

Best Practices for Traffic Modeling Software

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ABSTRACT

Based on current job postings, traffic analysis software packages such as Synchro and HCS are most popular in the category of algorithm analysis, with VISSIM serving as the simulation software of choice whenever modeling non-standard facilities. This research seeks to investigate the robustness of traffic simulation software, examining the strengths and weaknesses of the VISSIM software package. Ongoing work is using VISSIM to analyze specific sub-tasks within transportation simulation, including modeling of two-way left-turn lanes, modeling roundabouts and routing decisions. This paper will present a brief tutorial of how these conditions are modeled in the VISSIM software, and provide recommendations about the appropriate methods to use for modeling a network from scratch.

INTRODUCTION

As traffic increases in the surface transportation network, more complex and innovative concepts of transportation systems are developing to meet the growing demand. Transportation modeling is an essential tool to assess the implementation of these advancements, and ensure they are being utilized in the transportation network effectively. The use of modeling software can accurately depict transportation's network geometry and traffic flow. Transportation modeling software also has the capability of being able to model all modes of transportation and their interactions with one another.

In the world of traffic engineering, the need to know how a traffic network operates is extremely important. One of the ways to model this is through the use of traffic simulation software. Modeling a traffic network is designing a network in an abstract system that represents the system at a particular time or space, which is helpful for understanding the real system [1]. For modeling a traffic network, many traffic simulation software packages are available to choose from. Each traffic simulation software package has some unique characteristics, allowing each to best fit certain traffic circumstances.

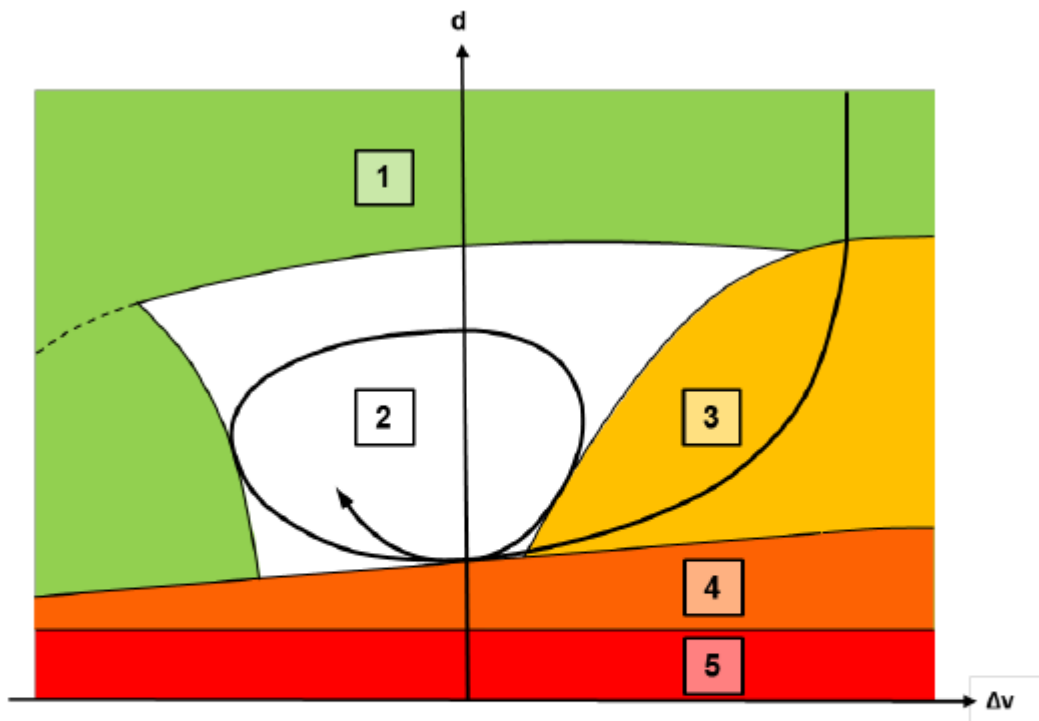
One of the more widely used software packages in the consulting industry is VISSIM. VISSIM is popular because of its robustness is being able to model multiple aspects of a transportation in the same network. The VISSIM model uses a link to connector method to model a network [2]. Other common traffic simulating software are modeled by a link to node structure. Using this link to connector structure enables VISSIM to model more dynamic traffic networks. Some of the more complex issues that VISSIM is able to model that cannot be depicted by algorithm-based software such as Synchro include two-way left-turn lanes, roundabouts, and advanced routing decisions.

GENERAL VISSIM MODEL STRUCTURE

VISSIM is a microscopic simulation program used for modeling multimodal transport operations. VISSIM has the capability of modeling integrated roadway networks as well as traffic networks consisting of general vehicle traffic, buses, heavy rail, light rail, trucks, pedestrians, and bicyclists. VISSIM is flexible in being able to integrate multiple modes of transportation in different control strategies [3].

The VISSIM model is based on a traffic flow model and a light signal control that exchange signaling status and detector readings. The traffic flow model used in VISSIM is based on a car-following model for users in a single lane and then utilizing a lane-changing model [4]. In the VISSIM program, a psycho-physical perception model developed by Wiedemann (1974) is used for a car following logic [4]. The main idea of this car following behavior is that a vehicle at a higher speed approaching a slower moving vehicle will start to decelerate as it approaches a slower moving vehicle in its initial perception threshold. This initial deceleration will fall below the slower moving vehicle and adjust its acceleration and deceleration based on distribution functions of the speed and distance behavior of the slower moving vehicle [4]. When more than one lane is utilized in a VISSIM model, a vehicle will also take into account vehicles in the two

adjacent lanes. There are five stages that a vehicle can experience in the Wiedemann model, as shown in **Figure 1**.



Car following model (according to: Wiedemann 1974)

Legend

Axes: d : Distance, Δv : Change in speed	3: Approaching state
1: "Free flow" state	4: Braking state
2: Following state	5: Collision state

Figure 1 Car following model implemented in VISSIM [3]

Wiedemann Car following Model Application in VISSIM

The car following model consists of five different classifications. The first stage (1) is considered the free flow state or free driving. In this stage, the vehicle's speed is not influenced by any other vehicles. In a free flow state, a vehicle is looking to maintain a desired speed by oscillating around the speed set in the VISSIM model. [3, 4]

The next stage (2) that a vehicle will experience is an approaching state. In this stage, a vehicle adapts its speed to prepare for following the preceding vehicle. In the approaching stage, a vehicle will initially drop its speed lower than the preceding vehicle and then rotate through accelerating and decelerating to match a speed differential of zero when the vehicle is at a desired safe distance. [3, 4]

Once a vehicle reaches a safe distance behind a preceding vehicle, the following vehicle is now in a following state. In this stage (3), the following state, a vehicle will follow the

preceding car with little acceleration and deceleration. Due to some imperfect estimation, the following vehicle will oscillate its speed around zero to keep a safe distance behind the preceding vehicle. [3, 4]

The breaking stage (4) occurs when the following vehicle begins to decelerate at a medium to high rate. This deceleration occurs when the distance of safety gap between two vehicles becomes inadequate. A vehicle will fall below the safe following distance due to abrupt changes in the preceding vehicle's speed. [3, 4]

The final stage (5) that can occur is a collision state. A collision state will happen if there is not adequate amount of time for a vehicle to decelerate and slow down to avoid the preceding vehicle. This mode does not take place in a VISSIM model, but is included in the Wiedemann car following model. [3, 4]

FEATURES OF VISSIM

In the VISSIM model, building a network requires some basic tools. The main tools for basic networks are links and connectors, routing decisions, conflict areas, and priority rules.

Links and Connectors

The basic feature that is used to build the geometry of the road network is the links and connectors tool. Links are used to create the roadway segments in a network. When creating a network, links can be modified for curvature with the addition of inflection points on a link. When multiple links come to an intersection, connectors must be used to connect multiple links. Connectors are used to bridge a gap between links in a network.

Routing Decisions

Routing decisions are used to route traffic in the network. Routing of traffic can be utilized by movement or by lane. This feature is helpful for continuously routing traffic as traffic progresses through the network. Routing decisions can determine the volume of traffic on each route by the actual volume or as a percent of the predetermined volume.

Conflict Areas

Conflict areas are used to set priority on conflicting or overlapping links and connectors. Conflict areas are used as a simple way to identify priority when vehicles might meet at a conflict on a link or connector. When identifying a conflict area, if both areas are listed as yellow, both vehicles will act passive in the conflict. If an area is listed as red in the conflict area, a vehicle will stop and wait for the other vehicle to proceed through the conflict area. When an area is listed as red in the conflict area, the other area will be listed as green. The green area allows vehicles in this area to proceed with little caution because this vehicle has the right of way.

Priority rules

Priority rules are used to set priority in more complex situations. Priority rules are utilized by setting a stop bar and green markers. The stop bar identifies where a vehicle should stop and analyze the priority conflicts at the green markers. The green markers are utilized by establishing either a gap time or headway to consider for these markers. A gap time is utilized by establishing an appropriate amount of time between vehicles that a vehicle at the stop bar should wait to safely proceed beyond the stop bar. Headway is used to establish a safe distance behind the green marker that the vehicle should look for before proceeding beyond the stop bar.

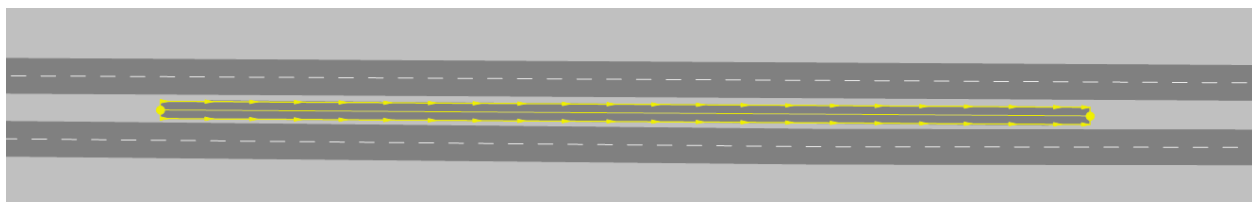
TWO-WAY LEFT-TURN LANES

A two-way left-turn lane is a lane in the center of two opposing lanes of traffic, set aside as a refuge area for making left turns in both directions. One of the more difficult scenarios to model in transportation software is the two-way left turn lane (TWLTL). This lane can cause confusion to drivers that are uneducated about the purpose of this lane or who choose to disobey the rules. Some drivers may use this lane as a merge lane or ignore the turn signals and drive continuously in this lane. In this paper, TWLTLs are explored in modeling based on the assumption that drivers in the model will follow the rules of the road, generally speaking a valid assumption within North America.

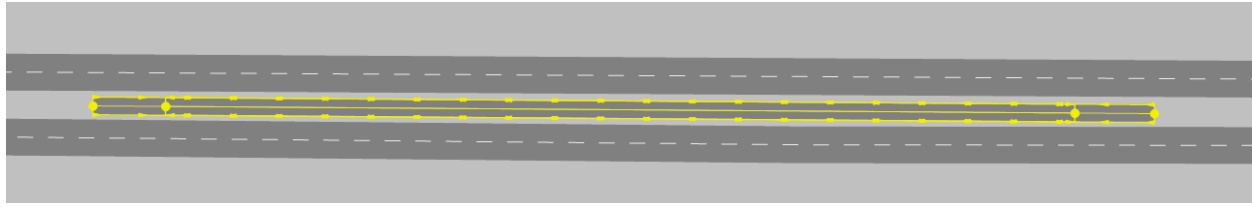
Simulation Modeling of TWLTL

Two-way left turn lanes are a complex issue that not all modeling software addresses. The problem with modeling TWLTLs in VISSIM is coordinating and visualizing traffic that goes both directions in one lane. There are alternative methods to model TWLTLs, but the method shown is one the author found most practical.

The first step to model a TWLTL is to create the network for both directions, leaving space to add the shared lane in later. The next step is to create a single lane going in one direction, as shown in **Figure 2 (a)**. Another lane should be created that is directed in the opposite direction. This other lane should extend further than the original lane on one side but not the other. This is not essential to the design of the TWLTL, but can make the process simpler later on. **Figure 2 (b)** shows both lanes that overlay each other.



(a) First overlaying link added in eastbound direction

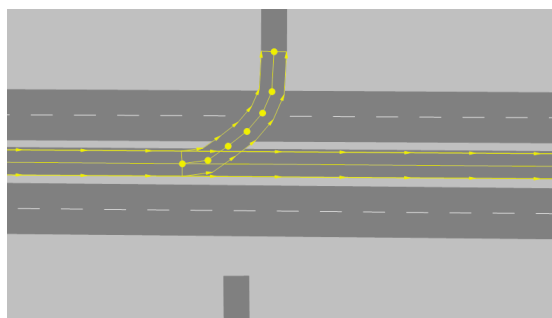


(b) Second overlaying link added in westbound direction

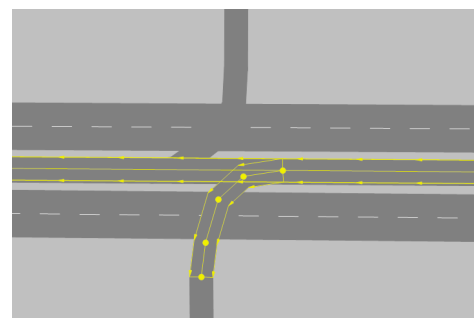
Figure 2 Layout of two-way left-turn lane (TWLTL)

With the overlapping lanes created, the next step is to create the merging lanes onto the TWLTL. A TWLTL has the capability of a user being able to merge whenever it desires onto the TWLTL. For modeling purposes, this capability is not available. Merging onto a TWLTL is modeled by creating connectors onto the TWLTL. If multiple entry points are desired, multiple connectors are created to closely simulate multiple access points onto a TWLTL. With multiple connectors created on to the TWLTL, static routes are used to define the volume of vehicles entering the TWLTL and at the desired entry point/connector.

With merging capability on to a TWLTL created, the next step is to complete the turning movements for the TWLTL. When creating these turning movements, it is important to ensure that the turn movements are associated with the correct lane. In order to do so, create a connector that starts on the lane that is extended further out. This ensures the connector is on the correct directional link. Once the connector is completed, it can be altered for curvature and length. An example of both left turn movements are shown in **Figure 3**.



(a) Eastbound left movement from TWLTL



(b) Westbound left movement from TWLTL

Figure 3 Layout of left-turn movements exiting the two-way left-turn lane (TWLTL)

With the completion of creating the TWLTL, more complex scenarios can be created with this lane. TWLTLs are often implemented because there are multiple access points for a TWLTL segment length. One of the more problematic issues with modeling TWLTLs is if these access points have limited spacing between driveways and roadways. When the spacing is minimal, the problem arises in the model if multiple vehicles merge onto the TWLTL and need to wait for another vehicle utilizing the TWLTL to turn. This problem can be solved through the

use of priority rules. In the VISSIM model when two links overlap each other, the vehicles will not stop for vehicles going the other way unless priority rules are set. In order to properly have vehicles wait for other vehicles on the TWLTL, priority rules need to be set in the areas where these vehicles may encounter this kind of conflict. The priority rules should be set in the TWLTL before the opposing turn movement. This will enable a vehicle to finish the turn movement before the vehicles progress through the TWLTL to their respective turn movements. An example image is shown below, in **Figure 4**. When a vehicle in the bottom lane merges into the TWLTL, the vehicle will stop at the red line if a vehicle is in the headway zone for one of the green lines. There are a couple of key things to note about this example. The most important thing is to ensure the red line for the TWLTL is on the directional movement of eastbound. The green lines should be for the opposite TWLTL that is directing westbound. The reason there are two green lines for this priority rule is to make sure that the vehicles heading eastbound will wait for vehicles that are on the TWLTL link heading westbound and the turning movement link. Priority rules function on a link to link basis, so accounting for every nearby link is crucial in this format. Ideal locations for the utilization of priority rules are shown in **Figure 4**.

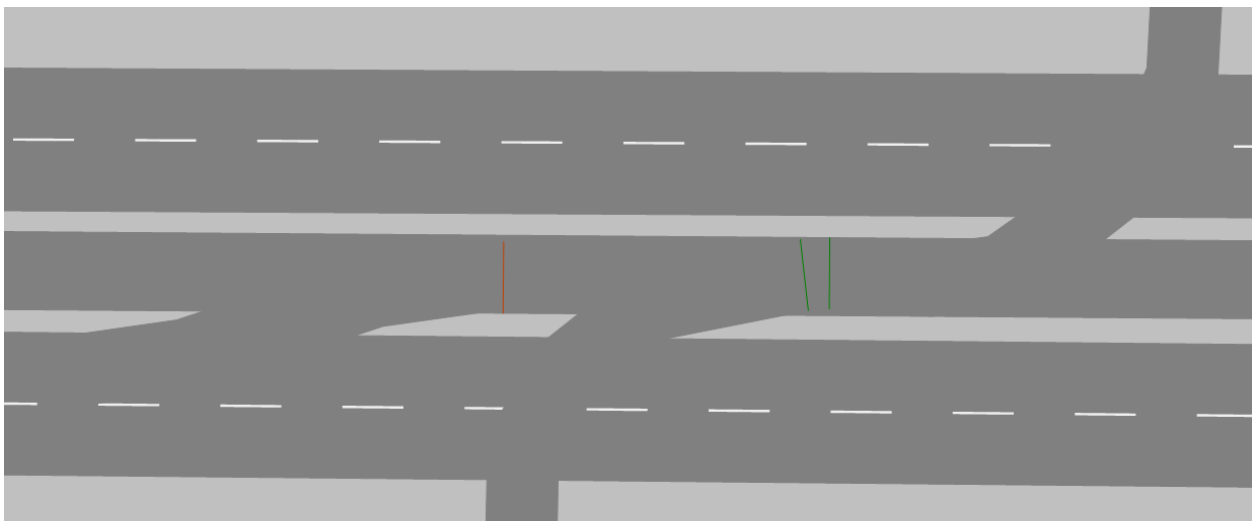


Figure 4 Setting priority rules for two-way left-turn lanes (TWLTL)

ROUNDABOUT MODELING ISSUES

A roundabout is a type of circular intersection that has proven to be safer and more efficient than other types of circular intersections, particularly in low-volume conditions. The modern roundabout has evolved and does not necessarily come in a uniform geometry. There are many issues that can arise when modeling roundabouts. Many of the problems that occur are due to different roundabout configurations. When modeling roundabouts certain criteria need to be accounted for. Some of these factors include gap and headway acceptance, merging areas within the roundabout, and yielding when approaching the roundabout. These criteria and others are utilized based on how the user wants to model the roundabout.

One of the main issues for modeling roundabouts is how to determine when a user is able to enter the roundabout at the correct time. In order to properly account for this issue, a combination of priority rules and conflict areas are used. Conflict areas should be assigned first and are rather simple to assign. For roundabouts, areas that are considered the circulating lane should always have priority over other lanes.

After assigning conflict areas the proper priority, priority rules should be set next. Priority rules can be a rather difficult aspect to understand. A priority rule enables the VISSIM model to incorporate flexibility with modeling traffic flow. A priority rule is used by setting a stop line and conflicting markers. A priority rule is utilized by initially setting a stop line on the link prior to vehicles entering the circulating lane. This stop line acts as a point for vehicles to stop and look at the conflicting markers for a proper time to proceed into the roundabout. A conflicting marker is used to establish an acceptable headway distance and gap time for vehicles to look for. For roundabouts, a headway distance and gap time should be utilized to accurately model the behavior of vehicles entering a roundabout. A headway distance should be placed in the circulating lane beyond the entry point. The headway distance accounts for distance behind the conflict marker. For roundabouts, a distance should be used to calculate from the conflict marker to the stop bar. The second type of conflict marker that is used is a gap time marker. This time is to establish a safe time gap between vehicles to properly enter the roundabout. An ideal location for these two types of conflict markers are shown in **Figure 5**.

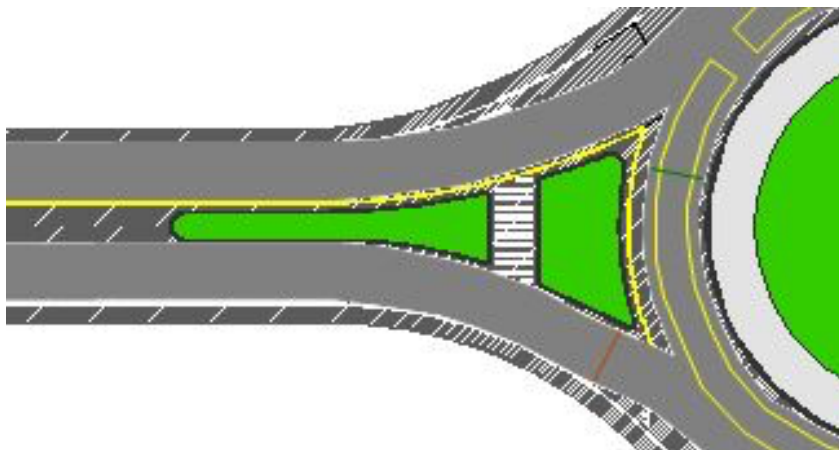


Figure 5 Example location of priority rules for roundabout

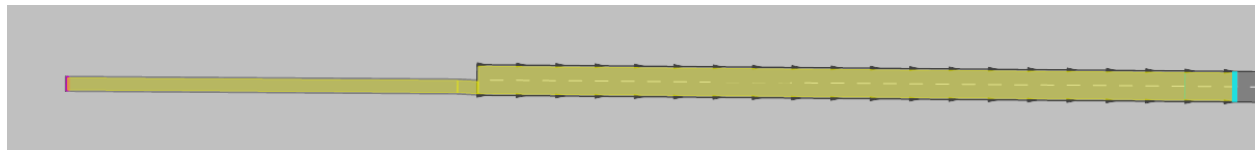
ROUTING DECISIONS

Routing decisions are an important tool within VISSIM. Routing decisions enable the modeler to decide the routing of vehicles by movement and even by lane. This tool is helpful if the traffic in a model is not behaving in a realistic manner. In the VISSIM model, lane utilization can exhibit unrealistic behavior for many reasons. Some of the more common reasons are skewed configurations, extended networks, complex configurations, and lane addition or reduction. For this example, lane addition will be explored to illustrate how this unrealistic behavior can happen.

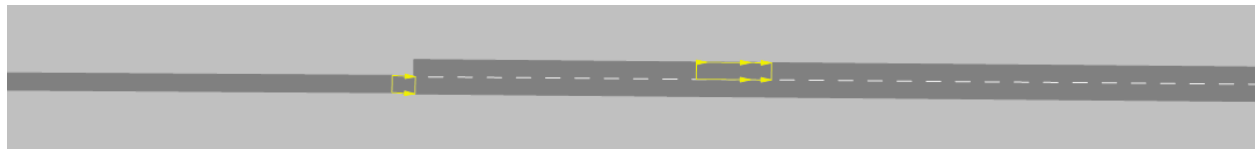
When a single lane roadway adds an additional lane, the VISSIM model may not evenly distribute this volume throughout the model. The reason this happens is because the VISSIM model cannot connect a link with one lane to a link with two lanes. To counteract this problem, the single lane should connect to the two-lane roadway by one connector as shown in **Figure 6 (a)**. With the model configured as shown, the vehicles will be more inclined to use the right-most lane, since the connector is connecting to this lane. The rest of the model should be completed with the exception of *Vehicle Routes*. Once the model is complete, altering the lane utilization can begin. To begin this process, create a *Vehicle Route* that passes through the first connector and a little ways down the segment as indicated in **Figure 6 (b)**. To better control lane utilization, create a small link on the lane that is not being properly utilized. This link should be created where vehicles should begin to merge into the other lane. An example is shown in **Figure 6 (c)** to illustrate where the two connectors are located. After the additional connector is constructed, another *Vehicle Route* should be constructed this time passing through the additional connector as shown in **Figure 6 (d)**. The *Static Vehicle Routing Decisions/ Static Vehicle Routes* tab should be brought up. On this tab, the position should be set to the same starting point for both *Vehicle Routes* that were created. The relative flow can now be set for each lane, depending on how the user wants each lane to be utilized for the respective model. From this point, new *Vehicle Routes* can be constructed, but should be constructed at point beyond the ending of the lane utilization *Vehicle Routes*.



(a) Expanding single lane to double lane



(b) Vehicle route using default configuration



(c) Divide the link and create mid-block connectors



(d) Alternate routes allowing for specified lane utilization

Figure 6 Artificial control of lane utilization factors

DISCUSSION

When using the VISSIM software, there is somewhat of a learning curve to overcome before being able to model more complex situations. This learning curve can be mastered by better understanding how the VISSIM model works at its core. Before embarking on modeling complex traffic networks, there are some basic tips to keep in mind with modeling.

Links and connectors are the basis of the VISSIM simulation software. A majority of the network will be made out of links. With this in mind, connectors should be limited to the least amount necessary. Some major problems can be identified with vehicles not knowing if their respective vehicle or others vehicles are on a link or connector. Monitoring connector usage to only when they are necessary will help counteract this problem. Another helpful method for making links and connectors more easily to construct is to draft the network in a drafting software with exact measurements. By drafting a network precisely, geometry errors will be less likely to happen in VISSIM if the user is able to create links and connectors over an accurate geometry from a base drawing.

Another helpful hint is the usage of priority rules. Priority rules are one of the more complex tools in VISSIM but are crucial to the modeling of complex scenarios. One thing to keep in mind with the placement of priority rules and other stop bars is to make sure the stop bars are on links and not connectors. This can be quite confusing because links and connectors will overlap by default upon construction. The stop bars should be placed on links prior to the overlapping of the connectors. By placing the priority rules or stop bars before the connectors, it ensures that vehicles will not proceed until it's a safe opportunity. If these stop bars are placed on the overlapping of the link and connector, sometimes vehicles will proceed because the stop bar is associated with either the link or the connector. Whichever one it is associated with, the vehicles will act differently if the vehicle thinks it's on the other link or connector. The same applies for the conflict markers associated with the priority rules. The conflict markers should always consider the nearby links and connectors. If there are multiple links and connectors nearby, sometimes multiple conflict markers are needed.

Traffic microsimulation software can come in many different types of packages. Traffic analyzing software are quite complex, seeing that each software package has its own strengths and weaknesses. One of the main software packages used for traffic analysis is VISSIM. VISSIM is unique in that it analysis traffic based off a link to connector basis, instead of the more common link to node setup. One of the major strengths of VISSIM is the flexibility to model nearly all types of transportation modes and integrate them in the same network. This flexibility gives the modeler the capability and freedom to model a transportation network, as they seem fit. Alongside with the strengths of this program, VISSIM also has some weaknesses. One of the weaknesses that VISSIM lacks in is a data output system. Some consultants use traffic analysis software based off their ease for data output and measures of network classification. One of the weaknesses of VISSIM is that VISSIM requires a more detailed setup to get an accurate data output.

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