Use of MicroSimulation to Convey Access Management Techniques

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One of the biggest challenges we've experienced at MoDOT in using Access Management techniques in our designs or retrofit projects is convincing the public that what we're doing makes sense. They sometimes just don't understand why we want to construct a 4-lane divided roadway with a median through their community instead of the same old 5-lane cross section with a two way center left turn lane they're used to. A major contributor to this opposition can be the local business owner, who wants direct and full access to their property. If handled properly, however, the local business owner may become your biggest ally. In the past, it has been difficult to explain to business owners why we want a median, or why, for example, we want their customers to go downstream and make u-turns to access a business.

MoDOT has been working towards using simulation modeling to convey our intent to business owners and to the general public. Another difficulty we've had is with the public not truly grasping the extent of a proposed project. We have had some recent success in gaining public acceptance of projects through modeling. This doesn't mean everyone agrees on what the final product should be or that the residents and business owners are 100% satisfied, but they can accept the project as it is proposed. Through this process of informing the public, they feel more like they were treated fairly and that we've come up with something they can live with.

One of the reasons microsimulation has been successful is because it has the ability to take all of the engineering information put into a project and "explain" it in terms the public is comfortable with. The old expression, "A picture is a worth a thousand words" is realized and even magnified with a simulation of a design project. It allows the public to see vehicles traveling through a network on top of an aerial photograph they are familiar with. It's all too easy to be misquoted or misunderstood when describing the finer details of an Access Management project. It's much safer and more effective to show a simulation and let the public or a news reporter describe what they see in the simulation.

We're often asked, "What's the best simulation software?" Unfortunately, there is no panacea for traffic modeling, just as there's no perfect solution for all of our traffic engineering problems. MoDOT has primarily used two software programs for simulation purposes, namely Synchro (with Sim Traffic) and VISSIM. There are other software packages available, all with their own advantages and disadvantages, including programs that include detailed traffic analysis capabilities, but we will mainly focus on the simulation programs we have utilized.

Synchro vs. VISSIM

Both Synchro and VISSIM have advantages and disadvantages, and each should be considered when determining the appropriate software to use. Synchro is well suited for presenting "hard data" or engineering facts and numbers to fellow traffic engineers. However, data such as total delay per vehicle, queuing penalty, or stops per vehicle don't mean a whole lot to the average driver or public official. In fact, there aren't many ways to present numerical data to the layperson to describe changes to an arterial network, such as a 5-lane cross section vs. a divided section with a median. Synchro is very user friendly and detailed reports are fairly easy to produce. However, Syncrho is somewhat limited in the types of intersections it can realistically model. While signalized intersections are easily replicated, interchange footprints and freeway segments and their interaction with those signalized intersections are not easily modeled.

VISSIM, on the other hand, requires more input time, and is more difficult to obtain analysis from. However, VISSIM is designed to model freeway applications, such as merging and weaving situations. The flexibility of VISSIM allows a user to model network applications, with a mix of interchanges, signalized intersections, stop controlled intersections, roundabouts, and freeway segments all in the same model. The most powerful function VISSIM provides may be the ability to simulate in 3D, which has extraordinary benefits when attempting to convey design or project details to the public.

Calibration

An important step to having an accurate simulation is to properly calibrate the model. To some extent, traffic modeling can be considered as much of an art as it is a science. So, to accurately predict future events, we must be able to accurately represent existing events. Before projecting data, or proposing any scenarios for a model, we must ensure we can realistically model real life driver behavior. This is not only important for accurate and dependable results, but it also has a direct relationship of how accepting the public is of a model. If they see something in the model they don't consider to be realistic, they'll let you know about it and will be able to easily discredit your model. The major details to look for are the size of gaps drivers are willing to accept, and how drivers navigate through local intersections (i.e. Do drivers come to a complete stop for a right turn at a signal, or do they proceed with more of a "rolling-stop"?).

Case Study 1 – Kingdom City

Microscopic traffic models are a valuable tool when trying to describe a future condition to any audience (management, business owners, and the general public). As part of MoDOT's corridor study on Interstate 70, we were trying to address major interchanges that would be impacted by the project. One location where we used a traffic model to help us show the need to the local community was at Kingdom City, MO.

Location Background

Kingdom City is a very small community (population 112). It is the crossroads of two major routes in Missouri, Interstate 70 and US 54. Interstate 70 currently has an AADT of 33,500 with approximately 35% trucks in this area. US 54 is an expressway with an AADT of 16,000 and approximately 16% trucks. These factors have created an excellent environment for development. It is the home to two large truck stops, several hotels/motels, numerous restaurants and gas stations.

Major Findings

The local community was concerned that any changes to the interchange would cost them their business (and to some degree their town). The existing conditions are a typical diamond interchange with an outer road 850 ft. to the south that provides access to a significant portion of the current development. The ramp terminals and the south outer road are all signalized. In addition, the outer road has an unsignalized intersection within 200 ft. of the major signalized intersection on US 54.

Our concern was that regardless of any improvements to the interchange, the outer road location was too close to the ramp terminals to effectively handle the traffic. In addition, the location of the intersection on the south outer road was compounding the problem.

We used Synchro/SimTraffic to model the area. We developed three scenarios; existing conditions, 2010 traffic, and 2030 traffic. In this instance there were two key things about the model that helped convince the local leaders that something did need to be done. The most important part was showing the existing conditions with an aerial photograph. The business owners were able to identify their place of business and watch the simulation. When they saw the model duplicate conditions that they were seeing on a routine basis, they began to "trust" the simulation. When we displayed the future conditions, they showed more trust in what the model was showing.

Conclusion of Case Study 1: Traffic Models are a valuable resource when trying to present information to stakeholders. Calibrating and presenting existing conditions creates confidence in the model. The extras, such as aerial photography, are valuable in helping the public relate to what they are seeing.

Case Study 2 – Moscow Mills

This case study again points out the importance of outer road spacing in conjunction with an interchange. In this example, however, the existing location is completely undeveloped and all design plans were only in the conceptual phases. As such, there was no one specific group of people to present our model to. The current use of this model would be limited to MoDOT management, to prepare for any outside pressure, such as from elected officials. MoDOT's Access Management Guidelines specify the minimum distance to the first major public road intersection from an interchange ramp as 1,320 ft (1/4 mile). This distance has been set in order to maintain adequate operations within the interchange footprint.

Location Background

The location in question is along US Route 61 (running north and south) in Lincoln County, Missouri at the intersection of State Route U (running east and west), approximately 9 miles north of Interstate 70, near St. Louis. Although this particular location is currently undeveloped, it lies in one of the fastest growing areas in the state, in unincorporated, un-zoned Lincoln County, which sits just outside the reaches of the urban sprawling area of St. Louis. The local residents will most likely consider this area as the outskirts of St. Louis in the very near future, if not already. US Route 61 will be known in the future as the Avenue of the Saints, which will be a full-access controlled four lane divided highway from St. Louis, Missouri to St. Paul, Minnesota. Accordingly, it is assumed the area will continue to grow at rates higher than the state average, and this roadway will remain a high speed arterial route for the foreseeable future. State Route U is a rural, two-lane, undivided roadway that intersects US Route 61 at grade. Currently, there is very little traffic on Route U, as it provides access to a nearby rural residential area.

Proposed Scenario

The proposed mixed-use development will require significant roadway improvements, which include a new interchange on US Route 61 and several signalized intersections. The design, as proposed, has both interchange ramps signalized, with the first major signalized intersection spaced at approximately 600' from the interchange ramps. Even before creating a model to analyze the proposed improvements, we had concerns with the outer road spacing not meeting the Access Management Guidelines.

Using projected traffic data, the proposed roadways improvements were modeled using Synchro and VISSIM. The Synchro model showed that each individual intersection as proposed could adequately operate with the projected traffic, with only the main signalized intersection for the development operating near capacity. The VISSIM model showed, however, that while the interchange ramps and the main development interchange may adequately operate independently, the closely spaced outer road caused major problems within the functional area of the interchange. Although the signal system was coordinated, queues from the main development intersection were unable to clear the interchange ramp terminals, causing excess backup on the ramps, threatening to back up onto the main lanes of US Route 61. Additionally, the minimal outer road spacing did not provide sufficient room for vehicles to merge into the desired lane between the interchange ramps and the outer road.

Alternate Scenario

MoDOT looked at a scenario to address the concerns presented from the VISSIM model, which included an outer road spacing more similar to that found in the Access Management Guidelines, and more evenly spaced signalized intersections throughout the proposed development, which resulted in the elimination of one signal. This scenario was again modeled with both Synchro and VISSIM, using the same traffic data, with only distributions to each intersection modified to represent traffic using the signalized intersections. Again the Synchro model showed each individual intersection operating adequately, with only the main signalized intersection (now located approximately 1300' from the interchange ramps) operating near capacity. The VISSIM model, however, showed much better operations throughout the entire network than the proposed scenario. The greater outer road spacing allowed for better coordination along Route U, which allowed for queues at the main development intersection to clear well before reaching the interchange ramps.

By using the VISSIM model, we were able to demonstrate the need for properly spaced outer roads, where traditional analysis may not have pointed out the negative impacts of not achieving adequate outer road spacing. It should be noted, however, that data from the Synchro models was used in the VISSIM models. The signal timings created by Synchro were necessary in both scenarios to ensure we had the best possible signal timing plans in use. Although VISSIM could not optimize the signal timing plans, it gave us a better idea of the system wide effects of those signal plans.

In this project the state roadway system consists of US Route 61 running north and south; and State Route U, running from US 61 to the west. The roadways to the east of Route 61 are all county roads, thus not under the jurisdiction of MoDOT. However, because we realized many benefits by improving outer road spacing on the state system, we developed our model to show similar improvements to the county system.

Simulations to Convey General Access Management Techniques

MoDOT has also used simulations to demonstrate the need for general Access Management techniques. To most of us involved with traffic engineering, Access Management is seen as a beneficial technique to balance the needs of providing access to property owners while efficiently moving traffic. To the individual property owners, however, Access Management is sometimes seen as a "barrier to conduct business." One of our goals at MoDOT in promoting Access Management has evolved into explaining our reasons for using Access Management techniques to property owners and developers in an effort to better convey the benefits of Access Management to all drivers.

Driveway Egress Capacity

We will consider two general Access Management principles that may be difficult to explain to a property owner. The first is egress capacity of driveways. Any business owner would most likely tell you the more driveways they have to their store, the more business they will see. However, if motorists cannot safely use all of these driveways, business is likely to suffer. We have developed two short videos demonstrating the effects of multiple, closely spaced driveways. The first video shows two closely spaced driveways, separated by approximately 100 ft. A vehicle approaches the main roadway from each driveway, at the same time, as a platoon of vehicles travels down the roadway, in front of the two closely spaced driveways. A small gap is available behind the platoon, in front of additional trailing vehicles. As the first car pulls onto the roadway, the second vehicle must wait until the first vehicle clears both driveways. By this time, the trailing vehicles are now approaching the driveways, and the gap is gone. The second vehicle must wait for the next gap to enter the roadway.

The second video demonstrates the benefit of combining the two closely spaced driveways into one joint-use driveway. As the platoon of vehicles make their way down the main roadway, two vehicles again approach, but this time both vehicles approach from the same driveway. Again the lead vehicle waits for a gap behind the passing platoon. This time, however, both vehicles are able to enter the traffic stream because they can use essentially the same gap. The second vehicle does not have to wait for the first to clear, but both can enter almost simultaneously.

This simulation can be used to point out that the effective capacity of a driveway can actually be increased by reducing the number of access points to the main roadway. At first, this point may seem counterintuitive to a business owner, but with the aid of the simulation, they may begin to see that more is not always better. By reducing the number of driveways, the number of conflict points is also reduced, making the overall roadway safer. The business owner may or may not be concerned with this, but by pointing out fewer accidents are likely to occur in front of their store, they may be willing to consider this.

Desirable Driveway Width

Similarly, business owners prefer to have as large of a driveway as possible. When available, they will request the maximum possible width for their driveway, assuming the more area open to the roadway, the more vehicles will be able to use the driveway. MoDOT often utilizes AutoTurn, a vehicle maneuvering simulation program, in conjunction MicroStation, a CADD design program, to detail vehicle tracking movements through proposed designs of intersections.

MoDOT has created two drawings using AutoTurn to detail the vehicle path of a single unit truck (design vehicle – SU) into a driveway with various widths. The first drawing shows the vehicle entering a 60 foot driveway, with 10 foot curb radii. The 60 foot driveway is composed of one 20 foot inbound lane, one 20 foot outbound right turn lane, and one 20 foot outbound left turn lane. The animation shows that due to the small radius, the vehicle will make a wide turn to enter the driveway, and will encroach into the outbound lane, tracking over nearly half of the 60 foot driveway. Because of this encroachment, both outbound lanes are not able to be fully utilized and 15 feet of the inbound lane is wasted, creating an effective driveway width of only 45 feet. If the vehicle path of a simultaneous exiting vehicle were also considered, the effective width may shrink to well below 40 feet.

The second drawing shows the same vehicle entering a 40 foot driveway, with 40 foot curb radii. The 40 foot driveway is composed of one 14 foot inbound lane, one 14 foot outbound right turn lane, and one 12 foot outbound left turn lane. In the narrower driveway with more appropriate curb radii, the vehicle off-tracking occurs all within the curb radii, and not the exiting lanes of the driveway. Because entering and exiting vehicles stay within their lanes, the effective driveway width remains at 40 feet.

Thus, a 40 foot driveway with appropriate radii can actually provide a greater effective width than a 60 foot driveway. Simulations could also be used to point out other benefits of narrower driveways, such as proper delineation and reduced conflict points.

Conclusion

The general conclusion is that simulation models give the traffic engineer another tool to convey Access Management techniques to those who are not familiar with their uses. The main goal is to convey the ideas of Access Management in a clear and concise manner. This will provide for a better understanding of the techniques of Access Management and should help remove the fear of these principals being a "barrier to conduct business" and replace it with the knowledge that it can help move traffic safer and more efficiently.