Minnesota Arterial Travel Time (MATT) Project

Final Report

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1. Executive Summary

In the Twin Cities, the Minnesota Department of Transportation (Mn/DOT) calculates and disseminates freeway travel times based upon freeway loop detector data. However, currently there is not an operational approach toward monitoring or disseminating arterial travel times throughout the Twin Cities. Several recent initiatives now underway in Minnesota (including participation in the USDOT Integrated Corridor Management (ICM) initiative, and the Urban Partnership Agreement (UPA)) have increased the need for travel time reporting on arterial routes. A key element to both the ICM and UPA initiatives is to present travelers with travel time comparisons for freeways, arterials and transit. Mn/DOT has explored several options for cost effective arterial travel time monitoring and estimation. The Minnesota Arterial Travel Time (MATT) Project has researched and demonstrated one mechanism for arterial travel time reporting.

Project Location

Because of the emphasis on arterial travel time throughout the I-394 Corridor, Highway 55 (a parallel route to I-394) was selected as the test corridor for this project. The MATT Project attempted to develop an algorithm that could predict travel times along Highway 55 from I-494 to Theodore Wirth Parkway (Theo Wirth).

Infrastructure Needs of the Approach

The MATT Project recognized the limited data available along arterial highways. Therefore, the MATT algorithm was created to use the 15 minute traffic volume data available from advance detectors along the arterial routes. Therefore, no additional detection devices or subscriptions to data services are required to operate the MATT algorithm. The only exception is that the MATT algorithm does include a factor for weather impacts. The algorithm was developed to have a feed indicating if the highway is wet from either rain or snow.

MATT Algorithm Outputs

The MATT algorithm was designed to run in real-time, and to generate two primary outputs:

1. A prediction of the travel time for the immediate upcoming 15 minutes along the arterial route; and

2. A classification of the performance of the arterial route, classified as either:

    - ***Free flow*** (travel speeds are near the posted speed, and travelers may stop at a red light);

    - ***Minor delays*** (travel speeds are slower than the posted speed, and travelers are likely to stop at least once for a red light); and

- ***Moderate to heavy delays*** (travel speeds are slower than posted speeds and travelers are likely to stop multiple times for red lights).

MATT Algorithm Approach

The MATT algorithm was developed to predict increases to typical travel times as a result of high traffic volumes. The MATT algorithm examines the ratio of volume to operational capacity (V/C) along individual segments of the overall highway, and the predicted impacts of individual segments are summed across the entire route.

MATT Algorithm Performance

The algorithm was developed and threshold values adjusted using four days of eastbound (EB) travel time runs. A separate set of EB travel time runs (an additional 4 days) were used to test the algorithm (4 days of travel time runs not used during the algorithm development process).

Based on a statistical analysis comparing the 70 EB travel time runs conducted over the four days of testing against MATT predicted travel time values, the results are as follows:

- 90% of MATT predicted times fall within 2.6 minutes of the actual travel time;
- 80% of MATT predicted times fall within 2.0 minutes of the actual travel time.

In addition, the MATT algorithm was tested against travel time runs on westbound (WB) Hwy 55 during the same four days. The algorithm was not recalibrated or readjusted for the WB predictions. Based on a statistical analysis comparing the 70 WB travel time runs conducted over the four days of testing against MATT predicted travel time values, the results are as follows:

- 90% of MATT predicted times fall within 3.0 minutes of the actual travel time;
- 80% of MATT predicted times fall within 2.1 minutes of the actual travel time.

Future Development Efforts

The MATT algorithm appears to validate the hypothesis that V/C can be used to predict travel times in real-time. However, the limited number of days of travel time runs, and the fact that there were no incidents causing major delays during these days has not allowed the MATT algorithm to be evaluated under heavily congested conditions. Therefore, additional testing and calibration is needed under congested conditions.

2. Project Overview

The MATT Project was an initial effort to define a method for measuring arterial performance in real-time using the commonly available 15 minute volume detector readings at advance locations along arterial routes.

2.1 The Need for Arterial Performance Measures

Based on the input received from the Mn/DOT Planning Group, Arterial Signals Group, and the Traveler Information Group, the following needs were defined for arterial performance measurements:

- Arterial segments need to be classified into one of three condition descriptions to allow a color coding on Internet dissemination maps. Based upon the research of this project, the following classifications are suggested:
    - Free Flow (travel speeds are near the posted speed);
    - Minor delays (travel speeds are slower than the posted speed, and travelers are likely to stop at least once for a red light); and
    - Moderate to heavy delays (travel speeds are slower than posted speeds and travelers are likely to stop multiple times for red lights).

- Travel times shall be reported for stretches of the corridor that match key destinations or recognized landmarks (e.g. intersections of prominent roads). Therefore, it was important to test and determine if the MATT algorithm could predict a travel time for a stretch of road that extended beyond the area covered by the traffic volume detectors.

2.2 MATT Project Goals

In order to meet the needs identified in Section 2.1, the following goals and objectives were defined for Minnesota Arterial Travel Time reporting initiative:

Goal #1: To develop and reach consensus on definitions for the three classifications of the arterial route performance. The definitions must be based on conditions that are measurable in real-time or by analyzing historic data.

Goal #2: To develop an algorithm to categorize arterial traffic conditions as either ‘Free Flowing’, ‘Minor delays’, or ‘Moderate to heavy delays’, based upon the definitions indicated in Section 2.1.

Goal #3: To develop an algorithm to compute the predicted travel time for an arterial route

Goal #4: That any algorithm developed during the MATT project should be easily

transferred to other routes and/or expanded in length. The success of the project would rely on an easily calibrated algorithm, requiring minimal travel time runs and adjustments before operational use.

3. The MATT Algorithm

3.1 Algorithm Overview

The intent of the MATT algorithm is to predict the performance of arterial highways in real-time.

The performance measures identified in the project are as follows:

- *Classification of Route Performance.* The route is classified as either:
    - ***Free flow*** (travel speeds are near the posted speed);
    - ***Minor delays*** (travel speeds are slower than the posted speed, and travelers are likely to stop at least once for a red light); and
    - ***Moderate to heavy delays*** (travel speeds are slower than posted speeds and travelers are likely to stop multiple times for red lights).
- *Calculation of Travel Time.* A travel time is calculated that could be disseminated to travelers to estimate their time to travel the route in the very near future (e.g. next 15 minutes).

For purposes of the MATT Algorithm, the following definitions are used:

- **Route** is defined as the total length of the stretch of highway for which a performance measure is being calculated.
- **Segment** is defined as portions of an overall route, typically segments are divided by signalized intersections, and one advance volume measurement is available for each segment. The sum of the segments equals the route.

3.2 Key Algorithm Inputs, Thresholds, and Decisions

The MATT algorithm is based on the following key factors:

- A Travel Time (or typical travel speed) for the Route;
- The comparison of volume to operational capacity;
- Thresholds differentiating Levels of Service; and
- Increases to the typical travel times as thresholds are exceeded.

The remainder of this section will address each of these factors, describing the current MATT approach.

Typical Travel Time

The MATT algorithm is based on a typical travel time value for each segment along the entire route. Therefore, individual typical travel time values are required for each segment. Typical travel time values are derived based upon effective speeds for the corridor during free flow conditions. For the MATT algorithm on Highway 55, an effective speed value of 47 MPH is used for all eastbound segments; 43 MPH was used for westbound segments.

In transitioning MATT to other locations in Minnesota, an effective speed value would need to be computed for each route. The speed values for the MATT project were taken from a previous signal timing study conducted on the Highway 55 corridor.

The Comparison of Volume to Operational Capacity

The underlying hypothesis to the MATT algorithm is that impacts to the typical travel time along an arterial route (in the form of travel time increases) can be predicted by examining the ratio of the volume of traffic to the operational capacity of the route. In other words, if there is more volume on the route than the operational capacity allows (e.g. V/C>1.0) there is going to be a challenge moving all the vehicles effectively and efficiently. Similarly, as the ratio of V/C approaches 1.0, the typical travel patterns will be impacted.

The MATT Project explored several approaches to apply V/C to predict travel time impacts. Summarized as follows:

- ***Current V/C.*** The initial model used only the current 15 minute volume reading compared to the operational capacity of the signal timing pattern. This would be the simplest comparison to implement in real-time.

- ***Current and historic V/C.*** Another V/C approach calculated a modified value for the volume by averaging the most recent 15 minute average volume reading and the volume reading taken at the timestamp 15 minutes ahead of the current time, exactly one week prior the current time. In other words, at 8:00 AM on Monday March 16, the volume would be calculated by averaging the current reading taken during the 15 minute time

period form 7:45-8:00 AM and the reading from 8:00-8:15 AM on Monday March 9. The intent of this approach was to capture regular trends in the travel patterns in hopes of predicting the next 15 minutes more accurately.

The results section of this document describes the results of both analyses. Regardless of the selected approach for computing the V/C relationship, the MATT algorithm would process the V/C calculations with a threshold analysis, as described below.

Threshold Analysis Applied to V/C Calculations

The key strategy of the MATT algorithm is to increase the predicted travel time when the V/C ratio is higher than selected threshold values. The current MATT algorithm includes three threshold levels (ranges defined by upper/lower thresholds) that are used to compare the V/C ratio. These threshold levels are also used to determine if the segment is free flowing, a minor delay, or a moderate to heavy delay. The following table identifies the threshold levels and the role of each level in arterial performance monitoring.

Table 1 – MATT Algorithm Threshold Levels, Roadway Classification, and Travel Time Calculation

Threshold Range	Classification of Roadway	Calculation of Travel Time
0 < V/C < .75	Free Flow	No Change to Typical Travel Time
.75 < V/C < 1.0	Minor Delays	Level I Change to Typical Travel Time
V/C > 1.0	Moderate to Heavy Delays	Level II Change to Typical Travel Time

The current MATT algorithm uses a 'step function' approach where thresholds at each 'step' are used to determine the increase in the travel time. In future versions of the algorithm, it is possible for additional 'steps' to be introduced, creating a more gradual increase in travel times, or possibly an eventual linear determination of travel time increases. Figure 1 illustrates the current two threshold step function, and Figure 2 illustrates the potential for additional steps to help increase the accuracy of the algorithm by fine tuning the amount of travel time added to the typical travel time

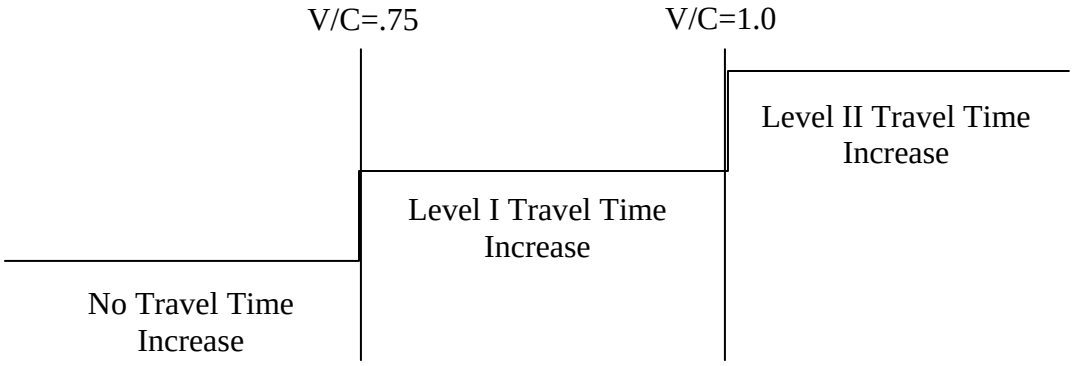


Figure 1 – Current MATT Algorithm Step Function Threshold Analysis

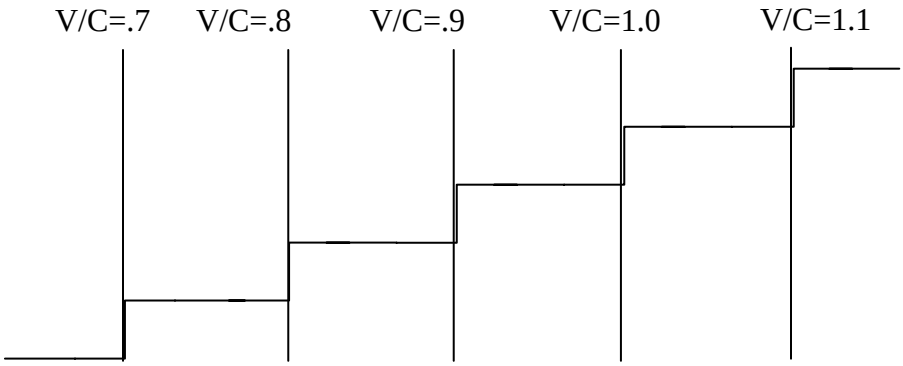


Figure 2 – Possible Future MATT Algorithm with Additional Steps

Determining Increases to Travel Times Based on Threshold Levels

As noted previously, the current MATT algorithm classifies each segment into one of three categories based on the V/C threshold comparison (no change, Level I change, Level II change). The algorithm development explored several options for determining the extent to which additional time would be applied to the travel times for both the Level I and Level II changes. The following are the current calculation strategies used to determine travel time increases for each level of change:

- Level I Change (.75<V/C<1.0) – An additional time equal to 25% of the effective wait time (yellow plus red time given to the approach by the operational signal timing plan) is added to the typical travel time for the individual segment.
- Level II Change (V/C>1.0) – An additional time equal to 50% of the effective wait time (yellow plus red) is added to the typical travel time for the individual segment.

Classifying Routes Based on V/C Values

The logic behind classifying the performance of the route is to describe to travelers the conditions they are likely to experience while driving the route. As the volume of traffic approaches the operational capacity, it is more likely that the queue at the intersection may not completely disperse; it is also likely that travel speeds will be slower. However, the nature of arterial travel is different than freeway travel. On arterial routes, two travelers departing within 10 seconds may have very different travel times (if one traveler encounters a yellow/red light that traveler will encounter a jump in their travel time immediately by waiting for the red light to turn green, and may encounter additional red lights). Therefore, the three classification levels identified for performance reporting reflect the likelihood that travelers may be stopped at red lights, and may encounter slower travel speeds.

The MATT algorithm approach to classifying the roadway is described as follows:

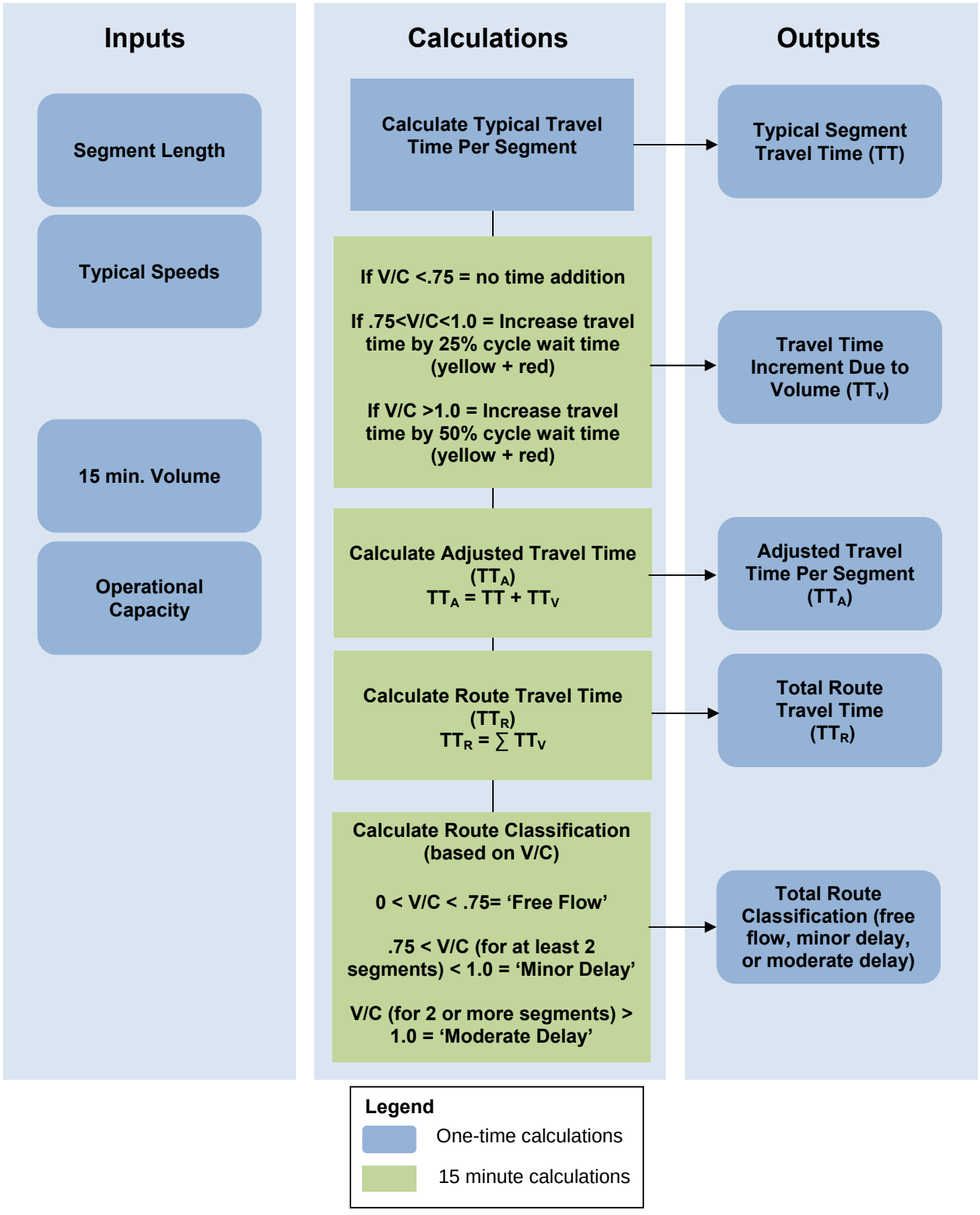
- If a route experiences V/C values less than .75 throughout all segments of the route, the route is classified as 'Free flow' or 'Clear';
- If a route experiences V/C values between .75 and 1.0 for at least two segments of the entire route (and there are not at least two segments experiencing V/C values greater than 1.0) the route is classified as 'Minor delays'. The definition for Minor delays is that travel speeds will be slower than posted speeds and travelers are likely to stop at least once for a red light while en-route.
- If a route experiences V/C values higher than 1.0 for at least two segments of the entire route, the route is classified as 'Moderate to heavy delays'. The definition for Moderate to heavy delays is travel speeds are slower than posted speeds and travelers are likely to stop multiple times for red lights.

These classification levels were defined because it is believed that they provide useful information to the travelers while respecting the variance in travel times that is common among arterial travelers. Using the earlier mentioned example of two travelers departing within 10 seconds of each other, the two travelers may end up with travel times across the route that differ by 2-3 minutes, but both travelers could agree that the definition of "Minor delays – travel speeds will be slower than posted speeds and travelers are likely to stop at least once for a red light while en-route" would describe their route.

Further Calibration and Portability of the MATT Algorithm

The two layers of decision processes (layer one defining the levels of thresholds and layer two defining how much time is added when each threshold is exceeded) were created intentionally to make the algorithm simple (only two figures need to be examined and possibly modified when expanding it) as well as to make it flexible to the option to further improve and enhance the algorithm (e.g. additional threshold levels could be added to further fine tune the additional travel time added).

Figure 3 – MATT Algorithm Flowchart



4. MATT Algorithm Performance Testing

In order to properly address the goals of this project, developers of the MATT algorithm recognize that if the MATT algorithm is to be of value to travelers, it must predict travel times for the immediate future (e.g. in the next 15 minutes). For example, if a 15 minute volume reading is collected from 7:15-7:30 AM, the earliest a travel time could be disseminated to the traveling public would be 7:30 AM or later. Therefore, if the travel time does not reflect a travel time experienced from 7:30-7:45 AM, it will be recognized by travelers as inaccurate. Therefore, there is an implied need for the MATT Algorithm to predict travel times in the immediate future in order to be effective.

This section describes the testing that was performed on the MATT algorithm to determine the likelihood that the algorithm can produce useful predictions of arterial travel times for the immediate future.

4.1 Algorithm Calibration and Testing

Two very distinct activities were performed on the algorithm:

- A calibration phase where multiple versions of threshold levels and travel time increases were tested against data collected using actual travel time runs; and

- A testing phase where the algorithm configurations determined in the calibration phase were tested against a separate set of actual travel time runs.

For both the calibration data sets and the testing data sets, an independent contractor executed a floating car survey of travel times (travel time runs) along Highway 55. A total of seven days of travel time runs were completed, collecting data for both the AM and PM peak periods. Three days' worth of the data was used in the calibration, and four days worth were used in the testing of the algorithm. The algorithm was tested using data collected on Thursday, October 30, Tuesday, December 9, Wednesday, December 10, and Thursday, December 11, 2008 which avoided Monday and Friday data. Weather was not a factor on any of the days except for December 9. It snowed during the AM peak period of December 9.

4.2 Algorithm Calibration Process

In order to calibrate the model the following processes were tried.

- A time of day factor was applied to the AM and PM peak (entering peak, peak, leaving peak) to add time to the predicted travel time
- The travel time was increased by a factor if the V/C was greater than .75
- The travel time was increased by a factor if the V/C was greater than 1.0
- The travel time was increased if it was raining or snowing by a set number.

A variety of approaches were used during the calibration process to test different theories on the algorithm.

4.3 Algorithm Testing Process

The process to test the algorithm was similar to the calibration process. ***It is important to note that for each test comparison, the departure time of the driver and vehicle making the travel time run varied (e.g. did not always occur on 15 minute increments). In order to test the predictability of the MATT algorithm, the MATT computed travel times were matched up with the next closest travel time run initiated after the MATT calculation. In other words, a travel time run that begins at 6:31 is compared with the MATT travel time calculated after the 6:15-6:30 data is processed (and therefore the MATT algorithm is using data that could have been collected as much as 30 minutes prior to the predicted time used in the comparison).*** Some travel time runs that begin less than 5 minutes before the end of the 15 minute period are compared to the current 15 minute period because the vehicles involved in the travel time runs traveled through several intersections before reaching the test corridor.

4.4 Algorithm Test Results

The analysis of actual travel times experienced by floating car surveys and predicted travel times computed by the MATT algorithm are the primary basis to assess the performance of the algorithm. However, the following key points must be considered when performing such an analysis:

- Unlike freeway travel, two vehicles can depart within seconds from each other and travel the same route. If one vehicle encounters one or more red lights, their travel time can be considerably higher than the other vehicle.
- Unlike freeway travel, emergency signal preemption can interfere with the progression of vehicles along a highway, often causing delays of several minutes.
- While the question of 'how good is good enough?' for arterial travel time predictions, there is a recognized need for the arterial travel time algorithms to predict the patterns of travel times, and to predict travel time values within a few minutes at least 80% of the time.

The following figure uses a line graph to illustrate the differences in actual travel times experienced by the floating car survey and the predicted travel times computed by the MATT algorithm for Eastbound Highway 55.

Figure 4 – Four Days (70 Travel Time Runs) of Eastbound Floating Car Surveys compared to MATT Predictions

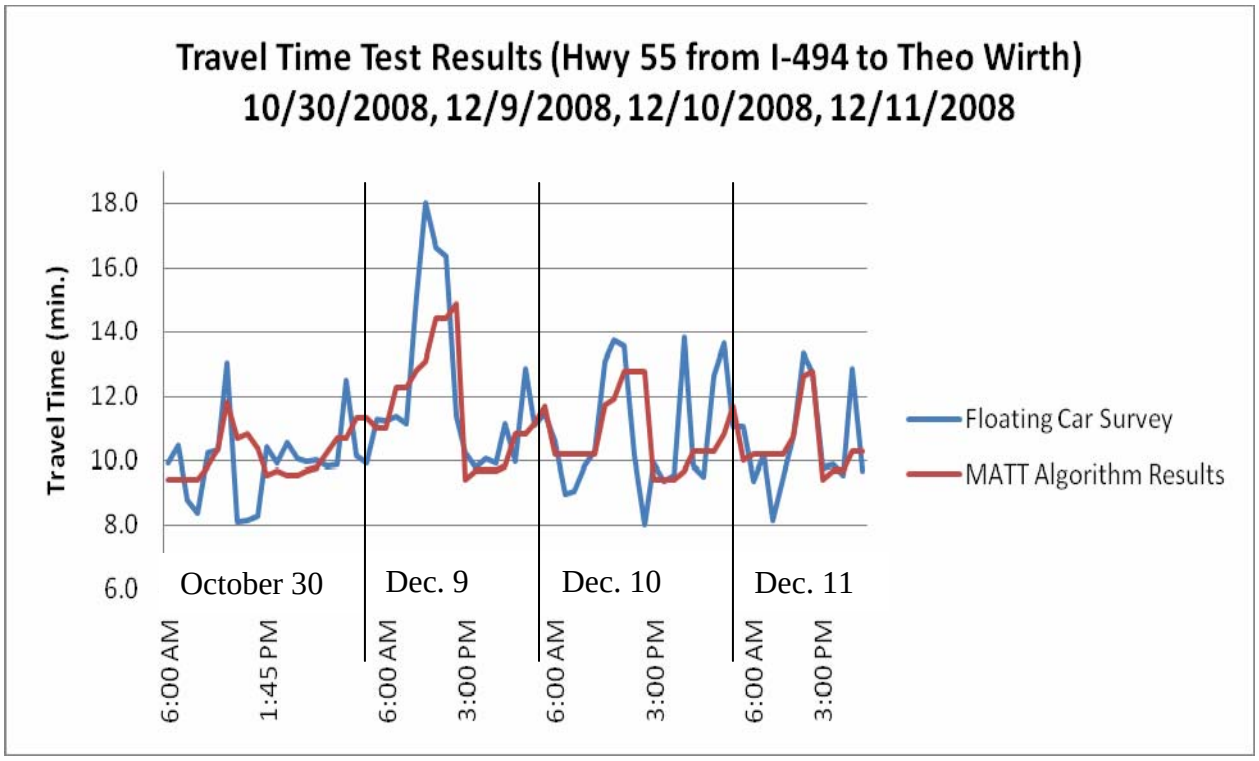
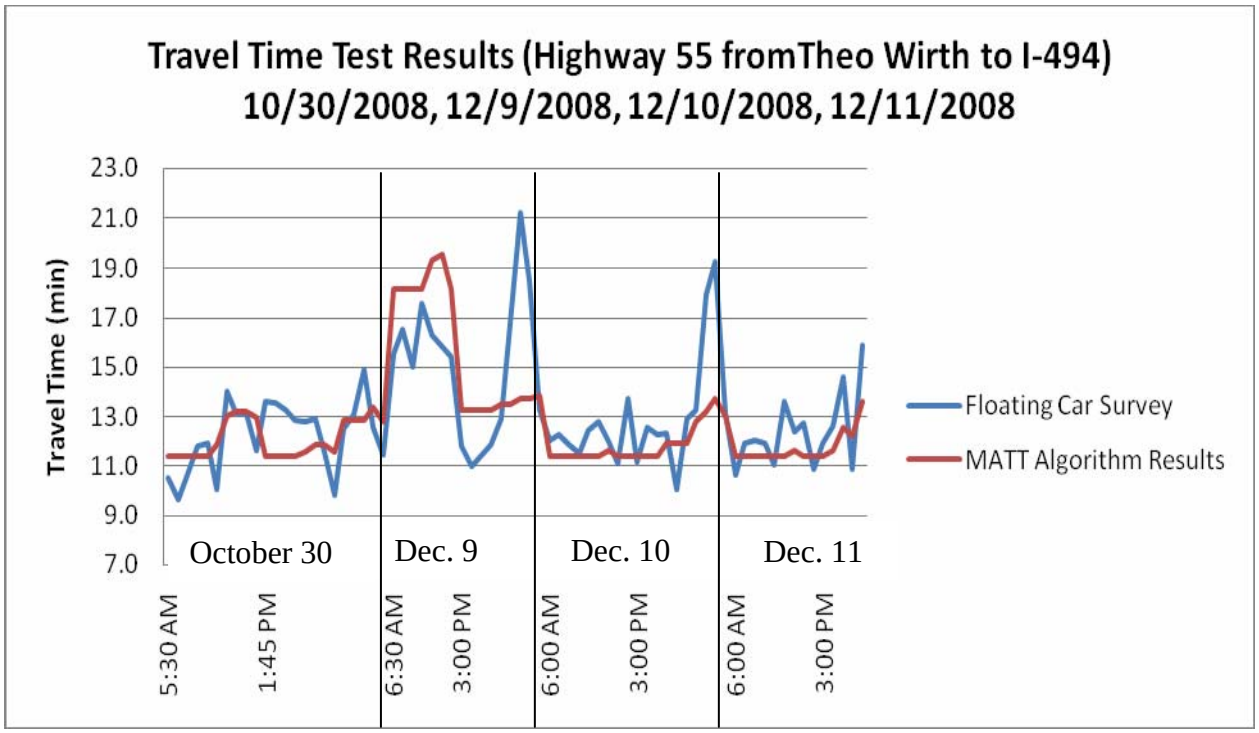


Figure 5 – Four Days (70 Travel Time Runs) of Westbound Floating Car Surveys compared to MATT Predictions



Tables 2-9 on the following pages identify the difference between the actual travel time calculated from the floating car surveys and the MATT algorithm. The tables also show the MATT algorithm classification (free flow, minor delay, or moderate delay).

Table 2 – October 30, 2008 Actual Travel Time Readings, MATT Predictions and MATT Classification - Eastbound TH 55 from I-494 to Theo Wirth

Time of Day	MATT Predicted Travel Time	Time Range to Display to Travelers	MATT Classification of Route	Actual Recorded Travel Time	Is Actual Time within MATT Predicted Time Range?
AM Peak					
5:59 AM	9.4	8-10	Free Flow	9.9	Yes
6:09 AM	9.4	8-10	Free Flow	10.5	Yes
6:31 AM	9.4	8-10	Free Flow	8.8	Yes
6:43 AM	9.4	8-10	Free Flow	8.4	Yes
7:04 AM	9.8	8-10	Moderate Delay	10.2	Yes
7:13 AM	10.4	9-11	Moderate Delay	10.3	Yes
7:40 AM	11.8	11-13	Moderate Delay	13.1	Yes
8:19 AM	10.7	10-12	Moderate Delay	8.1	No
8:28 AM	10.8	10-12	Moderate Delay	8.1	No
8:52 AM	10.4	9-11	Moderate Delay	8.3	No
PM Peak					
1:58 PM	9.5	9-11	Free Flow	10.4	Yes
2:15 PM	9.7	9-11	Minor Delay	9.9	Yes
2:33 PM	9.5	9-11	Free Flow	10.6	Yes
2:48 PM	9.5	9-11	Free Flow	10.1	Yes
3:08 PM	9.7	9-11	Minor Delay	10.0	Yes
3:20 PM	9.8	9-11	Minor Delay	10.0	Yes
3:42 PM	10.3	9-11	Minor Delay	9.9	Yes
4:18 PM	10.7	10-12	Moderate Delay	9.9	Yes
4:21 PM	10.7	10-12	Moderate Delay	12.5	Yes
4:54 PM	11.3	10-12	Moderate Delay	10.2	Yes
4:57 PM	11.3	10-12	Moderate Delay	9.9	Yes
5:36 PM	11.0	10-12	Moderate Delay	11.3	Yes
5:36 PM	11.0	10-12	Moderate Delay	11.3	Yes

Table 3 – December 9, 2008 Actual Travel Time Readings, MATT Predictions and MATT Classification - Eastbound TH 55 from I-494 to Theo Wirth

Time of Day	MATT Predicted Travel Time	Time Range to Display to Travelers	MATT Classification of Route	Actual Recorded Travel Time	Is Actual Time within MATT Predicted Time Range?
AM Peak					
6:08 AM	12.3	11-13	Free Flow	11.4	Yes
6:49 AM	12.3	11-13	Free Flow	11.2	Yes
7:13 AM	12.8	12-14	Minor Delay	15.2	No
7:28 AM	13.1	12-14	Minor Delay	18.0	No
7:58 AM	14.4	13-15	Moderate Delay	16.6	No
8:16 AM	14.4	13-15	Moderate Delay	16.4	No
8:46 AM	14.9	14-16	Moderate Delay	11.4	No
PM Peak					
3:03 PM	9.4	8-10	Free Flow	10.3	Yes
3:30 PM	9.7	9-11	Minor Delay	9.8	Yes
3:38 PM	9.7	9-11	Minor Delay	10.1	Yes
4:03 PM	9.7	9-11	Minor Delay	9.9	Yes
4:15 PM	9.9	9-11	Minor Delay	11.2	Yes
4:42 PM	10.8	10-12	Moderate Delay	10.0	Yes
5:00 PM	10.8	10-12	Moderate Delay	12.9	Yes
5:15 PM	11.1	10-12	Moderate Delay	11.1	Yes
5:30 PM	11.7	11-13	Moderate Delay	11.5	Yes

Table 4 – December 10, 2008 Actual Travel Time Readings, MATT Predictions and MATT Classification - Eastbound TH 55 from I-494 to Theo Wirth

Time of Day	MATT Predicted Travel Time	Time Range to Display to Travelers	MATT Classification of Route	Actual Recorded Travel Time	Is Actual Time within MATT Predicted Time Range?
AM Peak					
5:54 AM	10.2	9-11	Free Flow	10.6	Yes
6:19 AM	10.2	9-11	Free Flow	9.0	Yes
6:28 AM	10.2	9-11	Free Flow	9.1	Yes
6:52 AM	10.2	9-11	Free Flow	9.9	Yes
7:01 AM	10.2	9-11	Minor Delay	10.3	Yes
7:25 AM	11.7	11-13	Moderate Delay	13.1	Yes
7:54 AM	11.9	11-13	Moderate Delay	13.8	Yes
8:04 AM	12.8	12-14	Moderate Delay	13.6	Yes
8:37 AM	12.8	12-14	Moderate Delay	10.2	No
8:43 AM	12.8	12-14	Moderate Delay	8.0	No
PM Peak					
2:55 PM	9.4	8-10	Free Flow	9.9	Yes
3:08 PM	9.4	8-10	Free Flow	9.4	Yes
3:30 PM	9.4	8-10	Minor Delay	9.6	Yes
3:42 PM	9.7	9-11	Minor Delay	13.8	No
4:06 PM	10.3	9-11	Minor Delay	9.9	Yes
4:17 PM	10.3	9-11	Minor Delay	9.5	Yes
4:42 PM	10.3	9-11	Minor Delay	12.7	No
4:54 PM	10.8	10-12	Moderate Delay	13.7	No
5:30 PM	11.7	11-13	Moderate Delay	11.1	Yes
5:42 PM	10.0	9-11	Moderate Delay	11.1	Yes

Table 5 – December 11, 2008 Actual Travel Time Readings, MATT Predictions and MATT Classification - Eastbound TH 55 from I-494 to Theo Wirth

Time of Day	MATT Predicted Travel Time	Time Range to Display to Travelers	MATT Classification of Route	Actual Recorded Travel Time	Is Actual Time within MATT Predicted Time Range?
AM Peak					
5:57 AM	10.2	9-11	Free Flow	9.4	Yes
6:16 AM	10.2	9-11	Free Flow	10.2	Yes
6:31 AM	10.2	9-11	Free Flow	8.2	No
6:49 AM	10.2	9-11	Free Flow	9.5	Yes
7:16 AM	10.7	10-12	Minor Delay	10.8	Yes
7:49 AM	12.6	12-14	Moderate Delay	13.4	Yes
8:01 AM	12.8	12-14	Moderate Delay	12.8	Yes
PM Peak					
3:08 PM	9.4	8-10	Free Flow	9.8	Yes
3:42 PM	9.7	9-11	Minor Delay	9.9	Yes
4:24 PM	9.7	9-11	Minor Delay	9.6	Yes
5:00 PM	10.3	9-11	Moderate Delay	12.9	No
5:45 PM	10.3	9-11	Moderate Delay	9.7	Yes

Table 6 – October 30, 2008 Actual Travel Time Readings, MATT Predictions and MATT Classification - Westbound TH 55 from Theo Wirth to I-494

Time of Day	MATT Predicted Travel Time	Time Range to Display to Travelers	MATT Classification of Route	Actual Recorded Travel Time	Is Actual Time within MATT Predicted Time Range?
AM Peak					
5:44 AM	11.4	10-12	Free Flow	10.5	Yes
5:56 AM	11.4	10-12	Free Flow	9.6	Yes
6:14 AM	11.4	10-12	Free Flow	10.6	Yes
6:25 AM	11.4	10-12	Free Flow	11.8	Yes
6:44 AM	11.4	10-12	Free Flow	11.9	Yes
6:56 AM	11.9	11-13	Minor Delay	10.1	No
7:20 AM	13.0	12-14	Moderate Delay	14.0	Yes
7:59 AM	13.2	12-14	Moderate Delay	13.2	Yes
8:08 AM	13.2	12-14	Moderate Delay	13.1	Yes
8:34 AM	13.0	12-14	Moderate Delay	11.6	Yes
PM Peak					
1:57 PM	11.4	10-12	Free Flow	13.6	No
2:15 PM	11.4	10-12	Free Flow	13.5	No
2:30 PM	11.4	10-12	Free Flow	13.3	No
2:50 PM	11.4	10-12	Free Flow	12.9	Yes
3:03 PM	11.6	11-13	Free Flow	12.8	Yes
3:26 PM	11.9	11-13	Minor Delay	12.9	Yes
3:59 PM	11.9	11-13	Minor Delay	11.6	Yes
4:08 PM	11.6	11-13	Free Flow	9.8	No
4:36 PM	12.9	12-14	Moderate Delay	12.5	Yes
4:38 PM	12.9	12-14	Moderate Delay	13.1	Yes
5:13 PM	12.9	12-14	Moderate Delay	14.9	Yes
5:15 PM	13.4	12-14	Moderate Delay	12.6	Yes
5:55 PM	12.8	12-14	Moderate Delay	11.5	Yes

Table 7 – December 9, 2008 Actual Travel Time Readings, MATT Predictions and MATT Classification - Westbound TH 55 from Theo Wirth to I-494

Time of Day	MATT Predicted Travel Time	Time Range to Display to Travelers	MATT Classification of Route	Actual Recorded Travel Time	Is Actual Time within MATT Predicted Time Range?
AM Peak					
06:27 AM	18.2	17-19	Free Flow	15.5	No
06:50 AM	18.2	17-19	Free Flow	16.6	Yes
07:07 AM	18.2	17-19	Free Flow	15.0	No
07:35 AM	18.2	17-19	Free Flow	17.6	No
07:53 AM	19.3	18-20	Free Flow	16.3	No
08:24 AM	19.6	19-21	Free Flow	15.8	Yes
08:42 AM	18.2	17-19	Free Flow	15.4	No
PM Peak					
03:11 PM	13.3	12-14	Free Flow	11.8	Yes
03:20 PM	13.3	12-14	Free Flow	11.0	No
03:46 PM	13.3	12-14	Minor Delay	11.4	No
03:58 PM	13.3	12-14	Minor Delay	11.9	Yes
04:21 PM	13.5	13-15	Minor Delay	12.9	Yes
04:36 PM	13.5	13-15	Minor Delay	16.8	No
05:01 PM	13.8	13-15	Minor Delay	21.2	No
05:21 PM	13.8	13-15	Moderate Delay	18.5	No
05:47 PM	13.9	13-15	Moderate Delay	13.3	Yes

Table 8 – December 10, 2008 Actual Travel Time Readings, MATT Predictions and MATT Classification - Westbound TH 55 from Theo Wirth to I-494

Time of Day	MATT Predicted Travel Time	Time Range to Display to Travelers	MATT Classification of Route	Actual Recorded Travel Time	Is Actual Time within MATT Predicted Time Range?
AM Peak					
06:00 AM	11.4	10-12	Free Flow	12.0	Yes
06:10 AM	11.4	10-12	Free Flow	12.3	Yes
06:33 AM	11.4	10-12	Free Flow	11.9	Yes
06:43 AM	11.4	10-12	Free Flow	11.5	Yes
07:07 AM	11.4	10-12	Free Flow	12.4	Yes
07:18 AM	11.4	10-12	Free Flow	12.8	Yes
07:46 AM	11.7	11-13	Free Flow	12.0	Yes
08:26 AM	11.4	10-12	Free Flow	11.1	Yes
08:54 AM	11.4	10-12	Free Flow	13.8	No
PM Peak					
02:52 PM	11.4	10-12	Free Flow	11.2	Yes
03:13 PM	11.4	10-12	Free Flow	12.6	Yes
03:25 PM	11.4	10-12	Free Flow	12.3	Yes
03:46 PM	11.9	11-13	Minor Delay	12.3	Yes
04:02 PM	11.9	11-13	Minor Delay	10.1	No
04:23 PM	11.9	11-13	Minor Delay	12.9	Yes
04:32 PM	12.8	12-14	Moderate Delay	13.3	Yes
05:03 PM	13.2	12-14	Moderate Delay	18.0	No
05:15 PM	13.7	13-15	Moderate Delay	19.3	No
05:49 PM	13.0	12-14	Moderate Delay	13.1	Yes

Table 9 – December 11, 2008 Actual Travel Time Readings, MATT Predictions and MATT Classification - Westbound TH 55 from Theo Wirth to I-494

Time of Day	MATT Predicted Travel Time	Time Range to Display to Travelers	MATT Classification of Route	Actual Recorded Travel Time	Is Actual Time within MATT Predicted Time Range?
AM Peak					
06:00 AM	11.4	10-12	Free Flow	10.6	Yes
06:12 AM	11.4	10-12	Free Flow	11.9	Yes
06:31 AM	11.4	10-12	Free Flow	12.0	Yes
07:04 AM	11.4	10-12	Free Flow	11.9	Yes
07:32 AM	11.4	10-12	Free Flow	11.0	Yes
07:41 AM	11.4	10-12	Free Flow	13.6	No
08:09 AM	11.7	11-13	Free Flow	12.4	Yes
08:21 AM	11.4	10-12	Free Flow	12.7	Yes
08:44 AM	11.4	10-12	Free Flow	10.9	Yes
PM Peak					
02:52 PM	11.4	10-12	Free Flow	11.9	Yes
03:24 PM	11.7	11-13	Free Flow	12.6	Yes
03:59 PM	12.6	12-14	Minor Delay	14.6	Yes
04:41 PM	12.2	11-13	Minor Delay	10.9	Yes
05:21 PM	13.6	13-15	Moderate Delay	15.9	Yes

4.5 Future Algorithm Development Needs

Based on the test results of the MATT algorithm presented in the previous section, future algorithm needs were identified.

Congested Conditions

After the actual travel time runs were calculated for this project it was concluded that the days tested were not heavily congested. Therefore, as the MATT algorithm is moved to other arterial corridors, additional analysis is needed to identify time additions for heavily congested conditions.

Additional Thresholds

The MATT Algorithm analyzed V/C to determine if a segment was classified as free flow, minor delay, and moderate delay. Again since Highway 55 did not produce heavily congested corridors during the testing period additional considerations are needed to identify the appropriate time additions for an increase of v/c over a number of intersections. Considerations could also be applied for consecutive intersections that produce a v/c between .75 and 1 or over 1.

Classification of a segment could also be identified by identifying a mph threshold for the corridor. Additional travel time would be added if the travel time for a segment was above the mph threshold.

A time of day factor was also used in the current MATT algorithm. However additional analyzing is needed to identify the appropriate travel time additions for the AM and PM peak periods during congested conditions.

Operational Capacity Considerations

Finally, the initial MATT algorithm development and testing used an assumed value of 1900 vehicles per hour for the Operational Capacity for each intersection. This value could be adjusted per intersection (and per timing plan implemented) to increase performance of the algorithm.