

A COMPARISON OF THE VISSIM MODEL TO OTHER WIDELY USED TRAFFIC SIMULATION AND ANALYSIS PROGRAMS

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1.0 INTRODUCTION

VISSIM is a German microscopic traffic and transit simulation model that is beginning to see increased use within the United States. It is capable of modeling typical passenger vehicles and trucks for freeways and arterials as well as modes of transit such as buses, HOVs, light rail, commuter rail, and heavy rail. In addition, it is also capable of modeling complex traffic control situations which include: priority and preemption for buses and light rail, all way stop control, and pedestrians.

This paper describes the procedures and results of a comparison of the VISSIM (Version 2.91) simulation model to the more well known CORSIM (Version 4.2) and TRANSYT-7F (Release 8.1) models. In addition, VISSIM's ability to model train operations is also compared to the ARENA model which simulates train operations. These comparisons were made while modeling the existing traffic conditions for the roadway network surrounding the transitway mall in downtown Dallas. This modeling effort was part of two separate projects conducted by Parsons Transportation Group (PTG). The first project was conducted using TRANSYT-7F for the City of Dallas and the second project was conducted for Dallas Area Rapid Transit (DART) using VISSIM and CORSIM. In addition, Manuel Padron & Associates conducted an independent study on train operations for DART using the ARENA software. Ultimately, it is anticipated that the VISSIM model will be used for subsequent analyses of future light rail transit (LRT) expansion in the downtown transitway mall.

The study area for these projects is an area of downtown Dallas generally bounded by Houston Street on the west, Ross Avenue on the north, Routh Street/Good Latimer Street on the east, and Commerce Street on the south. The study area and the proposed light rail extensions are shown in Figure 1.

2.0 BACKGROUND AND PURPOSE

The existing transitway mall accommodates light rail vehicles from both the Red and the Blue Lines that travel from West Oak Cliff and South Oak Cliff (south of downtown) up to Mockingbird Station (north of downtown). The Red Line currently continues north to Park Lane in Dallas while the Blue Line stops at Mockingbird Station. The Red and the Blue Lines are currently being extended so that the Blue Line will extend east to Garland and the Red Line will extend north to Richardson and Plano in the year 2002.



Figure 1. Study Area

DART is currently in the process of conducting two Major Investment Studies (MIS) that could increase the number of light rail vehicles that operate along the CBD transitway mall. The Northwest Corridor MIS is evaluating the potential alignment of rail from downtown Dallas to Farmers Branch and Carrollton with options to add connectivity to Irving, DFW Airport, and Love Field Airport. If the Northwest Corridor MIS concludes with a light rail alignment, it will most likely connect to the existing transitway mall near the intersection of Houston Street and Pacific Avenue. This connection will allow LRT vehicles to interline with the proposed Southeast Corridor which connects to the transitway mall on the east end of Bryan Street near U.S. 75. The Southeast Corridor travels from Bryan Street, down Good Latimer to the freight rail line right-of-way just south of Gaston Avenue. The Southeast Corridor then connects to the areas of Baylor Hospital, Fair Park, and Pleasant Grove. The proposed service date for rail service on these corridors is the year 2007.

During peak hours of operation, DART currently runs trains at 10-minute headways on each rail line. Because the rail lines overlap within downtown, the average headway in each direction is 5 minutes. If the new NW and SE Corridors interline through downtown on the transitway mall, the average peak period headways would be 3 1/3 minutes. Recent patronage projections indicate that the Red Line to Plano may need to operate at shorter than 10-minute headways, which could reduce the future headway through the transitway mall down to 2 1/2 minutes. The purpose of this DART study was to determine if the transitway mall has the capacity to accommodate the increase in train operations without degrading either transit service or traffic operations.

With that purpose in mind, the next question became which model(s) should be used. Possible models which were considered included VISSIM, CORSIM, TRANSYT-7F, WATSIM, and TRANSIM. VISSIM was selected based on a number of factors. During 1997 and 1998, PTG conducted a study for the Long Island Rail Railroad in New York City which included a detailed evaluation of VISSIM, CORSIM, WATSIM, and TRANSIM. As a result, VISSIM was selected for that project based on its overall ability to model transit, automobile traffic, complex traffic and transit geometries, and complex user defined traffic control strategies such as preemption and priority. While WATSIM and TRANSIM can also provide many of these same features, it was felt that VISSIM would be most suitable to the task. Based on this previous evaluation and the fact that the authors have successfully used VISSIM for three other non-related projects for DART, VISSIM was selected for this project.

CORSIM was selected in order to help evaluate VISSIM's ability to model automobile traffic. CORSIM has been widely used within the United States and is regarded as an acceptable traffic simulation tool by many engineers. Since all but one of the LRT crossings in the transitway mall are controlled by pretimed traffic signals, CORSIM could be used to replicate the existing traffic conditions since the effect of the existing timing could be modeled without have to worry about modeling LRT operations themselves.

TRANSYT-7F was included in the comparison since it is also widely used in the United States and the City of Dallas project utilizing TRANSYT-7F was conducted in parallel with the DART project. Due to the fact that TRANSYT-7F does not explicitly model buses, LRT activity, or

complex geometry and traffic control, its capabilities and results will not be compared to VISSIM in the same detailed manner that CORSIM will be.

The purpose of this comparison was to determine if VISSIM could satisfactorily model automobile traffic. If the comparison is successful, VISSIM would be used to analyze the effects that the future LRT extensions would have on automobile traffic and LRT operations. Due to its relatively new arrival on the scene in the United States, the authors have noticed some reluctance to the use of VISSIM on the part of practitioners in the Dallas area. This reluctance is justified since it has been difficult to obtain a large amount of research that documents VISSIM's use and calibration in contrast to the literature available on CORSIM's use. While this paper cannot solve this problem entirely, hopefully it can help point out some of the features of VISSIM and provide a relatively short and concise comparison of VISSIM to CORSIM and TRANSYT-7F.

Finally, it should be noted that the size of the simulation area is much larger than would normally be used when applying a microscopic simulation. The size of the model was driven by the need to include the entire Dallas CBD transitway mall in one model. In addition, it was deemed appropriate that at least two parallel arterials on either side of transitway mall be included in order to limit the effect of the boundary areas and produce more accurate results for the intersections along the transitway mall. The resulting model contains 97 downtown intersections and allows for the comparison of a variety of traffic control situations.

3.0 MODEL DESCRIPTIONS

VISSIM Description

VISSIM (*1*), a German acronym for "traffic in towns - simulation", is a stochastic microscopic simulation model that has the ability to evaluate vehicular traffic, transit operations, and pedestrians. VISSIM was developed by PTV AG in Germany and is distributed in the North America by Innovative Transportation Concepts. One of VISSIM's strengths is its ability to model complex traffic control strategies such as preemption and priority systems. The model uses inputs such as lane assignments and geometries, intersection turning movement volumes, vehicle speeds, percentages of vehicles by type, and pretimed and/or actuated signal timing. It is capable of producing output that contains measures of effectiveness commonly used in the traffic engineering profession. These measures of effectiveness include total delay, stopped-time delay, stops, queue lengths, fuel emissions, and fuel consumption.

In order for VISSIM to model complex traffic control strategies such as preemption and priority systems, a vehicle actuated program (VAP) must be developed in most cases. This is essentially a computer program, written in a language similar to BASIC, that is used to emulate a traffic signal controller or other types of traffic control devices such as gate crossings and LRT track switches. In addition to the VAPs, there are existing controller software packages that can work directly with VISSIM. Some of these packages are capable of SCATS and SCOOT operations in addition to built-in preemption and priority systems.

The VISSIM model is made up of two components. The first component, the traffic simulator, simulates the movement of vehicles, provides fixed time signal control, and generates the

corresponding output. The second component, known as a signal state generator, simulates the operations of a traffic signal controller or other traffic control device through the use of a VAP. Using detector information from the traffic simulator on a time step basis (time steps per second can vary from 1 to 10), the signal state generator determines the signal status for the following time step of simulation and passes this information back to the traffic simulator.

CORSIM Description

CORSIM (2) (CORridor microscopic SIMulation) is a combination of the arterial simulation model NETSIM and the freeway simulation model FREESIM. Each model is a stochastic microscopic simulation model that simulates on a one-second time step. While the CORSIM concept of combining the arterial and freeway simulations is relatively new, NETSIM was originally developed and calibrated during the 1970's. It has been continuously updated through field studies and software revisions by the Federal Highway Administration (FHWA). FRESIM is an enhanced version of the INTRAS model.

CORSIM applications have been documented extensively in publications published by both the Transportation Research Board and the Institute of Transportation Engineers. It has been studied and used by many engineers all over the world. In addition, the CORSIM program has also been the basis for other models including WATSIM by KLD & Associates and SimTraffic from Trafficware. SimTraffic is the simulation program included with Synchro Professional, a traffic signal timing optimization package.

Like VISSIM, CORSIM is capable of producing output that contains measures of effectiveness commonly used in the traffic engineering profession. These measures of effectiveness include total delay, stopped-time delay, stops, queue lengths, fuel emissions, and fuel consumption. It is also capable of modeling both pre-timed and actuated traffic signals.

TRANSYT-7F Description

TRANSYT-7F (3) is a traffic simulation and signal timing optimization program. In contrast to CORSIM and VISSIM, TRANSYT-7F is a macroscopic model that considers platoons of vehicles rather than individual vehicles. A platoon dispersion algorithm is utilized to simulate the normal dispersion of platoons as they travel downstream. TRANSYT-7F is an acronym for TRAFFIC Network StudY Tool, version 7F. The Transport and Road Research Laboratory (TRRL) developed the original TRANSYT model in the United Kingdom. TRANSYT (version 7) was later "Americanized" for the Federal Highway Administration (FHWA); thus the "7F". It claims to be the most comprehensive tool for traffic signal timing and analysis in existence – particularly for two-dimensional networks. However, the program does not support the direct simulation of transit vehicles such as buses and light rail vehicles that are required in this study. Therefore, certain conversions and coding techniques were utilized when creating the models for comparison.

4.0 MODEL COMPARISONS

The following discussion will compare the VISSIM and CORSIM models in more detail. A detailed comparison to TRANSYT-7F is not provided. The inclusion of TRANSYT-7F results in this paper is for evaluation of the CORSIM and VISSIM results.

VISSIM and CORSIM are both stochastic microscopic computer simulation programs capable of modeling individual vehicle interactions on complex roadway networks. Both models use inputs such as lane assignments and geometries, intersection turning movement volumes, vehicle speeds, percentages of vehicles by type, and pretimed and/or actuated signal timing. And both programs produce output that contains measures of effectiveness commonly used in the traffic engineering profession, including total delay, stopped delay, and queue lengths.

VISSIM, however, is more capable of modeling the interaction of various modes of transit with automobile traffic. While CORSIM can effectively model simple bus routes within a roadway network, VISSIM can model light rail transit and can model more bus routes and bus stops than CORSIM. In addition, unlike CORSIM, VISSIM is capable of modeling gates at rail crossings as well as complex traffic control strategies such as preemption and priority systems.

As described in the previous section, CORSIM is a more well-known traffic simulation program, but VISSIM has superior capabilities in modeling transit operations. Due to the fact that the proposed changes to the downtown transitway mall will entail changes in LRT operation, VISSIM is better suited to provide comparisons of future conditions to existing conditions. Due to the fact that CORSIM is more widely accepted for its simulation of automobile traffic, CORSIM, TRANSYT-7F, and field data were used to evaluate the VISSIM results to ensure that VISSIM simulates automobile traffic satisfactorily as well as transit.

Computer models of the same study area in downtown Dallas were coded in VISSIM and in CORSIM. Due to modeling constraints, the CORSIM model does not have LRT running in the transitway mall. In addition, there are some inherent differences between the way the two models are constructed and the way the two models calculate traffic statistics. However, each model should produce similar results despite these differences. Table 1 presents the characteristics of the parameters used in the VISSIM and CORSIM models and how they differ. Default values were used for CORSIM and those values were approximated in VISSIM as closely as possible.

As shown in Table 1, various traffic characteristics differ between the models due to the way the models are coded. For example, CORSIM uses a two-digit headway value to specify the saturation flow rate on a link, which limits the accuracy of the specified saturation flow rate to increments of about 85 vphgpl. Other differences become apparent with the assignment of desired speeds, vehicle lengths, and turning speeds to individual vehicles in the traffic stream. However, it should be noted that both models produce similar average values of these parameters.

Table 1. Characteristics of Parameters used in VISSIM and CORSIM for Downtown Dallas

Parameter	VISSIM	CORSIM
Saturation Flow Rate	1714 vphgpl	1714 vphgpl (headway of 2.1 seconds)
Desired Speeds Assigned to Individual Vehicles	Min = Speed Limit – 10mph 15 th Percentile = Speed Limit – 5mph 50 th Percentile = Speed Limit 85 th Percentile = Speed Limit + 5mph Max = Speed Limit + 10mph (CBD Speed Limit = 25mph)	Desired Link Free-Flow Speed* multiplied by 75% to 127% depending on one of 10 driver types. (CORSIM Default Values) *CBD Speed Limit of 25mph
Vehicle Length (Passenger Cars)	Varied linearly from 4.0m to 5.5m (13.1ft to 18.0ft) Average = 15.6ft	75% of cars are 16ft, 25% of cars are 14ft Average = 15.5ft (CORSIM Default Values)
Vehicle Length (Buses)	Varied linearly from 12.0 to 12.1m (39.4ft to 39.7ft) Average = 39.6ft	100% of buses are 40ft Average = 40ft (CORSIM Default Value)
Queue Length Adjustments	1.0m (3.28ft) spacing between vehicles	3ft spacing between vehicles (CORSIM Default Value)
Turning Speeds (Right-Turns)	Varied linearly from 15km/h to 20km/h (13.7fps to 18.2fps)	13fps (CORSIM Default Value)
Turning Speeds (Left-Turns)	Varied linearly from 20km/h to 25km/h (18.2fps to 22.8fps)	22fps (CORSIM Default Value)
Delay Measurement	Setup up to measure from intersection exit to intersection exit. Can be customized to measure any area defined by user.	Measured from stop bar to stop bar.
Delay Calculation	The delay for each vehicle is calculated by subtracting the travel time at its individually desired speed from its actual travel time.	The delay for each vehicle is calculated by subtracting the travel time at the desired link free-flow speed from the vehicle's actual travel time. This calculation is not based on the individually assigned desired speed.
Transit Modes	Buses and LRT	Buses Only
Maximum Transit Stations/Stops	Unlimited Number	99 Bus Stations
Maximum Transit Routes	Unlimited Number	99 Bus Routes

There are many other differences between CORSIM and VISSIM and how they are used. Several of these differences are described below.

User Interface

CORSIM input files can be quickly created either through ITRAF or Synchro. Both methods have their own limitations when creating input files. In order to take full advantage of CORSIM's capabilities, it is often necessary to use a text editor to adjust the input file. While this may seem tedious, it can be done efficiently since the CORSIM input file follows a rigid structure. In fact, many experienced CORSIM users who learned how to code input files with a text editor will still use a text editor to build a model.

VISSIM network editing is done completely through the use of its Graphical User Interface which runs in various versions of Microsoft Windows. Due to the fact that the interface used to build a VISSIM model is also the same interface used to view the animation, you know exactly what your network structure is going to look like as you are building your model. In addition, VISSIM can also import scaled versions of background bitmap files which can be used to build the model upon. All of this is in contrast to CORSIM where the TRAVU software must be used iteratively to view CORSIM's graphical interpretation of the input file.

Network Structure

Unlike CORSIM, which uses a link-node network structure, VISSIM uses links and connectors. These links and connectors are used to construct both streets and intersections. This permits VISSIM to be very flexible when working with complex geometries. VISSIM can easily be used to accurately model curvature, variable location of stop lines, and correct turning paths. Although link curvature can also be modeled in CORSIM, TRAFVU has a tendency to show strange loops or other graphical misrepresentations based upon limited input options.

Computer Time

A typical CORSIM run of the existing conditions model used for this analysis took approximately 10 to 15 minutes to simulate a 1-hour simulation. This also included about 6 minutes of initialization time before the CORSIM model reached equilibrium and began collecting statistics. VISSIM, however, took an average 70 to 80 minutes to simulate a 1 hour and 15 minute simulation on the same computer (PIII/450). The first 15 minutes were used to initialize the model. Statistics were gathered for the VISSIM runs only after the initial 15-minute period had elapsed. In addition, the VISSIM model was used with 0.5-second time steps (2 time steps per second). This essentially doubled the run time compared to a 1-second time step.

Vehicle Entry

CORSIM generates vehicles using a uniform distribution at its entry points. In contrast, VISSIM generates vehicles randomly.

Mid-Block Source/Sinks

CORSIM Source and Sink nodes simply add or remove vehicles from a link without regard to lane position, acceleration, or deceleration. Specifically, when using source nodes, vehicles just appear on the roadway in any lane, traveling at full speed. When using sink nodes, vehicles just disappear from the roadway in any lane, traveling at full speed. This does not accurately represent the effect of entering and exiting vehicles would have on the link. In addition, the use of CORSIM source and sink nodes requires an understanding of how CORSIM's output statistics account for the appearing and disappearing vehicles. In contrast, VISSIM's flexible link capabilities can be used to create mid-block source and sink locations where vehicles accelerate, decelerate, and use lanes more realistically when they enter or exit. In addition, VISSIM can more easily account for these vehicles in the statistics if desired. It should be noted that CORSIM links can be split into two links to create mid-block entry and exit locations for traffic so that more realistic maneuvers will be simulated, but this complicates the collection of output statistics for the link in question.

Terminology

CORSIM uses terminology for signal controllers and phases that are used by traffic engineers in the United States. VISSIM on the other hand, uses traffic signal terminology that is commonly used in Germany and other European countries. This difference is not surprising due to each model's origin. However, this difference does not affect model performance, it only requires a little extra effort to acclimate to the terminology used by VISSIM.

Output

CORSIM provides detailed output in a series of standardized tables contained in one output file. This output is usually easy to read and has been summarized to a great extent. This can be either advantageous or disadvantageous depending on the user's intent. Like many CORSIM users, the authors currently use an in-house computer program to assist in reducing the output data to a manageable level which can then be summarized efficiently in a spreadsheet.

In contrast, VISSIM's output is contained in several separate output files which are sometimes difficult to extract data from. The authors have developed their own in-house software to quickly reduce and reformat the data so it can easily be used in a spreadsheet. This is especially necessary when reducing output data from a large network. It appears this problem has been addressed to some extent in the latest version of VISSIM (3.01), however, the authors have not tested this as of yet.

One advantage VISSIM has is that it can produce very detailed results on any time interval defined by the user. This is a common need in research applications or when developing new control algorithms. CORSIM can also generate this data, but usually a special version of the software is needed.

5.0 DATA COLLECTION

The data necessary for simulating and analyzing the existing conditions within the study area include traffic signal timing data, traffic volume counts, traffic saturation flow rates, roadway geometric data, and transit schedules. Detailed information for each mode of transit includes routing, station/stop location, headway, scheduled arrival, dwell time, as well as the average passenger occupancy on each transit vehicle. The City of Dallas provided a database of existing traffic signal timing in the downtown area and transit schedules were gathered from DART. Field visits were conducted in order to verify roadway geometric data, parking lane usage information, transit operations, turning movement counts, saturation flow rates, travel time studies, and field delay studies.

Turning Movement Counts

Turning movement volume counts were conducted at 92 intersections in May and June 1999. These traffic volume counts consisted of turning movement counts at each study intersection during the AM and PM peak periods of traffic activity, and 24-hour traffic volume counts conducted on roadways entering and exiting the study area. Subsequent turning movement counts were conducted in September and October 1999 to verify the data.

It should be noted that the turning movement counts did not include buses. Since one bus takes up more space and is more disruptive to traffic flow than one passenger car, it is better to count automobiles and buses separately. This was done for the turning movement counts but was impossible to do with the 24-hour traffic counts, which were collected mechanically. Regardless, the VISSIM and CORSIM models were coded with the automobile turning movement counts. Buses can be added separately to VISSIM and CORSIM since specific routing information is entered.

In order to account for buses in TRANSYT-7F, the routing information was summarized to determine the bus turning movement volumes that should be present at each intersection. These volumes were then turned into passenger car equivalents by equating a bus to 3 passenger cars.

Saturation Flow Rate Studies

Saturation flow studies were conducted on 12 approaches within the study area. There were six studies conducted during the AM peak hour and six conducted during the PM peak hour. The average saturation flow rate measured in the field was 1704 vphgpl.

Travel Time Studies

Travel time studies were conducted in November 1999. These studies were conducted along nine separate corridors using the average car technique. The runs started and ended at the model boundary locations. These runs were made during both the AM and PM peak hours. A minimum of six travel time studies were made in each corridor during each peak hour.

Intersection Delay Studies

Intersection delay studies were conducted at eight different intersections in April 2000. These studies were conducted at four separate locations in the AM peak hour and four different locations in the PM peak hour. The City of Dallas requested these studies after reviewing the preliminary report submitted to DART that summarized the existing conditions. An attempt was made to conduct the delay studies in the field according to the procedures outlined in the 1997 Highway Capacity Manual (4) (HCM). However, the number of vehicles that stop at least once (“Vstop” in HCM) could not be counted due to budgetary constraints. Therefore, the resulting study was more equivalent to the technique described in the 1994 Highway Capacity Manual (5).

LRT Travel Time and Stop Studies

In addition to the automobile and bus data collected by PTG, DART conducted LRT travel time studies and counted the number of LRT stops at various intersections for the PM peak during December 1998 and September 1999.

6.0 CALIBRATION PROCEDURE

Preliminary VISSIM and CORSIM simulations of each peak hour were performed and the results were compared with field observations to ensure that the models were simulating the actual conditions in the real world. To produce the average results, five runs using different random number seeds were made for both CORSIM and VISSIM. Several iterations of the models were conducted by adjusting model parameters at various locations until the models satisfactorily represented the existing traffic conditions at all locations within the study area. These adjustments included relocating turning movement decision points, redefining yield priorities at various intersections, changing lane usage to correspond with parking restrictions, and adjusting speeds in the model to better reflect real-world conditions. Once it was determined that the VISSIM and CORISM models were simulating existing conditions satisfactorily, they were used to produce the existing conditions results.

Comparison of Traffic Results with Travel Time Studies

The travel time studies conducted in November 1999 allow a more detailed comparison of the model output with real-world data. Travel time studies were conducted during both the AM and PM peak hours along Ross, Elm, Main, Commerce, Lamar, Griffin, St. Paul, Ervay, Central, and Pearl Streets. Multiple travel time runs (minimum of 6) were conducted on each street and the results were averaged to arrive at one field value of travel time for each street. This value was then compared to the average travel time reported by the VISSIM and CORSIM models for each street. This comparison is summarized in Tables 2 and 3 for the AM and PM peak hours, respectively. The individual link travel times that make up the corridors were also compared to CORSIM and VISSIM for calibration purposes. These tables are not included in this paper, but were published in a report by PTG (6) that summarized the existing conditions and results of both models. This report was provided to DART and the City of Dallas.

Corridor	Link Length (feet)	Travel Time (minutes:sec) Delay Time from 25mph			Difference (sec)		
		Field Survey	CORSIM	VISSIM	CORSIM vs Field Survey	VISSIM vs Field Survey	VISSIM vs CORSIM
Elm	5270	0:04:08	0:04:29	0:04:05	21	-3	-24
		0:01:44	0:02:06	0:01:41			
Commerce	5305	0:04:38	0:05:41	0:04:28	64	-10	-73
		0:02:08	0:03:12	0:01:58			
Main Eastbound	5255	0:06:33	0:05:22	0:05:25	-71	-68	4
		0:04:04	0:02:53	0:02:56			
Main Westbound	5255	0:05:15	0:04:47	0:06:10	-28	55	83
		0:02:52	0:02:24	0:03:47			
St. Paul	2780	0:01:33	0:01:58	0:02:15	25	42	17
		0:00:14	0:00:39	0:00:55			
Erway	2325	0:03:11	0:02:29	0:02:46	-42	-25	18
		0:02:04	0:01:22	0:01:40			
Ross Westbound	3255	0:02:30	0:02:25	0:02:40	-5	10	15
		0:01:05	0:01:00	0:01:15			
Ross Eastbound	3255	0:04:11	0:03:43	0:03:39	-28	-32	-4
		0:02:36	0:02:08	0:02:04			
Pearl Northbound	3370	0:03:53	0:04:31	0:03:33	39	-19	-58
		0:02:28	0:03:06	0:02:08			
Pearl Southbound	3370	0:03:22	0:03:39	0:03:42	17	20	3
		0:01:45	0:02:02	0:02:05			
Griffin Northbound	1475	0:01:43	0:02:37	0:02:46	54	62	9
		0:01:03	0:01:57	0:02:06			
Griffin Southbound	1475	0:01:29	0:01:29	0:01:29	1	0	-1
		0:00:49	0:00:49	0:00:49			
Lamar Northbound	1240	0:01:37	0:01:39	0:01:47	2	10	8
		0:01:03	0:01:05	0:01:13			
Lamar Southbound	1240	0:01:28	0:01:18	0:01:22	-9	-6	3
		0:00:54	0:00:44	0:00:48			
Total	44870	0:45:30	0:46:08	0:46:07	39	37	-2
		0:24:48	0:25:27	0:25:25			

It should be noted that the travel time study runs were conducted in a vehicle that traveled straight through the entire corridor from one study-area boundary to the other. Likewise, the travel time data extracted from the VISSIM and CORSIM models are for through vehicles. However, the models compile results on a link-by-link basis so vehicles that turn onto a street within the network and travel through a downstream intersection are included in the “through” vehicle travel time. It is not possible to compile statistics for traffic that travels straight through the entire length of the network in CORSIM. This is possible in VISSIM if a route is set up that travels straight through the corridor from one end to the other and is assigned the appropriate volume of vehicles. Although this was possible in VISSIM, the link by link through-vehicle travel times were used for the sake of consistency for the comparison to CORSIM. As a result, some variance between the models and field travel times may result where signal progression

favors the through movement. On the other hand, if both models vary from the field observations and are consistent with each other, it is reasonable to assume that they are adequately modeling field conditions as long as their delay and queuing conditions are consistent with observed field conditions.

Corridor	Link Length (feet)	Travel Time (minutes:sec) Delay Time from 25mph			Difference (sec)		
		Field Survey	CORSIM	VISSIM	CORSIM vs Field Survey	VISSIM vs Field Survey	VISSIM vs CORSIM
Elm	5270	0:04:08	0:04:20	0:04:56	12	48	36
		0:01:44	0:01:56	0:02:32			
Commerce	5305	0:04:05	0:03:58	0:04:09	-7	4	11
		0:01:35	0:01:28	0:01:39			
Main Eastbound	5255	0:05:07	0:04:59	0:05:14	-8	7	15
		0:02:38	0:02:30	0:02:45			
Main Westbound	5255	0:06:13	0:05:19	0:06:10	-55	-3	52
		0:03:50	0:02:55	0:03:47			
St. Paul	2780	0:03:19	0:02:14	0:02:16	-66	-63	3
		0:01:59	0:00:54	0:00:56			
Ervey	2325	0:02:17	0:02:27	0:02:29	9	12	3
		0:01:10	0:01:20	0:01:22			
Ross Westbound	3255	0:02:40	0:03:10	0:03:09	30	29	-1
		0:01:15	0:01:45	0:01:44			
Ross Eastbound	3255	0:04:08	0:03:40	0:03:35	-29	-33	-4
		0:02:34	0:02:05	0:02:01			
Pearl Northbound	3370	0:02:37	0:03:03	0:03:14	26	37	11
		0:01:12	0:01:38	0:01:49			
Pearl Southbound	3370	0:02:40	0:02:58	0:02:57	19	17	-2
		0:01:03	0:01:22	0:01:20			
Griffin Northbound	1475	0:01:21	0:01:32	0:01:49	11	28	17
		0:00:41	0:00:52	0:01:09			
Griffin Southbound	1475	0:01:55	0:01:31	0:02:44	-24	49	72
		0:01:15	0:00:51	0:02:03			
Lamar Northbound	1240	0:01:58	0:01:24	0:01:31	-34	-26	7
		0:01:24	0:00:50	0:00:58			
Lamar Southbound	1240	0:02:05	0:01:33	0:01:29	-32	-36	-4
		0:01:31	0:00:59	0:00:55			
Total	44870	0:44:33	0:42:06	0:45:43	-147	70	217
		0:23:50	0:21:24	0:25:00			

In the case of the CORSIM model, the travel time data for through-bound cars and buses are reported together. In the case of the VISSIM model, this data can be reported for cars alone, buses alone, and cars and buses together. The VISSIM results compared in Tables 2 and 3 include both cars and buses to maintain consistency with the CORSIM output.

On the left half of Tables 2 and 3, the average travel time and average delay time for each study corridor is shown as collected in the field and as reported by CORSIM and VISSIM. On the right half of each table, the differences between the model results and the field study values are calculated. Comparing the first two columns on the right half of the table determines which model is closest to the field survey values, while the last column compares the models to each other.

Within each row, the travel time is reported above the corresponding delay time. This delay time is a value calculated in a manner similar to that used by CORSIM and VISSIM. Specifically, the actual travel time is compared to the time it would have taken to traverse the corridor at a desired speed of 25 mph without stopping. The difference in these times is reported here as the delay time.

Tables 2 and 3 show that VISSIM and CORSIM typically generated travel times that differed within reasonable limits from the field results. Overall, each model predicted corridor travel times that were closer to the field measurements an equal number of times. Specifically, VISSIM was closer to the field measurements than CORSIM for 7 of the 14 corridors in each peak hour, and vice versa.

Comparison of Traffic Results with Intersection Delay Studies

Table 4 is a summary of the field intersection delay studies that were conducted in April 2000. As described earlier in this paper, the field intersection delay measurements were conducted according to the procedure outlined in the 1997 HCM, with one exception. The number of cars which stop at least once were not collected due to budgetary constraints. Therefore, the field measurement represents queue delay and is missing the adjustment that tries to account for the delay due to the deceleration and acceleration of each vehicle on the intersection approach.

The delay values from the VISSIM and CORSIM models shown in Table 4 are measures of total delay. The total delay includes control delay in addition to other delays caused by geometry and other factors such as traffic flow. This poses a difficult problem of how to compare simulation model delays to field measured control delay. Showers and Courage (7) and Wu (8) have studied this problem with CORSIM in particular. This problem also exists with the VISSIM model.

Both models include stop delay as part of their output. While stop delay is easily collected in a simulation (time when velocity = 0), it is not economically feasible to measure in the field. Since it is also difficult to measure control delay in the field, the solution for calibration would be a measure of queue delay.

CORSIM does provide queue delay as an output, however, Showers and Courage determined that the existing parameters and procedures used to define queue delay in CORSIM cannot be verified in the field. They recommended an adjustment to how CORSIM could calculate queue time. The correction recommended for CORSIM could also be applied to VISSIM since it also does not directly measure queue delay.

Table 4. Field Intersection Delay Study Comparison					
Peak Period	Intersection	Approach	Field Measured Queue Delay	VISSIM Total Delay	CORSIM Total Delay
AM	Pearl at Ross	NB	17	18	17
		SB*	21	49	69
		EB	16	4	5
		WB	49	28	26
		ALL	29	29	34
AM	Pearl at Bryan	NB	29	21	29
		SB	22	28	20
		ALL	27	22	26
AM	Good Latimer at Live Oak	NB	36	37	29
		SB	16	12	12
		EB	16	16	22
		WB*	13	16	15
		ALL	21	23	20
AM	Market at Commerce	NB*	17	38	58
		EB	14	14	15
		ALL	16	26	37
PM	Griffin at Ross	NB	21	23	19
		SB*	126	47	27
		EB	8	26	23
		WB	24	28	25
		ALL	58	35	24
PM	Harwood at San Jacinto	SB	17	21	27
		EB	21	10	7
		ALL	18	16	17
PM	Elm at Houston	SB	10	20	10
		EB*	12	46	39
		WB	13	16	15
		ALL	12	17	14
PM	Routh at San Jacinto	NB	28	28	17
		SB	202	309	89
		EB	27	51	23
		ALL	52	73	31

* - approach is an entry link to the model.

With these problems in mind, the field measured delay data in Table 4 has not been adjusted to equate to a delay measure that both simulation models can produce. Therefore, the results are shown “as is” and examination of those numbers through the use of engineering judgement should be used to determine whether the models match the field results.

The results do indicate areas where the models are significantly different than field measured results. Some of this is due to the fact that the field results were measured on one day only and it occurred almost one year after all of the input volumes were gathered for use in the models. In addition, several of the intersections are on the boundary area of the model which makes it difficult to replicate the existing platoon arrival patterns at these locations.

The effect of this passage of time is most apparent at the intersection of Griffin and Ross. The congestion on Griffin has increased dramatically since November 1999 (when travel-time data collection was conducted). The travel time runs from November 1999 do not reflect what the traffic operations look like in the field in April 2000. At the time of writing this paper, this discrepancy is being re-examined and new travel time runs are being conducted. It appears from recent field observation that most of the backup is created by too many busses arriving at a downtown transfer center at the same time. This transfer center is two blocks south of the Griffin and Ross intersection.

This problem did not occur in November 1999, but it occurs now due to the completion of a major reconstruction of Central Expressway (US 75). Before the completion of construction, the bus routes that used Central Expressway had extra time built into their routes because of the congestion on the freeway. However, now that the freeway has been reopened into downtown and the congestion is gone, the routes have not been readjusted. As a result, DART believes this is causing several buses to arrive early and therefore too many arrive at once at the transfer center.

Another comparison of note within Table 4 is the intersection of Routh and San Jacinto where the field-measured delays were slightly lower than in VISSIM. It is at this location in the CBD where preemption currently is used for the LRT. All other intersections along the transitway mall that the LRT travels through operate with pre-timed signal control. This is a location, therefore, where the added signal control capabilities in VISSIM become necessary to model existing conditions. This comparison shows that VISSIM is overestimating the delay on the southbound approach, which is the most congested. However, VISSIM's results for this approach are much closer to field measurements than CORSIM's results are.

7.0 MODEL COMPARISONS VISSIM MODEL

Comparison of Traffic Results with CORSIM

Table 5 presents a summary of the comparison of the results of the VISSIM and CORSIM models. The table indicates that during the AM peak hour, 83% of 256 intersection approaches have total delays that are within 10 seconds of each other in each model. As for total intersection delay, 91% of the 97 intersections are within 10 seconds of each other. During the PM peak, 82% of the approach delays and 92% of the total intersection delays are within 10 seconds of each other.

These comparisons of approach delay and intersection delay show that, overall, the VISSIM and CORSIM models are producing very similar results for both peak hours. However, while most

approaches produce similar results between the models, certain approaches differ to a greater degree. Some of these differences occur at intersections on the boundary of the study area and therefore are not as detrimental in the comparison as they otherwise would be. Other differences are generally due to the differences between the models presented in Table 1. For example, VISSIM can simulate a three-car LRT train that blocks a cross-street while it is stopped at certain intersections, while CORSIM cannot. In addition, bus behavior is modeled more realistically in VISSIM while in CORSIM buses often interfere with traffic more than is realistic.

Table 5. Comparison of VISSIM and CORSIM Traffic Results

Delay Difference (sec./veh.)	AM Peak Hour				PM Peak Hour			
	Approach Delay		Intersection Delay		Approach Delay		Intersection Delay	
	Distrib	Cumul	Distrib	Cumul	Distrib	Cumul	Distrib	Cumul
0	0%	0%	0%	0%	1%	1%	0%	0%
0< and <=5	63%	63%	74%	74%	67%	68%	77%	77%
5< and <=10	20%	83%	16%	91%	14%	82%	14%	92%
10< and <=15	6%	89%	3%	94%	7%	88%	4%	96%
15< and <=20	4%	93%	2%	96%	4%	93%	1%	97%
20< and <=25	3%	96%	1%	97%	3%	95%	0%	97%
25< and <=30	2%	98%	1%	98%	2%	97%	1%	98%
30< and <=35	1%	99%	0%	98%	0%	98%	0%	98%
35< and <=40	0%	99%	0%	98%	1%	98%	0%	98%
40<	1%	100%	2%	100%	2%	100%	2%	100%

Note: Each model contained 97 intersections with 256 approaches

Most of the areas where the VISSIM and CORSIM models predict significantly different results are in areas near a LRT crossing with preemption, areas where a 3-car train can block an intersection, and at intersections with stop control. VISSIM was able to accurately simulate the LRT interactions whereas CORSIM underestimated the delay at these locations due to its inability to model LRT operations. In the case of stop controlled intersections, VISSIM usually reported delay values higher than CORSIM's.

A specific example of a difference between the models is demonstrated by the fact that VISSIM reports intersections along Routh Street as having much worse levels of service than CORSIM due to the delay caused by the LRT gates that block traffic from time to time. This difference is especially pronounced during the PM peak hour. CORSIM cannot simulate actuated gates and therefore does not block southbound traffic in the same manner. In this case, VISSIM simulates the traffic operations more realistically than CORSIM as shown in Table 4 (Routh at San Jacinto).

Despite the differences described above, a comparison of the VISSIM and CORSIM output reveals that both models produce very similar results for both the AM and PM peak hours. Therefore, VISSIM's simulation of automobile traffic has been verified by CORSIM. In cases where VISSIM and CORSIM differ, the reason is usually related to the presence of LRT activity and or extensive bus activity, both of which VISSIM simulates with a greater degree of realism.

Comparison of Traffic Results with TRANSYT-7F

The TRANSYT-7F model used in this comparison included a relatively small portion of the CBD which coincided with both the VISSIM and CORSIM models. There were a total of 22 common intersections which could be included in this comparison.

Table 6 presents a summary of the comparison of the results of the VISSIM and TRANSYT-7F models. The table indicates that during the AM peak hour, 85% of 52 intersection approaches have total delays that are within 10 seconds of each other in each model. As for total intersection delay, 82% of the 22 intersections are within 10 seconds of each other. During the PM peak, 81% of the approach delays and 77% of the total intersection delays are within 10 seconds of each other.

These comparisons of approach delay and intersection delay show that, overall, the VISSIM and TRANSYT-7F models are producing similar results for both peak hours, but to a lesser degree than the similarity between VISSIM and CORSIM. This larger difference in results is due primarily to the inability of TRANSYT-7F to explicitly model buses, LRT, and complex intersection geometries.

Table 6. Comparison of VISSIM and TRANSYT-7F Traffic Results

Delay Difference (sec./veh.)	AM Peak Hour				PM Peak Hour			
	Approach Delay		Intersection Delay		Approach Delay		Intersection Delay	
	Distrib	Cumul	Distrib	Cumul	Distrib	Cumul	Distrib	Cumul
0	0%	0%	0%	0%	0%	0%	0%	0%
0 < and ≤ 5	71%	71%	77%	77%	60%	60%	68%	68%
5 < and ≤ 10	13%	85%	5%	82%	21%	81%	9%	77%
10 < and ≤ 15	2%	87%	5%	86%	12%	92%	5%	82%
15 < and ≤ 20	2%	88%	5%	91%	2%	94%	5%	86%
20 < and ≤ 25	4%	92%	0%	91%	0%	94%	5%	91%
25 < and ≤ 30	2%	94%	0%	91%	2%	96%	0%	91%
30 < and ≤ 35	0%	94%	0%	91%	0%	96%	0%	91%
35 < and ≤ 40	0%	94%	0%	91%	0%	96%	5%	95%
40 <	6%	100%	9%	100%	4%	100%	5%	100%

Note: Each model contained 22 intersections with 52 approaches

Most of the areas where the VISSIM and TRANSYT-7F models predict significantly different results are at intersections where a 3-car train can block an intersection, intersections that have heavy bus volumes turning left, and at intersections with stop control. (TRANSYT-7F would have assuredly differed from VISSIM at locations where LRT preemption was provided, but this comparison could not be made due to the smaller TRANSYT-7F model.) VISSIM was able to accurately simulate the bus and LRT interactions whereas TRANSYT-7F overestimated delay at heavy bus locations and underestimated delay at LRT-blocked locations.

A specific example of a difference between the models is demonstrated by the fact that TRANSYT-7F reports intersections along Main Street as having much worse levels of service than VISSIM due to the heavy volume of buses making permitted left-turns off of Main Street. These are locations where there is no left-turn bay, no protected left-turn green phase, and only buses are allowed to turn left. TRANSYT-7F does not explicitly model buses so a passenger car equivalent factor was applied to the bus volumes and added to the traffic flow. While this helps estimate the effect of buses in other areas of the model, it unrealistically magnifies the effect at these congested, permitted left-turn movements and increases the resulting delay.

Despite the differences described above, a comparison of the VISSIM and TRANSYT-7F output reveals that, in general, both models produce similar results for both the AM and PM peak. In cases where VISSIM and CORSIM differ significantly, the reason is usually related to the presence of LRT activity and or extensive bus activity, both of which TRANSYT-7F cannot simulate with any degree of realism. Therefore, this comparison demonstrates that VISSIM reports results similar to TRANSYT-7F at locations without extensive transit activity, and that TRANSYT-7F should not be used to simulate LRT or extensive bus activity.

Comparison of VISSIM LRT Results with ARENA

Study results from the VISSIM model were also compared to the study results obtained from a model of the transitway mall coded in ARENA software. The ARENA model was used by Manuel Padron & Associates (9) to analyze the potential impacts on LRT operations during the PM peak hour due to the proposed expansion of LRT service in the downtown transitway mall.

The ARENA model is a computer program that simulates rail operations based on parameters such as acceleration, speed, deceleration, distance, and time. The model simulates the behavior of LRT trains and their operators in the transitway mall and calculates run time between stations, dwell time at stations, and wait time at street intersections, track crossings and merge points. The model provides the status of trains either as a group or individually at any point in the simulation and accounts for irregularity of arrival time at the ends of the transitway mall, fluctuations in train running time through the mall, and variations in station dwell time. In addition, the ARENA model uses the traffic signal timing along the mall as an input to evaluate train operations, but it does not produce any measures of effectiveness for traffic flow.

Since both VISSIM and ARENA have the capability of modeling LRT operations, the common measures of effectiveness, such as train travel time and stops at traffic intersections, were compared under the existing conditions. DART staff also conducted a field survey of these measures of effectiveness in December 1998 and September 1999. These surveys collected data that was used to validate ARENA's results. A comparison of VISSIM's PM peak hour results with ARENA results and the field observations is shown in Table 7.

The comparison of VISSIM and ARENA PM peak hour results indicates that both models are able to simulate the train operations realistically when compared to field observations. As shown in Table 7, the average travel time through the transitway mall is similar between the two models

and the field survey. In addition, the majority of train stops at specific signalized intersections are predicted by the computer models under the existing traffic conditions.

Table 7. Comparison of VISSIM with ARENA Results and Field Survey Data

Southbound Trains Stopping at Each Intersection			Intersection * LRT Station *	Northbound Trains Stopping at Each Intersection		
VISSIM Results	ARENA Results	Field Survey		VISSIM Results	ARENA Results	Field Survey
10	9	--	Leonard	0	14	--
0	1	--	Crocket *	24	0	--
18	21	--	* Pearl	26	6	16
0	0	1	Olive	0	8	14
10	13	15	Harwood *	20	15	--
8	18	--	* St. Paul	0	3	1
2	0	--	Ervay	20	10	--
2	0	1	Thanksgiving	0	1	9
0	2	1	Akard *	18	1	--
10	12	--	* Field	12	0	10
10	13	15	Griffin	10	23	20
0	7	1	Lamar *	6	0	--
4	11	--	* Market	4	15	1
0	0	3	Record	0	14	1
0	2	2	Houston	12	3	21
9:06	9:44	9:09	Average Travel Time Through Transit Mall	10:33	10:11	10:20

Note: Number of stops based on 2-hour peak period, "--" indicates that no data was collected.

CONCLUSIONS

Based on the results of the existing conditions analysis and calibration procedure, it is concluded that both CORSIM and VISSIM were able to adequately model the existing conditions for automobile traffic within the Dallas CBD. Furthermore, the analysis and calibration procedure indicated that VISSIM could adequately model LRT operations within the transitway mall. As a result, the overall study concluded that VISSIM should be used to determine the effects of the future light rail expansion within the transitway mall.

This analysis also showed that the measurement of intersection delay to calibrate simulation models needs to be considered very carefully. As mentioned by Showers and Courage, it would only take a minor modification to get CORSIM to report queue delay in a manner similar to how it is measured in the field. This statement would also be true for VISSIM. Until these changes are made, it is a good idea to always include travel time runs as part of any model calibration process.

Since VISSIM and CORSIM both model traffic conditions adequately, several factors must be considered when choosing which model to use. In most cases, a CORSIM model that does not include a transit element such as buses or LRTs can be built quicker than a corresponding VISSIM model. However, when complex geometry, complex traffic control, or transit elements are required, it is easier to build and manipulate these items in VISSIM.

While VISSIM costs significantly more than CORSIM, it is worth the additional cost when the ramifications of a decision can be in the millions to hundreds of millions of dollars. It is important to realize that engineering judgement still must play a significant role in the decision process of any project. From the practitioner and decision maker's point of view, the simulation models need to be able to help identify operational differences between potential solutions.

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