Development and Use of a 700-square mile DTA Model for Corridor Maintenance of Traffic Decision-Making

Sarah E. Binkowski, P.E., PTOE *
Parsons Brinckerhoff, Inc.
500 Griswold Street, Suite 2900
Detroit, Michigan 48226
(313) 963-4679 (office)
(313) 963-4679 (fax)
Binkowski@pbworld.com

James E. Hicks, Ph.D.
Parsons Brinckerhoff, Inc.
6100 Uptown Boulevard NE, Suite 700
Albuquerque, New Mexico 87110
(505) 881-5357 (office)
(505) 881-7602 (fax)
hicksji@pbworld.com

* Corresponding author

Words: 5,463
Figures: 5
Tables: 3
Total: 7,463

August 1, 2013

Submitted to the 93rd Annual Meeting of the Transportation Research Board for consideration for both presentation and publication
ABSTRACT

The Michigan Department of Transportation (MDOT) wanted to develop a dynamic traffic assignment (DTA) model to assist in decision making for a major freeway rehabilitation of the I-96 freeway in the Metro Detroit area. Approximately seven miles of an eight-lane freeway, carrying approximately 160,000 vehicles per day, requires a total reconstruction, including 37 bridges. The DTA model was developed from the Southeastern Michigan Council of Governments travel demand forecasting model utilizing DynusT, a simulation-based DTA software program. As part of the freeway construction, MDOT desired to use the DTA model to assist in the decision-making process of various construction staging scenarios. Over 15 scenarios were tested and compared to the base condition. These scenarios included total closure and maintaining various lanes of travel by direction. The DTA model was overlaid with the various scenarios and used in the public involvement process to aid in decision making. A hot spot analysis was also performed using the DTA model to test various improvements that could be made to the region that would ease the construction of the freeway when it is under construction.
INTRODUCTION

The complete reconstruction of the I-96 freeway between I-275 and US-24 in Southeastern Michigan prompted MDOT to create and utilize a DTA model for analyzing the effect of closing portions of the freeway or reducing capacity in the project corridor while evaluating scenarios for construction staging and maintenance of traffic.

I-96 is an urban, depressed freeway that carries four through lanes of traffic in each direction between I-275 and US-24 (Figure 1). The I-96 corridor in the study area is approximately seven miles in length and carries approximately 160,000 vehicles per day and has a commercial vehicle percentage of 5.6-percent.

Due to the amount of vehicles that utilize I-96 on a daily basis, MDOT desired to know the impact that various construction scenarios would have on the larger regional freeway and local roadway system. In the past, more traditional microscopic network equilibrium models, such as Paramics, were utilized to determine static (not time-dependent) paths with travel times derived from simple mathematical functions. A microscopic model was developed for parts of other southeastern Michigan projects, but this model did not assign traffic dynamically and could not be easily expanded. MDOT has utilized the SEMCOG regional macroscopic travel demand forecasting model for larger projects and found that it did not capture the hourly or more time-dependent congestion well and did not take into account queuing. A DTA model, being mesoscopic in nature, allows for the traffic flows to be modeled based on the determination of time-dependent user-equilibrium routes and in this case more realistically simulates traffic than a macroscopic model. A DTA model is suitable here due to the regional importance of the I-96 corridor and thus the expansive area of impact. A microscopic traffic simulation tool might have been a good option if the area being studied was much smaller, the network involved was much smaller, and the portion of the smaller network under consideration contained all the possible points of likely diversion under the various scenarios to be considered, but that was not the case with the I-96 project.

This paper describes the development process for the DTA model used to evaluate possible work zone closures along I-96. The process required development of a demand adjustment procedure to take original demand tables from the SEMCOG regional macroscopic model and produce demand files suitable for mesoscopic traffic simulation. The project also required the identification of a subarea large enough to evaluate traffic impacts with vehicles able to avoid closure areas by determining new equilibrium route flow solutions under various closure scenarios. Demand calibration procedures for both the AM and PM period subarea models used to evaluate work zone scenarios are described. This paper also describes the application of various maintenance of traffic alternatives that were analyzed with the model and how those results were utilized in decision making.
FIGURE 1 SEMCOG Region, DTA Subarea, and Work Zone area
DTA MODEL DEVELOPMENT

This section of the report summarizes the development of the Dynamic Traffic Assignment (DTA) model, including what inputs were utilized in the development of the model, additional data that was used in calibration, the development of a subarea model, and testing that was done with the DTA model prior to use for the evaluation of alternatives.

Demand Calibration Procedure

Demand adjustment procedures typically used in practice either involve a procedure called matrix origin-destination (OD) estimation, a manual procedure of adjusting flows between specific ODs, or a combination of the two. For this project, due to the scale of the model, a new kind of procedure was used to prepare demand files for the DTA model. This section describes the demand adjustment procedure used to calibrate the demand for the I-96 DTA model.

The relatively long demand loading period required (6:00-10:00 AM and 2:00-7:00 PM) and the size of the regional network and subsequent sub-area network for the I-96 DTA model made the use of more typical origin-destination (OD) estimation methods questionable. The typical calibration method uses static, macroscopic traffic assignment methods in conjunction with mathematical optimization procedures to find the optimal adjustment of demand to best match observed link counts when assigned with the macroscopic traffic assignment model. The shortcomings of static models are the reason DTA models are desirable in the first place. While those procedures might prove adequate for developing demand to load on small networks where peak traffic periods are fairly uniform, the I-96 DTA model, was developed to capture diversion effects over a large spatial region and did not fit this criterion. For the sub-area under consideration, traffic peaks occur at different locations and at different times due to the size of the area. Furthermore, any manual procedure would prove to be too time consuming and biased, as the number of ODs to be adjusted and the number of possible adjustments makes a manual procedure impractical.

To address the shortcomings described above, a more dynamic adjustment procedure is required. A procedure that sought to adjust time-dependent vehicle trajectories developed using DynusT (a simulation-based DTA software package) to match observed 15-minute interval traffic volume counts was employed. The observed 15-minute interval count locations were taken from traffic count data from Traffic.com. The Traffic.com website contains historical 15-minute count data for multiple freeway locations within southeast Michigan. For the calibration of this model, historical count data from all the Tuesdays, Wednesdays, and Thursdays in October 2010 were utilized. The month of October 2010 was determined to be an average month throughout the year with little chance of major construction projects along major freeways that could create traffic diversion that would impact counts.

Demand adjustment for this calibration effort was performed at the regional level and at the sub-area level and was performed for both the AM period and PM period models. The dynamic demand adjustment works by analyzing the vehicle trajectory file produced by DynusT. The vehicle trajectory file contains information about the DTA assigned vehicles, such as the node sequence followed by the vehicle and the arrival times at each node. From this file, it is possible to summarize the 15-minute interval model flows and compare those to the associated observed counts. To understand the procedure, consider a file containing the final trajectory of every vehicle simulated. The file contains the information necessary to develop a path/link incidence table. For any given link in the path/link incidence table, it is possible to
count the number of link traversals over a given time interval (time-dependent model flows) and compare
those flows to observed counts over the same interval for the links which have associated counts. The
idea of the demand adjustment procedure is to develop an adjustment factor for every path in the path/link
incidence table. If the adjustment factors were all exactly 1.0, it would indicate that the modeled flows
from the assigned vehicle trajectory file exactly matched the observed counts. This is an unlikely
outcome. A more likely outcome is that some of the link flows are too high compared to the observed
counts, and some are too low. The dynamic demand adjustment procedure determines factors greater
than 1.0 to apply to vehicles on paths containing links where the flow is less than the counts, and factors
less than 1.0 for vehicles on paths with link flows greater than the counts.

The dynamic demand adjustment procedure generally works as follows, with some specific details to be addressed later:

1. Initial DTA model is run to produce a vehicle trajectory file with crude, time sliced demand
   matrices derived from static models.
2. A balancing procedure is run to determine vehicle factors which when summarized as link flows
closely replicate associated link counts.
3. Vehicle and path input files are prepared for the DTA model.
4. A subsequent DTA model run is created to produce a new, improved vehicle trajectory file.
5. Steps 2-4 are repeated, until satisfactory adjusted demand is achieved.

At the end of the procedure, the adjusted demand files, assigned to the network with dynamic user
equilibrium DTA, produce link flows by interval that match observed link counts reasonably well. The
final vehicle file with information about departure time, origin zone, and destination zone for each
vehicle, as well as a final path file with the sequence of links followed for each vehicle along its path, are
used to assign traffic for each scenario to be evaluated. In the case of analyzing the impact of a closure on
I-96, a base scenario would have no work zone defined, and the resulting DTA assignment would produce
the calibrated link flows that closely match observed counts. For alternative work zone scenarios, the
same demand files would be assigned so that the impacts of traffic diversion and reduced capacity in the
work zone can be evaluated for each of the scenarios.

Full Region Model Demand Calibration

Due to the importance of the I-96 corridor to regional traffic flow, a modeling area much larger than the
area of the corridor was warranted. Traffic impacts as far west as US-23 were considered a possibility.
Vehicles that travel through the I-96 construction corridor could potentially make regional diversions to I-
94 or I-696, as well as all the many possibilities for more local diversions. The feasibility of using a full
region DTA model was considered, however the software runtimes for the full region network would
make demand calibration and scenario analyses infeasible. As a result, a fairly large subarea shown in
Figure 1 was identified by MDOT and determined to meet the needs of the project. The subarea,
indicated by the yellow outline, and the I-96 work zone location indicated by red, are shown in relation to
the SEMCOG regional model network. This subarea extends as far west as US-23, north of I-696, just
east of I-75 and just south of I-94.

Demand from the four period models that SEMCOG uses was taken and factored to demand tables
departing during the 6-10 AM and 2-7 PM periods. The factors were derived from diurnal travel pattern

TRB 2014 Annual Meeting
Original paper submittal - not revised by author
data in SEMCOG’s regional macroscopic model development report. The trip departure profile from the report showed the percentage of trips departing during each 30-minute period of the day, as determined from home interview surveys. This departure pattern was thus applied to the four period regional trip tables, to derive initial regional DynusT trip tables with OD demand by 30-minute interval. The initial demand converted from the SEMCOG model was calibrated through a dynamic demand calibration procedure for the full regional DTA model. The demand for the full regional DTA model was not calibrated to the extent the subarea models were, but rather was calibrated “enough” to provide a better starting point for extracting subarea data, with the knowledge that subarea models would then be more fully calibrated.

Subarea Extraction

The subarea extraction process involves selecting the links to include in the subarea, eliminating the links that are outside the study area, eliminating traffic analysis zones that are outside the study area, converting links crossing the subarea boundary into traffic zones, and finally converting the full region demand into subarea demand files where only the demand intersecting the subarea is retained. For the I-96 DTA model development, a subarea extraction tool that is built into DynusT was used.

For each subarea model, a boundary was defined to identify the subarea. The yellow line in Figure 1 shows one such boundary. Using DynusT, a subarea network file and subarea demand files for vehicles that intersect the subarea were created. These provide initial subarea DTA basic model inputs. Since the network has fewer links, the demand travels between fewer OD pairs, and there are fewer vehicles to simulate, the model runs significantly faster than the full region model. For example, a typical subarea user-equilibrium model run takes approximately eight-hours to complete 30-35 equilibrium iterations. This run-time is appropriate for running several iterations of demand adjustment to produce finer tuned demand tables.

Subarea Demand Calibration

Both the AM and PM subarea models extracted from the full region model were further calibrated to yield base subarea model results that matched observed counts reasonably well. The process of taking output from a user-equilibrium model run, adjusting demand, simulating that adjusted demand, repeating the adjustment and simulation step two to three times, then rerunning the user-equilibrium model was repeated. Three to four iterations were sufficient to produce the higher quality comparison results shown in Figures 2.

Note that these figures show all the data points for multiple 15-minute time intervals and multiple network links. R-Square measures in the 0.6 and above range for all data points combined resulted in R-square measures of between 0.7 and 0.85 when graphed for each individual 15-minute interval. The 0.6 and above measure was therefore an indicator that the individual interval comparisons were of a high quality.
Besides the good results achieved from comparing modeled flows by 15-minute intervals, the user-equilibrium models were solved to a fairly high degree of convergence. DTA models typically do not converge as well as macroscopic models. There were several measures of convergence that were considered in the subarea model runs. First was the relative gap measure produced by the DynusT software. The relative gap measure was below 1%. There is also a measure of the percentage of vehicles changing paths during each iteration which was another consideration. Guidance from colleagues at the University of Arizona was that values below 4-5% were good measures. The measure for these models was around 3.5%. Finally, average travel time values were changing by in the range of hundredths of minutes when the model finished from the previous iteration. These results were achieved with 30-35 iterations of dynamic user equilibrium for the subarea models.

Work Zone Closure Testing

As part of the DTA model development process, a work zone scenario was defined to prepare a set of equilibrium model results with the closure in place. This was done to evaluate the quality of the model results with the closure in place. During this step, some summary programs were also developed as part of the evaluation process. Final summary tables used to evaluate work zone alternative scenarios included link flows and turning-movement flows by 15-minute interval and turning-movement flows by one hour interval. The latter proved to be a better scale for evaluation as there was less variance due to

FIGURE 2 PM Subarea Model Final Demand Comparison

![PM Subarea Model Final Demand Comparison](image.png)
the longer interval and the results were therefore easier to understand as compared to many scenarios
differing only by the closure strategy.

**USE OF THE DTA MODEL IN EVALUATION OF MAINTENANCE OF TRAFFIC (MOT)**

This section of the paper summarizes the various maintenance of traffic (MOT) alternatives that were
evaluated using the DTA model and presented to the public, as well as additional analysis which included
a closure analysis, the five bridge closure scenarios and a hot-spot analysis.

I-96 between I-275 and US-24 in the study area carries approximately 160,000 vehicles per day, has a
commercial vehicle percentage of 5.6-percent and is approximately seven miles in length (Figure 3).
Continuous service drives (Schoolcraft Road) are located along eastbound (EB) and westbound (WB) I-
96 and each carries two through lanes of traffic. Seven full interchanges are present along I-96 as shown
ion Figure 3. An EB entrance ramp and a WB exit ramp are also located east of Levan Road. There are
37 bridges that cross over I-96 in this section, all of which need some sort of construction ranging from
rehabilitation to replacement.

**FIGURE 3 I-96 Corridor Summary**

There was a tiered process developed in analyzing various maintenance of traffic (MOT) alternatives for
the planned construction. The process for developing I-96 staging concepts began by conceiving and
reviewing 17 potential alternatives for maintaining traffic. Each of these alternatives had multiple stages
of construction, which ranged from one stage to eight stages. Eight alternatives were rejected in the early
stages of development for various reasons that resulted in a long construction period which would be
unacceptable to the public and have high costs. The resulting nine alternatives are summarized in Table
1, which shows the overall closure concept, the number of construction stages for each concept, and the
highest-impact construction stage that was evaluated within the DTA model. To reduce the number of
DTA model runs, only the highest-impact stage of construction was modeled using the DTA model. For all alternatives, closure of a single lane of traffic in each direction on the EB and WB service drives was assumed to be in place at all times for work on the ramp terminals, the bridge approaches, and reconstruction of the service drives between approximately Middlebelt Road and Inkster Road. For the first and second tier analysis, all bridges were assumed to open over the freeway.

**TABLE 1 Summary of Tier 1 Alternatives**

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Stages*</th>
<th>Description of Worst Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 1</td>
<td>1</td>
<td>EB and WB freeway and ramps closed</td>
</tr>
<tr>
<td>Alternative 2</td>
<td>2</td>
<td>EB freeway and ramps open WB freeway and ramps closed</td>
</tr>
<tr>
<td>Alternative 3</td>
<td>3</td>
<td>EB Freeway and ramps closed WB Freeway open, but ramps closed</td>
</tr>
<tr>
<td>Alternative 4</td>
<td>3</td>
<td>EB Freeway open but ramps closed WB Freeway and ramps closed</td>
</tr>
<tr>
<td>Alternative 5</td>
<td>5</td>
<td>2 Lanes EB and WB, EB ramps closed except to Merriman, WB on-ramps closed but off-ramps open</td>
</tr>
<tr>
<td>Alternative 6</td>
<td>6</td>
<td>2 Lanes EB, EB on-ramps closed, all off-ramps open 3 Lanes WB, on and off-ramps closed except to Middlebelt</td>
</tr>
<tr>
<td>Alternative 7</td>
<td>6</td>
<td>3 Lanes EB, on and off-ramps closed except to Merriman 2 Lanes WB, on ramps closed but off-ramps open</td>
</tr>
<tr>
<td>Alternative 8</td>
<td>6</td>
<td>2 Lanes WB, on ramps closed, off-ramps are open 3 Lanes EB, on and off-ramps closed except to Middlebelt</td>
</tr>
<tr>
<td>Alternative 9</td>
<td>4</td>
<td>3 Lanes EB, on and off-ramps closed except to Middlebelt</td>
</tr>
</tbody>
</table>

*Number of Construction Stages

The AM and PM DTA models were run for the highest-impact stage of construction for each of the alternative. The following information was summarized for each of the alternatives and compared to existing conditions:

1. Percent Diversion: the amount of vehicles that would have travelled along I-96 between I-275 and US-24 went to another facility and did not use I-96 while under construction.
2. Vehicle Miles of Travel: total length (in miles) that vehicles travelled within the subarea for all roadways and for congested roadways (with a LOS E or LOS F).
3. Vehicle Hours of Travel: total amount of time (in hours) for all vehicles that travelled within the subarea for all roadways and for congested roadways.
4. Vehicle Minutes of Delay: Average additional delay (in minutes) experienced by different users in the subarea, three different users were evaluated:
   - All Users in the subarea
   - I-96 Users: Those vehicles still using I-96 during construction
I-96 Diverted Users: Those vehicles that would have I-96 and diverted to another route during construction.

5. Percent of Congested Roadways: Percentage of roadways that had a LOS E or LOS F (based on length).

Note that items 1 and 4 involve summaries of diverted vehicles. These summaries are only possible by comparing vehicle trajectories from the baseline and closure scenarios to identify vehicles which intersected work zone areas in the base case but did not after the closure. The capabilities afforded by dynamic traffic assignment analysis therefore extend to the types of information that can be derived from their outputs, in addition to the higher quality of traffic representation and route choice determination.

The information above, as well as information on the cost of maintaining traffic, the number of construction stages, and the number of additional construction seasons that may be needed for bridge work was used to eliminate additional alternatives. As a result, the first five alternatives as well as Alternative 7 were moved forward to the next tier of analysis.

The Tier 2 analysis further analyzed each of the top six MOT alternatives during the AM and PM period for each stage of construction. Peak period user cost of delay was developed for each stage of the alternatives. This cost was based on the number of days of construction as well as a user cost per hour, which was assumed to be $16.56 for cars and $29.22 for trucks. The Tier 2 analysis also resulted in videos illustrating the diversion of vehicles from I-96 to other roadways within the region. A video was developed for each alternative for the worst time period based on the results from the Tier 1 analysis. Figure 4 illustrates a screen shot of a video that was developed for Alternative 1.

The videos show animation of total link flows over time with red colors indicating where traffic was diverted to and green showing where traffic was diverted from. The videos were shown at public meetings along with a summary of the impact of each MOT alternative, the cost of each MOT alternative
and the duration of construction under each alternative. Table 2 summarizes the information that was presented at the public meeting.

**TABLE 2 Comparison of Tier 2 Alternatives**

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Construction Seasons</th>
<th>Total Cost of Maintaining Traffic (in millions)</th>
<th>Total Peak Period Delay Cost (in millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 1</td>
<td>1+</td>
<td>$500k</td>
<td>$298.8</td>
</tr>
<tr>
<td>EB and WB Closed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 2</td>
<td>2</td>
<td>$2.3</td>
<td>$382.5</td>
</tr>
<tr>
<td>EB or WB Closed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 3</td>
<td>2</td>
<td>$3.2</td>
<td>$369.0</td>
</tr>
<tr>
<td>EB Closed / 3 Lanes WB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 4</td>
<td>2</td>
<td>$3.5</td>
<td>$373.1</td>
</tr>
<tr>
<td>3 Lanes EB / WB Closed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 5</td>
<td>2</td>
<td>$5.7</td>
<td>$377.3</td>
</tr>
<tr>
<td>2 Lanes EB / 2 Lanes WB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 7</td>
<td>3</td>
<td>$9.1</td>
<td>$367.3</td>
</tr>
<tr>
<td>3 Lanes EB / 2 Lanes WB</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As shown in Table 2, the user cost of delay was lower with Alternative 1 mainly due to the shorter construction season. Alternative 7 has the lowest impact to travel on a daily basis; however, the length of construction increased the overall delay through the life of the project to be consistent with the other alternatives. A survey was provided at the public meeting as well as made available through social networks (project website, Facebook and Twitter) asking the public their preference for the MOT alternative. Approximately 1,787 surveys were collected between March 1-11, 2012. From the survey, approximately 56-percent of responses indicated a preference for full closure of the freeway. Of those that preferred a partial closure, approximately 76-percent preferred Alternative 5, which would keep two lanes open in each direction. Figure 5 illustrates these preferences. As a result of the survey, cost of MOT alternatives, length of construction, and impact to local and regional roadways, three alternatives were moved forward for consideration, which were Alternatives 1, 2, and 5.

**FIGURE 5 Public Preferences**
Considering public preference, cost of the alternative, length of construction, and the impact of the MOT alternative to other local and regional roadways, Alternative 1 (full closure) was the preferred MOT alternative.

### Additional Analysis on Alternative 1

Once the preferred MOT alternative was chosen, additional analysis was conducted utilizing the AM and PM DTA models. This included determining methods of closing the freeway on either end that would have the least impact to motorists, and determining the impact that the various bridge closures along the corridor would have on local traffic. The latter prompted a hot-spot analysis which reviewed impacts to local roadways and intersections.

#### Freeway Closure Analysis

This first set of additional analysis determined how to implement the full closure the freeway with the least impact to motorists. There were eight closure scenarios that were evaluated for I-96 between I-275 and US-24. There were five closure scenarios tested for the eastbound direction in the vicinity of I-275/M-14/Newburgh Road and three closure scenarios tested for the westbound direction in the vicinity of US-24. I-96 directly east of US-24 has both local lanes and express lanes which are divided by a concrete barrier. The local lanes allow access to and from all ramps along I-96 while the express lanes have access to and from the local lanes occasionally. Both the local and express lanes have access to and from M-39. These closure scenarios were a combination of closing various freeway ramps to access the Newburgh Road exit from the west or which of the local/express lane would access M-39 and US-24 from the east.

The AM and PM DTA models were run for each of the scenarios. For all scenarios, all the bridges were open over the freeway and the same westbound closure scenario was utilized. Given that the AM DTA model had the higher eastbound traffic volume, only the AM results were reported and are summarized in Table 3.

After the eastbound closure analysis was completed but not yet submitted, it was announced publicly by MDOT that the northbound and southbound I-275 ramps would have access to Newburgh Road. As a result, the first three closure scenarios were eliminated since those three scenarios did not have access to Newburgh Road from northbound I-275. As a result, Eastbound Closure 4 was selected as the preferred closure scenario, where eastbound M-14 would have access to I-275 and the I-275 ramps would have access to Newburgh Road.

Like the eastbound scenarios, the AM and PM DTA models were run for each of the scenarios and all the bridges were open over the freeway and the same eastbound closure scenario was utilized. Given that the PM DTA model had the higher westbound traffic volume, only the PM results were report and are summarized in Table 3. Given the results, it was decided that Westbound Closure 1 scenario was the preferred closure method, where the express lanes would exit to M-39 and the local lanes would exit to US-24.
TABLE 3 Freeway Closure Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Total Travel Time (hours)</th>
<th>Additional Hours of Travel Time</th>
<th>Vehicle Hours of Delay (All Users)</th>
<th>Additional Hours of Delay (I-96 Users)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Users</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-96 Users</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>AM PEAK PERIOD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current AM</td>
<td>1,487,130</td>
<td>78,704</td>
<td>N/A</td>
<td>579,661</td>
</tr>
<tr>
<td>Eastbound Closure 1</td>
<td>1,513,786</td>
<td>89,933</td>
<td>26,656</td>
<td>592,926</td>
</tr>
<tr>
<td>Eastbound Closure 2</td>
<td>1,519,864</td>
<td>90,431</td>
<td>32,734</td>
<td>595,997</td>
</tr>
<tr>
<td>Eastbound Closure 3</td>
<td>1,516,948</td>
<td>89,337</td>
<td>29,818</td>
<td>596,343</td>
</tr>
<tr>
<td>Eastbound Closure 4</td>
<td>1,513,233</td>
<td>89,534</td>
<td>26,103</td>
<td>593,566</td>
</tr>
<tr>
<td>Eastbound Closure 5</td>
<td>1,518,017</td>
<td>90,051</td>
<td>30,887</td>
<td>604,623</td>
</tr>
<tr>
<td><strong>PM PEAK PERIOD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current PM</td>
<td>2,708,585</td>
<td>169,644</td>
<td>N/A</td>
<td>950,824</td>
</tr>
<tr>
<td>Westbound Closure 1</td>
<td>2,766,009</td>
<td>175,282</td>
<td>57,424</td>
<td>971,873</td>
</tr>
<tr>
<td>Westbound Closure 2</td>
<td>2,769,568</td>
<td>176,162</td>
<td>60,983</td>
<td>979,642</td>
</tr>
<tr>
<td>Westbound Closure 3</td>
<td>2,766,914</td>
<td>175,305</td>
<td>58,329</td>
<td>986,371</td>
</tr>
</tbody>
</table>

Bridge Closure Analysis and Hot-spot analysis

Once a method of closing the freeway on either end was chosen, a bridge analysis was conducted. As mentioned earlier, there are 37 bridges that cross over I-96 in this section, all of which need some sort of construction ranging from rehabilitation to replacement. Of the 37 bridges, eight are for major north-south roadways within the corridor. The other bridges are either minor north-south roadways or u-turn structures which allow access across the freeway. Not all of the bridges can be closed or worked on at the same time since it would cause too much disruption in north-south traffic in the study area. As a result, five different bridge closure scenarios were tested using the AM and PM DTA models. Structures were grouped and scheduled based on school, construction time required, not having consecutive major north-south roadway bridges scheduled at the same time, and corresponding u-turn structures not being scheduled at the same time as their main structure. Two through lanes could be accommodated between the structures but not always at the structure, therefore only one lane was coded into the DTA model in order to capture the worst case scenario. Various structure groups were modeled using the DTA model to identify areas of heavy congestion during construction. These “hot-spots” were then reviewed to determine what mitigation measures could be taken to alleviate potential delays.

Each of the five DTA models were then compared to the model with no construction to determine changes in turning movements along key corridors within the study area. Turning movements that had a maximum increase of 40% or 200 vehicles per hour were flagged to be reviewed to determine if any
improvements could be recommended to ease any additional congestion. Recommendations ranged from adding a right-turn lane to assist additional right-turning traffic to retiming traffic signals for additional through volumes expected along the major roadways north and south of I-96. A table was developed summarizing an expected change in volumes in the AM and PM peak hours with recommendations by intersection. For each location, there was also a priority (low, medium, high) and the expected cost (low, medium, high). Some of the recommendations would need to be completed prior to construction (i.e. the addition of a turn lane or signal) while others could be done during construction if increased traffic volumes were actually observed (i.e. signal timing changes or striping/signing).

CONCLUSIONS AND LESSONS LEARNED

Many lessons were learned during this model development project regarding the demand adjustment procedures and use of the DynusT software. These include:

- Several hours of computer processing time were required for each DTA model run for evaluations of alternatives. It was a time-taking process.
- Visualization of the DTA results allowed videos to be developed for the Tier 2 Alternatives analysis, and were very helpful for public involvement and during the decision making process.
- Cost of delay developed from the DTA model compared to the length of construction was helpful in the decision making process.
- Subsequent use of the I-96 DTA model for the freeway closure analysis, bridge and hot-spot analysis was also found to be useful in decision making and reducing delay.

FUTURE POSSIBILITIES

The subarea models developed to study the I-96 closures could potentially be used by MDOT to evaluate other projects in the subareas. A determination should be made as to whether the projects are sufficiently represented in the subarea models, but assuming they are, project level analysis for closures or other analyses could be performed with these developed models. The I-96 DTA model could be utilized to evaluate the following conditions and understand that the impact of these conditions on local and regional roadways, including short or long-term roadway network disruptions (either planned or unplanned), ITS evaluation and asset deployment, and active traffic management strategies (ramp metering, integrated corridor management and hard shoulder running).

ACKNOWLEDGEMENTS

- Michigan Department of Transportation
  - Oladayo Akinyemi, P.E.
  - Gorette Yung, P.E.
- Southeast Michigan Council of Governments
- University of Arizona
  - Yi-Chang Chiu, Ph.D.
  - Eric Nava
- Parsons Brinckerhoff, Inc.
REFERENCES
