MODELING OF OVERSATURATED CONDITIONS ON ARTERIAL NETWORKS

By

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Oversaturated conditions on arterial networks are an issue of concern for both transportation agencies and the traveling public. The cost of construction, right of way constraints, as well as environmental, political and other social issues often prohibit facility expansion and place extra emphasis in optimizing operations of existing facilities. One of the options available to urban planners and transportation professionals for handling recurring and non-recurring oversaturation conditions is traffic signal optimization.

The objective of this study is to develop a better understanding of traffic signal system performance in oversaturated conditions. The case study reported in this paper focuses on the analysis of recurring oversaturated conditions and non-recurring or special events traffic conditions of McFarland Blvd (US 82) in Tuscaloosa, Alabama. The Visual Interactive System for Transport Algorithm (VISTA) platform is utilized to model the city of Tuscaloosa traffic network, including the study corridor. VISTA is a mesoscopic simulation tool with Dynamic Traffic Assignment (DTA) capabilities for modeling real time traffic conditions and spatio-temporal path for every vehicle. Several study scenarios are developed by varying traffic and control conditions and tested on the VISTA Tuscaloosa model in order to assess the impact of excess demand on traffic operations along the study corridor and parallel streets. Moreover, signal timing optimization studies are performed using SYNCHRO to supplement the VISTA model with optimal signal settings under varying demand conditions. The study confirms that optimization of travelers paths, coupled with signal timing optimization could be beneficial in mitigating congestion in arterial networks and improving local and regional mobility.

1.0 INTRODUCTION

1.1 Problem Statement

The United States of America is constantly growing in population, especially in metropolitan areas. Thus transportation demand is increasing every year significantly. According to the 2003-2008 Strategic Plan by the U.S. Department of Transportation (DOT), the U.S. transportation system annually serves over 4.9 trillion of passenger miles and 3.8 trillion ton miles of domestic freight. (1).

It is apparent that construction of new highways and increase of transportation supply is lagging in pace with the increasing demand. Between 1980 and 2003 the roadway miles was increased by 5 percent whereas in the same period Vehicle Miles Travelled (VMT) increased by an impressive 89 percent (2). Hence the congestion is inevitable, especially in urban areas. According to a 2005 study conducted on 85 urban areas by Texas Transportation Institute (TTI), congestion results in 3.7 billion hours of delay, or an annual delay per person of 43 hours. The study estimates the cost of congestion on those 85 metropolitan areas to over $63 billion or $384 per person in wasted time and extra fuel (2). It is well recognized that congestion severely hampers the roadway efficiency, reduces productivity and creates economic and environmental problems.

Congestion can occur due to various reasons, and can be recurring or non-recurring. In addition to commuting, special planned or unplanned events such as construction and traffic crashes can generate significant congestion. These events generate high traffic volume because full utilization of roadway capacity is not permitted. The extent of congestion varies depending upon the severity and duration of incident or road closure.

The vast majority of U.S. metropolitan areas are currently facing congestion problems and congestion mitigation strategies are being considered to improve the situation. In the recent years, the focus of congestion mitigation strategies changed from supply expansion to better utilization of existing transportation infrastructure assets and demand management. Due to issues related to cost, available right of way, and environmental and social considerations in many cases it is impractical to built new roads or expand the existing facilities. Hence engineers, planners, and developers are looking for ways to optimize the use of existing facilities by spreading the demand over time and space.

Traffic signal optimization is considered as one of the alternatives in minimizing arterial network congestion during peak hours. Many studies document the benefits from improved signal timings on traffic operations. For example, signal timing improvements in Chandler, Arizona reduced AM peak-period delays by 30 percent and PM peak-period delays by 7 percent (2). Researchers and engineers are considering this option for minimizing the non-recurring traffic congestion.

Similarly, incident management is another important option that is being considered for increasing the operational efficiency of transportation system. Incident management is a coordinated management technique for detecting a potential incident on the transportation system and responding to that with proper measures thus increasing operational efficiency. The 2005 Urban Mobility Report by TTI indicates that implementation of an incident management program provides smoother and faster traffic flow and also improve traffic safety by reducing emergency response time and the likelihood of occurrence of secondary crash collisions. This reports also highlighted that incident management in freeway results in 177 million hours in delay reduction and saves $2.93 billion due to congestion (3).

1.2 Objective

The major objective of this study is to evaluate the performance of an arterial network under oversaturated conditions. Furthermore, the study investigates the applicability of signal timing optimization as well as Dynamic Traffic Assignment (DTA) in mitigating arterial congestion. To achieve these objectives, an arterial corridor is selected and analyzed for various supply and demand scenarios. For instance, the impact of lane closures is evaluated for varying degrees of severity. The study first models an existing traffic signal system and reports arterial performance under base conditions. Then the impacts from signal timing optimization on arterial performance as well as system performance are predicted. This is done through the employment of simulation and DTA modeling. With the results obtained through simulation, the study is expected to provide guidance and develop procedures that can be used by Traffic Management Centers (TMC) to realize the full potential of utilizing traffic signal timing to mitigate congestion on oversaturated arterials and enhance traffic management.

The project selected an arterial corridor in the city of Tuscaloosa, Alabama as the study test bed. A regional transportation network model was developed and tested with various conditions. DTA using the Visual Interactive System for Transportation Algorithm (VISTA) platform was performed to assess the impact of signals on the system as well as the consequences of optimization. Similarly congestion due to construction event was carried out with DTA simulation. The following sections describe the main features of the VISTA model, followed by the study methodology, results obtained and main conclusions.

2.0 VISTA OVERVIEW AND APPLICATION

2.1 VISTA Background

The Visual Interactive System for Transportation Algorithm (VISTA) is an innovative network-enabled framework with Dynamic Traffic Assignment (DTA) capabilities. This model was developed at Northwestern University under the guidance of Dr. Ziliaskopoulous. VISTA integrates spatio-temporal data to model a variety of transportation application ranging from long term transportation planning activities to operational analysis. This model is well tested in various projects in the USA and Europe. One major advantage of this model compared to traditional traffic simulation models is the way it handles Intelligent Transportation Systems (ITS) applications. Moreover, VISTA can model very large networks within considerable time and can incorporate real-time conditions into the modeling process.

2.2 VISTA Capabilities

As explained earlier the VISTA model can be used for wide range of applications in transportation engineering and planning. Some of the capabilities of VISTA are highlighted as follows.

- VISTA runs over a cluster of Unix/Linux machines and it is easily accessible to any and all authorized users via Internet/Intranet. This allows accessibility and utilization of the model by a variety of users, and eliminates the need to installing new software and software upgrades.
- VISTA utilizes a universal database model that can be access through web interface or GIS interface. The GIS interfaces enables user for all kind of editing on the network.
- VISTA has enormous capacity of handling large network.
- The model provides DTA capabilities. Dynamic User Equilibrium (DUE) is the main traffic assignment technique employed in VISTA. Hence no user can switch path to decrease his/her travel time.
- VISTA can meet the functional needs of various areas by multiple types of DTA capabilities (descriptive vs. normative).
- VISTA is capable of distinguishing between informed and non-informed road user as well as user classes in terms of operation characteristics.
- Congestion management strategies such as incident management techniques, ITS technologies, and work zone management activities can be easily modeled using VISTA.
- VISTA can perform signal warrant analysis at unsignalized intersections as well as optimize signal timing plans.
- VISTA offers a number of pre-confined reports to provide information on various kinds of Measure of Effectiveness (MOE) such as travel time, delays, Vehicle Miles Travelled (VMT) etc. which can be access through both web interface and GIS interface.
- In addition, VISTA offers other customized outputs by running query to the database directly in web interface.

2.3 VISTA Limitations

VISTA offers great advantages for traffic analysis but still has some limitations that need to be recognized. As with other simulation models, the user should understand these limitations before utilizing the model. Some of the limitations of VISTA are as follows.

- VISTA is not capable of detecting vehicle stops precisely because of its inherent nature.
- The computational time required for DTA within the VISTA environment is still high. Thus it is not practical to use VISTA for very detailed analysis over large transportation networks.

- Since VISTA is a mesoscopic model it is not as efficient in modeling detailed traffic interactions like car-following, lane changing and weaving as some microscopic simulation models counterparts.
- VISTA offers details at cell level but it is hard for users to determine the cell length and time step required for desired level of detail.

2.4 VISTA Applications

VISTA is successfully tested in many research studies and implemented for various purposes all around the world. Examples include: (7).

- Atlanta Department of Transportation (DOT): Establishment of a DTA model for the Atlanta region to support various planning and operational improvements.
- New Jersey: Evaluation of various infrastructure and operational improvements scenarios, establishment of land-use. Similarly corridor DTA/simulation and evaluation of ITS technologies were done on I-80.
- Chicago: Evaluation of the impacts and effectiveness of various transit signal priority strategies.
- US Army Crops of Engineers: Prediction of transportation impacts of flooding on various areas around US.
- Illinois DOT: Evaluation of trucking policies and interaction of trucks and cars.
- Lake-Cook County, Illinois: Evaluation of multi-agency cooperation in emergency evacuation scenarios on Lake-Cook Road, Chicago.
- Athens, Greece: Simulation/DTA for traffic management strategies for the Olympics.
- Ohio-DOT: Simulation/ DTA for large scale assignment solutions.
- Bologna, Italy: Model traffic accidents to determine their impact on traffic operations in the province of Bologna.

2.5 VISTA Simulator

VISTA uses a mesoscopic simulator called RouteSim which is based on the extension of Daganzo’s (1994) cell-transmission model introduced by Ziliaskopoulos and Lee (8), (9). RouteSim offers adjustable cell size which improves flexibility, accuracy and other computational needs of the simulation model. It can use a single cell and a long time step for a long stretch of freeway which is not necessary to model in great detail whereas it uses multiple cells and short time steps for surface streets with congestion (9). Similarly, all vehicles are propagated according to cell transmission rule. It should be noted that the RouteSim simulator can differentiate between transit vehicles and passenger cars and it assign transit vehicles as longer vehicles and modeled accordingly (10). Similarly RouteSim offers high level of modeling options for Dynamic Traffic Assignment (DTA), optimization and evaluation of performance.

2.6 VISTA Modules

2.6.1 Cell Generator

This module is used for converting the network of links and nodes into the networks of cells. The RouteSim simulator employed in VISTA uses the cell transmission model to propagate vehicles in the cells. Links are divided into multiple cells of length equal to the distance traveled in one time step by a vehicle moving at free flow speed. In other words, vehicles can move one cell in one time step given that there is no congestion present. In fact, the number of vehicles that moves depends upon the space available on the downstream cell and the maximum flow permitted. In case of space constraints, vehicles do not move forward and queues will develop (7).

2.6.2 Prepare Demand

The percentage of delay in the delay table to implement during the simulation and DTA run can be specified in VISTA through the Demand Profiler. Although Origin-Destination (O-D) demands refer to the whole simulation period, time dependent simulation or dynamic demand requires exact percentage of vehicles departure. Hence each interval in the simulation can assign different weight using Prepare Demand Module (10), (11).

2.6.3 DTA – Path Generation

In the DTA – Path generation module, traffic assignment is done by calculating time dependent shortest path at every iteration. This process is a simulation-based process of dynamic traffic assignment; hence RouteSim simulator is automatically called in this module. Simulation process starts when DTA – Path generation is started (11). Hence this process generates dynamic least cost path for all vehicles in O-D demand depending upon shortest path algorithm.

2.6.4 DTA – Dynamic User Equilibrium (DUE)

The DTA – Dynamic User Equilibrium module does not calculate paths for the vehicles but it reshuffles the vehicles among the existing sets of path. It should be noted that DTA – Path Generation should be performed before employing DTA – Dynamic User Equilibrium. In the process of DUE, vehicles are redistributed until the desirable cost gap factor is reached (10), (11). Cost gap is the percentage error for the convergence of traffic assignment to equilibrium condition. Generally cost gap of 5 percent or less is considered as acceptable.

2.6.5 Simulation

The simulator used in VISTA can also simulate vehicles without DTA. Hence RouteSim simulator is active in doing traditional simulation process without carrying Dynamic Traffic Assignment. In case of simulation only runs vehicles are assigned according to originally assigned path, and real time conditions such as information provision do not affect the users' route choices (11).

2.6.6 Signal Optimization

This module is used for the optimization of traffic signals in transportation networks. VISTA offers its own optimization tool for signal timing optimization. Moreover, it provides interfaces with other signal timing optimization programs like SYNCHRO and TRANSYT. Also the VISTA signal optimization module can conduct signal warrant analysis according to Manual of Traffic Control Devices (MUTCD) guidelines. The capability to conduct signal warrant analysis at intersection and generate signals if warranted is unique, when compared with similar models and enables transportation agencies and analysts to create signal plans in case of lack of actual data.

3.0 METHODOLOGY

3.1 Approach

This paper studies oversaturation on the arterial networks and ways to address it. Emphasis is placed on optimization of signal timings through traditional simulation as well as DTA procedures. Prior experience indicates that traditional methods (i.e., Static Traffic Assignment, or STA) fails to capture the spatio-temporal variation of traffic. Therefore, despite its popularity and extensive use, STA is now believed not a practical tool for assigning traffic under oversaturated conditions. Under congested traffic conditions STA simply stacks-up the vehicles into the links of the network with volume to capacity ratios over one, which is not physically possible. It should be noted that VISTA DTA overcomes the limitations associated with STA through the use of a traffic simulator that models traffic signals properly as well as the congested conditions. The dynamic traffic assignment capabilities of VISTA can be useful in the evaluation of system performance as well as the development of guidelines for employment of traffic signal optimization at TMCs to mitigate the problem of recurring and non-recurring congestion and oversaturation. The basic procedure considered for the accomplishment of these research goals are listed below.

1. Selection of study test bed
2. Selection of simulation model
3. Data acquisition and model development
4. Development of testing scenarios
5. Simulation and optimization
6. Analysis of results and conclusions

3.1.1 Selection of Study Test Bed

The case study focused on the city of Tuscaloosa regional transportation network in the state of Alabama. The network comprises of major interstate and other multilane highways along with arterials and collector facilities serving the city of Tuscaloosa. The general map of the major facilities is depicted in Figure 3-1. The two major facilities serving this study area are interstates I-20/59 and I-359. Along with those, state highways US-11 and US-82 pass through the study network. I-20/59 is a facility serving east/west traffic that provides great mobility of people and goods in the state of Alabama. Similarly I-359 is a short spur, extending in the north/south direction which links I-20/59 with US-43, hence providing downtown Tuscaloosa with high speed access to the interstate. Highway US-11 runs parallel to I-20/59 and serves the east west direction of travel whereas US-82 runs north/south direct.

Highway US-82, also known as McFarland Blvd, is a major arterial corridor connecting the University of Alabama in Tuscaloosa with interstate I-20/59 to the south. It is a six-lane arterial with an average daily traffic (ADT) of roughly 51,000 vehicles per day (vpd). In addition to the demand on McFarland Blvd, several of its cross streets also serve substantial traffic volumes. As such, there are multiple congestion choke points at several of the signalized intersections along the corridor. Local studies confirm that McFarland Boulevard operates under oversaturated conditions on a recurring basis and is subject to

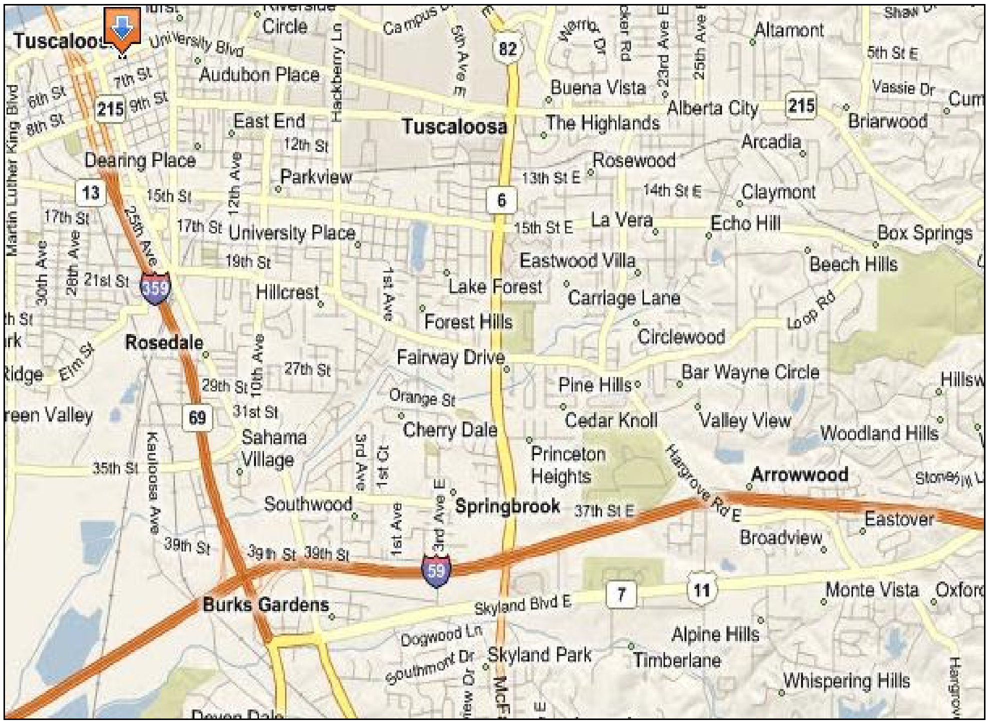

Figure 3-1: General Map of the Study Location

significant events of non-recurring congestion due to special event traffic (such as the University of Alabama football games). For these reasons, McFarland Blvd was an ideal test bed for the purposes of this research and was select as the main test corridor for this study (Figure 3-2).

3.1.2 Selection of Simulation Model

Simulation model selection is very crucial in the outcome of the study. Selection of the proper tool should consider:

- Model Capabilities (Size of Network, Network Representation, Traffic Representation, Traffic Composition, Traffic Operations, Traffic Control, Model Output)
- Data Requirements (Model Inputs, Calibration/Validation Data)
- Ease of Use (Pre processor, Post processor, Graphics display, On-line help, Demos)
- Resources Required (Cost of software, Cost to run the model, Staff expertise requirements, Technical support)
- Past Performance (Credibility and User Acceptance)

The investigation done as part of the literature review in this study highlighted the importance of DTA to address the condition of oversaturation. Among options considered, the VISTA software was chosen as the best available tool because of its unique capabilities to employing DTA techniques and deal with signal optimization for different conditions.

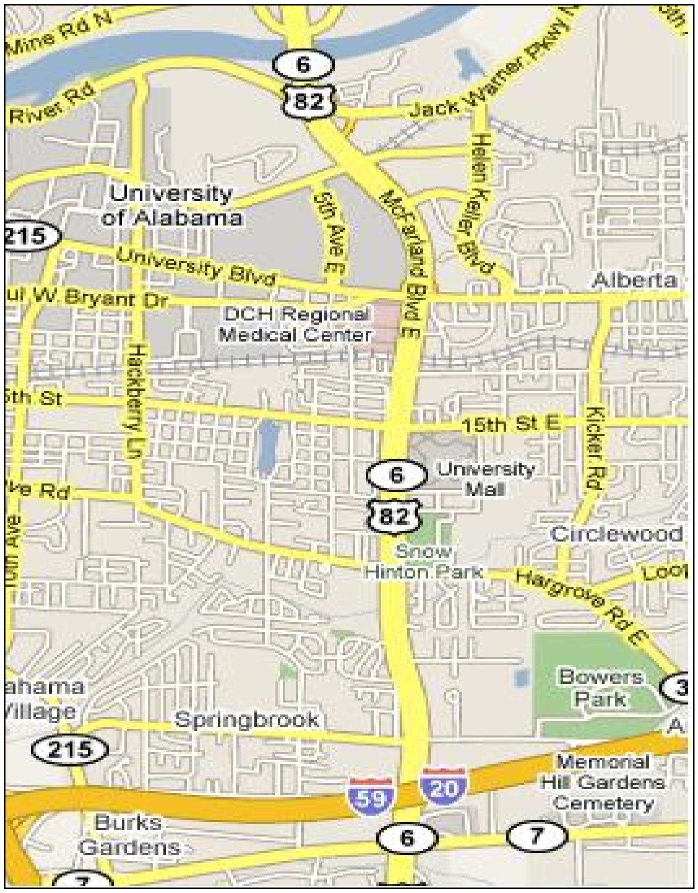

Figure 3-2: Study Corridor and Location of Major Traffic Generator

VISTA is a planning model that can be used for planning analysis as well as operational analysis. Since VISTA is a mesoscopic simulation model, it bridges the microscopic and macroscopic simulation models capabilities. This feature makes mesoscopic model uniquely flexible as it considers the route choice behavior of individual drivers but limits the level of detail in modeling driver interaction with infrastructure and other drivers (12).

3.1.3 Data Acquisition and Model Development

Data acquisition is a very important part in any study as the quality of input data directly correlates with the value of the outcomes of the analysis. Hence the simulation model input data should be of good quality and well tested. The data requirements and the data sources for the VISTA simulation model are discussed in the following sections.

3.1.3.1 Network Data

VISTA is a simulation model that runs online through web and client interface. While the user can operate the model through both interfaces, it is not possible to create the network on the web interface but only in client interface or Postgre Structured Query Language (PSQL) (11). Alternatively, VISTA can incorporate networks created in other models such as TRANPLAN and CORSIM.

The VISTA study network development for this study was created using a TRANPLAN file for the city of Tuscaloosa, AL that was made available through the Alabama Department of Transportation (ALDOT). The VISTA network was checked for errors and manual refinement was performed, as needed, to correct inconsistencies and improve model accuracy. The VISTA Tuscaloosa network developed in the study contains 3,395 links and 2,780 nodes, 924 of which are centroids as shown in Figure 3-3.

Figure 3-3: Basic Tuscaloosa Network Developed in VISTA

3.1.3.2 Demand Data

VISTA generates demand through origin-destination (O-D) trip matrices. The program also allows the user to input dynamic demand. O-D trip tables from TRANPLAN were used as demand data in Tuscaloosa VISTA model. Initially the model was developed for 24 hours and demand was also for a 24-hour period. Since the study concentrated on peak hours were oversaturated conditions are more likely to occur, the demand was adjusted to the evening peak starting from 4 PM to 8 PM. The four hour time block considered in this study meets the analysis requirement for peak hour congestion. The O-D demand loaded 128,765 vehicles into the study network which generated 16,485 trips during the peak study period hours.

3.1.3.3 Control Data

As this study mainly focuses on signal timing optimization, control data is a very important part of this study. The SYNCHRO signal timing file for the McFarland Blvd was obtained from the city of Tuscaloosa and was inputted in VISTA. The inputted signal timing values cover 10 intersections, from the intersection of McFarland Blvd and Skyland Blvd (which is one intersection south of I-20/59) to 13th Str (one intersection south of University Blvd). The intersections considered for signal timing optimization and study analysis purposes are shown in Figure 3-4.

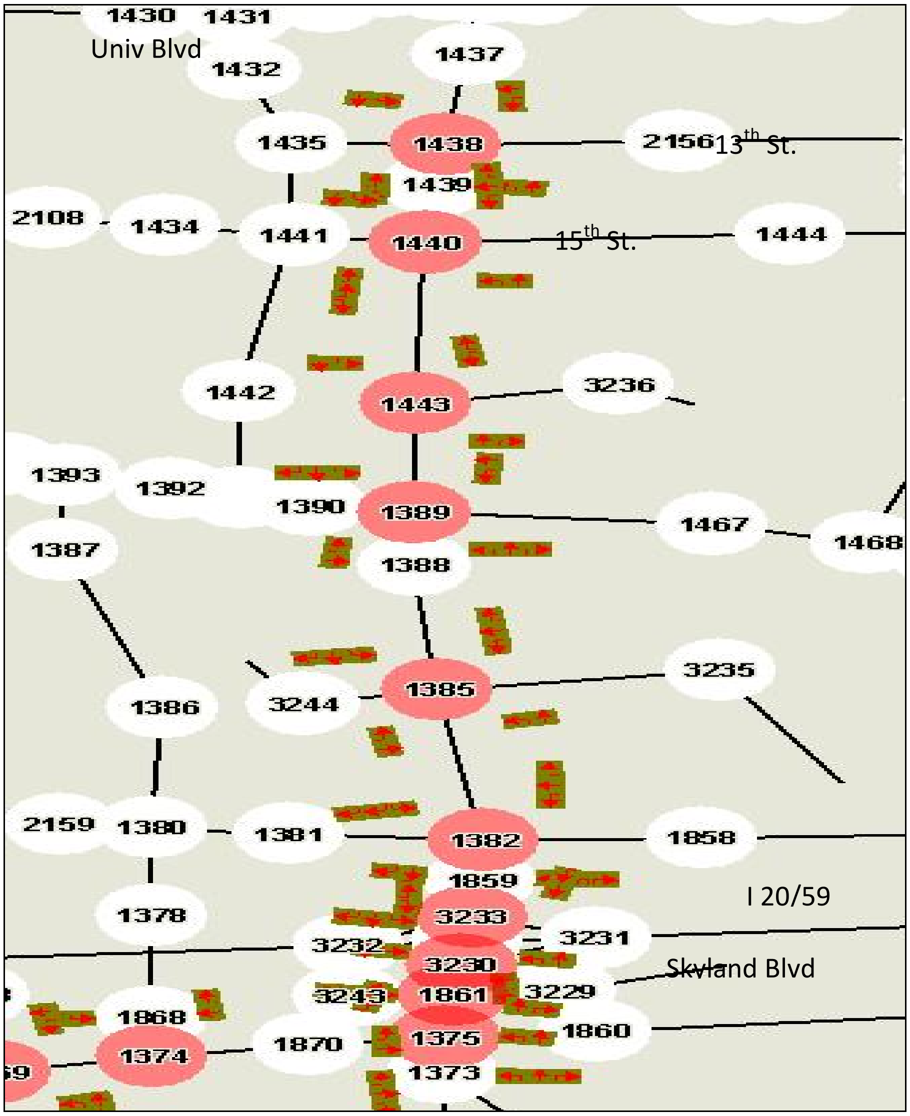

Figure 3-4: Signals Considered for the Study

3.1.4 Development of Testing Scenarios

As part of the study, various test scenarios were considered to study traffic congestion along McFarland Blvd and ways to alleviate it. First, scenarios involving capacity reductions were modeled such as closures due to construction or incidents. Moreover, scenarios considering traffic demand increase leading to congestion along McFarland

Blvd were modeled. This paper presents the findings from a representative scenario involving lane closures along McFarland Blvd as described below.

3.1.4.1 Sample Test Scenario Description

Lane closures due to incidents were considered on the southbound (SB) section of McFarland Blvd extending from the intersection with 13th Str to the north to the intersection with Skyland Blvd to the south. A sensitivity analysis was performed with the degree of severity changing in each of the cases considered, as follows.

1. <u>Base case</u> – No closure due to incident
2. <u>Incident case 1</u> – 1 lane closure for incident duration of 15 min, 30min, 45min and 60 min with existing signal timing
3. <u>Incident case 2</u> – 2 lane closure for incident duration of 15 min, 30min, 45min and 60 min with existing signal timing.
4. <u>Incident case</u> 3 – 2 lane closure for incident duration of 15 min, 30min, 45min and 60 min with optimized signal timings.

4.0 RESULTS AND ANALYSIS

4.1 Base Case

The base case was simulated with the existing features of the corridor. No incident scenario was incorporated in this case. The traffic assignment procedure used for this case was Dynamic Traffic Assignment (DTA). The focus on the analysis was on travel time and delay MOEs for the McFarland Blvd corridor and the entire VISTA Tuscaloosa network as a whole.

Table 4-1 provides detailed information on the system performance obtained from the VISTA simulation model for the base case scenario. This table highlights the number of vehicles loaded in the system during the simulation, the total Vehicle Miles Traveled (VMT), average travel time, average delay and standard deviation for travel time and delay for the system.

Loaded Vehicles	Total Travel time (hr)	Average Travel Time (min)	TT STD (min)	VMT (miles)	Total Delay (hr)	Average Delay (min/vehicle)	Delay STD (min)
128660	40755.32	19.01	17.79	1591969.13	1565.36	0.73	1.03

Table 4-1 Base Case System Performance Results

Analysis of the results shows that the average travel time in the system is 19 min for an average distance of 12.37 miles with corresponding delay of 44 sec/veh. The results imply that under normal conditions the Tuscaloosa city transportation network provides ample network capacity to its road users and a reasonable level of service.

Similarly, Table 4-2 provides results from performance analysis of the McFarland Blvd network under normal conditions (Base Case). This table further gives the information on corridor length, free flow travel time, simulation travel time, total delay and average delay for the corridor under study.

Corridor Links	Corridor Length (miles)	Free Flow Travel time (min)	Simulation Travel Time (min)	Total Delay (min)	Average Delay (min/mile)
252,254,256,259,263,240,238,236,235,3385,3381,3379,3341,66	2.58	4.10	4.12	0.02	0.01

Table 4-2 Base Case Corridor Performance Results

The results in Table 4-2 show that the McFarland Blvd study corridor is functioning very well under normal conditions.

4.2 Incident Case 1-One Lane Closure on Study Corridor

This scenario examines the effect a lane closure along the McFarland Blvd on the overall network performance as well as on the operation of the study corridor itself. In this scenario, existing traffic control is assumed, i.e. no adjustments in signal timings as compared to the base case. Various degrees of incident severity were considered by varying the duration of the lane closure 15 min to 1 hr in 15 min increments. Hence the system and corridor performance were tested for a lane closure imposed for 15min, 30 min, 45 min and 60 min and the results are summarized in Tables 4-3 and 4-4 respectively.

Loaded Vehicle	Closure Duration (min)	Total Travel Time (hr)	Avg. Travel Time (min)	TT STD (min)	VMT (miles)	Total Delay (hr)	Average Delay (min/veh)	Delay STD (min)
128660	15	40763.73	19.01	17.79	1591969.13	1565.36	0.73	1.05
128660	30	40793.51	19.02	17.79	1591969.13	1586.30	0.74	1.09
128660	45	40835.10	19.04	17.80	1591969.13	1629.69	0.76	1.16
128660	60	40893.66	19.07	17.81	1591969.13	1694.02	0.79	1.26

Table 4-3 One Lane Closure System Performance Results

As expected, longer closure duration results in longer average travel times and delays. However, the results confirm that the impact of the lane closure is fairly localized and thus the system performance under the one lane closure does not differ significantly to that of the base case.

Corridor Links	Closure Duration (min)	Corridor Length (miles)	Free Flow Travel time (min)	Simulation Travel Time (min)	Total Delay (min)	Average Delay (min/mile)
252,254,256,259,263, 240,238,236,235,3385 ,3381,3379,3341,66	15	2.58	4.10	4.15	0.05	0.02
	30	2.58	4.10	4.27	0.17	0.07
	45	2.58	4.10	4.43	0.33	0.13
	60	2.58	4.10	4.68	0.58	0.22

Table 4-4 One Lane Closure Corridor Performance Results

Comparison of the study corridor analysis results in Tables 4-2 and 4-4 shows an increase in the average delay from 0.02 min/mi in base case to 0.22 min/mile due to a 60-min one lane closure along the study corridor.

4.3 Incident Case 2-Two Lane Closure on Study Corridor

This case is similar to the case present in 4-2 except that 2 lanes were now considered closed, instead of one. Existing signal timing plans and lack of information provision to drivers are assumed. The duration of the two lane closure varied from 15 min, to 30 min, 45 min and 60 min.

Table 4-5 showcases the impact of a two lane closure on the study corridor on the performance of the overall Tuscaloosa network. It can be seen that the severe deterioration of traffic conditions on McFarland Blvd in this scenario has a small but noticeable impact on the overall system performance. This impact becomes more apparent as the duration of the lane closure increases.

Loaded Vehicle	Closure Duration (min)	Total Travel Time (hr)	Avg. Travel Time (min)	TT STD (min)	VMT (miles)	Total Delay (hr)	Average Delay (min/veh)	Delay STD (min)
128660	15	40842.76	19.05	17.81	1591969.13	1651.13	0.77	1.21
128660	30	41121.71	19.81	17.90	1591969.13	1929.90	0.90	1.94
128660	45	41585.56	19.39	18.09	1591969.13	2380.21	1.11	3.06
128660	60	42597.10	19.89	18.50	1591969.13	3388.04	1.58	4.79

Table 4-5 Two Lane Closure System Performance Results

Corridor travel time and delay results for the directly impacted corridor are summarized in Table 4-6. The results clearly show that the closure of two lanes results in a significant deterioration in travel conditions along the study corridor which increases in severity as the duration of the impact increases. For example, an incident blocking two lanes for 15 min results in 0.40 min of delay per vehicle traversing the study corridor. However, if the lane closure persists for 1 hr then an average of 2.93 min of delay is reported, instead. This observation confirms further the importance of quick clearance of incidents as a means to reduce non-recurrent congestion associated with incidents.

Corridor Links	Closure Duration (min)	Corridor Length (miles)	Free Flow Travel time (min)	Simulation Travel Time (min)	Total Delay (min)	Average Delay (min/mile)
252,254,256,259,263,240,238,236,235,3385,3381,3379,334,66	15	2.58	4.10	4.50	0.40	0.15
	30	2.58	4.10	5.36	1.26	0.49
	45	2.58	4.10	6.20	2.10	0.81
	60	2.58	4.10	7.03	2.93	1.14

Table 4-6 Two Lane Closure Corridor Performance Results

4.4 Incident Case 3-Two Lane Closure on Study Corridor with Optimized Signal Timings

In this scenario geometric and demand conditions were assumed similar to Incident Case 2 with the difference being that the signal timings were optimized in order to better serve traffic traveling on the congested corridor. The signal timing optimization was performed using the signal optimization tool available in VISTA. The effect that 15- to 60-min 2 lane closures of system and corridor performance was obtained through simulation and presented in Tables 4-7 and 4-8 respectively.

Loaded Vehicle	Closure Duration (min)	Total Travel Time (hr)	Avg. Travel Time (min)	TT STD (min)	VMT (miles)	Total Delay (hr)	Average Delay (min/veh)	Delay STD (min)
128660	15	40415.31	19.01	17.79	1591969.13	1222.27	0.57	0.94
128660	30	40467.38	19.02	17.89	1591969.13	1265.15	0.59	1.01
128660	45	40835.10	19.04	17.80	1591969.13	1350.93	0.63	1.21
128660	60	40893.66	19.07	18.81	1591969.13	1479.59	0.69	1.50

Table 4-7 Two Lane Closure with Optimized Signal Plan System Performance Results

Corridor Links	Closure Duration (min)	Corridor Length (miles)	Free Flow Travel time (min)	Simulation Travel Time (min)	Total Delay (min)	Average Delay (min/mile)
252,254,256,259,263, 240,238,236,235,338, 3381,3379,3341, 66	15	2.58	4.10	4.13	0.03	0.01
	30	2.58	4.10	4.32	0.22	0.09
	45	2.58	4.10	4.54	0.44	0.17
	60	2.58	4.10	4.75	0.65	0.25

Table 4-8 Two Lane Closure with Optimized Signal Plan Corridor Performance Results

The results indicate that significant improvements in travel times and delays can be realized through the optimization of signal timings in response to congestion. These findings confirm that signal optimization is an effective strategy for alleviation of traffic congestion along oversaturated corridors.

4.5 Analysis of Results

4.5.1 One Lane Closure vs. Two Lanes Closure with Existing Signal Timing Plan

Figure 4-1 shows a comparison between one lane and two lane closures with the existing signal timing plan.

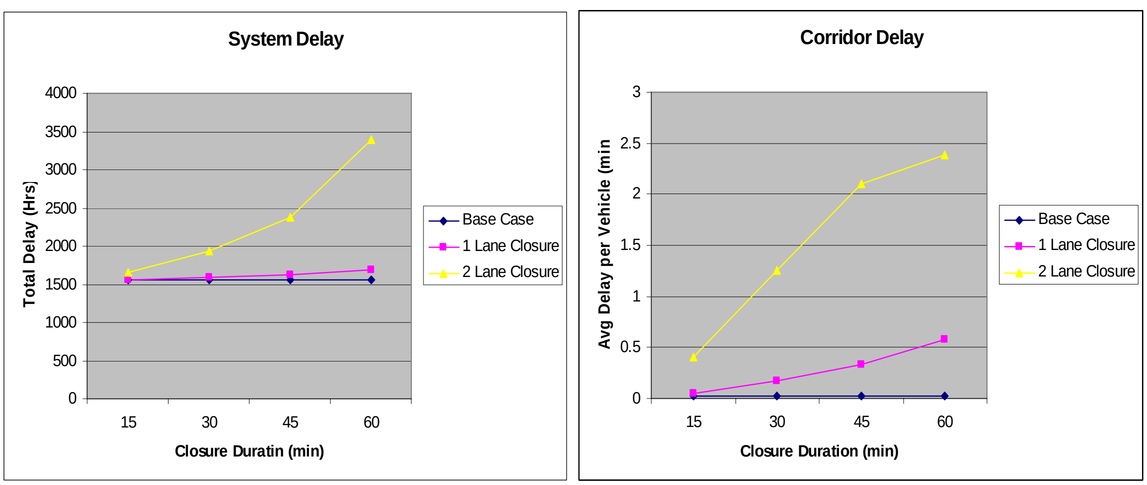

Figure 4-1 One Lane Closure vs. Two Lanes Closure with Existing Signal Timing Plan

It is apparent from the graphs that the one lane closure does not have much of an effect on system performance, compared with the base case. Hence the aggregate delay increase on the system due to the one lane closure is not considerable. On the other hand, under the two lane closure scenario, the system delays increase exponentially with the increase in closure duration. At the corridor level, significant increases in average delays per vehicle are observed under both lane closure scenarios, with a clear correlation between average delay per vehicle and severity of incident (expressed by number and duration of lanes closed.

4.5.2 Existing and Optimized Signal Timing Plans for Two Lane Closure

Figure 4-2 provides a comparison of system and corridor performance under existing and optimized signal timing plans for two lane closures scenario.

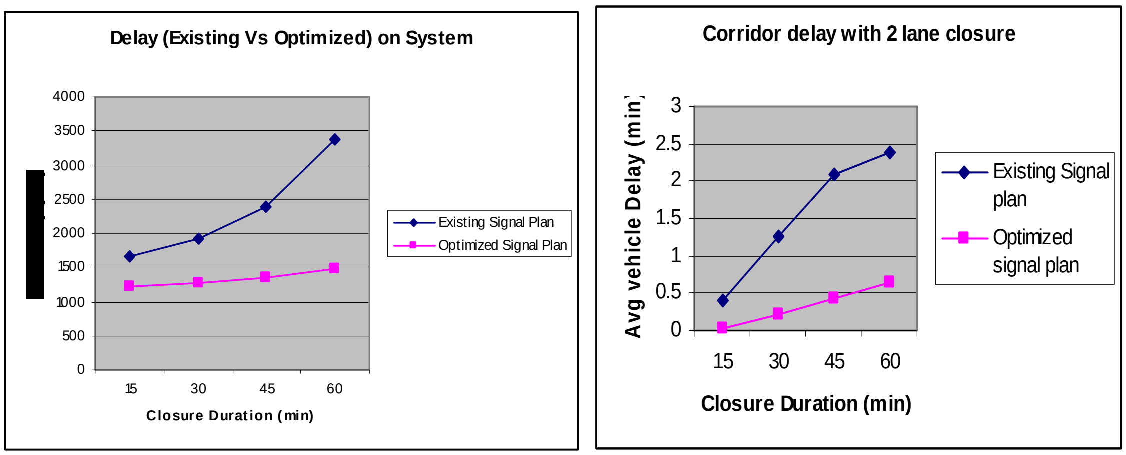

Figure 4-2 Two Lanes Closure with Existing and Optimized Signal Timing Plans

Figure 4-2 provides undeniable evidence that signal time optimization is beneficial for both system performance as well as corridor performance. It is clear from the above graphs that considerable decrease in the delay can be experienced by optimizing signal timings in response to congestion. Hence signal optimization can be an effective technique to handle the oversaturated condition in arterial corridors.

5. CONCLUSIONS

This study presents some significant findings regarding transportation facility and system wide performance under congestion. Conclusions drawn from this study are summarized below.

- The VISTA simulation/optimization environment can be used by various transportation agencies for different planning and transportation management purposes including congestion mitigation, incident management, construction management, signal optimization and signal preemption etc.

- Although the Tuscaloosa network has large residual capacity available, the network is still sensitive to sever oversaturation along McFarland Blvd.

- The existing signal timing plan on McFarland Blvd performs well under the normal conditions and minor incidents. However, when the corridor is experiencing non-recurring congestion, optimized signal timing plans are recommended to mitigate the congestion, as justified from this study.

- VISTA has unique capacity for signal timing optimization and signal warrant at unsignalized intersection but has limited capabilities to model actuated signals. Incorporation of this feature into the VISTA model is desirable and recommended for future research.

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