Wisconsin DOT Travel Time Technology Evaluation (T3E)

Analysis Plan

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1. Task Introduction

This is a detailed analysis plan to determine how best to compare all of the travel time technologies being studied in the Travel Time Technology Evaluation (T3E).

As part of this analysis plan, a detailed literature review was completed. This review looked at previous studies analyzing travel times. This will include looking at related efforts and past efforts including the 2008 AirSage/INRIX evaluation report, the TOPS Bluetooth traffic detector comparison study completed in 2013, and recent Great Lakes Regional Transportation Operations Coalition (GLRTOC) work with Bluetooth and probe data including work completed in Janesville comparing Bluetooth, probe data, and NPMRDS data. The literature review is included in Appendix B.

Next, specific routes/segments are chosen based on data availability and relevancy to the project. Time periods have also been chosen as appropriate for the comparison.

The process for data source retrieval will be determined for all data sets including:

- Purchased TomTom GPS-based probe data and additional interstate TomTom data;
- The free FHWA National Performance Management Research Data Set (NPMRDS);
- Bluetooth detection maintained by WisDOT or GLRTOC;
- Microwave detection;
- Inductive loops, available via WisTransPortal; and
- Automatic Traffic Recorders (ATRs).

Statistics and metrics are chosen based on the literature review and the adaptation of WisDOT travel time quality assurance, quality control (QAQC) process.

This project does not include field data collection such as travel time runs.

See Appendix A for the project management timeline for this project.

2. Background

The overall purpose of the T3E project is to understand the quality of probe data and appropriate use applications. In conjunction with the I-39/90 expansion project and the Verona Road project, a real time data feed has been purchased by WisDOT with expansion and renewal options up to seven years covering Rock and Dane counties. This evaluation will compare the TomTom data with other travel time calculation technologies to determine which technology is most appropriate. It is possible that certain technologies will work better on different types of highways and in rural/urban areas.

2.1. Reasons for Evaluating Technologies

WisDOT has many dynamic message signs (DMS) stating travel times to aid commuters and other travelers throughout the state in typically congested areas. Roadway users expect that these times are accurate, and if the times are not accurate, users will lose faith in the system. In situations where delays are expected, accurate freeway and alternate route travel times are imperative. This allows drivers to divert onto the alternate route when the route offers a faster travel time, thus maximizing the capacity of the built highway network and minimizing user delay cost.

With the onset of connected vehicles, travel time information can be made available in the vehicle as part of the heads-up display. This will result in roadway users expecting the most precise travel times available in all situations.

In order to provide these travel times, WisDOT is performing this evaluation to

- Compare arterial versus freeway travel times
- Compare long term versus short term travel times (cases such as alternative routes for construction projects).
- Compare costs of acquiring and maintaining data
- Compare difficulty of accessing and processing data sources
- Determine other uses of travel time data
- Integrate technologies into the transportation systems management and operations (TSM&O) decision process for detection

The better WisDOT understands the quality of data available now, the better the accuracy of travel times that will be available now for use on installed DMS and in the near future in the roadway users' vehicles.

2.2. Existing Travel Times

WisDOT travel time information is currently calculated based on speed data collected by a variety of traffic data detection devices located along a road corridor that is then integrated into the Advanced Traffic Management System software (ATMS) used by WisDOT.

WisDOT has been using speed data from in-pavement loops and microwave detection devices to calculate travel times for over a decade. WisDOT recently began using Bluetooth detection devices in 2014 to provide speed data for arterial routes in the Southeast Region and for freeway routes in the Southwest Region. Bluetooth data processed by C2Web software from Drakewell at the STOC was then integrated into WisDOT's ATMS software around the same time and can now be used as another data source for travel time calculation.

2.3. Existing Technology for Study

WisDOT is currently comparing three TomTom applications including the Traffic Flow Viewer (TFV) for real-time traffic, the Live Traffic Archive (LTA) for viewing all historic data in 1-minute intervals, and the Custom Travel Time (CTT) tool for viewing travel times on custom routes. In conjunction with these tools, data will be collected and analyzed from WisDOT's current sources (automatic traffic recorders (ATRs), microwave detectors, and loop detectors) as well as other emerging data sources (Bluetooth detectors and the National Performance Management Research Data Set (NPMRDS)).

Most data sources include historic data as well as real-time information. The TFV tool from TomTom and the NPMRDS do not include real-time information and are used for verification purposes only.

Table 1 summarizes the technologies to be analyzed for this project along with their availability.

Table 1. Travel Time Technologies used in the Travel Time Technology Evaluation (T3E)

Technology	Time Interval (min)	Availability Period	Access Time	Availability Ends	Data Format
TomTom (CTT)	15	January 1, 2008, (0:00) – Present	Average	June 27, 2016 (19:00)	KML, XLS, SHP
TomTom (LTA)	1	April 14, 2015, (8:00) – Present	Difficult	January 29, 2017 (19:00)	Protobuf (OpenLR)
NPMRDS	5	July 1, 2013, (0:00) – Present	Average	June 30, 2017 (23:33)	Database (CSV)
Bluetooth	1	Varies by site (see Table 3)	Average	Varies by site (see Table 3)	XLS
ATR	60	January 1, 2014, (0:00) – Present	Average	N/A	Database (CSV)
Microwave	1	January 1, 2012, (0:00) – Present	Average	N/A	CSV
Loop	1	January 1, 2012, (0:00) – Present	Average	N/A	CSV

2.4. Other Technologies

Many technologies exist to calculate route travel times. Although some of these are used in this study, there are many that will not be compared. For completion purposes, all major methods are listed here. These are detailed in Section 2 of the Literature Review and summarized here.

2.4.1. Point Sensors

A point sensor measures the presence and speed of vehicles that travel by the location point where the sensor device is deployed. These include loop detectors, microwave detectors, and ATRs. These devices are generally used for volume, speed, and occupancy measurements. However, travel times can be measured between two devices using either the half-distance approach or the minimum speed approach as outlined in the literature review.

2.4.2. Video and License Plate Readers

Travel time can be measured by automatic plate recognition systems (APRs). The measurement requires at least two fixed APR systems on the road. When a vehicle passes by the first APR system, the video recorder of the APR will read its plate number. Then when the same vehicle passes through the second APR system, its plate number will be recorded again. Finally, the server will match the plate numbers and their time stamp tags. By matching the time stamp and measuring the distances between the set of APR systems, the travel time and travel speed of the vehicles could be measured.

2.4.3. Radar

Radar detectors can collect velocity, flows, and occupancy data when they are deployed along the roadside. Since the radar detection is strongly impacted by the road environment, radar is more widely implemented on rural highways rather than in urban areas. Although radar is suitable with massive data collection, the collected data has low accuracy.

2.4.4. Bluetooth

Bluetooth detectors scan the area range and check if any Bluetooth enabled device are detected. Once the vehicle equipped with Bluetooth devices drive into the detection range of a Bluetooth reader, enter and exit time stamps of the devices are recorded. Therefore, travel time and travel speed can be determined between points on the roadway.

The Bluetooth data gives a straight measurement of travel time between pairs of scanners. The data includes the “duration” of time required for the vehicle to pass the range detection limits of the Bluetooth scanner. Thus, Bluetooth data can give the entry and exit timestamp for each of the detectors which provides the duration of each Bluetooth device.

2.4.5. Wi-Fi Technology

Wi-Fi Technology can be used to measure the travel time of vehicles when the location of the probe vehicle and its distance to the next Wi-Fi spot is known. However, the measurement is affected by the noise impacting the localization of the car. Therefore, this technology is accurate enough for route planning, but it does not work well for individual road section estimation.

2.4.6. High-Frequency GPS Data

High-frequency GPS is a method where the probe vehicle can send GPS information every few second or each second (no more than 10 seconds). This aspect makes the data the most accurate for travel time estimation. However, the number of GPS enabled probes may limit its application. There are also some map matching problems for the complex environment such as roundabouts or intersections. This is the general strategy used by providers such as TomTom, Inrix, HERE, Google, and Waze; although they do use a variety of other probe data sources that are proprietary and thus not fully disclosed.

2.5. Current Wisconsin Travel Time Information Sharing and Users

Travel times in Wisconsin are currently available through 511 Wisconsin online and through an XML feed. Access to the 511 site is open to the public. The XML feed is available by subscription with subscribers including media outlets, researchers, and construction project teams. In particular, the Zoo Interchange team in Milwaukee is using travel time records for performance evaluation.

With the onset of connected vehicle technologies, the same travel times disseminated through 511 could eventually be displayed real-time on vehicle's heads-up display units, which will vastly expand the routes in which travel times are made available.

The Madison Area Transportation Planning Board, Madison's Metropolitan Planning Organization (MPO), currently is working with WisDOT to obtain Bluetooth travel time information. Research has been conducted at the University of Wisconsin-Madison and is in preliminary phases at the University of Wisconsin-Milwaukee using a combination of WisDOT Bluetooth detectors and detectors used by GLRTOC on DMSs throughout the state on major corridors.

3. Study Area and Period

3.1. Data Comparison

The following items will be considered when comparing data in this study:

- Data availability and data source variability
- Ease of access and user interface
- Latency for real time application
- Reliability
- Ability to archive data (for public inquiries, QA/QC, or performance reporting)
- Durability of equipment (for hardware maintenance)

3.2. Selected Routes

Eight routes have been selected to complete the study. The routes offer a mix of rural and urban as well as freeway and arterial. This will allow for comparison between freeways and arterials, as freeway travel times are generally more precise than for interrupted flow facilities. These routes are shown in Table 3 and Figure 1. TomTom and NPMRDS data is available on all routes and Bluetooth data is available on multiple routes. Specific segments within these corridors will be chosen for statistical analysis. Note that the WIS 73 route is highlighted in Figure 1 with a circle, as the route is short and difficult to see.

Table 2. Selected Routes for the Travel Time Technology Evaluation with Data Types

Corridor	Corridor Start/End	Location	Route Type	Data Types
US 12/18	I-39/90 to WIS 73	East of Madison	Rural Arterial	TomTom, NPMRDS, Bluetooth
US 14 M (Madison)	US 12/18 to County MM	Fitchburg	Urban Freeway	TomTom, NPMRDS, Bluetooth, ATR
County M	US 18/151 to County MM	Fitchburg/ Verona	Rural Arterial	TomTom, NPMRDS
US 14 J (Janesville)	I-39/90 to WIS 140	East of Janesville	Rural/Urban Arterial	TomTom, NPMRDS, Bluetooth, ATR
WIS 73	I-39/90 to WIS 106	Albion	Rural Arterial	TomTom, NPMRDS, Microwave
E Washington (US 151)	Blair St to Portage Rd	Madison	Urban Arterial	TomTom, NPMRDS, Bluetooth, ATR
I-39/90	IL Border to I-94	Dane/ Rock	Rural Freeway	TomTom, NPMRDS, Bluetooth, ATR, Microwave
US 12	I-39/90 to Parmenter St	South of Madison	Urban Freeway	TomTom, NPMRDS, Bluetooth, ATR, Microwave, Loop

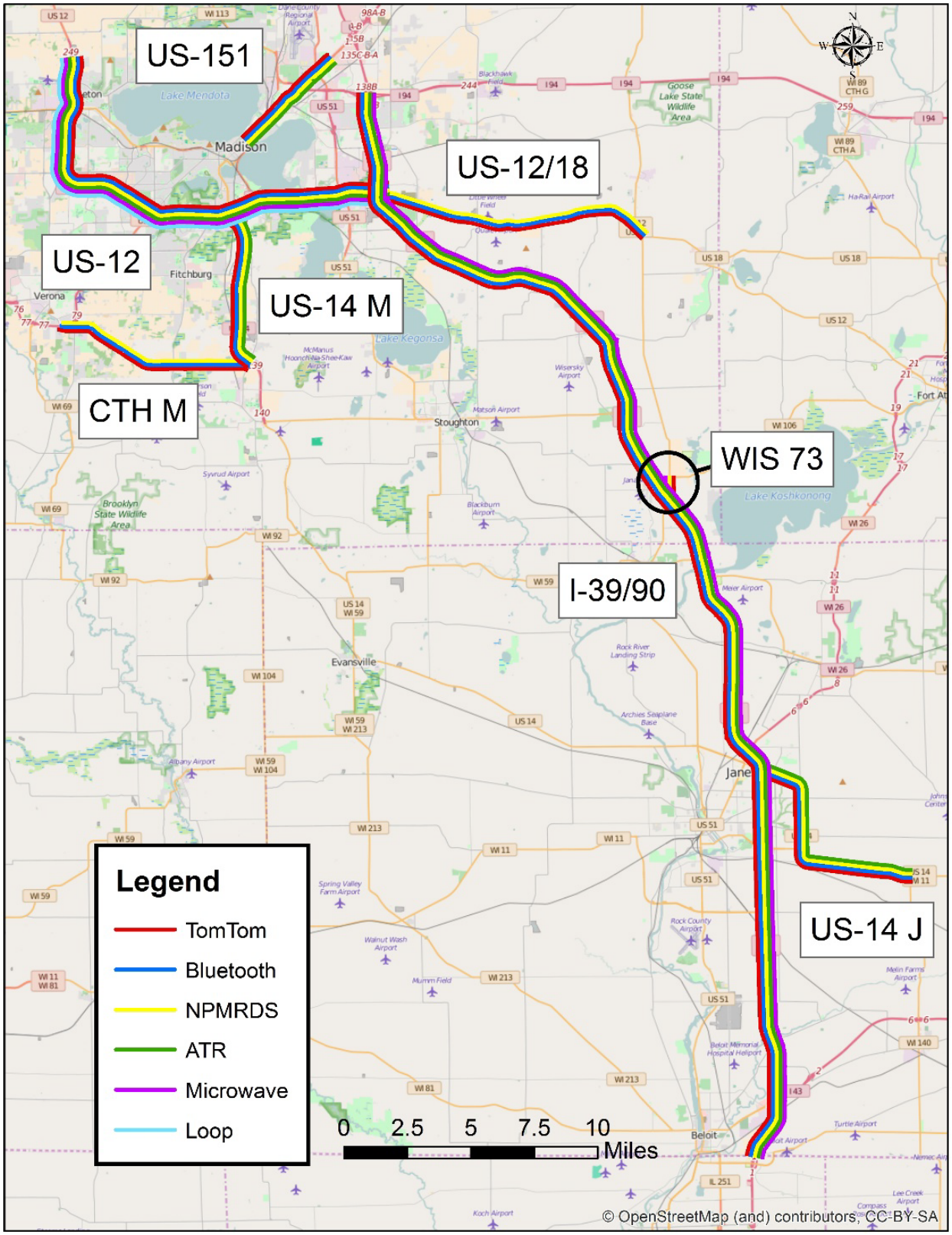


Figure 1. Travel Time Technology Evaluation (T3E) Route Overview Map

3.3 Study Time Periods

To make sure that statistical comparisons are as consistent as possible, specific dates and times have been chosen for the analysis. These dates are limited to the intersection of data availability and thus are different depending on the corridor. Time periods chosen for the study are shown in Table 3.

Specific study time ranges within the chosen time periods will be used and comparisons will be made within the corridor and cross-corridor depending on highway classification. The time ranges used are:

- AM Rush, 7:00am-9:00am (weekdays)
- AM Peak, 7:30am-8:30am (weekdays)
- PM Rush, 3:00pm-6:00pm (weekdays)
- PM Peak, 4:30pm-5:30pm (weekdays)
- Weekday Daytime, 6:00am-6:00pm
- Weekend Daytime, 7:00am-7:00pm
- Nighttime, 10:00pm-4:00am
- Holiday Travel (Memorial Day or Independence Day)

Table 3. Selected Time Periods for Study by Corridor

Corridor	Corridor Start/End	Available Period	Chosen Periods
US 12/18	I-39/90 to WIS 73	04/14/2015 to Present	05/01/2015 to 05/31/2015 and 05/01/2016 to 05/31/2016
US 14 M (Madison)	US 12/18 to County MM	04/14/2015 to Present	05/01/2015 to 05/31/2015 and 05/01/2016 to 05/31/2016
County M	US 18/151 to County MM	04/14/2015 to Present	05/01/2015 to 05/31/2015 and 05/01/2016 to 05/31/2016
US 14 J (Janesville)	I-39/90 to WIS 140	04/14/2015 to 11/02/2015	05/01/2015 to 05/31/2015
WIS 73	I-39/90 to WIS 106	04/14/2015 to Present	05/01/2015 to 05/31/2015 and 05/01/2016 to 05/31/2016
E Washington (US 151)	Blair St to Portage Rd	06/10/2016 to Present	07/01/2016 to 07/31/2016
I-39/90	IL Border to I-94	06/05/2015 to Present	07/01/2015 to 07/31/2015 and 07/01/2016 to 07/31/2016
US 12	I-39/90 to Parmenter St	04/15/2015 to 05/04/2015	04/15/2015 to 05/04/2015

4. Analysis Steps

4.1. Data Acquisition and Storage

Data will be acquired from all sources using various means. Data that is less time consuming to access (e.g., NPMRDS) will be acquired for all times that the data is available. Data that is more time consuming to access will be acquired only for the times that are specified in Section 3.

This section summarizes the data available and access basics for each data source. A complete download and processing guide for the LTA will be included in Task 3 of this project.

4.1.1 TomTom LTA (Live Traffic Archive)

Access Point: TomTom, http://trafficstats.tomtom.com/
Access Settings: Date, hour, and minute (range)
Interval Size: 1 minute
Dates Available: April 14, 2015 (8:00) - Present
Routes Available: Most freeways and arterials as well as some major collectors
Link Type: OpenLR
Data Format: Protocol Buffer / OpenLR
Information Provided: Average Speed, Travel Time
Data Access Screen: See Figure 2

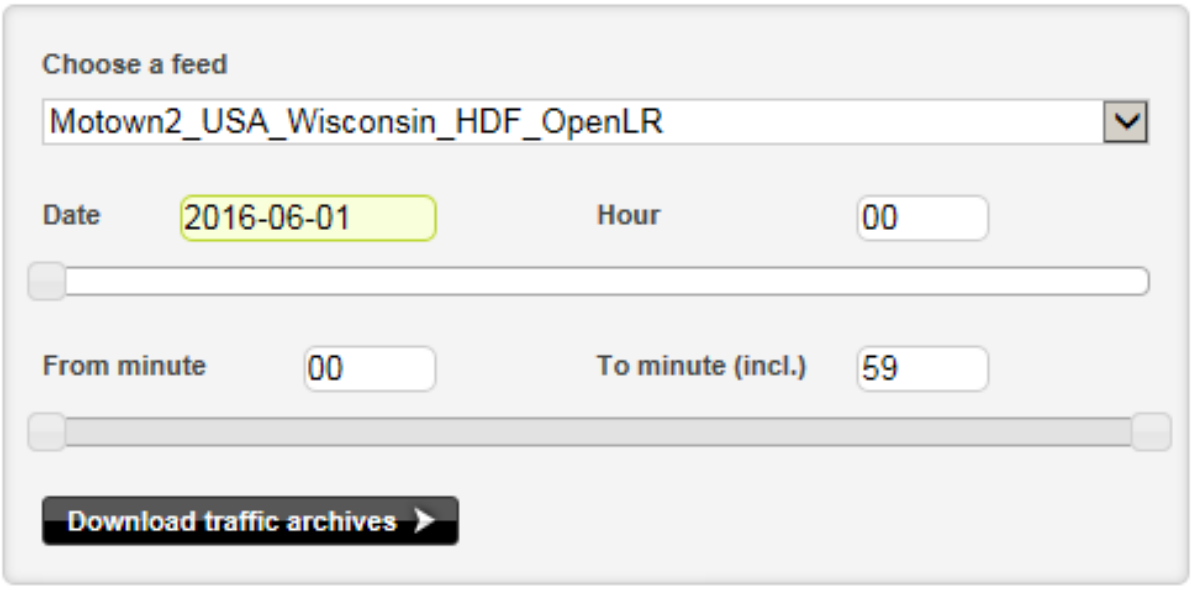


Figure 2. Data Access Screen for TomTom Live Traffic Archive Tool

4.1.2. TomTom CTT (Custom Travel Times)

Access Point: TomTom, http://trafficstats.tomtom.com/
Access Settings: Routes, dates, and time sets
Interval Size: 15 minutes
Dates Available: January 1, 2008, (0:00) - Present
Routes Available: Most freeways and arterials as well as some major collectors
Link Type: TomTom Segment Identifiers
Data Format: Google KML, ArcGIS Shapefile, and Excel Spreadsheet
Information Provided: Average/Percentile Speeds, Average/Median Travel Time
Data Access Screen: See Figures 3, 4, and 5

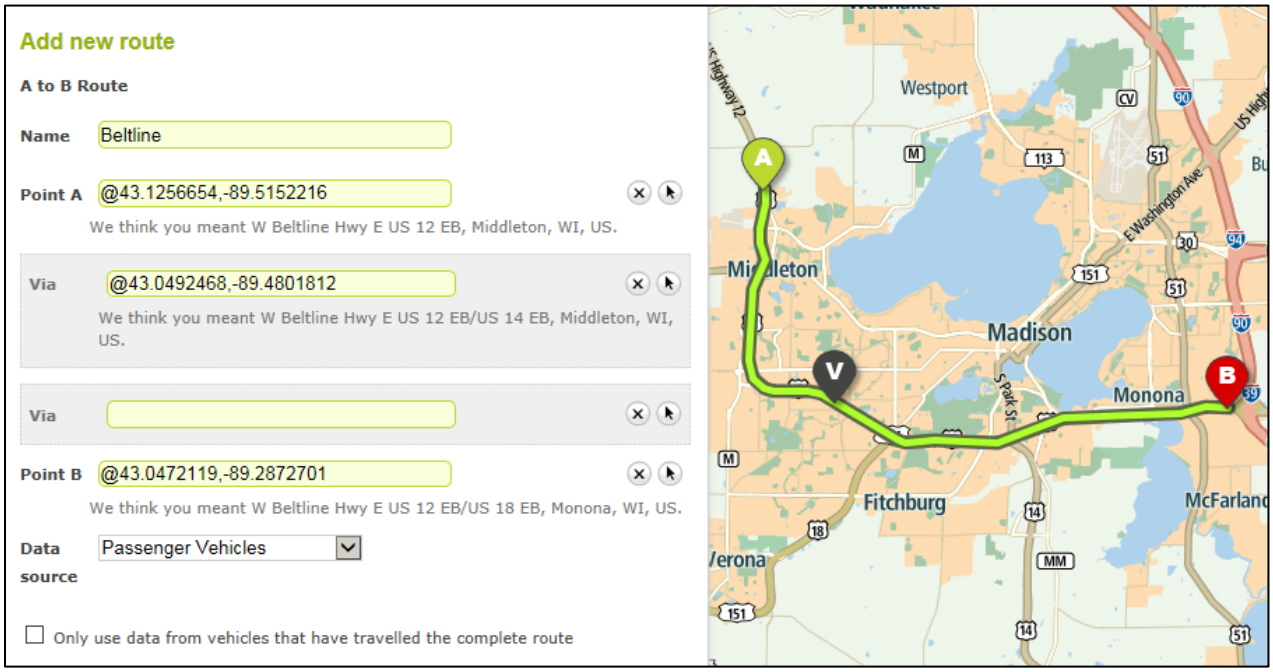


Figure 3. Data Access Screen (Routes) for TomTom Custom Travel Time Tool

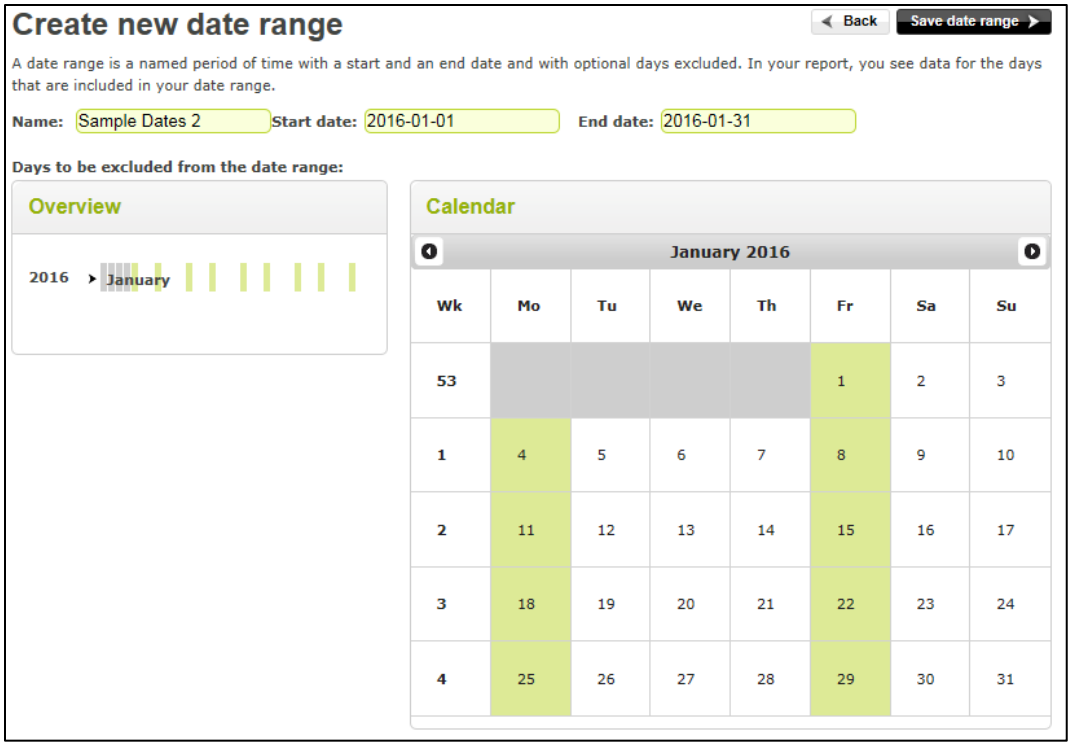


Figure 4. Data Access Screen (Dates) for TomTom Custom Travel Time Tool

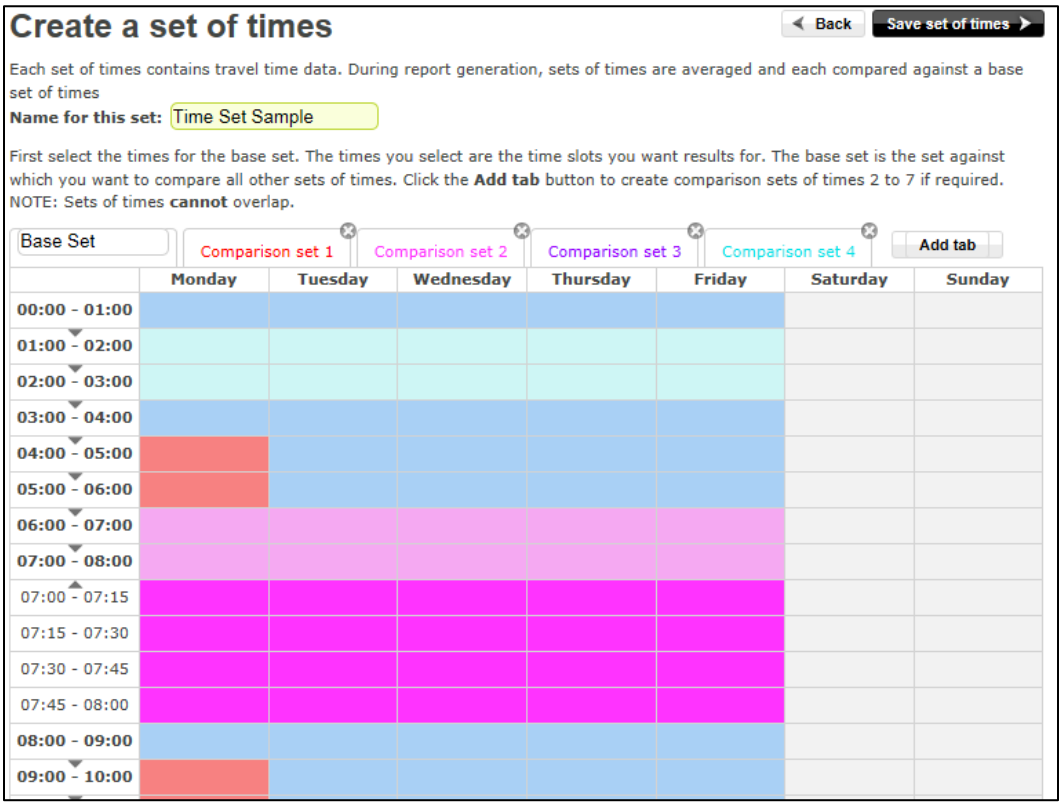
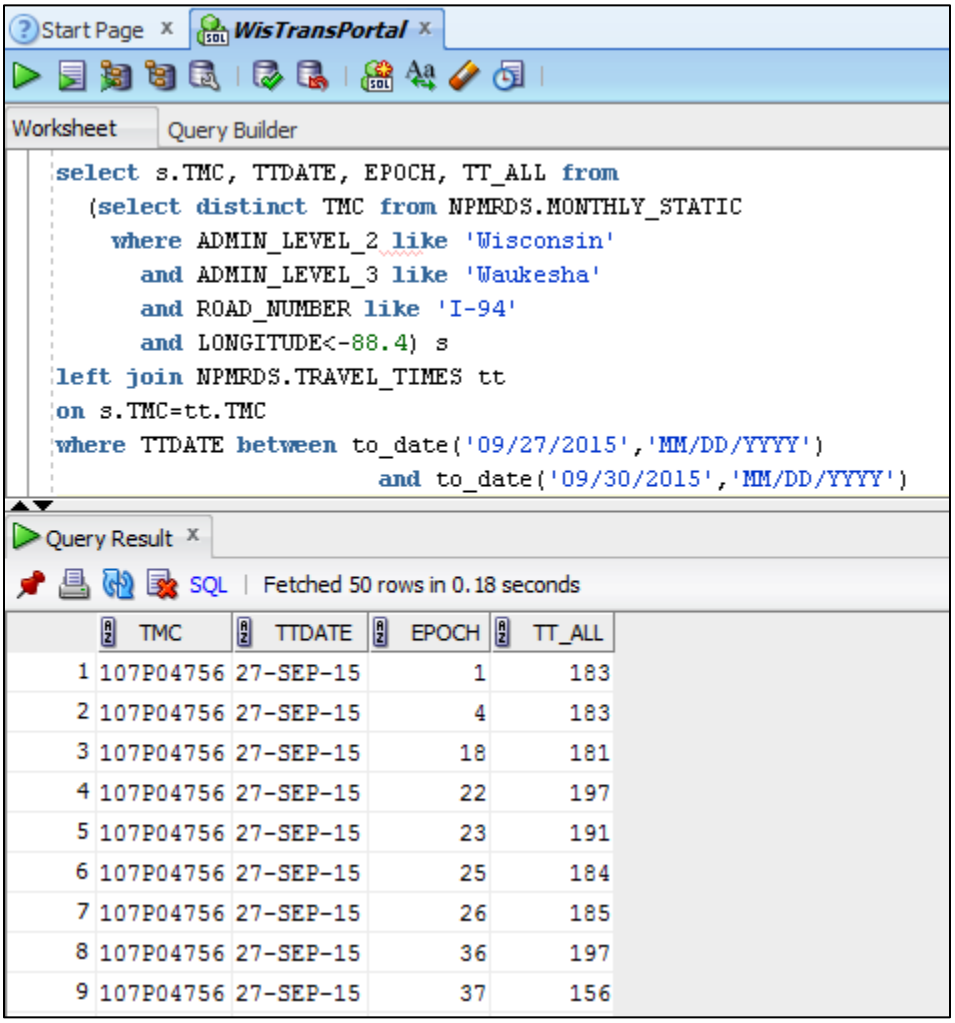


Figure 5. Data Access Screen (Times) for TomTom Custom Travel Time Tool

4.1.3. NPMRDS (National Performance Management Research Data Set)

Access Point: FHWA, https://here.flexnetoperations.com/control/navt/emailnotice
(Data downloaded and then stored in Oracle database)
Access Settings: Route settings, dates, epochs (times)
Interval Size: 5 minutes (epoch)
Dates Available: July 1, 2013, (0:00) - Present
Routes Available: All National Highway System (NHS) routes
Link Type: TMCs
Data Format: Comma Separated Value (static file and travel time data file)
Information Provided: Travel Time
Data Access Screen: See Figure 6



	TMC	TTDATE	EPOCH	TT_ALL
1	107P04756	27-SEP-15	1	183
2	107P04756	27-SEP-15	4	183
3	107P04756	27-SEP-15	18	181
4	107P04756	27-SEP-15	22	197
5	107P04756	27-SEP-15	23	191
6	107P04756	27-SEP-15	25	184
7	107P04756	27-SEP-15	26	185
8	107P04756	27-SEP-15	36	197
9	107P04756	27-SEP-15	37	156

Figure 6. Data Access Screen for NPMRDS (using Oracle SQL Developer)

4.1.4. Bluetooth

Access Point: Drakewell, https://drakewell06.drakewell.com/
Access Settings: Bluetooth units, dates, times
Interval Size: 1 minute
Dates Available: Route Dependent as shown below

Table 4. Bluetooth Data Availability by Route

Corridor	Begin Date	End Date	Bluetooth Units On Route
US 12/18	05/13/2014	Present	WDS-0029, WDS-0030[2], WDS-0031, WDS-0032, WDS-0033[1], WDS-0130, WDS-0034[1], WDS-0035, WDS-0131[2], WDS-0041, WDS-0044, WDS-0046, WDS-0047, WDS-0050, WDS-0051, WDS-0052, WDS-0132[2], WDS-0053, WDS-0133, WDS-0134, WDS-0054, WDS-0028
US 14 M (Madison)	05/16/2014	Present	WDS-0048, WDS-0049, WDS-0078, WDS-0077
US 14 J (Janesville)	10/23/2014	11/02/2015	GL-004, GL-017 (old)[3], GL-014 (old)
E Washington (US 151)	06/10/2016	Present	GL-021, GL-014, GL-025
I-39/90	06/05/2015	Present	GL-005, GL-019, GL-023, WDS-0001, WDS-0136[4], WDS-0135[4], WDS-0002, WDS-0003, WDS-0004, WDS-0005, WDS-0006, WDS-0007, WDS-0008, WDS-0009, WDS-0010, WDS-0012, WDS-0013, WDS-0014, WDS-0016, WDS-0017, WDS-0019, WDS-0020, WDS-0021, WDS-0022, WDS-0023, WDS-0025, WDS-0026, WDS-0027
US 12	11/19/2014	05/04/2015	GL-021 (old), GL-018 (old)[5], GL-001 (old)

[1]Data from these units only available from 11/17/2015
[2]Data from these units only available from 05/22/2016
[3]Data from this unit only available until 04/03/2015
[4]Data from these units only available from 10/22/2015
[5]Data from this unit only available from 04/15/2015

Routes Available: Limited – based on where units are placed
Link Type: Latitude/Longitude Points
Data Format: Excel Spreadsheet
Information Provided: Speed, Travel Time, Match Count
Data Access Screen: See Figure 7

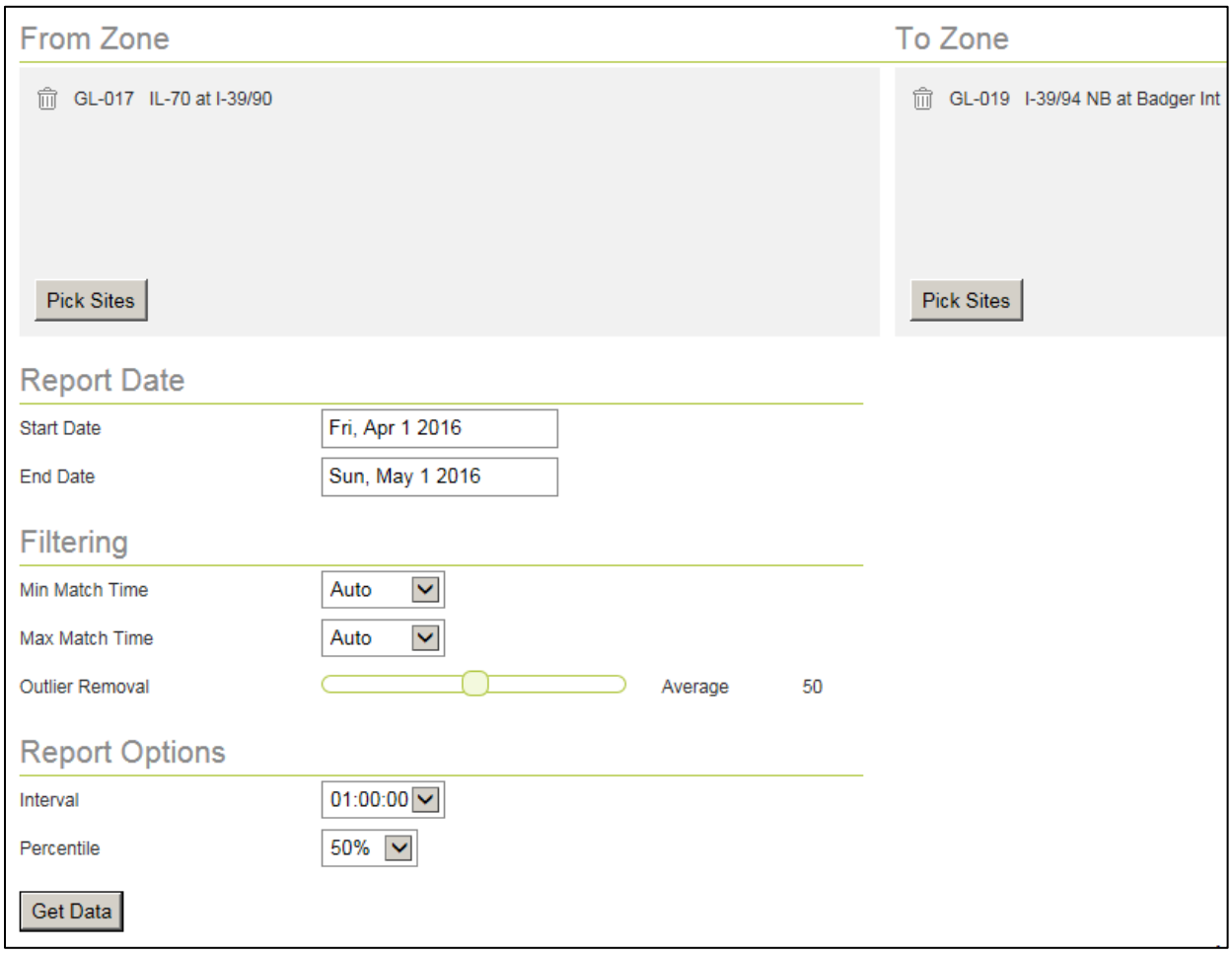
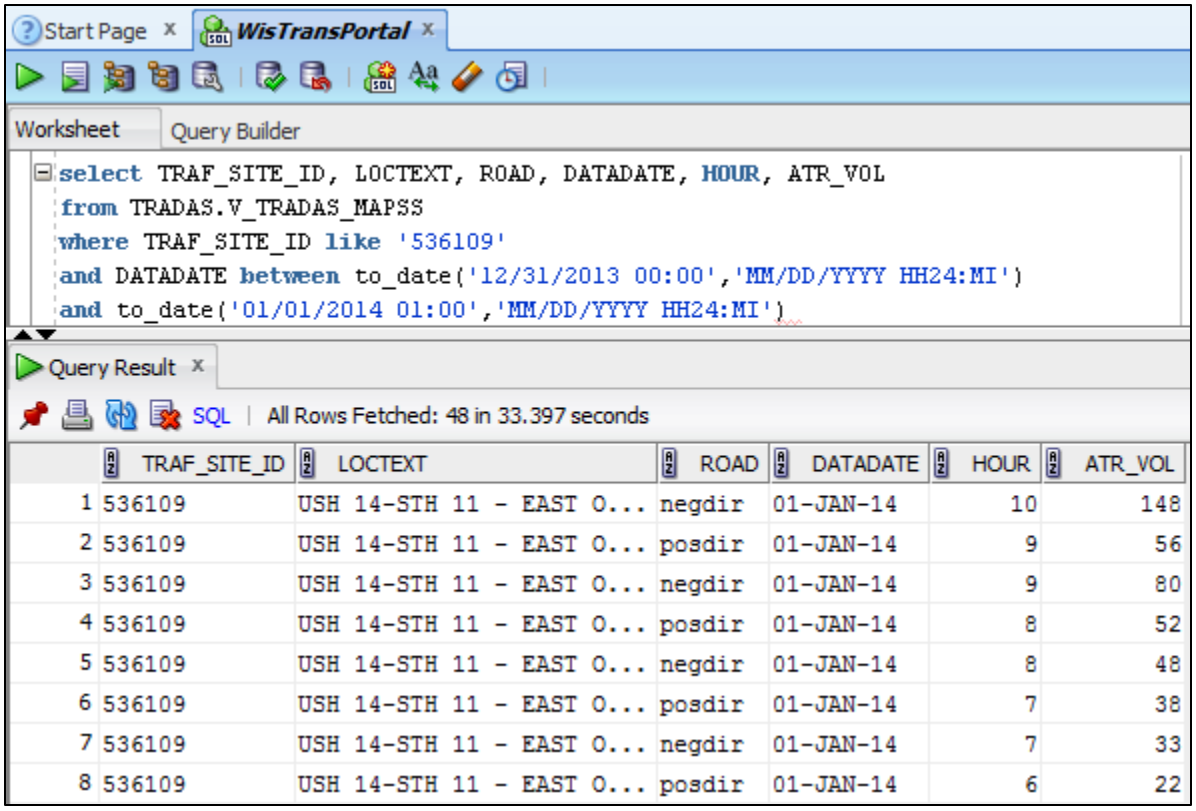


Figure 7. Data Access Screen for Bluetooth Data (using Drakewell Online)

4.1.5. ATR (Automated Traffic Recorder)

Access Point: TOPS Lab TRAffic DAta System (TRADAS),
http://transportal.cee.wisc.edu/products/hourly-traffic-data/
(Data downloaded and then stored in Oracle database)
Access Settings: Traffic site ID, dates, epochs (times)
Interval Size: 60 minutes
Dates Available: January 1, 2014, (0:00) - Present
Routes Available: Limited – based on where units are placed; statewide coverage
Link Type: Latitude/Longitude Points
Data Format: Comma Separated Value
Information Provided: Volume, Speed, Classification
Data Access Screen: See Figure 8



	TRAF_SITE_ID	LOCTEXT	ROAD	DATADATE	HOUR	ATR_VOL
1	536109	USH 14-STH 11 - EAST O...	negdir	01-JAN-14	10	148
2	536109	USH 14-STH 11 - EAST O...	posdir	01-JAN-14	9	56
3	536109	USH 14-STH 11 - EAST O...	negdir	01-JAN-14	9	80
4	536109	USH 14-STH 11 - EAST O...	posdir	01-JAN-14	8	52
5	536109	USH 14-STH 11 - EAST O...	negdir	01-JAN-14	8	48
6	536109	USH 14-STH 11 - EAST O...	posdir	01-JAN-14	7	38
7	536109	USH 14-STH 11 - EAST O...	negdir	01-JAN-14	7	33
8	536109	USH 14-STH 11 - EAST O...	posdir	01-JAN-14	6	22

Figure 8. Data Access Screen for ATR Data (using Oracle SQL Developer)

4.1.6. Microwave/Loop

Access Point: TOPS Lab Volume, SPeed, and Occupancy (VSPOC),
http://transportal.cee.wisc.edu/applications/V-SPOC/
Access Settings: Controller, Date, Time, Time Interval
Interval Size: 1 minute (or 5 minute)
Dates Available: January 1, 2012, (0:00) – Present for 1-minute data
January 1, 1996, (0:00) – Present for 5-minute data
Routes Available: Limited – based on where units are placed
around cities and majority in SE/SW regions
Link Type: Latitude/Longitude Points
Data Format: Comma Separated Value
Information Provided: Volume, Speed, Occupancy
Data Access Screen: See Figures 9 and 10

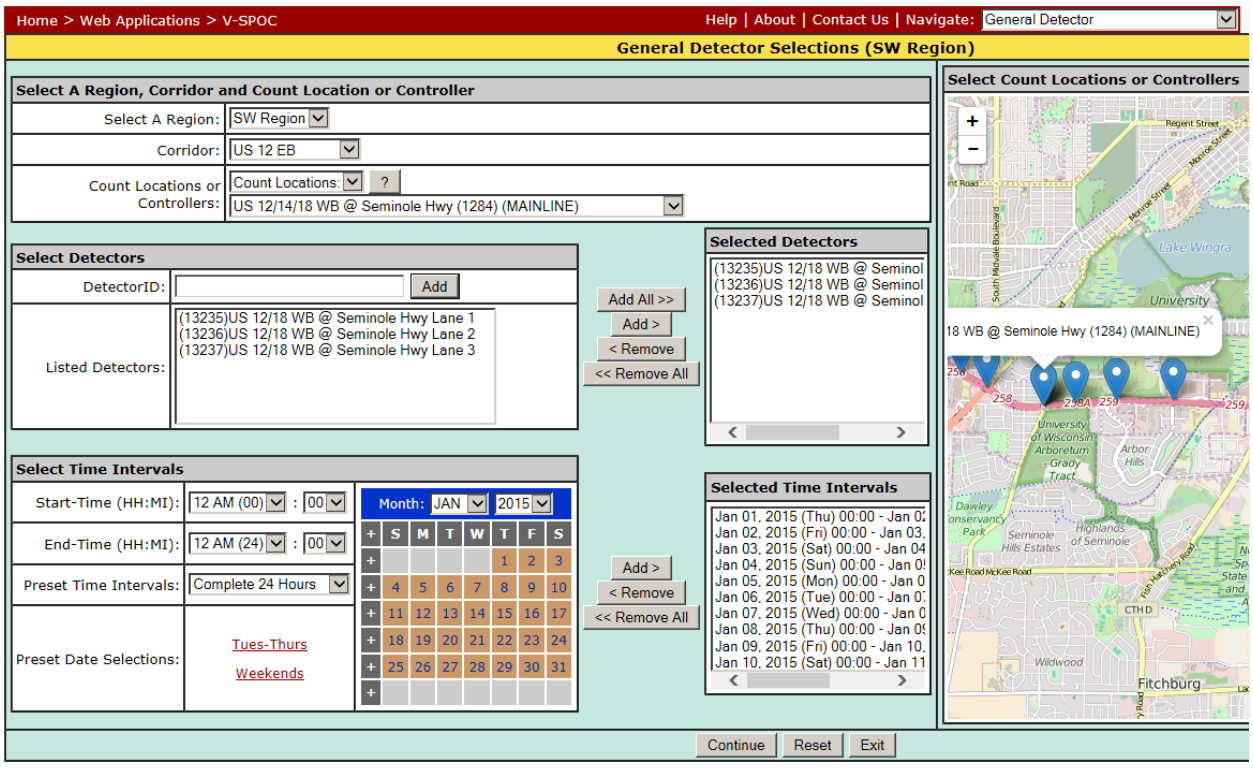


Figure 9. Data Access Screen 1 for Microwave/Loop Data (using V-SPOC online)

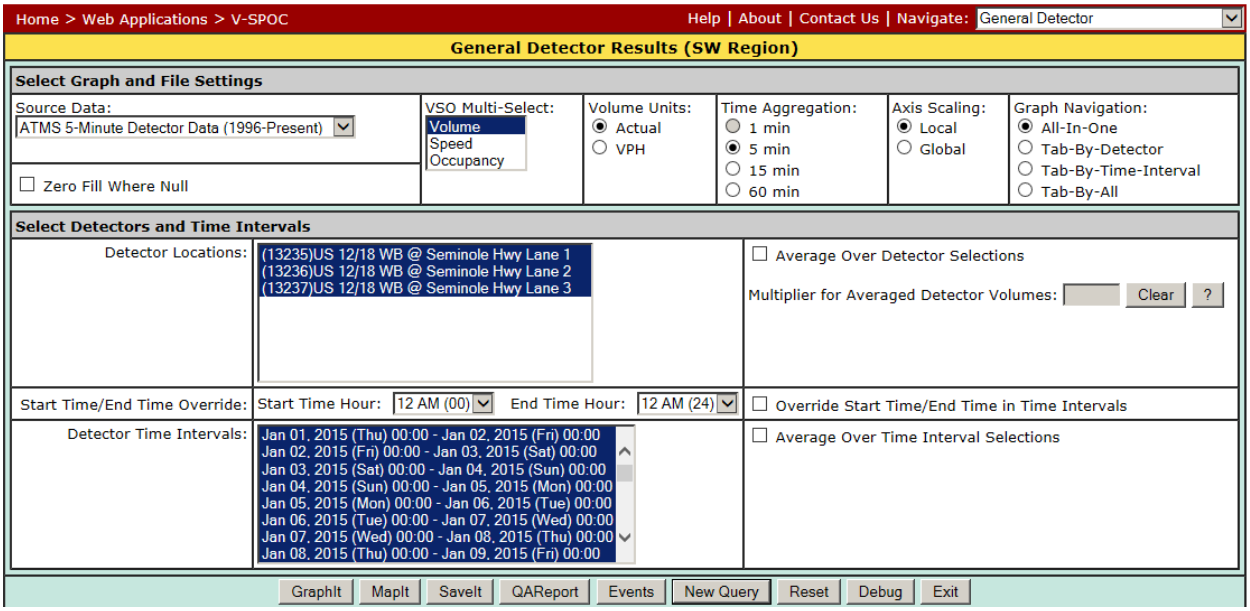


Figure 10. Data Access Screen 2 for Microwave/Loop Data (using V-SPOC online)

4.2. Travel Time Computation

Travel time computation varies by type of data. The computation steps are described briefly below:

4.2.1. TomTom LTA (Live Traffic Archive)

The most difficult data to access is data from the TomTom Live Traffic Archive tool. This data is served in a protocol buffer format from TomTom. Data is accessed using a Protobuf reader and a .proto decoder file. The software used for accessing this data is a modified version of Record Editor (https://sourceforge.net/projects/protobufeditor/) which is a free, open-source software.

Data from the LTA tool is served for the entire state with limited spatial definitions. Therefore, once data is decoded using Record Editor, data must be extracted to a mappable format. Links are represented in OpenLR format which provides the start and end coordinates. This information must be matched to a roadway segments (preferable on the State Trunk Network (STN) used by MetaManager) to create actual highway links. This process is difficult due to varying lengths of segments by route and a disconnect between these segments and the STN and NPMRDS TMC links. Once this is done once, data can be extracted and matched to these links, assuming no changes in the OpenLR codes. If these codes change, the links would have to be reprocessed.

Data is obtained in one-minute intervals and is not filtered for outliers or confidence. Historic data is available for all routes. Full computation steps will be included in the final report as part of the description of Task 3.

4.2.2. TomTom CTT (Custom Travel Times)

TomTom data from the Custom Travel Times tool is much easier to work with than the LTA data, as the output format provided includes an ArcGIS shapefile and an Excel spreadsheet. Excel data can be joined to the routes provided in the shapefile. For reference of this project, the links provided in the shapefile are adequate, however it is preferable to match these segments to the STN.

Data is obtained in 15-minute intervals and is not filtered for outliers or confidence. Historic data is available for all routes. Full computation steps will be included in the final report as part of the description of Task 3.

4.2.3. NPMRDS (National Performance Management Research Data Set)

The National Performance Management Research Data Set is provided as a CSV file which can be joined to the NPMRDS route map which offers segments geo-referenced to traffic message channels (TMCs) and HERE link IDs. Again, for reference of this project, these links are adequate, however it is preferable to match these segments to the STN.

4.2.4. Bluetooth

Bluetooth data is provided from WisDOT owned and GLRTOC owned Bluetooth units. These units are located at various points throughout the state and are referenced by their point coordinates. The software used to access data, C2-Web by Drakewell, allows for routes to be created from multiple Bluetooth points. The software creates routes that match up with Google Maps routes. Like other data sets, these routes are adequate for use in this project, but it is preferable to have these segments matched to the STN for consistency.

4.2.5. ATR (Automated Traffic Recorder)

Automated traffic recorder (ATR) data is available through the TRAffic DAta System (TRADAS). Units are located throughout the state and are referenced by point coordinates. Route creation must be done by matching two or more ATRs along a route and mapping these to the STN.

4.2.6. Microwave/Loop

Microwave and inductive loop data is available through the Volume, SPeed, and Occupancy (VSPOC) data stored on the Wisconsin Transportal. Units are located throughout the state and are referenced by point coordinates. Route creation must be done by matching two or more detectors along a route and mapping these to the STN.

4.3. Statistical Analysis

Once all data is collected and examined, travel times will be compared for all routes and all modes. Based on the literature review, Theil's Inequality Coefficient along with Bias Proportion, Variance Proportion, and Covariance Proportion will be used to compare travel times. These statistics are powerful tools to presents the accuracy and reliability of travel time estimation results across time series. The statistical methods are discussed in detail in the Literature Review.

Analysis will be performed for aggregate data, as well as for specific time intervals

4.4. Data Comparison

A final data comparison will be provided as part of the final report. In addition to comparing travel times for accuracy, data reliability will be measured. For instance, some TomTom links, such as those including heavily traveled interstate highways, include enough observations to make data very reliable. Other links, such as those on two-lane rural arterials, may offer travel times, but only limited observations.

Preferred applications for accessing and processing data will also be compared.

5. Results

5.1. Cost Effectiveness Assessment

A final cost effectiveness assessment will be done to weigh the quality of the travel times and data reliability versus costs of acquiring, maintaining, and processing the data.

5.2. Deliverables

All required tools for processing TomTom archive data from the Live Traffic Archive tool will be included. This includes and algorithms written to process data. The processed TomTom LTA data will also be included for future ease of use. All required tools for processing all other data will also be included along with the processed data.

There will be three written deliverables provided for this project as described below:

5.2.1. Literature Review (Appendix B of this document)

The literature review was completed to both survey previous travel time studies as well as statistical methods used to analyze differences in travel times. Portions of the literature review are included in the analysis plan (with full text in Appendix B of the document). Other parts will be used during the data collection, analysis, and reporting process.

This review included looking at related efforts and past efforts including the 2008 AirSage/INRIX evaluation report and recent GLRTOC work with Bluetooth and probe data including work completed in Janesville comparing Bluetooth, probe data, and NPMRDS data.

5.2.2. Analysis Plan (this document)

The analysis plan (this document) was completed to outline

- the chosen corridors for this study along with dates/times of data comparisons,
- the procedures for accessing and processing the data,
- the statistical methods used to compare travel times and reliability,
- and the procedures for reporting the information.

5.2.3. Final Report

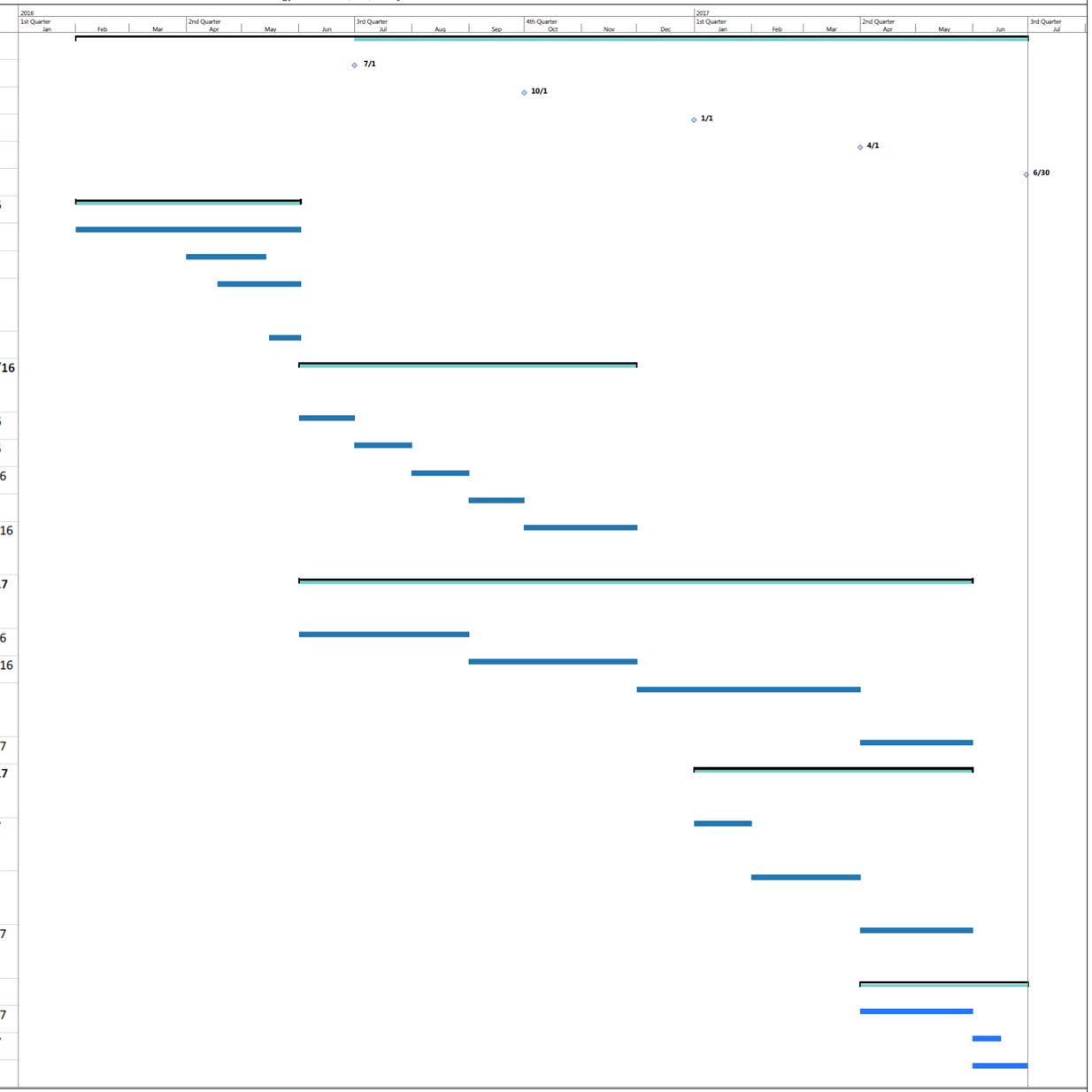
The final report will include all information regarding the process of comparing travel times and reliability. The cost effectiveness assessment will be included to summarize the results and offer recommendations for moving forward.

Once the draft final report is written, a presentation will be delivered to BTO staff and managers. After the presentation, the report will be finalized.

Appendix A. Project Management Timeline

Travel Time Technology Evaluation (T3E) - Project Timeline

ID	Task Mode	Task Name	Duration	Start	Finish
1		**1 Project Management**	**370 days**	**Mon 2/1/16**	**Fri 6/30/17**
2		1.1 Report and Invoice		Fri 7/1/16	
3		1.2 Report and Invoice		Sat 10/1/16	
4		1.3 Report and Invoice		Sun 1/1/17	
5		1.4 Report and Invoice		Sat 4/1/17	
6		1.5 Report and Invoice		Fri 6/30/17	
7		**2 Analysis Plan**	**88 days**	**Mon 2/1/16**	**Wed 6/1/16**
8		2.1 Literature Review	88 days	Mon 2/1/16	Wed 6/1/16
9		2.2 Analysis Plan - Draft	31 days	Fri 4/1/16	Fri 5/13/16
10		2.3 Data Availability Map and Table - Beta	33 days	Mon 4/18/16	Wed 6/1/16
11		2.4 Analysis Plan - Final	13 days	Mon 5/16/16	Wed 6/1/16
12		**3 TomTom Data Development**	**131 days**	**Wed 6/1/16**	**Wed 11/30/16**
13		3.1 Data Access	22 days	Wed 6/1/16	Thu 6/30/16
14		3.2 Data Decoding	22 days	Fri 7/1/16	Sun 7/31/16
15		3.3 Link Decoding	23 days	Mon 8/1/16	Wed 8/31/16
16		3.4 Shapefile Creation	22 days	Thu 9/1/16	Fri 9/30/16
17		3.5 Data Availability Map - Integration	44 days	Sat 10/1/16	Wed 11/30/16
18		**4 Retreiving and Processing Data**	**261 days**	**Wed 6/1/16**	**Wed 5/31/17**
19		4.1 Data Access	66 days	Wed 6/1/16	Wed 8/31/16
20		4.2 Data Processing	65 days	Thu 9/1/16	Wed 11/30/16
21		4.3 Data Availability Map and Table - Final	87 days	Thu 12/1/16	Fri 3/31/17
22		4.4 Summary Statistics	44 days	Sat 4/1/17	Wed 5/31/17
23		**5 Cost Effectiveness Assessment**	**109 days**	**Sun 1/1/17**	**Wed 5/31/17**
24		5.1 Initial and Lifecycle Cost Assessment	23 days	Sun 1/1/17	Tue 1/31/17
25		5.2 Travel Time Effectiveness Assessment	43 days	Wed 2/1/17	Fri 3/31/17
26		5.3 Cost Effectiveness Assessment Summary	44 days	Sat 4/1/17	Wed 5/31/17
27		**6 Report and Presentation**	**66 days**	**Sat 4/1/17**	**Fri 6/30/17**
28		6.1 Draft Report	44 days	Sat 4/1/17	Wed 5/31/17
29		6.2 Final Presentation	11 days	Thu 6/1/17	Thu 6/15/17
30		6.3 Final Report	22 days	Thu 6/1/17	Fri 6/30/17



Project: T3E Project Manageme
Date: Wed 8/17/16

Task, Split, Milestone, Summary, Project Summary, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, External Tasks, External Milestone, Deadline, Progress, Manual Progress

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Appendix B. Literature Review

Literature review begins on next page