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**IConSEP2018**

*"Toward Innovative Practices  
for Sustainable Engineering"*

## **BOOK OF ABSTRACT**

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Manado, North Sulawesi - Indonesia**





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## **The Comparison of Dynamic Assignment in Microscopic and Mesoscopic Modeling**

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### **Abstract**

Transportation modeling in mesoscopic level has been developed rapidly since this level of modeling is assumed as an answer to overcome the shortcoming of modeling at macroscopic level and microscopic level. However, some improvements need to be made so that this type of modeling can substitute the one at microscopic level. This study aimed to evaluate the reliability of modeling at mesoscopic level using Cube Avenue by comparing it to the one at microscopic level using Vissim. The result showed that there are differences between the outputs of both software, however the trends are the same. The significant difference is in average travel time, which is an indicator that is the principle of both software in handling dynamic assignment.

*Keywords:* transportation modeling, mesoscopic level, dynamic assignment

## **1. Introduction**

### **1.1 Background**

Transportation modeling was used to be known merely as a beneficial tool to have a good long-term strategic transportation planning. By modeling several transportation scenarios, alternatives could be tested and the best one could be implemented subsequently. Transportation modeling in this sense is extremely important when building a new road or extending and widening the existing road, and also this kind of modeling can predict the impact of land use changing to surround transportation facilities, for example, an establishment of a new shopping center area and etc. This kind is known as the transportation modeling at macroscopic level, which is implemented in a relatively big network.

These days, the transportation modeling is not used for this purpose only. By series of recent research, at least for about the last twenty years, transportation modeling now is developed to be used for transportation management. In other words instead of just been utilized for long term strategic planning, transportation modeling is now used to solve transportation problems in a

short term such as traffic jam / congestion, delay, queue and etc. This modeling is also could be used to improve road safety. Unlike the previous transportation modeling that used static traffic assignment, this kind of modeling implemented dynamic traffic assignment to reach the solution. Dynamic traffic assignment is a dependent time assignment which is needed to model a more realistic model. This kind of modeling is implemented in microscopic level, a level that focus the modeling in a relatively small network and recently the researchers has develop this kind of modeling in mesoscopic level, to model a region size area.

This study is conducted to evaluate the performance of modeling at mesoscopic level. This study is carried out by comparing the modeling at mesoscopic level to the one at microscopic level, including the similarity and the dissimilarity of these two levels of modeling in handling the dynamic traffic assignment. To perform this study, popular software for both levels have been utilized, which are Vissim for microscopic level and Cube Avenue for mesoscopic level.

## **1.2 The objective of the study**

The problem in this study was formulated as follows:

- How reliable the mesoscopic modeling in handling DTA?
- What are the important similarity and dissimilarity between those two?

This study was conducted by utilizing Vissim for microscopic level and Cube Avenue for mesoscopic level, thus the characteristic of dynamic traffic assignment was concluded based on the characteristic of these two softwares. The aim of this study is to have the comparison of microscopic modeling using Vissim and mesoscopic modeling using Cube Avenue in handling dynamic traffic assignment. It is hoped that this study will result in a good understanding of how the dynamic traffic assignment is coped in mesoscopic and microscopic, so that a more accurate and realistic transport modeling could be conducted to represent reality.

## **2. Methodology**

### **2.1 Research methodology**

This study was conducted by carried out the comparison between microscopic modeling (Vissim) and mesoscopic modeling (Cube Avenue). The first step was to conduct the modeling for both software using the same network and also the same input to have a proper comparison. However to have identical input between those two is a bit problematic since the input between Vissim and Avenue are different. So calibration process was utilized to this. In this calibration process Vissim output was utilized as ‘synthetic data’ to get calibrated parameter for Cube Avenue. The next step is verification. Verification was conducted by applying the calibrated parameter in Cube Avenue and the compare the result. At the end is validation, which is get by employed root mean square error (RMSE) to have the difference between Vissim and Cube Avenue output.

## **2.2 The modeling**

### **2.2.1 Network**

The network is the simple network that consists of two zones and eight links. The upstream link is about 3200 feet, the downstream link is 1200 feet and the rest, is about 1000 feet each. The network attributes for this Vissim modeling are as follows:

#### *a. Zone*

This sample network has two zones, which are zone one and zone two. The zones were assigned by creating parking lot in each zone. The parking lot should be drawn in a link. Vissim will recognize the parking lot as zones, when the type of parking lot was set as zone connector. There are two parking lots for two zones. Each parking lot was drawn in about 100 ft distance from the edge of upstream link and downstream link. The size of parking lots was about 100 feet each. So the effective link distance for upstream link will become the link distance minus the summation of the parking lot distance and the size of parking lot, which is 3000 ft, and analogous to that the effective link distance for downstream link will become 1000 ft.

#### *b. Node*

In Vissim, the parking lot should be in between two nodes in the network in order to make Vissim recognize the parking lot. Thus in this network there are four nodes which located at the border of the network and also at every junction / intersection of the network

#### *c. Speed*

In Vissim the speeds were distributed in a range. The speed range for this modeling is 29.8 to 36 miles/hour. The speed was assigned in vehicle composition input in Traffic pull down menu on Vissim interface.

#### *d. Number of lanes*

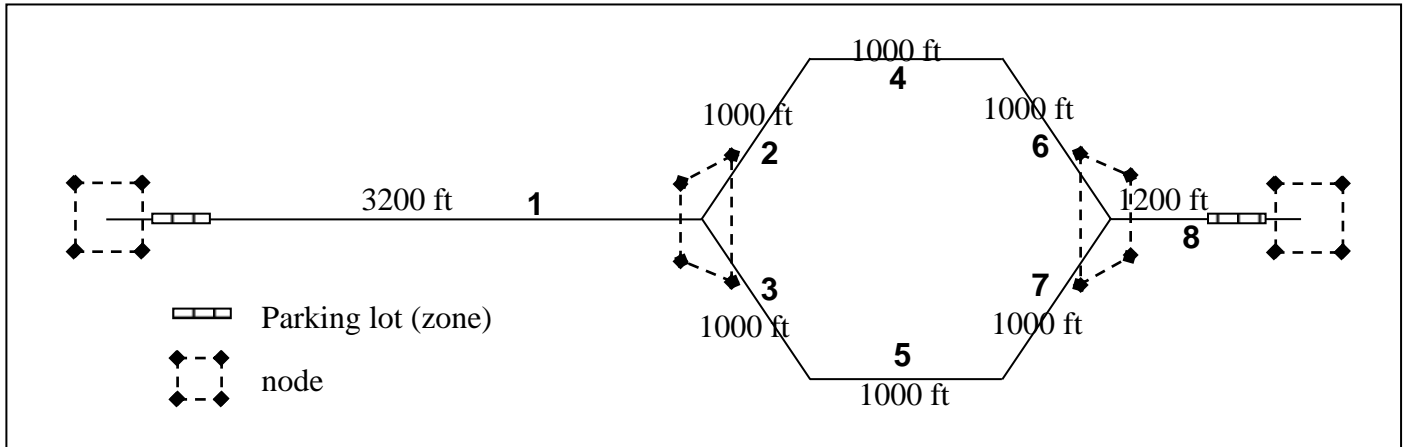
There is only 1 lane for each links in the network. The number of lanes was assigned as an input while drawing the network.

#### *e. Capacities*

There is no exact capacity input in Vissim, except the number of lanes. In fact, the capacity is one of the output of Vissim.

The Vissim network and is shown in figure 2-1.

Figure 2-1 Vissim network



### 2.2.2 Origin – Destination (OD) Matrix

In performing dynamic traffic assignment, the volumes are not input to each links, instead the volume was loaded into the network using origin destination (OD) matrix. OD matrix is a matrix that contains the number of trips from each origin zones to each destination zone. In Vissim the OD matrix was loaded to the network using Dynamic Assignment in Traffic menu, however the code cannot be edited using Vissim interface. The code should be written using common word processor software. In this modeling, the code was edited using Notepad, word processor software of Windows 7. The code the OD matrix is shown in figure 2-2 below.

Figure 2-2 Code for OD matrix

```
* time interval [hh.mm]
0.00 1.00
* scaling factor
1.0
* number of zones:
2
* zones:
1 2
* number of trips between zones
0 2000
0 0
```



### **2.2.3 Traffic Composition**

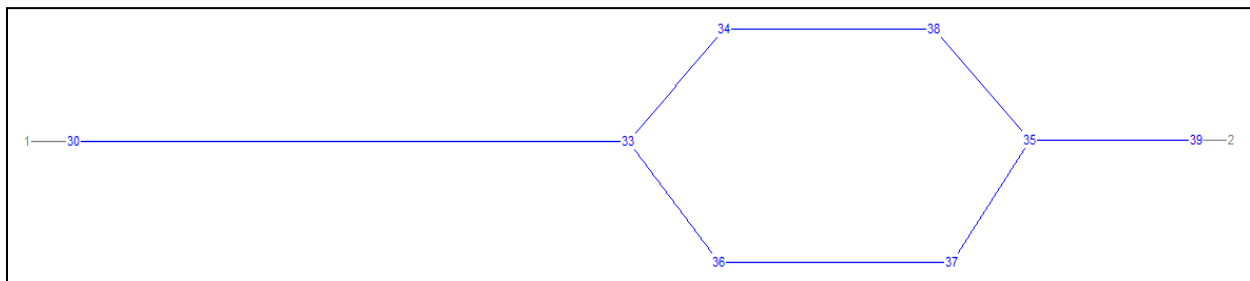
Vissim is software for microscopic simulation modeling, which model the traffic by individual vehicle. Thus, traffic composition can be assigned by user. In this modeling, the traffic composition was set just for passenger car. In Vissim the code for passenger car is 100.

## **2.3 Mesoscopic modeling using Cube Avenue**

### **2.3.1 Network**

The network, as has been uttered in the methodology part, is identical with Vissim network, in order to have a proper comparison between those two. Therefore, the network also has two zones. The upstream link is 3000 feet, the downstream link is 1000 feet and the rest, is 1000 feet each. The network is shown in figure 2-3 below.

**Figure 2-3 The Network in Cube Avenue**



### **2.3.2 Network Attributes**

#### *a. Zone*

As mentioned before the network in Cube Avenue consists of two zones which are zone one and zone two. The traffic will be originated from zone one and the destination will be zone two. For this modeling the maximum number for zones was set to 20, so when the input node number was more than 20, Cube will recognize that it was not a zone but a node.

#### *b. Speed*

The speed in this modeling was assigned for every link. To have the same input, the speed will be obtained in calibration process

#### *c. Number of lanes*

The initial number of lanes for every link in this modeling is 1 lane.

#### *d. Capacities*

The initial capacity for each link was set to 2000 vehicle/hour so that the network can easily accommodate the demand. However the capacity will depend on the speed, although the

maximum capacity was set to 2000 vehicle/hour, if the speed is not enough to reach that value, the maximum capacity will never be reach.

### **2.3.3 Origin Destination Matrix**

The demand in this modeling is identical to the demand in Vissim modeling, which is 2000 vehicles/hour. The demand was input in origin destination matrix. The origin destination matrix in this case is stated by a code “MW[1]=0,MW[1][2]=2000”.

### **2.3.4 The Script**

The script is an input in Cube Avenue. The script contains statements and commands about the name and location of input and output files, parameters, assignment command, statement of any function such as volume delay function and so forth. The script for this modeling is shown in appendix 1.

### **2.3.5 Traffic Composition**

In Cube Avenue, the traffic composition was setup by adding origin destination matrix for each kind of traffic. Since Cube Avenue performs transportation modeling in mesoscopic level, which simulates the traffic using package instead of simulating the vehicle individually, the traffic composition is the same as the mode split which could be passenger car, truck, public transportation, bicycle, etc. In this case the traffic composition is just passenger car.

## **2.4 Calibration, verification and validation**

Calibration, verification and validation are essential in this study to reach the objective. In fact these steps were conducted at the beginning of the modeling in order to have the same input data for the ones at microscopic and mesoscopic level. In this study in order to have the same input, the output of modeling at microscopic level by Vissim have been utilized as ‘synthetic data’ to calibrate several parameter which will become the input of the one at mesoscopic level by Cube Avenue.

### *Calibration*

The first parameter that needed to be calibrated was free flow speed (FFS). Free flow speed will influence the capacity, the more free flow speed the higher the capacity will be. In this study the free flow speed was obtained by taking the maximum speed in each link after 10 times multiple run in Vissim. The result can be seen in appendix 1. In Cube Avenue this FFS will be used as speed to calculate the free flow travel time (in minute) which is obtained according to the equation 1.



$$t^0 = \frac{\text{distance}}{\text{speed}} \times 60 \quad (1)$$

The second parameter to be calibrated was jam density. Jam density is the maximum number of vehicle that could sit on a lane every distance unit (mile) when there is traffic jam. This parameter was calibrated in Vissim by creating the traffic jam and took the highest density of all links. The result can be seen in appendix 2. In this study, all links have the same width which is 12 ft, thus the jam density was presumed to be just one number, the highest maximum density of all links. This parameter will be used to calculate the storage in Cube Avenue. In Cube Avenue the jam density is known as ‘vehperdist’. The storage (in vehicles) was calculated based on equation 2

$$\text{The storage} = \text{Vehperdist} \times \text{number of Lane} \times \text{Distance (vehicle)} \quad (2)$$

The last parameter to be calibrated was the delay time in merging point. The delay was defined as the subtraction of the time with the delay to free flow speed travel time ( $t^0$ ) in minute, in this case caused by the merging, as shown in equation 3. The result can be seen in appendix 3.

$$\text{Delay} = t - t^0 \quad (3)$$

#### *Verification*

The verification was done by applying the calibrated parameter as input in Cube Avenue, multiple run (10 times) and comparing the result. The comparison tables can be seen in appendix 5 and 6.

#### *Validation*

The validations were carried out by employing root mean square error (RMSE) to have the difference of the model (Cube Avenue’s result) to the data (Vissim’s result). RMSE is formed as equation (4)

$$RMSE = \sqrt{\frac{\sum_{i=1}^n (x_{1,i} - x_{2,i})^2}{n}} \quad (4)$$

### **3. Result and analysis**

#### **3.1 Calibration**

After accomplishing the calibration, the result for calibrated parameter which are free flow speed (FFS), jam density and delay were shown in table 3-1.

**Table 3-1                      Calibrated Parameter**

<b>Link</b>	<b>FFS mph</b>	<b>Jam Density vph</b>	<b>Delay minutes</b>
1	36.8	170	0
2	36.9	170	0
3	37.5	170	0
4	37.5	170	0
5	36.4	170	0
6	36.9	170	0.83
7	36.7	170	0.89
8	36.3	170	0

The jam density is 170 vph, just one number which is the highest jam density because the network links has the same characteristic especially the width (12 ft). The FFS is different between one link to the others because the FFS is not depend on link characteristic only but also depend on the headway. The delay is the delay in merging point at intersection, in this case the delay from link 6 and link 7 to link 8.

### **3.2 Input Comparison**

After the calibration process, the inputs for both software are completed. Thus, the comparison between both inputs can be acquired. For creating the network, Vissim is using graph scaling, so that after input the scale the distance for each link will be measured based on the link length drawn in the screen, while in Cube Avenue the distance could be an input, regardless the link length drawn in the screen. Both software can take the demand in the form of OD matrices although the code will obviously different. The other inputs in Cube Avenue such as free flow speed, jam density and delay are the output of Vissim. Those outputs were used as a calibrated parameter for Cube Avenue input. The input comparison is shown in table 3-2 below.

**Table 3-2 Input comparison of Vissim and Cube Avenue**

	<b>Vissim</b>	<b>Cube Avenue</b>
Distance	Graph Scaling which is applied strictly	- Project file scale - Calculated Scale (graph scaling)
Demand	OD Matrix	OD Matrix
Capacity	Depends on FFS	Input : 1. From Each Link on network or 2. From Script
FFS	Maximum Speed observed (output)	Input This speed is used to calculate Free

Jam Density	Maximum Density that can be reached if traffic jam occurred (output)	Flow Travel time Input : 1. From Each Link on network or 2. From Script
Delay	Average delay (output)	Input from intersection file

### 3.3 Verification

The calibrated parameters need to be applied in Cube Avenue as inputs in order to verify those calibrations before comparing the results side by side. The output comparison for speed and flow are shown in figure 3-1 and 3-2.

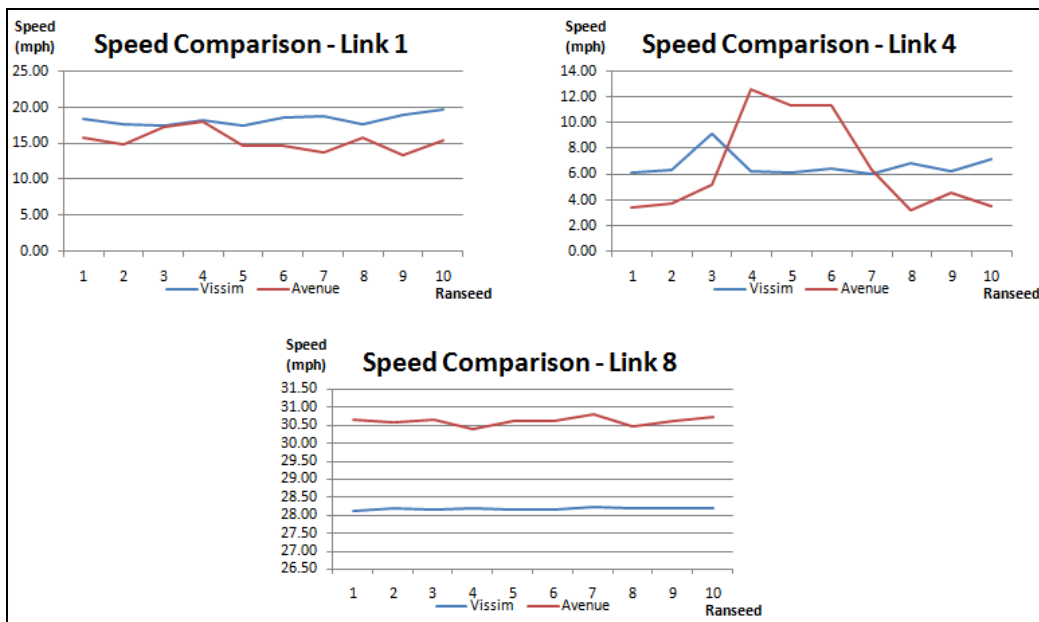
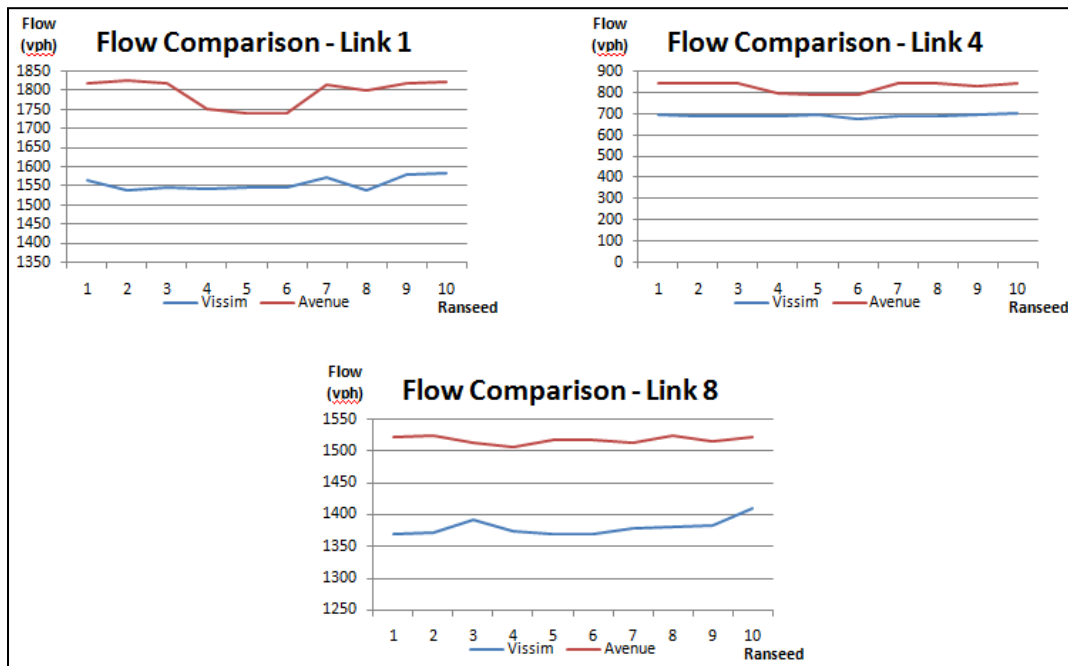


Figure 3-1 Speed output comparison

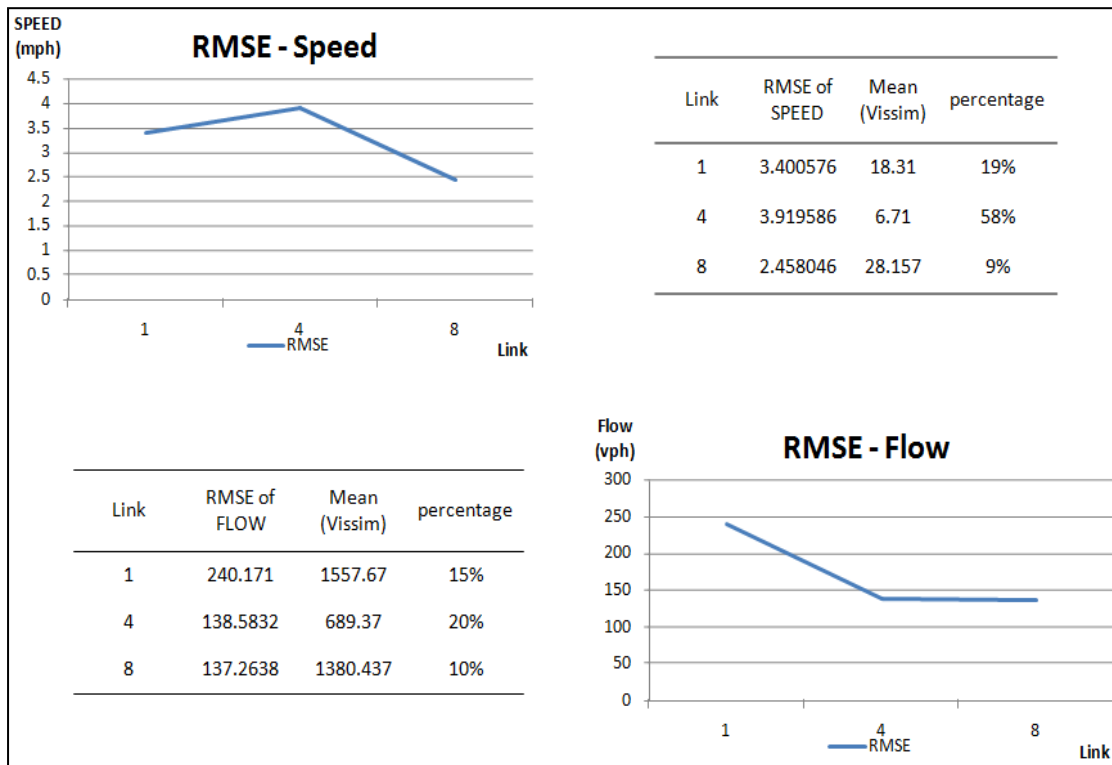
Link one was chosen to represent the upstream link, while link four to represent the link after splitting and before merging and link 8 was elected to represent the downstream link. From those comparison either for speed and flow, it can be seen that although there are differences between Vissim result and Cube Avenue result but the trends are similar, except for link four, where there is inconsistency in Cube Avenue result for speed.



**Figure 3-2 Flow output comparison**

### **3.4 Validation**

The validation was accomplished by employing root mean square error. The results of the validation were shown in figure 3-3. From RMSE result, it was shown that the difference between the result of Vissim and the result of Cube Avenue for Speed and Flow is 9 to 20%, except for speed in link 4, where the difference was 58%. This fact might be related to the different between those softwares in calculating the queue, since the queue length will influence the speed.



**Figure 3-3 RMSE for Speed and Flow**

### 3.5 Comparison in Handling Dynamic Assignment

There are two evaluation that have been undertaken in order to have a comparison in handling dynamic assignment, which are path and travel time evaluation. The path evaluation would show the occupancy of every path in the network, while the travel time evaluation was expected to show the average travel time for two software, especially in handling dynamic assignment phenomena such as queue and blocking (if any). Those comparison is shown in figure 3-4.

The outcomes have shown that for path evaluation, Vissim’s result has larger variance then Cube Avenue, however the difference between those two are not significant. Surprising results were obtained from travel time evaluation, where the average travel time for Vissim is relatively constant while the average travel time for Cube Avenue was increasing significantly during the model period. This fact is a prove that there are difference between Cube Avenue and Vissim in handling dynamic assignment especially for handling the queue and delay, since the average travel time is depend on whether there are queue and blocking in the network during the simulation.

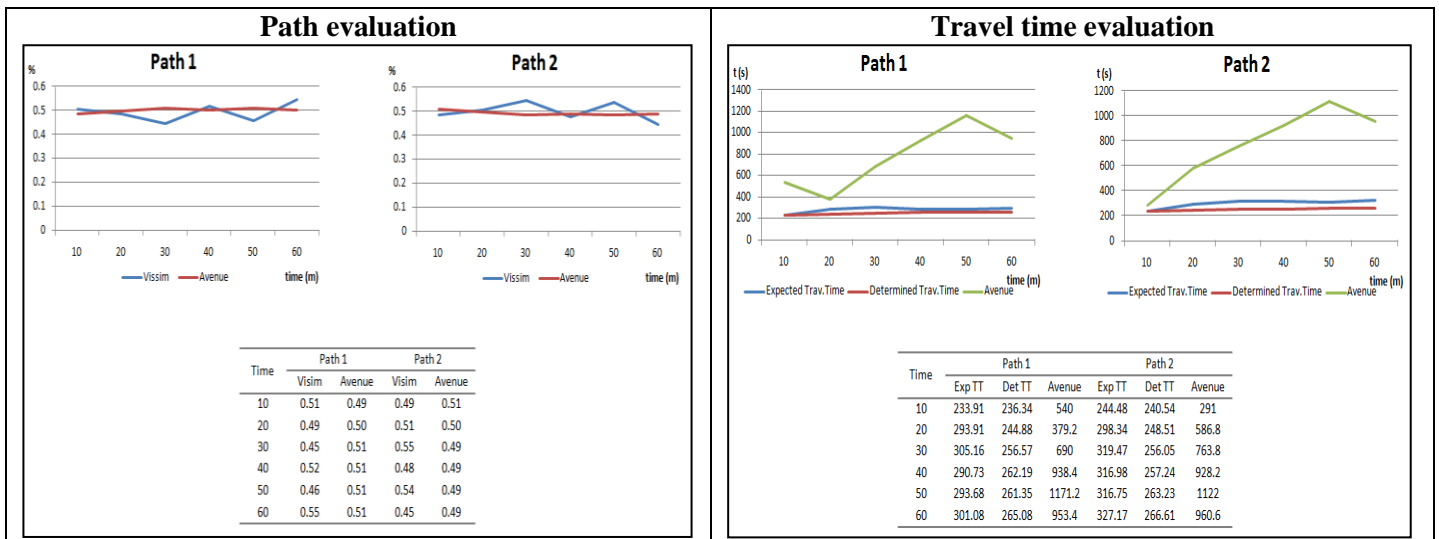


Figure 3-4 Comparison for path evaluation and travel time

#### 4. Conclusions and recommendations

Some conclusion that could be withdraw from the study are,

- Some parameter can be as inputs to both software, however parameters such as capacity, FFS and jam density are the input for Cube Avenue and the output for Vissim
- There are differences in the output of one to the other however they share the same trend
- In Handling DTA the path selections more or less are the same, but there are significant differences in travel time, this might be an indicator that there are differences between Vissim and Cube Avenue in handling dynamic assignment.
- Overall both software has shown each capabilities in handling DTA for their level of modeling

The microscopic modeling has shown a great performance and very detail in representing the real world, however the fact that this type of modeling is very hard to be implemented in regionally has brought to the finding of new type of modeling which is mesoscopic modeling. Although still need a lot of improvements such as the lane changing, display and etc, the mesoscopic modeling can be a reliable modeling to substitute the microscopic modeling in regional level.

#### References

- \_\_\_\_\_, 2011, Voyager Reference Guide, Cube Version 5.1.3, Citilabs
- \_\_\_\_\_, 2011, Vissim 5.30 manual, Ptv Vision

## Appendix 1 The script in Cube Avenue

```
; Do not change filenames or add or remove FILEI/FILEO statements using an editor. Use Cube/Application Manager.
RUN PGM=AVENUE PRNFILE="D:\My Documents\Simulation Modeling in Transportation Network\Class project\Cube - Avenue\avenue - simulation
project\0EAVN00C"; Do not change filenames or add or remove FILEI/FILEO statements using an editor. Use Cube/Application Manager.
RUN PGM=AVENUE PRNFILE="D:\My Documents\Simulation Modeling in Transportation Network\Class project\Cube - Avenue\avenue - simulation
project\0EAVN00C.PRN"
FILEI JUNCTIONI = "D:\My Documents\Simulation Modeling in Transportation Network\Class project\Cube - Avenue\avenue - simulation
project\intersection.ind",
set=3
FILEI NETI = "D:\My Documents\Simulation Modeling in Transportation Network\Class project\Cube - Avenue\avenue - simulation
project\0ENET00A.NET"
FILEO TURNVOLO[1] = "D:\My Documents\Simulation Modeling in Transportation Network\Class project\Cube - Avenue\avenue - simulation
project\0EAVN00B.TRN"
FILEO PACKETLOG = "D:\My Documents\Simulation Modeling in Transportation Network\Class project\Cube - Avenue\avenue - simulation
project\0EAVN00D.LOG"
FILEO NETO = "D:\My Documents\Simulation Modeling in Transportation Network\Class project\Cube - Avenue\avenue - simulation
project\0EAVN00D.NET"
FILEI MATI[1] = "D:\My Documents\Simulation Modeling in Transportation Network\Class project\Cube - Avenue\avenue - simulation
project\INPUT.MAT"

;p represents the modelling time period - Hours
p=1

;k1 represents the conversion factor to hourly traffic
k1=1

; =====
; OVERALL ASSIGNMENT PARAMETERS
PAR COMBINE=AVE ,GAP=0.001,MAXITERS=10
PAR VEHPERDIST=210.00
PAR MODELPERIOD=60, SEGMENTS=15,15,15,15
X=RANDSEED(165)

; =====
; Fixed Factors
TURNS N=1-99999
; =====
; ----- SET CAPACITY and group links
; .....
PHASE=LINKREAD

ENDPHASE

PHASE=ILOOP

; Dynamic Assignment Command fifteen minute increments
DYNAMICLOAD PATH=COST, PACKETSIZE={packet}, DemandIsHourly=T,
VOL[1]=MI.1.1,MI.1.1,MI.1.1,MI.1.1,peni=3

ENDPHASE

ENDRTIN
```



**Appendix 2 The number of vehicle and maximum speed (Vissim)**

Ra see d	1		2		3		4		5		6		7		8	
	Number Veh (veh)	Speed max mph	Number Veh (veh)	Speed max mph	Number Veh (veh)	Speed max mph	Number Veh (veh)	Speed max mph	Number Veh (veh)	Speed max mph	Number Veh (veh)	Speed max mph	Number Veh (veh)	Speed max mph	Number Veh (veh)	Speed max mph
1	1644	33.9	794	36.1	811	36.8	764	36.7	781	36.6	741	35.8	755	35	1476	35.9
2	1641	35.3	798	36.9	800	36.9	766	36.3	772	35.4	743	34.8	746	35.2	1468	36.7
3	1632	33.6	834	37.5	775	36.9	803	34.2	753	36.4	779	33.7	727	35.8	1485	35.7
4	1641	34.7	858	36	757	37.5	830	34.2	747	37.3	806	33.4	721	36	1507	36.2
5	1605	34.4	789	36.1	787	34.9	763	34.5	760	33.5	739	34.8	735	34	1454	36.4
6	1588	36.8	794	35.9	766	36.9	762	34.7	761	36.3	739	34.7	738	35.4	1458	36.1
7	1619	34	797	36.7	791	36.7	772	33.5	766	35.4	748	31.7	741	33.9	1469	36.1
8	1640	35.4	804	36.2	806	36.3	773	36.3	776	36	752	35.2	750	34.6	1482	36.1
9	1576	35.6	801	36.8	753	37.1	768	37.7	749	35.7	745	36.2	726	35	1451	36.6
10	1616	36.4	802	36.9	788	36.9	771	36.3	780	35.7	748	37.6	754	34.7	1483	35.6
<b>ma x</b>	<b>1644</b>	<b>36.8</b>	<b>858</b>	<b>37.5</b>	<b>811</b>	<b>37.5</b>	<b>830</b>	<b>37.7</b>	<b>781</b>	<b>37.3</b>	<b>806</b>	<b>37.6</b>	<b>755</b>	<b>36</b>	<b>1507</b>	<b>36.7</b>

The results to have maximum speed in Vissim are obtained by

- Put detector in all links, multiple run (10 x)
- Using “data collection” take the highest speeds. This will be used as FFS (in Cube Avenue as Speed)

**Appendix 3 The maximum density (Vissim)**

Link	1	2	3	4	5	6	7
Ranseed							
1	150.05	96.54	152.27	162.39	156.49	166.66	162.08
2	147.82	160.24	89.03	165.9	153.48	168.76	159.6
3	149.7	160.08	41.46	166.09	154.12	169.02	162.13
4	152.79	160.96	5.76	166.55	31.29	170	123.67
5	148.91	149.85	142.91	163.27	160.11	167.74	162.55
6	146.93	142.94	149.66	164.69	155.72	167.08	161.68
7	149.62	161.45	88.04	166.34	154.69	169.47	157.86
8	148.9	75.41	154.41	162.42	157.34	167.47	162.6
9	147.8	157.7	147.7	165.41	156.51	168.91	161.86
10	143.29	155.83	143.16	162.41	154.77	166.03	160.21
Max	152.79	161.45	154.41	166.55	160.11	<b>170</b>	162.6

In Vissim to find the jam density

- Put “reduce speed” in downstream link to create traffic jam
- Multiple run (10 x)
- Using link evaluation, highest density can be obtained to be used as jam density.

**Appendix 4 Delay**

No. 1: Travel time section(s) 1

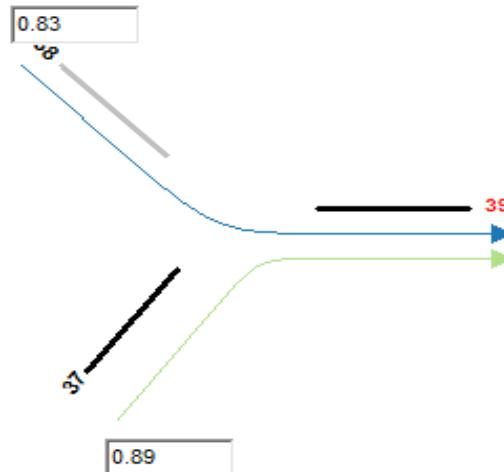
No. 2: Travel time section(s) 2

Time No.:	Delay	Stopd 1	Stops 1	#Veh 1	Pers. 1	#Pers 1	Delay 2	Stopd 2	Stops 2	#Veh 2	Pers. 2	#Pers 2	
1	3600	49.1	0.1	0.14	741	49.1	741	53.2	0.1	0.19	734	53.2	734
2	3600	50.2	0.1	0.17	738	50.2	738	55.2	0.1	0.21	729	55.2	729
3	3600	48.6	0.1	0.19	767	48.6	767	51.3	0.1	0.19	721	51.3	721
4	3600	49.6	0.1	0.16	759	49.6	759	47.1	0.1	0.21	713	47.1	713
5	3600	53.1	0.2	0.22	718	53.1	718	57.1	0.1	0.19	740	57.1	740
6	3600	53.2	0.1	0.2	720	53.2	720	55.6	0.1	0.19	735	55.6	735
7	3600	48.6	0.1	0.17	744	48.6	744	55.9	0.1	0.21	730	55.9	730
8	3600	47.9	0.1	0.19	739	47.9	739	53.5	0.1	0.18	744	53.5	744
9	3600	52.5	0.1	0.2	732	52.5	732	56.3	0.1	0.21	730	56.3	730
10	3600	45.1	0.1	0.18	743	45.1	743	48.8	0.1	0.16	747	48.8	747

second 49.79  
 minute 0.829833

second 53.4  
 minute 0.89

- In Vissim find the average delay at the merging point for both link that merge became one link
- By applying “travel time section and using “delay” in evaluation menu, the delay time for merging point can be obtained



**Appendix 5 Speed output comparison (mph)**

Link Ran- seed	1		2		3		4		5		6		7		8	
	Vissim	Avenue	Vissim	Avenue	Vissim	Avenue	Vissim	Avenue	Vissim	Avenue	Vissim	Avenue	Vissim	Avenue	Vissim	Avenue
1	18.46	15.87	7.43	12.15	9.32	11.53	6.13	3.37	6.64	3.23	5.93	5.34	5.78	5.46	28.10	30.65
2	17.74	14.87	9.17	11.73	7.38	12.66	6.34	3.71	6.13	3.21	5.80	5.23	5.81	5.32	28.17	30.56
3	17.51	17.33	15.35	11.63	7.58	3.31	9.15	5.23	6.29	2.92	6.13	5.21	5.99	5.18	28.15	30.64
4	18.27	18.13	7.35	20.92	12.42	11.76	6.29	12.66	6.44	3.26	5.86	6.36	6.04	6.22	28.16	30.38
5	17.53	14.73	7.01	17.42	11.07	11.70	6.14	11.43	6.07	3.94	5.84	5.59	5.67	6.56	28.14	30.62
6	18.53	14.73	8.02	17.42	8.83	11.70	6.50	11.43	6.09	3.94	6.00	5.59	5.86	6.56	28.12	30.62
7	18.72	13.70	8.22	20.48	8.41	3.81	6.07	6.35	6.54	3.05	5.95	5.16	5.97	5.99	28.21	30.81
8	17.63	15.80	17.05	12.18	6.76	12.29	6.88	3.19	6.00	3.39	5.69	5.61	5.77	5.77	28.18	30.47
9	19.02	13.34	7.67	20.22	9.36	11.64	6.31	4.54	7.03	2.86	5.98	5.63	6.11	5.83	28.16	30.63
10	19.69	15.51	9.35	11.86	10.59	20.26	7.24	3.50	7.75	4.21	6.74	5.39	6.87	4.77	28.18	30.75

**Appendix 6 Flow output comparison (vph)**

Link Ran- seed	1		2		3		4		5		6		7		8	
	Vissim	Avenue	Vissim	Avenue	Vissim	Avenue	Vissim	Avenue	Vissim	Avenue	Vissim	Avenue	Vissim	Avenue	Vissim	Avenue
1	1565.89	1,817.37	715.98	877.25	677.8	841.32	692.76	841.32	644.91	811.38	658.55	808.38	618.66	778.44	1371.1	1,520.96
2	1541.95	1,826.35	693.38	868.26	683.26	859.28	685.99	841.32	649.67	820.36	653.77	808.38	624.3	787.43	1372.38	1,523.95
3	1550.04	1,817.37	694.14	877.25	695.77	841.32	690.05	841.32	661.07	808.38	660.52	808.38	635.47	775.45	1392.64	1,511.98
4	1545.4	1,754.49	710.45	802.40	678.3	853.29	685.04	796.41	654.61	817.37	650.98	790.42	628.8	784.43	1373.96	1,505.99
5	1548.06	1,742.52	718.12	796.41	669.1	847.31	696.62	790.42	643.55	814.37	661.78	790.42	615.45	778.44	1370.19	1,517.96
6	1546.98	1,742.52	699.09	796.41	682.06	847.31	675.38	790.42	660.93	814.37	641.59	790.42	635.07	778.44	1370.5	1,517.96
7	1572.91	1,814.37	709.7	877.25	692.03	838.32	688.59	844.31	656.18	805.39	654.37	811.38	630.04	772.46	1379.17	1,511.98
8	1541.07	1,802.40	689.83	847.31	689.36	856.29	685.91	841.32	655.16	820.36	656.67	808.38	629.24	781.44	1380.87	1,523.95
9	1580.28	1,820.36	716.78	871.26	690.03	850.30	692.85	832.34	654.52	814.37	659.4	799.40	628.34	781.44	1382.7	1,514.97
10	1584.13	1,823.35	713.71	871.26	707.53	853.29	700.51	844.31	673.16	817.37	665.91	808.38	647.75	781.44	1410.86	1,520.96