Traffic Re-Direction Simulation during a Road Disaster/Collapse on Toll Road 408 in Florida

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Abstract
Society takes for granted the ability to get from place to place on the existing transportation systems. The major method of transportation in the U.S. is the many surface roads, freeways, and corresponding overpasses and bridges. What happens when these paths are not available or when they are obstructed by a natural disaster or other event? We can observe the results of such events first hand by the many bridges and overpasses that have collapsed over the past 20 years. Cities and metropolitan areas must be sufficiently prepared for such events and need to carefully plan. For example, after the devastation of the bridge collapse over the Mississippi River in Minneapolis, MN, and ensuing confusion, simulations to redirect traffic in the event of another tragedy could be very beneficial. The aftermath of the collapse of the bridge impacted railways, river, road, and air transit. Even small businesses surrounding the bridge were affected by the blocked roadway. So a collapse cannot be seen as an isolated event, but as a cascading event that not only impacts traffic and safety but even the livelihood of surrounding businesses.

Key Words
Simulation
Transportation
Collapse
Redirection

Introduction
According to the Federal Highway Administration (FHA) the loads at several points on the bridge in Minneapolis were overstressed, and the construction materials used were insufficient to handle the weight (Roy, 2008). All over the country bridges and overpasses are now being inspected to determine their structural integrity and more bridges and overpasses are getting unsatisfactory ratings. Officials with Florida Department of Transportation’s District 2 office -- which covers all of north Florida -- said that while the 1,100 bridges it inspects are safe, they listed five that were structurally deficient (News4Jax, 2007).

There are many causes of bridge and road collapses. According to Wardhana (2003) the primary causes of bridge collapse can be attributed to floods and collisions. Other causes also include age and poor construction, lack of proper inspection frequency, construction (repair and new construction), weight limitation exceeded, soil erosion, weather (snow, ice, etc.), and acts of terrorism (truck bomb, etc.). No matter what the cause of a collapse, it is very obvious that proper preparation is necessary to handle the rerouting of traffic and prompt notification of the disaster to the public.

Modeling and simulation is an effective and inexpensive way to deal with roadway collapse scenarios. Many software programs have been created to simulate traffic conditions for improving flow throughout a defined road network. A few of the most common software packages are TSIS-CORSIM, AIMSUN, SimTraffic, and TransModeler. “In today’s information technology-driven environment, the need for modeling complex, large-scale systems is critical. Responding to natural disasters, evaluating terrorist attack scenarios, modeling breaches in national transportation networks, or analyzing impacts of rare events are essential to maintaining security of all sectors of society” (Bandini, 2004).

In the future, effective simulations for the routing of traffic to bypass a collapsed bridge or overpass could help minimize the traffic confusion if another tragedy were to happen. Also, these simulations could help in the case of construction down time due to the repairs of existing structures. Since, more and more bridges are getting a poor rating, being able to reroute traffic efficiently away from the bridges will become very beneficial.

Project Focus
The focus of the project is a traffic re-direction simulation in case of an overpass collapse along Toll Road 408 in Orlando, FL. Specifically, evaluating the results if the overpass at South Conway Road were to collapse and block Toll Road 408 (see Figure 1). We will examine the impact of the collapsed overpass and which are the possible reroutes in the existing roadway system around the defined traffic network. In this effort, we will have to take into consideration the potential alternate routes, traffic loads, and other relevant data elements related to the traffic network surroundings. In addition, the availability of roads around our defined traffic network will have to be reviewed due to the fact that they might be compromised due to the current road re-construction projects. Currently the FHP has nothing specifically in writing for bridge or overpass collapses (Miller, 2008). They do have standard procedures that they follow, but they have not looked at the impact of such a disaster on the surrounding road systems and traffic load efficiency.

What makes this particular overpass one of Orlando’s most critical traffic locations is its position directly after a major toll collection site (408 and 436 an exit used for the Orlando International Airport) and its proximity to 1-4 and Toll Road 417. If this particular overpass were to collapse traffic would be gridlocked for miles in either direction on Toll Road 408 and the surrounding road systems would quickly become severely congested. The ongoing expansion of Toll Road 408, and current construction at this overpass, would make the traffic problem even worse. Currently the 436 off-ramp is a single lane off-ramp and is limited to the number of vehicles that could be routed off Toll Road 408. Also, the 436 off-ramp is approximately 7,513 feet. If a collapse were to occur cars would be backed up from the 436 exit to the collapse site. At present this is a 3-lane road and could hold up to 1,127 cars (assuming an average of
20 feet per car). These vehicles would then have to be directed to the eastbound lanes of 408 and sent back the other way to exit at 436 or another location. In addition, the distance between the collapse point and the closest egress route is significant.

Figure 2 is an image of our network prior to the collapse over 408 at Conway Road. Each circle in the network represents a point on the network where either the roads intersect or where a traffic signal is located. The grey lines are the 408 links eastbound and westbound, and all of the black lines are the surface roads that make up our suggested network path to reroute traffic around the collapse.

During our traffic re-direction simulation we will be using CORSIM (Corridor Simulation), a microscopic traffic simulation software package. In a collaboration effort with the Department of Civil Engineering at UCF we were able to utilize a licensed copy of CORSIM to implement the models for the 408 collapse scenario. The CORSIM simulation package provides a graphical interface to define the traffic networks that is relatively user friendly. It can handle freeway systems, surface road systems, and a host of other standard traffic events (signals, stop/yield signs, different types of vehicles, turn ratios, etc.)

CORSIM can be configured to accurately simulate a wide range of traffic conditions, from moderate to very congested demand. It can also effectively simulate traffic flow during an incident, from queue buildup to recovery to normalcy. The ability to simulate over-congested traffic flow conditions gives CORSIM a unique advantage over traditional empirical/analytical methods.

**Literature Review**

Traffic congestion has become more of a problem in recent years due to the increased number of cars on the roadways. To alleviate some of the traffic issues, governments are spending more money building new roads, but this is a costly solution. Computer traffic simulation is a more efficient method of solving some of the traffic problems because it looks at finding new strategies to control the flow of cars on the roadways instead of just building new infrastructures. Therefore, it maximizes the efficiency of the current traffic system (Elhert, 2001).

Hurricanes, earthquakes, terrorist attacks, bridge collapses, etc., are all either natural or human-caused disasters that may require a massive evacuation from an area. However, most traffic systems are not able to handle such an influx of vehicles onto the roadways at once. As a result, special evacuation routes need to be planned in advance. The problem associated with creating evacuation routes though, is that recreating these evacuation scenarios in the real world to test the efficiency of the plans is unrealistic. It would cost too much in time and money. Computer traffic simulations can therefore be used to simulate events that require a mass evacuation or traffic reroute, and find the best traffic management strategies (AHB20, 2006).

There are primarily three types of traffic simulations models used today: microscopic, macroscopic, and mesoscopic. Microscopic simulations are the most popular type of simulation model (Burghout, 2005). Such a model can be used in many different traffic situations because of the high number of variables that are produced that can be adapted to a variety of different events (AHB20, 2006). These simulations can also “model the temporal and spatial evolution of specified non-recurrent traffic conditions” (Hawas, 2007). Microscopic traffic simulations track the movements of individual cars throughout the system and produce simulated results for each one. Every car, truck, bus, etc., is moved according to the characteristics of its vehicle type. These characteristics can include acceleration, weight, length, braking distance, and typical vehicle driver characteristics (DOT, 2007). Including these parameters makes it ideal for modeling traffic in a more realistic manner, because in the real world every vehicle is not driven the same way and people have different driving habits (Ehlert, 2001).

Problems with the microscopic model are their prolonged runtime and probabilistic nature. These problems are due to the high number of tracked variables, and the fact that they are usually calibrated the same for every simulation run. Microscopic models are also the most costly due to the complexity of its algorithms and training of users. Examples of microscopic tools include AIMSUN, CORSIM, PARAMICS, SimTraffic and VISSIM (AHB20, 2006).

Macroscopic simulations are the second most popular traffic simulation model. Similar to the microscopic models, they are also used for a wide array of applications. However, they do not track individual vehicle movements throughout the system. Unlike a microscopic model, a macroscopic model does not account for individual vehicle interactions and variables in the system but rather focuses on the collective flow of vehicles through the system (Burghout, 2005). It uses “fluid dynamics” (Ehlert, 2001) with “cumulative traffic stream characteristics” (DOT, 2007) that can include flow, speed, and density to produce simulations (DOT, 2007). Macroscopic models concentrate on the timing of traffic from one section of the simulation to the other. It was originally designed to track the collective flow of traffic on major highways and corridors. Therefore, it may not be as flexible to be used for different types of simulations as the other two models (DOT, 2007). Examples of macroscopic tools include FREQ, FREELO, SATURN, TRANSYT-7F, and KRONOS (AHB20, 2006).

Mesoscopic models are third most popular type of model used in traffic simulations. Mesoscopic models are also the newest approach (AHB20, 2006). These models are used predominately with simulating dynamic traffic situations such as in traveler information systems (DOT, 2007). Mesoscopic models are unique because they simulate individual vehicles using a “macroscopic speed-density relationship” (AHB20, 2006). Therefore, by combining the “detail of micro and scalability of macro” (AHB20, 2006) these models tend to be less probabilistic then microscopic models because they do not track as many parameters per vehicle and rely more on grouping vehicle interactions into macroscopic relationship (DOT, 2007). Examples of mesoscopic tools include TRANSMODELER, DYNAMIT, CONTRAM, and DYNAMEQ (AHB20, 2006).

The state of the art of traffic simulations has advanced dramatically in recent years. Microscopic models continue to add different vehicle-to-
In general, our modeling approach can be defined by the following steps:

1. Gather the overall traffic system network characteristics
2. Define our traffic simulation model type
3. Traffic system network assessment of re-routing options
4. Traffic system network model creation
5. Run simulations and organize output data and perform analysis

First, as much data traffic was count data that we could find from public service entities to serve as inputs for our baseline scenario. Traffic flow data during the off-peak and peak periods were collected from the expressway authority, and the Department of Transportation. In addition to our initial effort to gather information we consulted the Florida Highway Patrol to find out about current traffic re-routing procedures and to gather any recommendations. We contacted the Orange County Graphical Information System (GIS) Department to obtain GIS shape files that depict roads and highways that will help us define our traffic system network domain to be modeled but our tool did not need the shapes nor was it readily available.

Some of the recent problems in the area of traffic simulations include performance measurements. Since most models use different criteria to measure performance, it is often difficult to compare the results of different approaches. Also, with the increased number of simulators, it is often hard to find the right application for a specific problem. The training, calibration, and software license costs have also had a major impact. These costs have resulted in users having to pick only one product to get specialized in (AHB20, 2006).

The recent Minneapolis bridge collapse caused a major traffic problem in the surrounding area and the Minnesota Department of Transportation (MnDOT) and the Federal Highway Administration (FHA) asked the University of Arizona (UA) for help in providing a solution to rerout traffic around the disaster. Professor Chiu at UA was working on a mesoscopic urban traffic simulation model that was being developed to solve the problems of large scale traffic management (Stiles, 2007). The research focused on handling cases of unexpected mass evacuations in the event of a disaster. Chiu says that because of poor planning people trying to evacuate will often get trapped in traffic jams and face the possibility of losing valuable time, property, and possibly human life.

The research that Chiu does at the University of Arizona is mainly focused on trying to develop an effective algorithm to dynamically direct mass evacuations and traffic rerouting for large networks or entire cities (Chiu, 2004). Previous research tended to focus on one specific highway or small network, but Chiu’s research focuses on simulating an entire region in a relatively short time frame. Since it is impossible to predict what drivers are going to do, it is difficult to pick one static route in the case of major disaster. Therefore, UA created a dynamic traffic management software package for the entire area around the bridge collapse to help manage the flow of traffic. Chiu’s software uses real time traffic information along with census data to simulate how drivers will react to different conditions and information received through the media. It then simulates the entire city’s traffic system, either in real time or offline to allow the operators at the FHWA to determine the best traffic management strategy. These strategies can include re-timing stop lights and producing efficient detours according to current traffic information (Stiles, 2007).

**Modeling Approach**

The modeling approach consisted of first creating a baseline scenario that described the current freeway and surface roadway system surrounding the area of interest (Toll Road 408 and the Conway Rd overpass). Subsequently, all the egress routes from Toll Road 408 were identified and the surface roadway system surrounding these exit points were noted and evaluated. During the evaluation of these exit points, we had to take into consideration the possible surface roads that could be utilized for the re-route paths in order to more clearly define our traffic network to be studied. Once the re-route paths were selected, traffic count data had to be gathered from public service entities and from our own data collection efforts.

In general, our modeling approach can be defined by the following steps:

1. Gather the overall traffic system network characteristics
2. Define our traffic simulation model type
3. Traffic system network assessment of re-routing options
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5. Run simulations and organize output data and perform analysis

During our traffic system network assessment of the re-routing process, we studied the network links (particular stretches of streets or highways) that will be modeled in our microscopic model. With this simulation model type we were able to define detailed traffic performance measures to be evaluated during different network representations (re-routes). These performance measures include delays, average times, number of stops per vehicles and other parameter values like individual and overall vehicle flow, speed, and density.

The microscopic modeling package we use for our traffic system network model creation is TSIS-CORSIM. CORSIM incorporates in its modeling package two industry proven simulation tools; NETSIM (for surface street simulation) and FRESIM (for freeway simulation). The CORSIM tool allowed us to place surface streets and freeways in one simulation. In addition, CORSIM permits analysis of individual vehicles and summative statistics of overall flow (link volume), gap reduction, acceleration, turning movements, and network wide average statistics. Also, as part of the model creation efforts we defined the network links characteristic of the reroute paths (length, turning lanes, speed limits, etc.) through the graphical interface provided by CORSIM called Trafed. Figure 2 illustrates the defined traffic network model.

Finally, as part of our model output and analysis efforts we had to specify the input parameters such as number of vehicles, stop light configurations, speed limits, etc. Output data provided by CORSIM included individual vehicle results such as emissions, delays, and average speed (MNDOT, 2004). The data was obtained from the tool to represent the simulation results at the network links of interest for analysis.

**Network Definition and Data Collection**

We have identified the following links for our network re-routing around the Conway Overpass collapse point. Westbound Traffic: 408 west to 436 off-ramp, 436 north to Colonial (SR 50), Colonial (SR 50) to North Bumby Ave., North Bumby Ave. to South Street, and South Street to 408 on-ramp west. Eastbound Traffic: 408 east to North Conway Road off-ramp; North Conway Road off-ramp to North Conway Road; North Conway Road to Curry Ford Road; Curry Ford Road to 436; 436 to Lake Underhill; and Lake Underhill to 408 on-ramp east (see Figure 3 below).
We selected these paths based on the number of lanes available, low-residential impact (we wanted to minimize rerouting traffic through neighborhoods), speed limits, and connections to other alternate links in the area.

Historical Data
According to the Expressway Authority, approximately 124,790 vehicles travel past the collapse point on a weekday in a 24-hour period (OOCEA, 2008). This is a significant increase from 2001 when the count was 107,940 vehicles (OOCEA, 2008). In 6 years the number of vehicles has increased by about 20,000 (see Table 1). If this trend continues, by the year 2016 there will be another 40,000 vehicles added to the network.

The 2007 numbers equate to an average of 86.6 vehicles per minute. This was in line with our observed manual traffic counts. They ranged from approximately 82 – 94 vehicles per minute (averaged over observed time period) which falls within the historical data collection number. The time of day will determine the density of vehicles traveling on the network and the immediate impact of a collapse.

Based on an average vehicle size of 16 ft. (typical full-size vehicle length) and assuming an average distance between vehicles of no more than 5 ft. (assuming cars are static), the specified network could have up to 6,880 vehicles locked in congestion throughout the network (in a two-way configuration). These numbers were used to determine the efficiency of the CORSIM data, and will be used as baseline parameters in network confirmation and to determine if one-way routing of traffic is more efficient.

<table>
<thead>
<tr>
<th>Location</th>
<th>Year 2001</th>
<th>Year 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conway Road to SR 436</td>
<td>107,940</td>
<td>124,790</td>
</tr>
<tr>
<td>/ Yucatan Drive</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 – Toll Road 408 Average Annual Weekday Traffic (OOCEA, 2008)

Observed Data Collection
Data was collected at several points over a two-week period at the end of March. We collected data on all of main traffic links including eastbound and westbound traffic along 408 at multiple time periods. We made sure that our data collection took place during peak travel times where traffic load was highest. Our purpose for collecting data during this time was to make sure that we provided the model with a traffic count for a collapse during the commute time windows of 7:30-9am and 4:30-6pm. Worst-case scenarios for planning provide for adequate load planning. More specifically, data was collected at the following intersections for the westbound section of our defined network: 436 and 408 west off-ramp; Colonial (50) and the 436 intersection; 50 and North Bumby; and South Street to the 408 on-ramp. For the eastbound section of our network we collected data at the following points: 408 off-ramp at South Conway and Lake Underhill roads; South Conway Rd at Curry Ford Rd; Curry Ford Rd. and 436; 436 and Lake Underhill; and Lake Underhill at the 408 eastbound on-ramp.

Vehicles were counted and recorded in 5-to-10 minute intervals and averaged to give vehicle per minute and vehicle per hour counts. Table 2 shows the exact numbers collected, the time period, and the vehicles per minute and per hour for westbound traffic, and Table 3 shows the data for eastbound traffic. Table 4 is the collected data at different peak times for Toll Road 408. Data sets were collected at different times and vantage points to ensure a higher degree of accuracy in tallying vehicles and vehicle types traversing the network.

Table 2 – Westbound Traffic Counts – Peak Time Period

Table 3 shows the data collected for the eastbound traffic on the defined network. As one can see, the number of links is similar to Table 2.
However, the impact on the network was greater due to the different perspectives for data collection and the greater number of entrance and exit points impacting our defined traffic network system. Table 4 contains observed vehicle counts for the 408 East-West Expressway during rush hour and non-rush hour times. Even though there is some difference in quantities, the toll road is still heavily used in non-rush hours.

Table 4 – 408 Toll Road Traffic Counts – Peek/Off Peek Time Periods

The main purpose of our analysis is to illustrate the impact of the overpass collapse on Toll Road 408 exit ramps in terms of vehicle flow, travel time of through traffic and delay time characteristics at the different exit ramps and intersections along the few possible re-routing paths. The results will be shown by a series of comparison tables that will demonstrate the difference between the vehicle flow, travel time, and time delays at different locations in the re-route paths in the simulated traffic network (Figure 4).

Table 5 – Entry Link Volumes for Network

The simulations were run for 10,800 seconds, or 180 minutes per each model. CORSIM uses vehicles per hour as its base metric and then creates a random seed for each simulation run. Three different scenarios were run in CORSIM to get comparative data. We defined the network model with no collapse, our baseline model, and ran that scenario multiple times to make sure that the results were similar. We found that the results did not vary significantly between runs, and in several cases were almost identical. We then altered this model to simulate the effects of a collapse at the specified overpass location. This meant redirecting the vehicles that would be on 408 to the specified off-ramps to then be placed on the street network (FRESIM) part of the model. We did not change the traffic signals or any other variables in this initial modified system referred to as the two-way model. Lastly, we decided to make the FRESIM portion of the network one-way, limiting traffic entering the network from other streets and keeping all signals green except at major street intersections. Table 5 shows the data that was provided to CORSIM for the traffic model and is labeled with the entry link numbers, link name, and vehicles per hour.

Table 6 – Sample Data from NetSim Output File

The simulations were run for 10,800 seconds, or 180 minutes per each model. This was the maximum time that the simulation could be run. CORSIM uses vehicles per hour as its base metric and then creates a random seed for each simulation run. Three different scenarios were run in CORSIM to get comparative data. We defined the network model with no collapse, our baseline model, and ran that scenario multiple times to make sure that the results were similar. We found that the results did not vary significantly between runs, and in several cases were almost identical. We then altered this model to simulate the effects of a collapse at the specified overpass location. This meant redirecting the vehicles that would be on 408 to the specified off-ramps to then be placed on the street network (FRESIM) part of the model. We did not change the traffic signals or any other variables in this initial modified system referred to as the two-way model. Lastly, we decided to make the FRESIM portion of the network one-way, limiting traffic entering the network from other streets and keeping all signals green except at major street intersections. Table 5 shows the data that was provided to CORSIM for the traffic model and is labeled with the entry link numbers, link name, and vehicles per hour.

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**Table 5 – Entry Link Volumes for Network**

**Table 6 – Sample Data from NetSim Output File**

Table 7 is the average from all of the data collected for one time period of a simulation. From the table, it is clear that the one-way model places more vehicles in the network (64%) than the two-way model, but at the cost of a higher delay time, slower overall speed, and more minutes/mile total time and delay time. A key indicator in the table is the minutes/mile which shows the one-way network taking over 4 minutes more per mile than the two-way network. There may be some minimal advantage to the one-way configuration, but we think that the trade-offs do not justify advocating this method.

**Table 7 – Averages Across Measurements of Effectiveness**
Table 7 – Averages for Models across Multiple MOE’s

Table 8 contains the network-wide average statistics for all three models; pre-collapse network (normal), collapse network (two-way traffic), and collapse network with one-way traffic and signal changes and entry point modifications. The one-way and two-way model summative data is similar except that the one-way network had more total traffic miles (over 16,000). Also, the delay time for the one-way network is larger (worse) than the two-way model. This appears to be caused by bottlenecks at intersection points where a road with more lanes attempts to turn into a road with fewer lanes. Even with reduced signal interruption the network is slower. This was the opposite of what we had expected. Between the two options modeled (one-way or two-way) the model is more efficient to run with the two-way configuration. This is obviously much easier to implement and will also permit other side traffic (residents of the area) to still use the network normally with obvious delay times due to congestion. One will notice a substantial difference between the pre-collapse and post-collapse network data values. The collapse will cause significant traffic congestion, but having a plan in place would allow for the authorities to quickly respond to the event and reroute vehicles more efficiently. Table 8 below shows the differences between normal traffic, and then traffic if the overpass were to collapse for both one-way and two-way traffic.

<table>
<thead>
<tr>
<th>Normal Network Statistics</th>
<th>Values</th>
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<tbody>
<tr>
<td>Total Vehicle Miles (miles)</td>
<td>16,069.44</td>
</tr>
<tr>
<td>Vehicle Hours of Move Time (veh/min)</td>
<td>3,378.87</td>
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<tr>
<td>Vehicle Hours of Delay Time (veh/min)</td>
<td>2,811.71</td>
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<tr>
<td>Vehicle Hours of Total Time (veh/min)</td>
<td>6,190.58</td>
</tr>
<tr>
<td>Average Speed (mph)</td>
<td>25.96</td>
</tr>
<tr>
<td>Minutes/Mile of Delay Time</td>
<td>1.05</td>
</tr>
<tr>
<td>Minutes/Mile of Total Time</td>
<td>2.31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Collapse Network Statistics (two-way)</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Vehicle Miles (miles)</td>
<td>40,290.41</td>
</tr>
<tr>
<td>Vehicle Hours of Move Time (veh/min)</td>
<td>1,002.73</td>
</tr>
<tr>
<td>Vehicle Hours of Delay Time (veh/min)</td>
<td>11,741.62</td>
</tr>
<tr>
<td>Vehicle Hours of Total Time (veh/min)</td>
<td>12,744.34</td>
</tr>
<tr>
<td>Average Speed (mph)</td>
<td>3.16</td>
</tr>
<tr>
<td>Minutes/Mile of Delay Time</td>
<td>17.49</td>
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<tr>
<td>Minutes/Mile of Total Time</td>
<td>18.98</td>
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<table>
<thead>
<tr>
<th>Collapse Network Statistics (one-way)</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Vehicle Miles (miles)</td>
<td>41,100.75</td>
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<tr>
<td>Vehicle Hours of Move Time (veh/min)</td>
<td>1,107.38</td>
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<tr>
<td>Vehicle Hours of Delay Time (veh/min)</td>
<td>14,772.46</td>
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<tr>
<td>Vehicle Hours of Total Time (veh/min)</td>
<td>15,110.85</td>
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<tr>
<td>Average Speed (mph)</td>
<td>2.60</td>
</tr>
<tr>
<td>Minutes/Mile of Delay Time</td>
<td>21.57</td>
</tr>
<tr>
<td>Minutes/Mile of Total Time</td>
<td>23.05</td>
</tr>
</tbody>
</table>

Table 8 – Network-Wide Average Statistics for all Models

Findings and Recommendations

The initial modeling efforts were conducted to recreate as accurately as possible the existing conditions of the defined traffic network. Particularly, we needed to realistically model vehicle flows and delay time around the possible overpass collapse. Analysis of our defined traffic network provided useful information in case the Conway Rd overpass were to collapse over the 408 East-West Expressway. Even though our model was confined to this location, it could be applied to any overpass or bridge collapse for planning purposes.

One of the primary questions we asked about the networks was “how long would it take someone to traverse the network using the three models”? If Joe was driving on 408, and had an E-PASS, it would take him approximately 3 minutes and 28 seconds to travel from one end of the network to the other. This is based on average travel data collected from the model of 50.96mph, over 2.95 miles. This also assumes that the travel time takes place during rush hour. If Joe had to exit at 436 and travel the street network without a collapse, he would travel approximately 5.14 miles at an average speed of 25.96mph. At this rate it would take him about 9 minutes and 23 seconds. If he were traveling eastbound on 408 and exiting at North Conway and then entering at Yukon/Lake Underhill he would travel 3.89 miles at an average speed of 25.96mph. At this rate it would take him about 9 minutes to complete the trip. The model shows that, obviously, once the collapse takes place, his travel time changes significantly. He can no longer take 408 and if he is fortunate to be on 408 before the eastbound or westbound exit links, he can expect the following times. If traffic is routed off 408 at 436 and the streets are functioning normally (no changes – two way traffic), then it will take him 97 minutes and 3 seconds at the average rate of 3.16 mph. It gets worse if the one way model is used as the speed drops to 2.60 mph. At this speed it will take him 118 minutes and 3 seconds to travel the same network. This is primarily due to bottlenecks at key sections of the network. What would Joe the most good would be to avoid the network and try to exit at an earlier point or take an alternate path such as 417 to 528. However, everyone else is probably doing the same thing so maybe he should just turn around and take the day off. Table 9 shows these data numbers.

<table>
<thead>
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<tr>
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Table 9 – Traffic Length, Speed and Time to Traverse the Network

We recommend that the two-way network be utilized in case of a collapse scenario. The data reveals that the one-way network does have some advantages but the data from the model shows that it is not efficient and would contribute to other problems related to side streets, requiring more emergency personnel to man the streets and extensive planning. Critical to the success of re-routing is the preparedness of emergency personnel to respond to such a disaster (Chiu, 2004). It will be important for the Expressway Authority, Department of Transportation, and Florida Highway Patrol to all agree upon a course of action in advance to effectively respond to such an event quickly. Communication with the public through radio, television, and signage also needs to be up and running as soon as possible.

Conclusion

Modeling and simulation is an effective and inexpensive tool to model county and state freeway and surface road system traffic scenarios. Organizing, planning and testing rerouting paths in real life scenarios will be too expensive and it will severely affect drivers, businesses and industries surrounding the particular traffic network being modeled. The simulated traffic network studied in this project is very close to one of Orlando’s most critical traffic locations. This is due to the fact that it is positioned directly after a major toll collection site (408 and 436 an exit used for the Orlando International Airport) and its proximity to I-4 and Toll Road 417. If the overpass collapse scenario actually happens the
traffic would be gridlocked for miles in either direction on 408 and the surrounding road systems would quickly become severely congested.

The simulated rerouted traffic network illustrated the impact of the overpass collapse on the 408 East-West Expressway in terms of vehicle flow, travel time of through traffic and delay time characteristics at the different freeway exit ramps and the surface road system available along the possible re-routing paths. Public service entities like The Expressway Authority, Department of Transportation and the Orange County Traffic Engineering Department are actively collecting traffic count data throughout the Orange County freeway and surface road system. The data collected is available to the public, private and academic entities providing services to the county or state.

In the past 6 years the number of vehicles traveling along the 408 stretch at the defined collapse point has increased by about 20,000 vehicles. If the observed count continues to grow then it is conceivable that another 20,000 vehicles could be added to the network. The need to continuously examine the current expressway and surface road systems is evident. Thus, the use of simulation to model traffic scenarios proves to be an effective and inexpensive tool to provide public service entities useful information for future road system planning and expansions due to the impact of traffic flow increase in a network.

In the future, effective simulations for the routing of traffic to bypass a collapsed bridge or overpass could help minimize traffic confusion if another tragedy were to occur. It could also help in the case of construction down time due to the repairs of the structures with poor ratings or new construction (which is prevalent throughout the United States). Governments need to be prepared to handle such events and modeling and simulation is an effective and inexpensive solution that can save time, money, and possibly human life.

**References**