS X HEALTH CARE COST per COLLISION

The cost of a collision varies by location and collision types. Health care authorities or insurance bodies may be able to provide this type of local information.

4.4.3.2 *Collision Types and Costs*

Collisions can be categorized into four overall groups:

- Fatal
- Serious injury
- Injury
- Property damage only

Each group has different types and values of cost associated with it. Property damage only collisions, for example, are not associated with health care costs. They do, however, have a personal cost for the vehicles owner and a cost for the insurance company.

Remember that the *health care costs* for a serious collision may be greater than the *health care cost* of a fatality. Fatalities have the additional cost of human life, which is difficult to quantify and should be addressed separately. Non health-care cost of fatalities can be calculated using the same logic as health care costs, but the cost per fatality should be estimated through consultation with insurance providers.

Health care cost per collision can be calculated in sub-groups (fatalities, serious injury collisions, injury collisions) and summed for greater accuracy. Alternatively, aggregate values can be used.

4.4.3.3 *Estimating the Number of Collisions*

The risk of collisions is related to exposure – to the number of kilometres driven. Collisions reduced can be estimated as VKT times a collision factor (number of collisions per VKT)

VKT X COLLISIONS PER VKT

The relationship between VKT and collisions can be defined nationally, regionally, or locally if the total number of collisions and the total number of VKT (including external and through trips) are known for an area. This is difficult to do on the local level, because few municipalities know how many VKT were on the entire road network in a year.

The VKT for all of Canada is available, as is the number of collisions in all of Canada in a given year. Determining a factor using these values is recommended

4.5 Examples

Regardless of the data source, a direct comparison of measures before and after TDM implementation will be required to determine impact. This means that when an indicator such as mode share or VKT is referenced, it is the change in the value that is most important.

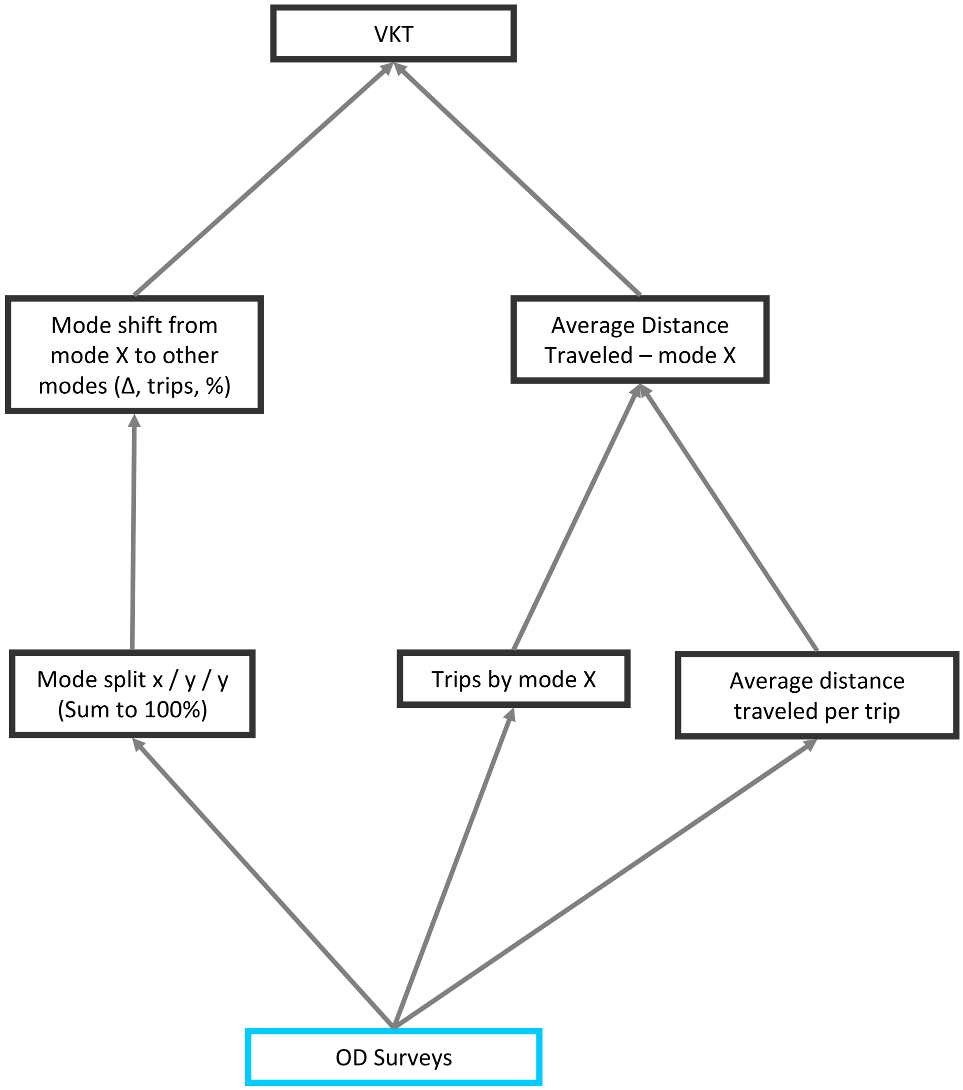
4.5.1 Evaluating GHG and CAC from VKT

O/D or Trip Diary surveys are the most direct way to gather information regarding trip making. The information can be ascertained through elasticity and forecasting models, but is often not reliable because the results are dependent on the original direct data inputs and the associated precisions.

From O/D Surveys (using panel or interview method)
Surveys where the individual travellers are interviewed and asked questions that specifically define trip making behaviour will provide a disaggregated level of detail in the data and provide the flexibility to reduce the number of assumptions required. One approach is to engage a panel group for surveys over a two year period. From this group, the VKT travelled by mode, purpose etc. could be tracked for Year 1, with a follow-up survey in Year 2 to ascertain mode choice changes by purpose and distance

travelled. The total VKT reduced can be calculated based on the survey results using the relationship seen in**Exhibit 2**.

Exhibit2: Determining VKT from Interview Survey Results



From the survey results, the following indicators are needed:

- Number of participants who changed behaviour
- Number of person trips reduced per day by mode (mode shift in trips per day)
- Number of days travelled per year
- Trip distance by mode

In a simplistic example, VKT can be derived in one of two ways using interview data with the above parameters:[15]

Reduction in VKT_{sample} = $\sum_{per\ sample}$(# of daily trips reduced * # of days/year * avg distance reduced)

or

Reduction in VKT_{sample} = Avg # of daily trips reduced * Avg # of days/year * avg total distance reduced

The resultant VKT from the sample will then need to be stratified to reflect the entire population:

Reduction in $VKT_{participants}$ = Reduction in VKT_{sample} * number of participants / sample size

The calculation of VKT is more flexible and accurate using interview survey data. Some assumptions may still be needed depending on the level of detail of the survey questions and the disaggregated data can be and is often combined to create assumptions at the localized level.

From Direct Data
An example of the deriving VKT from direct data (or Tier 1 data; see **Section 3.4**) is the use of cordon volume counts by mode, or mode choice surveys before and after the implementation of a TDM initiative. The difference before and after TDM implementation will then provide the basis for calculating a VKT based on the mode share or mode split, and the mode shift established. This is ideal for site specific applications, such as school or employer based programs where cordon counts can be easily conducted. This method is illustrated in**Exhibit 3**.

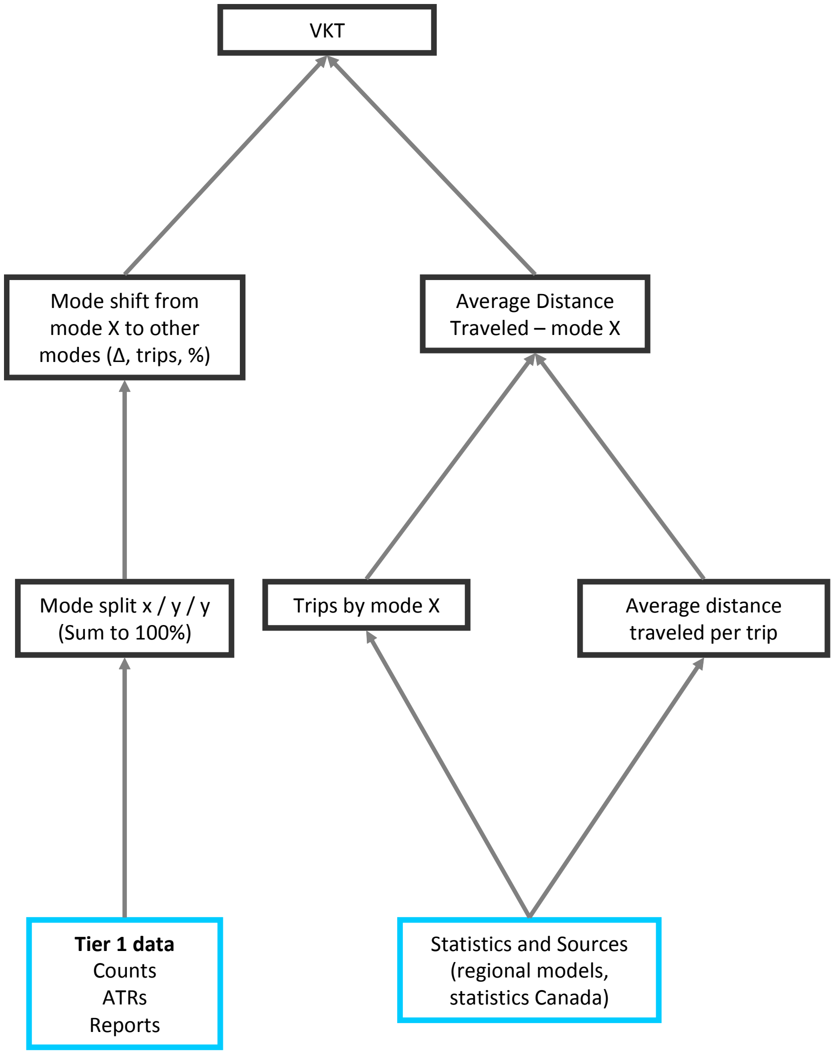
For instance, a university conducts an annual traffic count of vehicles and persons travelling to and from its campus by mode for a representative period of time. The university can determine the change in VKT using the change in mode share or mode shift.

What you need to count (simplified example):

Total person trips in private autos in Y1	=	10,000 person trips
Total person trips in other modes in Y1	=	10,000 person trips
Y1 mode share: 50/50		
Total person trips in private autos in Y2	=	10,000 person trips
Total person trips in other modes in Y2	=	12,000 person trips
Y2 mode share: 45/55		

[15] ∑ represents the “sum.” This calculation asks the practitioner to find the VKT reduced for EACH participant and then add all the VKT together.

Exhibit 3: Calculating VKT using Tier 1 Data and Outside Sources



In this example, the total number of trips goes up. This could be due to some other change at the University (i.e. increase in enrolment). At first, it seems like the TDM initiative has failed – the number of vehicle trips has not gone down. Looking at the mode split, however, shows that trips have shifted from autos to other modes.

Mode shift (given as a %)	=	-5% in auto mode share
Total person trips in Y2	=	22,000 person trips
Y2 total in autos using Y1 mode share	=	11,000 (50% of 22000)
Y2 total in autos using Y2 mode share	=	10,000 (45% of 22000)
Mode shift (person trips)	=	-1,000 auto person trips

Where Y1 = Year 1
Y2 = Year 2

What can be assumed:

Vehicle occupancy in auto (VO):	=	1.1 persons/auto
Average length of trips shifted km):	=	7 km/trip

The average length of trips shifted is the average length of trips by other modes. In this case, the majority of "other" trips were by transit. Here, the municipal government provided 7 km/trip as an estimate length based on the results of its travel demand forecasting model.

Reduction in VKT

= mode shift in persons * VO * Average km travelled per trip
= -1,000 / 1.1 * 7
= -6,364 km or a reduction of 6,364 in VKT for period X

The approach in this example is limited in that the average distance travelled by auto would grossly overestimate the VKT if the mode shift was predominantly due to shifts to an active mode with shorter travel distances. In other words, it is important to understand the characteristics of the 'sub-market' of personal vehicle users that would be most likely to shift to other modes. This sub-market is defined in terms of trip distance as well as trip purpose. Estimates can be derived from profiling origin-destination survey data to identify the average trip lengths of pedestrians and cyclists, and then use this average to calculate the applicable average trip length by auto. For example, an average pedestrian trip might be 1.0 km and an average cycling trip might be 2.5 kilometres, compared with the 7.0 km average cited above for auto trips. The appropriate value, then, for the equation would be the walk or cycling average. The trip purpose also is important, because commuters to or from work or school (who have little to carry and who might have to pay for parking) might be more conducive to switching to active modes than, say, shoppers who must carry bags, etc., and for whom parking may be free.

The same situation holds true for diversion to transit trips, whose average trip lengths and trip purpose mix also may differ from those of the auto.

4.5.2 Using Attitudinal Surveys to Derive Employee Satisfaction and/or Employee Retention

Attitudinal survey results can be used to effectively gauge employee satisfaction with changes as a result of a TDM initiative. In situations where it is not practical or affordable to include everyone in the survey, it may be possible to sample a subset of the employee pool in order to draw conclusions about the entire company. This leads to the obvious question, how many employees need to be surveyed, or in other words, what is an appropriate sample size? Unfortunately, the only simple answer to this question is to say, "It depends." The sample size needed depends on several different factors which include:

- The level of accuracy needed in the survey. A higher level of accuracy requires a larger sample size.
- The size of the population. A very large company will require a larger sample size than a smaller company.
- The amount of variation found in the population. For example, if it is known that management will have different satisfaction responses than administration, then the number of employees sampled will need to be increased to ensure that sufficient numbers of both groups are included.

Sample size should be determined before engaging the survey in order to determine whether the results will provide the confidence needed to defend the conclusions. In statistical terms, the accuracy of a sample size is expressed in terms of *confidence interval* and *level of confidence*. These two terms are interrelated and full descriptions about them may be found in many statistical books and resources, such as Rea & Parker[16]. More information about determining sample size is found in **AppendixB**.

[16] L. M. Rea and R. A. Parker, "Designing and Conducting Survey Research: A Comprehensive Guide," Second Edition, Published by Jossey-Bass, 1997

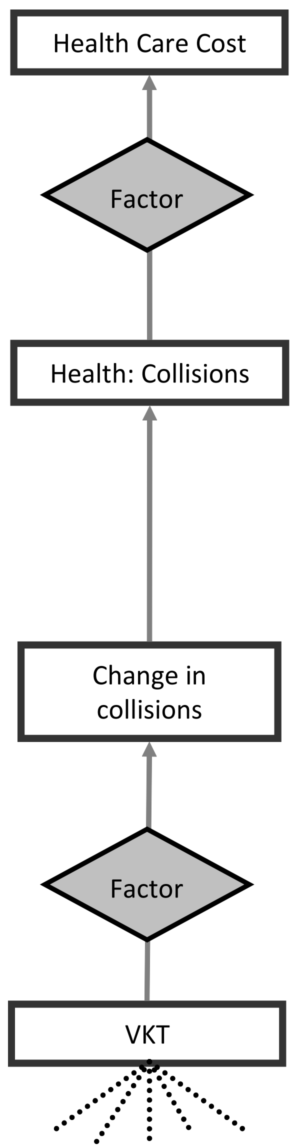
4.5.3 Using VKT and Collision Data to Derive Health Care Costs from Collisions

The impacts of TDM on health care costs can be estimated by relating the reduction in VKT to a reduction in the total number of collisions. A factor to relate total VKT and total collisions can be developed on a national level: this is simply the total number of collisions in Canada annually divided by the total VKT in Canada annually. National VKT may be more accurate and readily available than local data, as most municipalities are unable to determine their total VKT per year (including through traffic). Exhibit 4 shows the relationship between health care costs and VKT.

The use of local collision data per VKT to determine health care costs requires:

- Collision rate from local or national source (collisions causing bodily harm/VKT)
- Health care $ / serious injury collision (based on information from local health authority)

Exhibit 4: Estimating Health Care Costs from VKT



5. GLOSSARY

This section explains and defines key terms that are essential to the discussion of TDM and TDM impact measurement.

Assessment Levels
Within the evaluation framework, a TDM initiative can be evaluated on a number of different levels, each of which involves its own indicators and measurements.

Average Vehicle Ridership (AVR)
This is the ratio of the total number of travellers (all modes) to the total number of private vehicles. Again, this number is always equal to at least 1.0. It can be calculated as the total number of person trips (all modes) divided by the number of vehicle trips.

Best Practices:
The term "Best Practices" is used across many disciplines to describe desirable or successful approaches to a process or problem. In the Transportation Association of Canada (TAC) ***Best Practices for the Technical Delivery of Long-Term Planning Studies in Canada***, best practices were defined as either "applied innovation" or "practices proven successful." The same definition is applied in this guide.

Cost-effectiveness
Cost effectiveness is the value received for the investment. This is normally an economic measure of the results of a program, although it can also be expressed as a cost per unit (i.e. cost per tonne of CO_2 reduced).

Counts
Counts record and report data using actual observations (manual or automatic). Counts can record the number of vehicles, vehicle occupants, pedestrians, bicycle riders or other information across a cordon, at an intersection, or generated by a site.

Criteria Air Contaminants (CACs)
Environment Canada identifies seven air pollutants that are considered to be CACs. The seven contaminants are Total Particulate Matter, Particulate Matter with a diameter less than 10 microns, Particulate Matter with a diameter less than 2.5 microns, Carbon Monoxide, Nitrogen Oxides, Sulphur Oxides, and Volatile Organic Compounds.[17] More information on CACs can be found through various Environment Canada sources (www.ec.gc.ca).

Efficiency versus Equity
Transportation systems often have two different purposes. The first is the efficient movement of people and goods. The second is providing equitable access to all people. Often, one investment may provide both equity and efficiency, but other times they are mutually exclusive. For example, a new LRT line connecting a dense residential development to a downtown core may provide good efficiency returns based on the number of people moved and travel time for the financial investment. A bus serving a sprawling community with few riders may not be efficient (low returns for investment) but high equity (provides access for residents in that community who don't have access to a car).

Greenhouse Gases (GHG)
Environment Canada defines GHG as "gases in the atmosphere that trap energy from the sun. Naturally occurring GHGs include water vapour, ozone, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Without them, the Earth's average temperature would be about 33°C lower than it is, making the climate too cold to support life (Schneider, 1989). While these naturally occurring

[17] Environment Canada, *Air Pollutant Emissions: Glossary*, http://www.ec.gc.ca/pdb/cac/cac_gloss_e.cfm,2007-03-09.

gases are what make life possible, a serious concern today is the enhanced effect on the climate system of increased levels of some of these gases in the atmosphere, due mainly to human activities."[18] In order to meet Canada's GHG reduction targets, Canada monitors six gases (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), perfluerocarbons (PFCs), and hydrofluorocarbons (HFCs)).[19] Emissions from fossil fuel combustion for transportation include CO_2 (94.7%), N_2O (5.1%) and CH_4 (0.3%).[20]

Mobility Management (MM):
Mobility Management is the European term used to describe activities that promote sustainable transportation and reduce or manage demand for auto travel.[21] It is used in essentially the same context as **TDM**.

Mode share, Mode split, and Mode shift
A transportation mode describes a type or means of transportation. The number of modes differs for different types of analysis, organizations, or areas. Often, transportation models or analysis will take into account only one mode (auto) or two modes (auto and transit). For other models or types of analysis, the list of modes can be very extensive, with a number of sub categories. Some of the modes used for analysis include:

- Auto
  - Drive alone (also known as single occupancy vehicle (SOV))
  - Auto as driver
  - Auto as passenger
  - Auto with others from the same household
  - Auto with others from different households
  - Taxi
  - Motorcycle
- Transit
  - Bus
  - Light rail
  - Heavy rail (subway)
  - Commuter Rail
  - Ferry
- Active transport (modes of transport that are human-powered)
  - Walk
  - Cycle
  - Skateboard / rollerblade
  - Wheeling (wheelchair, scooter)

Some trips may include two or more modes. For example, a traveller may walk to a bus stop or drive to a park-and-ride.

Three different terms are used to describe the relationship between the different modes. These are mode share, mode split, and mode shift.

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[18] Environment Canada, *Greenhouse Gas Sources and Sinks: Frequently Asked Questions*, http://www.ec.gc.ca/pdb/ghg/about/FAQ_e.cfm,2006-11-18.

[19] Environment Canada, *Information on Greenhouse Gas Sources and Sinks: Monitoring, Accounting and Reporting on Greenhouse Gases*, http://www.ec.gc.ca/pdb/ghg/ghg_home_e.cfm, 2008-12-11.

[20] Environment Canada, *Information on Greenhouse Gas Sources and Sinks: Factsheet 3 – Transportation*: 1990-2000, http://www.ec.gc.ca/pdb/ghg/inventory_report/1990_00_factsheet/fs3_e.cfm, 2009-02-04.

[21] European Platform on Mobility Management, General Information, http://www.epomm.org/index.phtml?Main_ID=820

1. **Mode share** describes the percentage of all travellers using that mode. This is usually used when there are multiple modes and considers auto, transit, cycling, and walking.
2. **Mode split** normally describes the ratio of travellers between two or more modes (often auto and transit; although this also can be applied to other modal combinations) rather than among all travel modes.
3. **Mode shift** describes a change in travel patterns of a percentage of travellers from one mode to another over a given period of time. For example, if 100 of 100 employees in an office complex drove to work before the TDM initiative and 15 of 100 of those employees walked to work after the TDM initiative, the initiative has resulted in a mode shift of 15% from auto to walk mode.

Mode share, split, and shift should always be qualified (which mode (share); which mode compared to which mode(s) (split); which original mode(s) to which new mode(s) (shift))

Objectives, Indicators, and Measures
To evaluate the effectiveness of TDM, a program must first set objectives, identify indicators and then choose measures to evaluate success based on those indicators.

- **Objectives** are the overall goals of the program. They should reflect the purpose of the organization and the intention of funding bodies.
- **Indicators** describe the desired output or outcome based on the objectives set for the program. It describes an attribute of the programs performance.
- **Measures** are the means used to quantify or qualify the indicator. Measures can be quantifiable values such as percentages or rates, or they can be clearly defined qualitative values such as high, medium, low. Measures must be monitored at regular intervals to show changes over time.

For a TDM program, an example objective may be to lower travel by car with an indicator of reducing VKT by 5% a year. The measure would be the year-to-year change in VKT.

Outputs versus Outcomes
TDM programs have two types of results: outputs and outcomes.

- **Outputs** are the activities and processes of the program itself. They are the actions taken to achieve the overall goals of the program. Outputs include measures like the number of customers served or the number of brochures distributed. Outputs are necessary to achieving outcomes.
- **Outcomes** are the results of the program that will be measured against the overall goals. These may include emissions reduced, mode shift, or VKT reduced.

Person-Trip
A person-trip is a movement between one origin and one destination by a single person for a single purpose, using any mode or combination of modes. One person travelling by car between home and work is one person trip. Two people in one car travelling from home to work is two person trips.

This definition describes both ends of a trip. It should be noted that some TDM impact measures also consider the person-trip, or vehicle-trip (see below) in terms of the trip end to or from that site (i.e., the other end of the trip is not important): this is the case when considering trip generation rates to/from a specific site.

Surveys
Surveys ask individual respondents to provide data about their own actions and experiences directly. There are several different types of surveys:

- **Origin-destination survey**, also known as a revealed preference or travel behaviour survey, quantifies people's travel patterns by asking them to describe their actual travel activity (i.e., what they actually did) over a specified period of time. Information typically is gathered about the trip's origin, destination, purpose, mode(s) used, start time and end time.
- **Stated preference survey** quantifies how people *would* behave under a situation with which they do not yet have any experience. Stated preference surveys typically are used to quantify how people value travel time saved for a new toll road (i.e., their willingness to pay a toll of $X in order

save Y minutes of time), or the willingness of transit patrons to make a transfer to a new, faster rapid transit system, which might replace taking a slower bus all the way (i.e., the inconvenience of having to transfer mid-way in a trip, even if that trip is now faster or more comfortable).

- **Attitudinal surveys** also assess why people make the travel decisions they do, and how they might behave in a new situation, among other attributes (e.g., customer satisfaction with an existing programme). While this assessment is qualitative, it provides useful information for programme managers.

Vehicle Kilometres Travelled (VKT)

VKT, or Vehicle Miles Travelled (VMT) is a fundamental measure of vehicle activity, or usage – in this context, the reference is to the activity of personal vehicles. VKT measures the distance travelled by autos in a given time period in a given area. It reflects both the total number of vehicle trips and the distance of those vehicle trips (hence reductions in auto trips and auto trip distance will both reduce VKT).

For example, consider one person who commutes alone five kilometres from home to work five days per week. The individual's total weekly VKT is 5 km * 2 trips / day * 5 days / week, or 50 VKT. Prior to the introduction of TDM initiatives, the person drives alone. As a result of a TDM program, the commuter now cycles three days per week and drives alone the remaining two. The TDM program has shifted two five kilometres trips, three days per week from auto to bicycle. The commuter's VKT has dropped by 30 kilometres travelled per average work week (5 km * 2 trips / day * 3 days/week = 30 VKT).

In another example, an increase in the workplace parking price now might induce our commuter to drive to the nearest park-and-ride lot, and continue the trip via transit. In this case, the number of vehicle-trips remains the same, but vehicular portion of the commute distance has dropped.

As another example, suppose a neighbour, who formerly drove alone to her place of work, now drives the first commuter to his place of work. So, although the first commuter continues to drive all the way, 5 days per week, she is now transporting two people, reducing their combined VKT.

A reduction in VKT may be the central goal of a TDM program, or a change in VKT may be used to estimate progress against other goals. Changes in VKT are directly linked to changes in GHG and CAC emissions, as well as fuel use and other indicators.

Vehicle Occupancy

Vehicle occupancy is the ratio of the number of people per vehicle. This number is always equal to at least 1.0, because there must always be at least one person (driver) in each vehicle. Vehicle occupancy rates consider private vehicles only and do not normally account for transit or active mode trips. It can also be calculated as the number of person trips by auto mode divided by the number of vehicle trips.

Vehicle-Trip

A vehicle-trip is a movement by a single vehicle between one origin and one destination for a single purpose. One vehicle trip may be equivalent to one or more person-trips, dependant on vehicle occupancy.

Appendix A
TDM Evaluation Framework Planning Sheet

TDM Evaluation Framework Planning Sheet

TDM Program Name:		
1.	List the program's **goals**:	
2.	List **target groups**:	
3.	What **initiative** or group of initiatives is being measured? (complete one table for each group of initiatives to be measured separately)	
4.	Choose **assessment levels** and check one or more of the boxes below. ☐ S – System Conditions ☐ P – Personal Information ☐ A – Activities Undertaken ☐ B – Customer Satisfaction ☐ C – Awareness ☐ D – Participation ☐ E – Short-term Change ☐ F – Long-term Change ☐ G – Personal Impact ☐ H – System Impact ☐ I – Financial Effectiveness	
5.	Choose **indicators and define your measurement strategy**:	
	What external factors are you considering in Level S?	
	What personal information (Level P) do you need to identify sub-groups?	
	For each of the assessment levels from A to I checked in step 4, identify one or two indicators.	
	Divide those indicators into component parts (if applicable). Chart the relationships and look for overlaps (use a separate sheet). Refer to the indicator relationships exhibit for guidance. **Make a list of other information you need to calculate those indicators.** Add any personal information to your Level P indicators list.	

TDM Evaluation Framework Planning Sheet

TDM Program Name:		
	When and how often do you plan on collecting data?	
	Decide on a balance between Tier 1, Tier 2a, Tier 2b, and Tier 3 data. For surveys, what sampling strategy will you use?	
6.	Make a list of the **baseline data** you need and identify how you will be collecting that data. Look for efficiencies with data you require for project planning.	
7.	Identify which indicators you expect to set targets for.	
8.	Make a list of all the **after data** you need and identify how you will be collecting that data.	
	Look at your list of after data. • Put a checkmark beside data that is not expected to change between the before and after measurements. Do not collect this data twice (only collect it in the baseline assessment). • Highlight data that can be collected on a smaller scale in the follow-up survey	
9.	Refer to **your** chart of indicator relationships from Step 5. List the factors and assumptions you will be using in your **evaluation**. If a factor or assumption is unknown, identify how you will fill in the missing information.	

Appendix B
Survey Standards and Sampling

B1. BOUNDING DATA AND CALCULATION

TDM initiatives cover a wide range of scopes, geographic areas, target groups, and budgetary and time constraints. It is not reasonable to expect every project to have the same precision or accuracy of data and calculations. In this section, four different bounding levels are identified with high-level guidance on how to design a data collection and evaluation strategy within that bounding level. The bounding level should be chosen under the guidance of the funding body (e.g. Transport Canada) or agreed upon by key stakeholders.

Strategies for collecting data and evaluating indicators:

- Dependent on Tier 1 data, national factors, and well-supported assumptions derived from smaller-scale surveys or panel groups. Assumptions should be made clear in supporting documents. Practitioners also must describe assumptions for adjustments, based on changes in the project context.
- Data derived from random sample OD/Trip diary of the general population
- Data derived from random sample of participating population. Practitioners also must describe assumptions for adjustments, based on changes in the project context.
- Minimums reporting by willing participants. Can be used where reporting is a function of participation (i.e. in Whitehorse, participants in the “Wheel 2 Work” cycling program logged the number of kilometres they cycled on their commute each day – reporting was an inherent part of the program). In this case, practitioners should try, through program design, to have all participants directly report their change in travel behaviour. In some cases, not all participants or travel behaviour will be reported, making this a “minimum” change achieved. Practitioners also must describe assumptions for adjustments, based on changes in the project context.

B1.1 Data Sampling

If the population is small enough and easily accessible, such as for example the employees of a medium sized company with email access, it is quite possible to successfully survey the entire work force. High participation can be virtually guaranteed through enforcement of participation and/or the promise of reward for responding.

While it may be desirable to survey or interview every person within a population of interest, this option is often time and cost prohibitive. An example of a full population survey would be the Census of Canada, which is conducted every five years by Statistics Canada.

An alternative to a full survey of the population is data sampling. A data sampling methodology needs to address two main issues: 1) How will those people be selected for participation (participant sampling), and 2) how many participants will be sampled (sample size)?

B1.1.1 Participant Selection (Participant Sampling)

There are four frequently used random sampling strategies for selecting participants, as identified by Dattalo,[22] which are simple, systematic, stratified, and cluster. These four strategies are based upon probability theory and allow for estimates of the sampling error to be calculated. Random sampling is the gold standard for participant selection because it minimizes potential selection bias. Alternative participant selection non-random methods identified by Dattalo, , which do not allow for the quantification of sampling error, include availability, snowball, and quota.

Simple random sampling involves using a random number generator to select participants. Today the random number generator is usually a computer. Caution should be used when using a computer for large random number generation or where high-quality randomness is essential. Similar to simple

[22] P. Dattalo, Determining Sample Size: Balancing Power, Precision, and Practicality. Oxford University Press, Inc. 2008

random sampling is *systematic* random sampling which involves assigning numbers to the entire population, arranging the numbers in random order and selecting sequentially over the list of numbers. So for example, if there are 10,000 people in the population list randomly sorted and you wish to sample 500 of them, select a random position in the list and then select every 200th person.

Stratified sampling involves first breaking up the population into groups based upon some similar characteristics and then randomly selecting from each group. So for example if it is important to have equal representation from males and females, then the population would first be divided by gender and then an equal number selected from each group. Stratified sampling could be used to group other factors such as for example age, job type, vehicle type, salary, or family size. How the participants are stratified is obviously very much dependent upon the research question that is being studied. *Cluster* sampling is a type of stratified sampling where participants are selected as a function of where they are geographically located. This allows one to reduce the survey costs by sampling all participants within the same location at the same time.

If random sampling is not possible, non-random sampling methods are potentially applicable. *Availability* sampling is participant selection based upon their accessibility to the person conducting the study. However, using as participants one's colleagues at work or using one's family members could potentially introduce bias in the results. *Quota* sampling involves purposes selecting participants because they fall within a particular stratified group in order to ensure that representatives of that group are included. *Snowball* sampling is employed when it is difficult to find the type of person desired for participation. So for example, if it is difficult to find people who use public transit for people with disabilities, a known person with disabilities may be recruited to help recruit additional participants.

B1.1.2 Participant Size Selection (Sampling Size)

There will be error in the resulting conclusions anytime a sample of the population is used to extrapolate the results to the entire population. There are two types of error that can occur: *random error* and *systematic error*. Random error may be thought as simply what occurs by chance. For example, if one flips a coin twenty times, it is quite possible to get heads 11 times and tails 9 times leading one to conclude that the coin has 55% chance of getting heads when in fact it is 50%. This random error is inherent sampling. The basic rule of thumb is the larger the sample size, the smaller the random error. A larger sample size has the effect of increasing the precision. It is possible to estimate the size of the random error for a given sample size and population.

Systematic error, also referred to as bias, is a much more serious type of error and generally the size of the bias can not be estimated. In addition, having a larger sample size will not reduce the size of the systematic error. There are numerous ways that systematic error can occur. A common type of systematic error is *selection bias* which occurs when the process of participant selection inadvertently (or perhaps even purposefully) misses or omits subgroups of the population. For example, a telephone survey of a population using land lines might miss younger people who may not even own a land line phone number and, rather, depend on their cell phone.

Then number of participants that should be sampled as part of a survey depends on a number of factors. As a rule, the sample size needed should be determined before the survey is conducted. The sample size depends greatly on the type of question that needs to be answered. Consider the following questions:

Study Question	**Corresponding Survey Question**
What percent of the population takes less than one hour to drive to work?	On average does your drive to work take less than one hour to complete
What is the distribution of average time to drive to work for the population?	On average how many minutes is your drive to work?

The first question only asks if the drive to work takes less than one hour whereas the second question requires a much higher precision. A higher precision means that a larger sample size is required. A statistical analysis is needed in order to determine the *power* of a sample size, which is the probability of detecting an effect due to an independent variable.

In addition, the greater the level of stratification needed in the study question - for example, knowing the average time it takes a driver to travel to work as a function of the vehicle type driven - the greater the sample size that is needed. This ties into the greater the variation in the population information, the greater the sample size that is needed.

B1.1.3 Confidence Intervals and Sample Size

Confidence intervals express the reliability of the data and are tied to sample size. A confidence interval may be expressed as the range of numbers. For example, a confidence interval of 500±15 means the range is between a high of 515 and a low of 485. The confidence interval is saying that the mean response to this survey question is 500 and that, since this is a sample, the true answer may be as high as 515 or as low as 485. In this example, the confidence interval is ±3%. The confidence level for this may be 95%. In non-technical terms, the confidence level says that "We arrived at these numbers by a method that gives correct results 95% of the time."[23] **Table B-1 Minimum Sample Sizes for Selected Small Populations**, taken from Rea and Parker, illustrates different sample sizes as a function of the confidence interval and level of confidence. So, let us say that the number of employees in a company is 3,000, and we want to know the response to a survey question within ±3% and at the 95% level of confidence. This means that the survey sample size should be 788. Notice how Error! Reference source not found.the sample size greatly increases with more stringent (smaller) confidence intervals and higher levels of confidence. For a population of 3,000, knowing a survey response within ±3 with a 95% level of confidence requires a sample size of 788, but if the confidence interval is ±5% the sample size drops to 341, and if the confidence interval is ±10% then the sample size is only 94. Notice also that the change in sample size is minimal compared to the change in population size when going from 50,000 to 100,000. This is because the population size is now approaching what is considered a large population.

Table B-1: Minimum Sample Sizes for Selected Small Populations

95% Level of Confidence					99% Level of Confidence			
	Confidence Interval					Confidence Interval		
Population Size	±3%	±5%	±10%		Population Size	±3%	±5%	±10%
	Sample Size					Sample Size		
500	250	218	81		500	250	250	125
1,000	500	278	88		1,000	500	399	143
1,500	624	306	91		1,500	750	460	150
2,000	696	323	92		2,000	959	498	154
3,000	788	341	94		3,000	1,142	544	158
5,000	880	357	95		5,000	1,347	586	161
10,000	965	370	96		10,000	1,556	622	164
20,000	1,014	377	96		20,000	1,687	642	165
50,000	1,045	382	96		50,000	1,777	655	166
100,000	1,058	383	96		100,000	1,809	659	166

Source: Rea and Parker

Rarely are surveys conducted without any *a priori* knowledge about the population. There may have been surveys conducted in previous years, or published findings from similar initiatives elsewhere. A well designed survey will use the information already known about the population to tailor both the sampling strategy and the sample size. For example, the sampling strategy may include stratified random sampling, where specific numbers of management and administration are included.

[23] D. S. Moore, G. P. McCabe, "Introduction to the Practice of Statistics", published by the W. H. Freeman and Company, 1989