# Big Data for Transportation: Measuring and Monitoring Travel

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## Introduction

Relevant and reliable transportation and travel information is critical to the understanding, planning and implementation of transportation networks in major urban cities with road network growth constraints. Origin and destination (O-D) data is of fundamental importance to transportation planning professionals to understand travel patterns and the associated demands on a transportation network over an entire region. Such data can be entered into a transportation model to support the decision making process for urban planning and infrastructure capital expenditures, deployment of new transportation network technologies, and driver education to reduce idling and emissions. PERSENTECH has been developing and provisioning vehicle data loggers and data sets for large-scale transportation projects since 2007 for such applications. This paper presents examples from two of these projects: an idling and emissions project undertaken in Winnipeg, Manitoba, and a freight movement study by the Metropolitan Cluster of logistics and transportation of Montreal (CargoM) and Transport Canada.

## Data Collection Methods

The world-wide transportation survey and study market has relied on manual surveying techniques and manual-entry data collection methods including paper based questionnaires, telephone interviews, line-of-sight observations, and manual data entry for decades. This method of data collection has many disadvantages including subjective/biased data; observation, recall and data entry errors; high cost; and incomplete data sets. Perhaps the biggest drawback of these manual "travel diary" based studies is that they are one-time snapshots taken every 5 or more years rendering the data less and less relevant over time to answer current questions and challenges in the transportation networks of large complex cities.

## Transportation Data Collection Methods and Drivers for Change

Today there are a number of important drivers for change to the status quo data collection methods in use for major metropolitan areas. These include:

1. The need to increase the quality and variety of transportation and travel survey data.

2. The requirement to provide highly reliable and relevant data collection and analysis capabilities.
3. The need for ongoing data collection so that the transportation model can be continuously fed with accurate, current and relevant information that can be mined and analyzed to identify key trends and answer important questions.
4. The data needs to be collected with minimal disruption to the participant's activity and mobility.
5. The need to provide automated data collection options to survey and crosslink participant groups and multi-modal travel.

### *Otto Travel Study Solution (OTSS)*

The increased use of GPS-enabled devices, including smartphones and fleet-diagnostic devices ("data loggers"), in combination with legacy road sensor probes and traffic counters, creates many data sets. These data sets increase in numbers and in size as more vehicle probes and sensor information become available. The relevancy and accuracy of the data sets are key metrics that provide transportation planners and modellers with the information required for a proactive approach to city planning and traffic management. Establishing a collaborative and open data warehouse for contributions from data loggers and sensors will expedite the numbers of data sets and information that will become available for traffic management analysis.

PERSENTECH's OTSS solution was designed to uniquely address the industry drivers and challenges of transportation and travel survey data collection. The OTSS platform, shown in Figure 1, consists of the company's existing logger products, software and web-based services. OTSS is comprised of an integrated set of data logging products called Ottoview- a vehicle data logger, Ottomate – a personal data logger and Ottomobile –a smartphone application-based data logger; a data warehouse and analytics system called Ottodata; and a real-time data tracking and survey administration system called Ottotracker. The Ottoview data loggers have been used in numerous Origin-Destination (O-D) studies, household travel surveys and transportation research programs including Transport Canada's Canadian Vehicle Use Study[1].

[1] www.tc.gc.ca/eng/policy/aca-cvus-menu-2294.htm

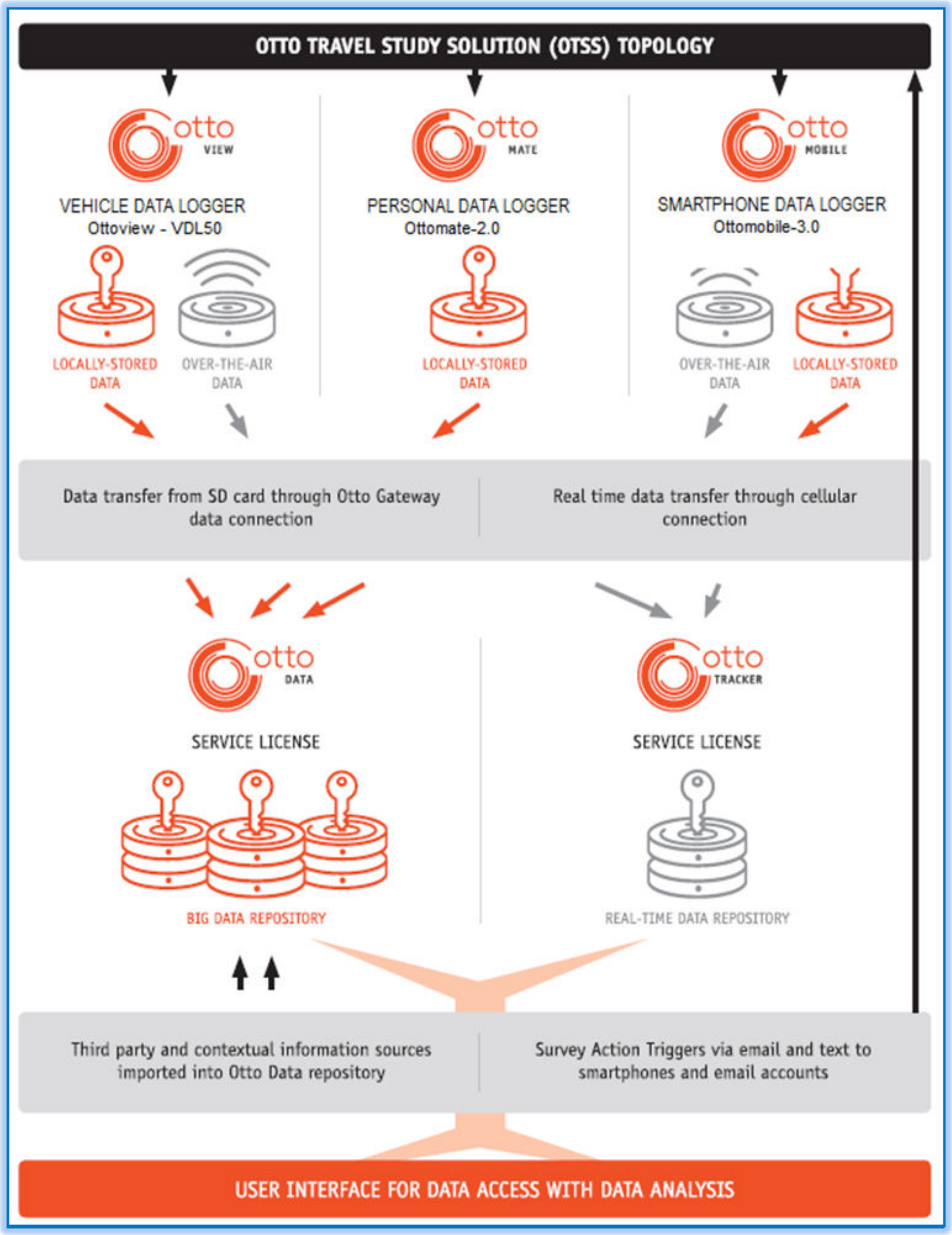


**Figure 1: Otto Travel Study Solution (OTSS) Topology**

This solution caters to the following transportation application areas:

(i) **Intelligent Transportation Systems:** increasing the amount and quality of traffic information for improved planning, prioritizing and performance evaluation;

(ii) **Congestion Management Studies**: identifying practical solutions to key expressway congestion and safety concerns through advanced technologies/systems or applying current solutions in innovative ways;

(iii) **Driver Education:** providing convenient access to current and reliable driving information and their driving behaviour, allowing them to make informed decisions on speed and idling and on the best timing and route of their trips; and

(iv) **Multi-modal transportation planning:** encouraging people to use modes other than their private vehicles – such as walking, cycling or public transit – is an important traffic management strategy as it reduces the number of vehicle trips.

### *Application example: City of Winnipeg – Congestion, Speeding and Emissions Study*

In collaboration with the Centre for Sustainable Transportation (CST) at the University of Winnipeg (U of W), PERSENTECH tested the effectiveness of implementing driving feedback technologies in their ability to reduce transportation carbon dioxide ($CO_2$) emissions in the city of Winnipeg. The study had two phases. Phase I used the Otto-driving companion® (Otto) device to provide real-time driver feedback based on speed and idling. Otto contains municipal Posted Speed Limit (PSL) information and uses GPS technology to cross-reference the location of the vehicle to the underlying PSL attribute and is able to record location-based driving behaviour. Phase II used the Ottoview™ device to provide real-time feedback to the user regarding the vehicle performance parameters including trip cost, fuel economy and $CO_2$ emissions in addition to their speeding and idling behavior.

The hypothesis of this study was that GPS and vehicle diagnostic real-time data feedback could improve driving behavior and subsequently reduce $CO_2$ emissions by generating fewer speeding and idling instances and by raising public awareness to actual fuel consumption, costs and $CO_2$ emissions. Terry Zdan, Past Research Director at the Centre for Sustainable Transportation, noted that "The aggregate data for excessive idling was surprisingly contrasted with excessive speeding. To CST's knowledge, this detailed real-time phenomenon has not been documented in any published literature. This new information has significant implications for traffic engineering and safety on urban streets." Another outcome also identified a lack of understanding of $CO_2$ emissions, and that such metrics need to be put it in terms that people understand. Figure 2 shows the congestion and speeding profile results for the City of Winnipeg as a result of the data collection with the Ottoview devices.

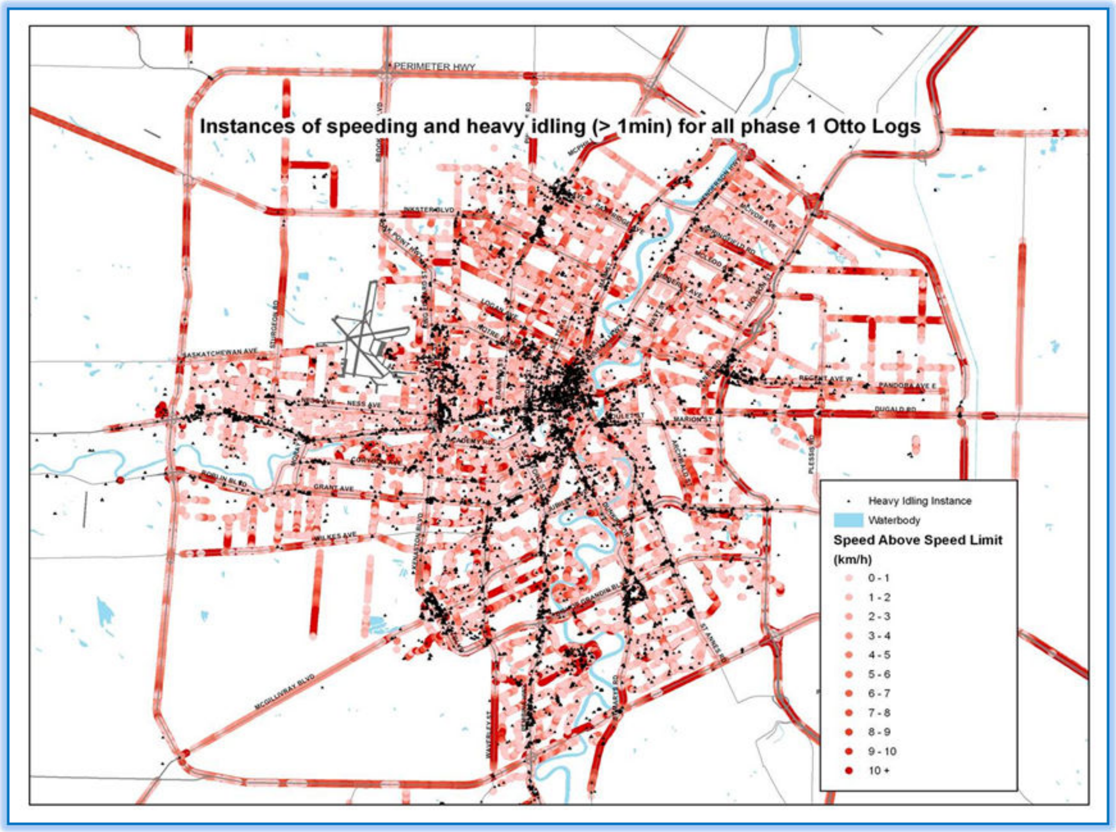


**Figure 2: City of Winnipeg Speeding and Idling Map (2009): credit U of W Ryan Smith**

### *Application example: CargoM and Transport Canada*

The Logistics and Transportation Metropolitan Cluster of Montreal – CargoM – complements the clusters that have been deployed in recent years in the Greater Montreal area. The CargoM mission is to bring together all players in the logistics and freight of Greater Montreal. The activities promote the Montreal hub around common goals and concerted actions to increase the cohesion, competitiveness, growth and expansion. More specifically, CargoM initiates developmental projects to promote Montreal's position as a transportation hub of goods, to ensure the sharing of best practices and technologies, to influence the harmonization and simplification of regulations, and to promote attraction and retention of labour in different sectors within the industry.

One of the CargoM's projects was to better understand the movements of trucks in Greater Montreal, specifically around the Port of Montreal. This project has been realized within the third working group called "Access and Fluidity For Truck Transportation in Greater Montreal" and in collaboration with

Transport Canada who provided access to the Ottoview data loggers. The data loggers were installed in trucks to collect the travel statistics in order to make better decisions towards improving traffic fluidity and to better understand carbon dioxide ($CO_2$) emissions in the area. The target sample included trucks going to the Port of Montreal and to intermodal centers.

The study would result in a better understanding of how vehicles were operated and how this data would help in determining concrete actions that could be taken to reduce traffic congestion and $CO_2$ emissions in the scenario involving trucks traveling to the Port of Montreal or to intermodal centres. The collected data would be analyzed and put into Business Intelligence (BI) decision tools.

The resulting analysis has reinforced previous observations about congestion issues, and has provided more detailed information than was anticipated at the start of the project. The results derived included traffic congestion density, driving behavior statistics such as speed, acceleration, “stop & start” intensity and quantity, vehicle travel versus idle time statistics, and $CO_2$ emissions over different spatial areas and periods of time. The results have also provided insight into potential traffic signal optimizations to improve traffic flow, the distribution pattern and reduction of $CO_2$ emissions in-and-around the port, and the identification of which operational plants could be moved closer to the port to improve the efficiency in the movement of cargo.

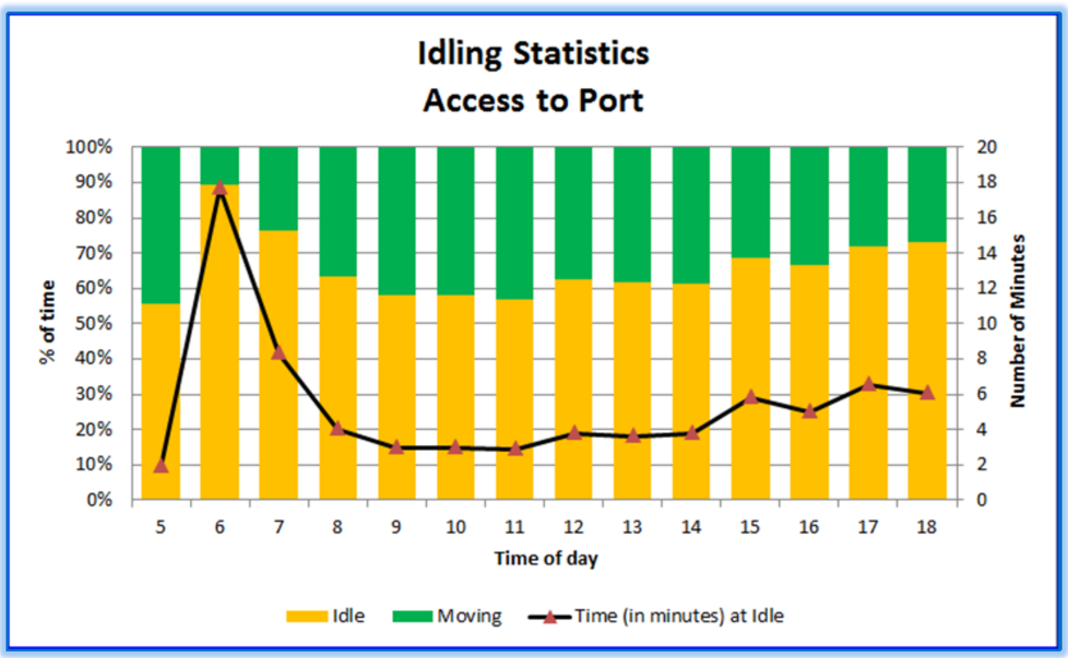


**Figure 3: Idling in-and-around the Port of Montreal during a typical work-week day (results depend on the target sample)**

Figure 3 shows a sample of the idling and vehicle movement profile per km of travel in-and-around the port of Montreal during a typical work-week day. We can see that between 6 am and 7 am, the sample of vehicles is idling 90% of the time or 18 minutes/km.

In Figure 4, we also find that between 6 and 7 am, the sample of vehicles are starting and stopping more than 3 times per km where the speed threshold is at least 9 km/hr, and where the posted speed limit is 60 km/hr. This type of operation results in a significant increase in fuel consumption and $CO_2$ emissions.[2]

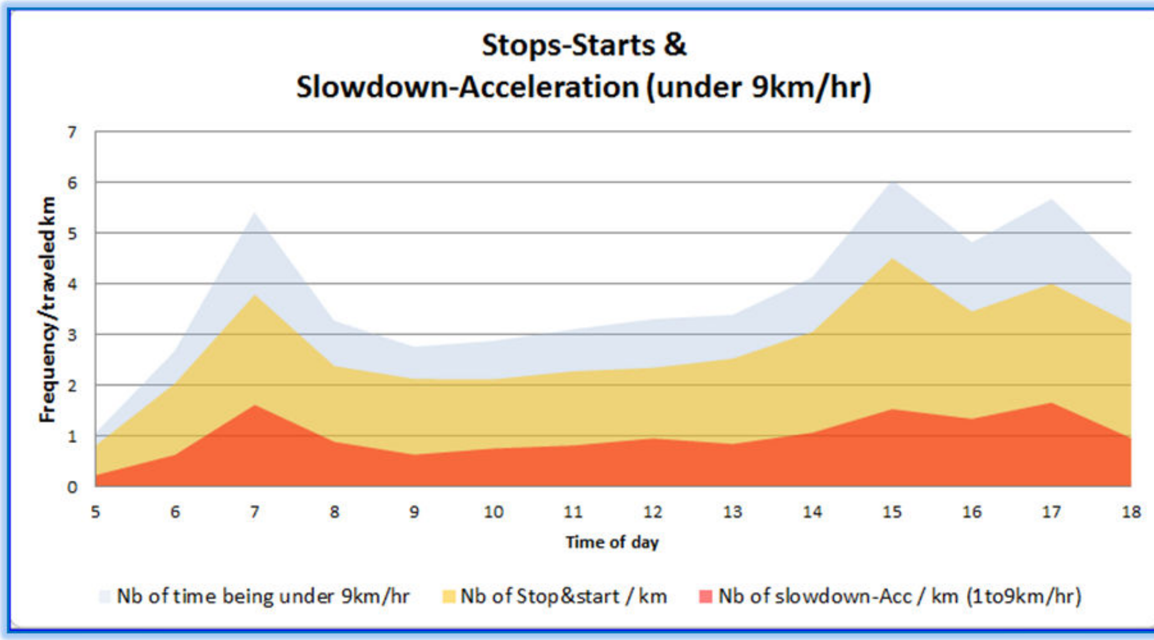


**Figure 4: Frequency of vehicle Stops and Starts during a work-day (results depend on the target sample)**

Using the sample, Figure 6 shows the potential savings if an operations plant is relocated closer to the port. The baseline assumption is a distance of 25 km from origin-to-destination, gas price at $1.250/l, one 60 minute load per trip, and other hypothesises for salary and maintenance costs. By re-locating the plant to within 2.5 km of the port, the potential savings in fuel costs alone for a single vehicle making 7 trips per day is $132.

[2] http://www.volvotrucks.com/trucks/qatar-market/en-qa/trucks/environment/Pages/fuel_consumption.aspx

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2015 only | | = | 250 | business days: 50 weeks X 5 days | = | 1 | year | Inflation (other) | 2% |
| | | | | | | | | Infl. Diesel | 3% |
| 2015 | to 2020 | = | 1500 | business days | = | 6 | years | Carbon tax | 5% |

| For 1 truck: 1<br>In taking the vacant site, the savings are, for "n" number of trips: | Nb of Trips | Total Distance (km) | Total Duration (hr) | Gas (liters) | CO2 Emissions (t) | Salary | Maintenance cost (by time) | Maintenance cost (by km) | Gas cost | Carbon cost Yearly Floor prices | Carbon cost Yearly Max |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 day - Hwy.20-Hwy.13 | 5 | 112,5 | 3,00 | 70,1 | **0,179** | 60,00 $ | 36,00 $ | 16,88 $ | 94,51 $ | **2,18 $** | **2,66 $** |
| 1 day - Hwy.20-Hwy.13 | 7 | 157,5 | 4,20 | 98,1 | **0,250** | 84,00 $ | 50,40 $ | 23,63 $ | 132,31 $ | **3,05 $** | **3,72 $** |
| 2015 - Hwy.20-Hwy.13 | 1 250 | 28 125 | 750 | 17 515 | **44,7** | 15 300 $ | 9 180 $ | 4 303 $ | 25 517 $ | **545 $** | **665 $** |
| 2015 - Hwy.20-Hwy.13 | 1 750 | 39 375 | 1 050 | 24 521 | **62,6** | 21 420 $ | 12 852 $ | 6 024 $ | 35 724 $ | **763 $** | **930 $** |
| 2015 ++ Hwy.20-Hwy.13 | 7 500 | 168 750 | 4 500 | 105 088 | **268,4** | 101 355 $ | 60 813 $ | 28 506 $ | 224 961 $ | **4 806 $** | **8 302 $** |
| 2015 ++ Hwy.20-Hwy.13 | 10 500 | 236 250 | 6 300 | 147 123 | **375,7** | 141 896 $ | 85 138 $ | 39 908 $ | 314 946 $ | **6 728 $** | **11 623 $** |

**Figure 5: Demonstration of savings estimates with one vehicle**

Figure 6 shows how quickly the savings can grow for a larger fleet of 30 vehicles. The relocation of the operations plant resulted in savings of $3,969 per day or $1,071,734 (with inflation) per year for a fleet of 30 vehicles making 300 trips per day to the port. The savings are even more significant when consideration is also give to other cost items including vehicle maintenance, driver salaries and the carbon-taxes. The calculations presented can be adjusted for different hypothesis variables including the distances, fleet size, the number of years, the inflation rate, and the carbon tax rate.

| For a truck fleet of: 30<br>In taking the vacant site, the savings are, for "n" number of trips: | Nb of Trips | Total Distance (km) | Total Duration (hr) | Gas (liters) | CO2 Emissions (t) | Salary | Maintenance cost (by time) | Maintenance cost (by km) | Gas cost | Carbon cost Yearly Floor prices | Carbon cost Yearly Max |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 day - Hwy.20-Hwy.13 | 150 | 3 375 | 90 | 2 102 | **5** | 1 800 $ | 1 080 $ | 506 $ | 2 835 $ | **65 $** | **80 $** |
| 1 day - Hwy.20-Hwy.13 | 210 | 4 725 | 126 | 2 942 | **8** | 2 520 $ | 1 512 $ | 709 $ | 3 969 $ | **92 $** | **112 $** |
| 2015 - Hwy.20-Hwy.13 | 37 500 | 843 750 | 22 500 | 525 440 | **1 342** | 459 000 $ | 275 400 $ | 129 094 $ | 765 524 $ | **16 353 $** | **19 939 $** |
| 2015 - Hwy.20-Hwy.13 | 52 500 | 1 181 250 | 31 500 | 735 616 | **1 879** | 642 600 $ | 385 560 $ | 180 731 $ | 1 071 734 $ | **22 894 $** | **27 915 $** |
| 2015 ++ Hwy.20-Hwy.13 | 225 000 | 5 062 500 | 135 000 | 3 152 641 | **8 051** | 3 040 639 $ | 1 824 383 $ | 855 180 $ | 6 748 837 $ | **144 167 $** | **249 072 $** |
| 2015 ++ Hwy.20-Hwy.13 | 315 000 | 7 087 500 | 189 000 | 4 413 697 | **11 271** | 4 256 894 $ | 2 554 136 $ | 1 197 251 $ | 9 448 372 $ | **201 833 $** | **348 700 $** |

**Figure 6: Demonstration of savings estimates with 30 vehicles**

The sample of data shows how more accurate and in-depth statistics can be used to build better cost models and to generate better information for the decision makers.

## *Conclusions*

The future in transportation planning and modelling involves the collection of large volumes of accurate multi-modal data –"Big Travel Data". The information derived from these data sets allow transportation planners and modellers to design transportation networks using reliable and relevant information to achieve the desired municipal and regional transportation objectives in improving traffic flows and reducing emissions. Disseminating the information to the road network infrastructure and to the drivers on the roads in real-time is an important part of any solution by way of traffic smoothing techniques through traffic signal optimization; congestion mitigation strategizes based on business analytics; and driver education. Educating drivers on eco-driving principles is complementary to implementing infrastructure changes. The net outcome is a win-win scenario for business, government and society through cost savings and environmental improvements. The City of Winnipeg and CargoM and Transport Canada projects are two examples of how the "Big Travel Data" has been useful to planners and decision makers in understanding the transportation patterns and opportunities to reduce congestion and emissions and to discover alternative solutions with significant cost saving benefits.


**Figure 7: Ottoview Vehicle Data Logger (VDL50, VDL50R)**