IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

MICRO SIMULATION MODELLING OF AN URBAN CORRIDOR IN PTV VISSIM

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***Abstract* - This research paper is about the micro simulation modelling of an over saturated congested urban corridor in PTV Vissim in Indian heterogeneous traffic conditions. Most of the developing nations currently face the challenge of excessive traffic congestions, and competing vehicles on their poor capacity, ill planned urban road network. The streets having dense population development around them, have worse traffic conditions, as the multiple access points to street, create a road block for the through moving vehicles. The capacity of nearly all roads is exhausted and the travel time requirements for short distances also is getting huge. This paper, tries to evaluate and understand a similar urban corridor in the city of Bangalore and gauges the situation with help of micro simulation tool of PTV Vissim. A scenario analysis is also attempted herewith to understand the effect of increase in road width and signal free corridor on the travel time.**

***keywords* - Corridor Analysis, Micro simulation, Modelling, PTV Vissim, Calibration and Urban traffic Congestion**

I. INTRODUCTION

Urban areas of most developing economies have seen a surge in traffic, increasing many fold with increase in GDP of the nation. The growth of cities and rapid urbanization of suburbs have led to an immense pressure on road ways and related infrastructure in the cities. The urban streets and corridors are mostly under pressure to cater to over saturated traffic conditions and people and commuters face huge traffic jams on them. The travel time on any road is unpredictable in current scenario and it can become 100 to 500% more than as it is in normal conditions. The traffic carrying capacity of the complete corridor and the travel time required on it, depends on the spacing, type and cycle lengths of the intersections on it. As frequent intersections denote, frequent deceleration, stopping and re-acceleration of the vehicles. This ultimately results in high travel time, and poor vehicle performance, giving huge socio economic costs in terms of a high fuel costs, vehicle maintenance costs, and cost of time lost in travel, and mental wellbeing of individuals who spent their most time stuck in traffic congestion trying to reach their destination.

Adding to the vows of traffic planners is the nature of complexities involved in trying to change any traffic circulation or signal timings and phases on ground in reality which creates havoc to the already congested network, so the micro simulation techniques of traffic modelling have come as a blessing in guise for the traffic planners. Micro Simulation modelling of traffic and infrastructure has evolved over time, as a safer, easier and economic bet for assessing the impacts of any changes in prevailing conditions to the traffic congestion. PTV Vissim is also one such tool, which is being deeply explored by many researches. PTV Vissim, is a state of art multi modal simulation tool, developed by PTV group Germany. VISSIM is a microscopic, time step oriented, and behaviour-based simulation tool for realistic modelling of urban and rural traffic as well as pedestrian flows. It was developed in University of Karlsruhe, which released its first version in 1994. Besides private traffic, rail and road base public transport traffic can also be modelled in Vissim. The traffic flow is simulated considering lane allocations, vehicle compositions, signal controls and detection of private and public transport vehicles. Vissim finds its applications in various transport and traffic engineering problems like recreating intersections and comparing their benefits, selecting best possible options of roads and corridors, doing capacity analysis for facilities , transport development planning, active traffic management, traffic and people circulation plans and public transport modelling as well. The heart of VISSIM is Wiedemann's car- following model. The version used in this study is PTV VISSIM 2020 SP 09 with verified thesis academic license issued by the PTV Group. PTV VISSIM 2020 SP09 is structured as two components first being the Traffic Flow Model and the other part is the Signal Control (signal programme) which constantly interacts with the other model. The signal programs are developed separately and are imported into traffic flow model to be used at the required positions.

II. LITERATURE REVIEW

Micro simulation modelling is already a decade old in field of traffic engineering, and various commercial packages are already in market to do the same. Many researchers have done work in this regard and even compared various parameters related to each software, in terms of its inputs, outputs and simulation methods. In order to achieve a thorough understanding of micro simulation modelling, various past papers and books by authors are been read during research the main components found in them are reiterated here. The main aim of literature review was to understand usability of simulation in Indian heterogeneous traffic conditions and key features that have to be checked while developing a model. In one such case study done at two signalized intersections in Bombay to evaluate the effectiveness of proposed method by Pruthvi Manjunatha et.al [10], a complete calibration methodology for local and global calibration with generic algorithm as the solver and delays as the performance parameter was done. The various unique characters and techniques are identified to incorporate them into the micro simulations. It was clearly identified that due to non-lane based movement the free left turn lanes generally remain un-utilized in Indian conditions. Similar work was done by Sidharth S M P [15] wherein he modelled an intersection in Chennai in VISSIM, this study checked for secondary sensitivity of parameters, i.e., parameters which would become sensitive after calibration of model, flow of vehicles was considered as performance parameter for calibration with GA Toolbox in MATLAB. The preliminary and secondary sensitivity analysis of behaviour parameters were carried out using ANOVA (Analysis of Variance) test and EE (Elementary Effects) test. They have taken driving behaviour parameters, desired speed distributions and desired acceleration and deceleration as the key calibrating parameters. They concluded that EE method gives better results for secondary sensitivity analysis. Tom.V.Mathew et.al [4] gives a detailed methodology of generating and calibrating a micro simulation model in Vissim. It have in particular observed about vehicle manoeuvring which happens in Indian conditions due to non-lane-based movement. It also suggested that diamond shaped queuing happens due to irregular road widths and Indian conditions also require modelling of different types and sizes of vehicles , which are non-conventional as compared to EU standards . It was found that playing numerous runs with various combinations of driving behaviours and parameters is required to accurately optimize the large number of simulation parameters. It was also stated that this methodology works best for VISSIM, as it was mainly developed for homogeneous traffic conditions and we have to change parameters to suit for heterogeneous traffic when working for Indian cities. Similar works done by other authors were also studied to establish the standard methodology to be adopted in our case study.

III. CASE STUDY

The sample case study was done at Wipro Avenue and Infosys Avenue roads in Electronic City Phase-1, Bangalore. The study corridor is 1. 45 km and the small stretch houses 5 signalized intersections. All the intersections are 3 legged signalized junctions (Jn) formed on confluence of a major road being joined by minor roads bringing major traffic flow to the main road. The corridor was selected as it is a major part in prime corridor passing through Electronic city phase –I. This corridor not only connects the high density residential and commercial area of E-city at one end i.e Neeladri nagar to the elevated flyover exit from E-city connecting it to whole of Bangalore, but also leads to NICE road (private ring road around Bangalore and connects to highway to Mysore city) and also NH-44 (Hosur Road) which connects Bangalore to Chennai via Hosur and other important towns of Tamil Nadu. The location of corridor is shown here in Figure 1.

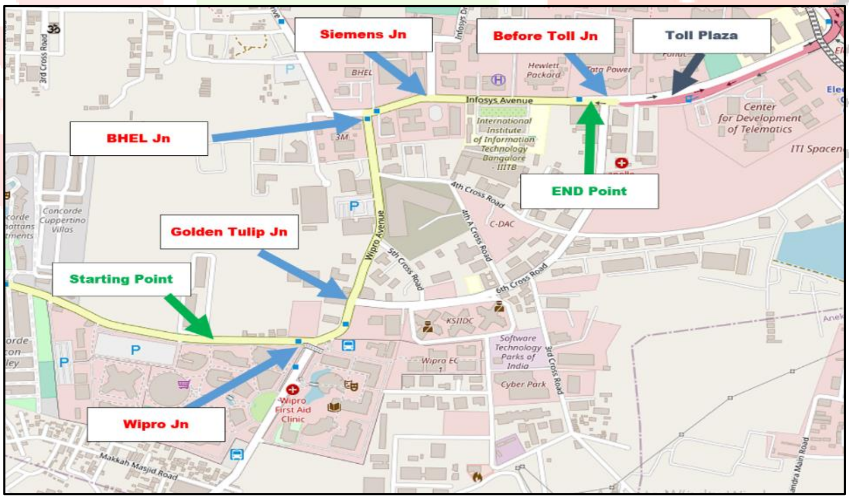


Figure 1 Study Corridor Location

IV. METHODLOGY

Method adopted for data collection was to first go for a detailed reconnaissance survey to establish details about the complete corridor and its junctions and assess the peak hours on it, thereafter the road inventory survey was done to measure and accurately map all dimensions of junctions and approach widths. The signal timing and phasing was studied on site to get the cycle length and green time information. The classified traffic count was conducted for complete turning movement count (TMC) on intersection with help of videography technique, wherein the video feeds from the high resolution installed cameras by area governing agency have been taken and analysed manually to get the traffic counts. The view of BHEL intersection from two cameras are shown in Figure 2.

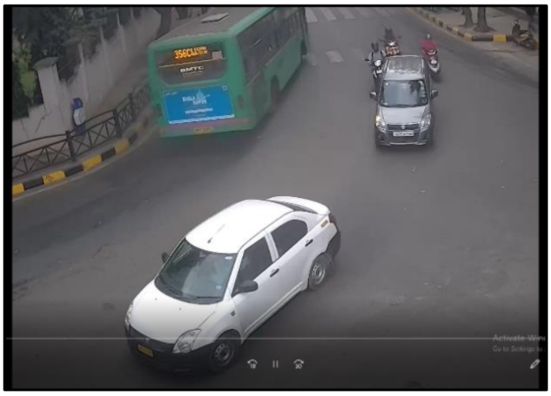


Figure 2 Snapshots of Traffic Videography

The complete data set collected during study was analysed to get desired data for generation of base scenario for Simulation Model formulation. This base scenario model represents the current site conditions. This is done by incorporating 3D models of vehicles into software, which match the vehicles in study area. Thereafter, the network was drawn in Vissim, with help of links and connectors on the base map background, with help of network geometry measurements taken from site. The vehicle inputs and composition were fed in it. The turning movement ratio as observed during TMC was entered in static routing decisions into the model. The each signal phase was programmed into a separate *.sig file, with complete details of signal cycles and phases. This signal program was written separately for each intersection, and all signal heads with their appropriate signal programs are placed on network.

Simulation multi runs were done to get the default values from model. The default values were analysed for the percentage of error

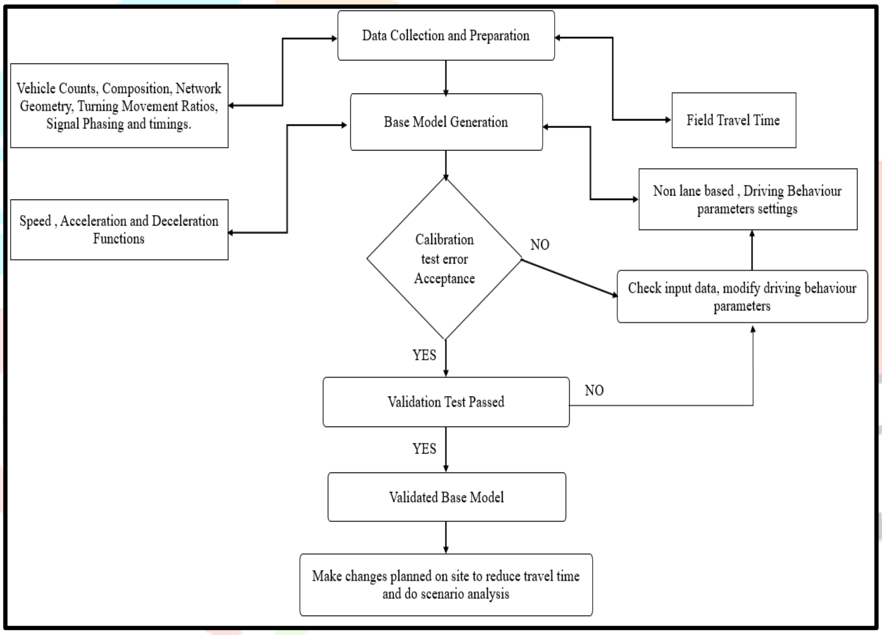


Figure 3: Methodology for Traffic Simulation in Vissim

in them, these errors were reduced by calibration process, in which the different driving behaviours were tweaked and results were noted. The calibration was done by iterative trial and error method. Once the error between simulated traffic flow and travel time parameters and the observed values come within acceptable range of 10-20%, the model is proved calibrated. This calibrated model was put to validation test, by feeding the traffic data from another date and time, and results of travel time to be matched with the observed travel time results within acceptable range again. After passing the validation test, the model is called the base model fit for any scenario analysis. The model can also be adorned with different static 3D objects like footpaths, bus stops, signals lights, street signage's etc. for beautification purpose. However this is optional and may be omitted as it does not impact the results and calculations required for study.

V. MODELLING OF NETWORK

To ease the model creation, Wipro Avenue and Infosys avenue have been created in it till the signal before toll junction. This was done to facilitate easy creation and understanding of simulation model, as only this length has 4 major intersections which add to the maximum delay to vehicles as found during the field travel time assessment. All the left and right turns are drawn with the help of connectors, which connect specific lanes of one road to other. The links are given width thickness as observed on site, and are formed separately for both directions of traffic movement. Fig 4 shows the snapshots of all the links and connectors drawn in Vissim over the background Open Street Maps (Mapnik) available in it. Vehicle inputs is a very complicated part in Vissim, because it enters vehicles at the terminals, so vehicle inputs are given at start of any corridor. For this model purpose, vehicles were entered at 6 locations, which are start of all 6 entry points of roads leading to the network. The vehicle input list as created in Vissim is shown in Fig 5. As the vehicle count was done in time interval of 15 minutes, it was also incorporated in same interval of 900 seconds in Vissim too. Therefore 1 hour traffic data is represented as hourly traffic volume in time intervals of 15 minutes each. The vehicle composition as observed during the classified traffic count is to be incorporated into model under vehicle composition. The same is been named as "E-city" composition here.

It is to be noted that the standard vehicular models which are present in Vissim, have dimensions and other static and dynamic characteristics based on European models, the same is to be modified to the extent to match standard Indian vehicle features. Thus new appropriate static models of vehicles are imported from the Open directory of Vehicle models available in Vissim, into this model to create relevant features of vehicles, like Auto (3 Wheeler) , and cars which are big and small on Indian roads with length ranging from 3.72 to 4.58 m. The vehicular characteristics were considered as given in Indo HCM for the standard vehicles generally available on Indian roads.

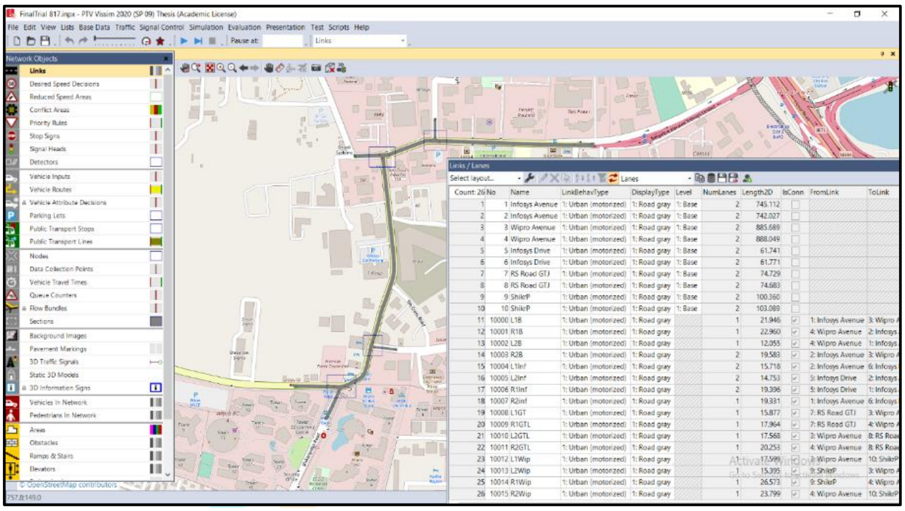
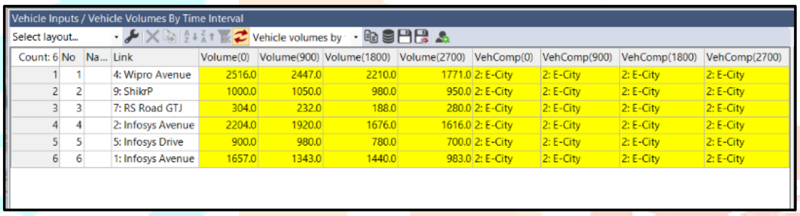


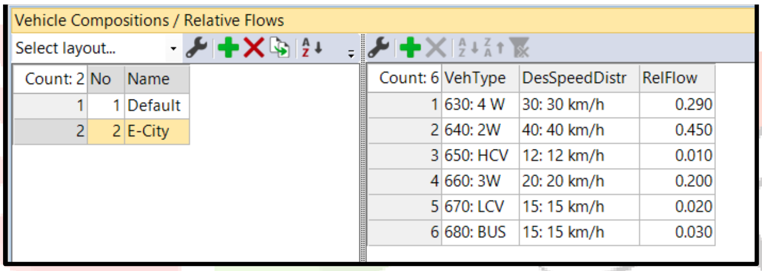
Figure 5 Snapshot of Links & Connectors drawn in Network in Vissim



Vehicle Inputs / Vehicle Volumes By Time Interval

Count: 6	No	Na...	Link	Volume(0)	Volume(900)	Volume(1800)	Volume(2700)	VehComp(0)	VehComp(900)	VehComp(1800)	VehComp(2700)
1	1		4: Wipro Avenue	2516.0	2447.0	2210.0	1771.0	2: E-City	2: E-City	2: E-City	2: E-City
2	2		9: ShikrP	1000.0	1050.0	980.0	950.0	2: E-City	2: E-City	2: E-City	2: E-City
3	3		7: RS Road GTJ	304.0	232.0	188.0	280.0	2: E-City	2: E-City	2: E-City	2: E-City
4	4		2: Infosys Avenue	2204.0	1920.0	1676.0	1616.0	2: E-City	2: E-City	2: E-City	2: E-City
5	5		5: Infosys Drive	900.0	980.0	780.0	700.0	2: E-City	2: E-City	2: E-City	2: E-City
6	6		1: Infosys Avenue	1657.0	1343.0	1440.0	983.0	2: E-City	2: E-City	2: E-City	2: E-City

Figure 4 Vehicle Input List in Vissim



Vehicle Compositions / Relative Flows

Count: 2	No	Name
1	1	Default
2	2	E-City

Count: 6	VehType	DesSpeedDistr	RelFlow
1	630: 4 W	30: 30 km/h	0.290
2	640: 2W	40: 40 km/h	0.450
3	650: HCV	12: 12 km/h	0.010
4	660: 3W	20: 20 km/h	0.200
5	670: LCV	15: 15 km/h	0.020
6	680: BUS	15: 15 km/h	0.030

Figure 6 Vehicle Composition in Vissim

The Control on the turning movement of vehicles from an approach is imitated by defining Network Object – Vehicle Routes (static routing decisions) and defining the flows in all the directions as a fraction of the total flow, (relative flow). The corridor vehicle flow was a very complex feature to analyse and input into the model. Because the actual traffic count was done only at 2 intersections i.e Golden Tulip Jn. and BHEL Jn., the traffic flow at the other two intersections of Wipro Jn and Siemens Jn was assumed and back calculated on the basis of prior traffic studies done on these junctions. The aim was to ensure that the number of vehicles reaching each approach arm of two important junctions remains the same as observed on field. A representative of northbound traffic on Wipro avenue is been shown in Fig 7, the yellow highlight line indicates the traffic static route which is to be followed by the fraction of traffic generating at the starting point on Wipro Avenue. All the 4 junctions modelled in network, have different signal phases and cycles. Even in absence of specific through or left turn lanes, the signal timings are different for each lane. All these specific signal phases were programmed in signal programs and signal heads were placed on individual lanes as per their movement timings. Vissim gives us the option of putting exact signal compliance on field i.e if the signals were followed meticulously by traffic or being over ruled and cross jumped, the signal compliance was found good on site, therefore this parameter is kept at 100% itself.

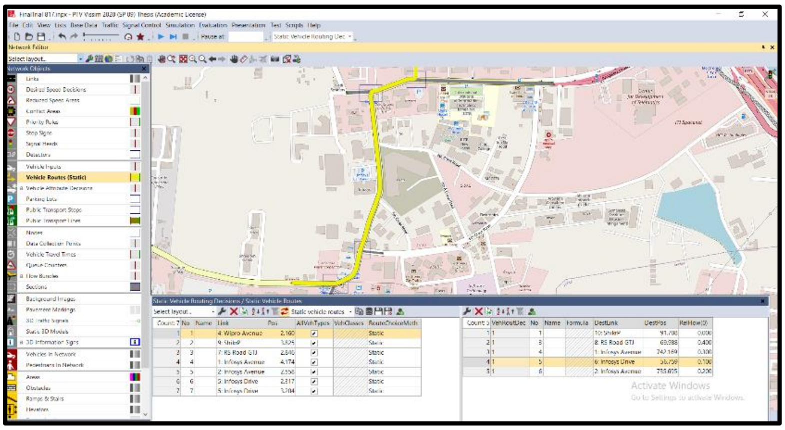


Figure 7 Static Routing Decisions in Vissim

VI. EVALUATION AND CALIBRATION

The vehicle simulation run in Vissim is performed for 10800 seconds i.e 3 hours in this study. In which the initial 3600 seconds are considered as warm up period for network to reach at steady state and last 3600 seconds are considered as cooling period. The simulation runs are done based on a Random Number Generator by Vissim, for which we give any arbitrary number as random seed, here it is taken as 42. The number of simulation runs can also be 1 to any number, we have taken as 3 simulation runs, in each run. So that we get results as average of 3 multi runs.

Before running simulation, we need to define the measurement metrics which we want to find and record in simulation runs. In this study Travel Time and traffic flow are taken as the key measurement output. The vehicle travel time is measured for all vehicles and for cars especially on corridor from starting point to ending point for a distance of nearly 1474 m. The traffic flow is measured at a Data collection Point inserted at a midblock part between Golden Tulip Jn and BHEL Jn, as an estimate of the number of vehicles running on the network in model. VISSIM applies all the in-built flow, car following, lane changing models, vehicular and geometric attributes for computing the results, therefore, the parameters of these models will affect the output from the simulation. The default parameters setup in the software represent the developed nation traffic conditions and does not yield meaningful results when applied for Indian conditions. Therefore the first simulation gives results with high percentage error and is called the default results. In this study, Travel time between two points and the North Bound flow on Wipro Avenue is taken as calibration parameter. The default parameters gives erroneous results, the error is estimated and calculated as compared to observed travel time and traffic flow.

Thereafter the driving behaviours and other parameters were corrected by trial and error method, based on the earlier studies done on Indian heterogeneous traffic conditions, some parameters were determined, which suit well for Indian traffic conditions. Those parameters were changed and numerous various combinations of them were performed and results were compared to assess the error. The parameters which were calibrated are shown in Table 1hereunder.

Table 1 : Attributes & Parameters Calibrated

List of Calibrated Attributes			
S. No.	**Parameter**	**Default value**	**Calibrated value**
Wiedemann 74 car following model			
1	Average standstill distance (m)	2	0.5
2	Additive part of safety distance	2	0.15
3	Multiplicative part of safety distance	3	0.2
Lane change			
4	Waiting time before diffusion (s)	60	120
5	Advanced Merging	No	Yes
6	Minimum headway (m)	0.5	0.1
Lateral behaviour			
7	Desired position at free flow	Middle	Any
8	Overtake on same lane	No	Yes
9	Min. lateral distance at 0 & 50 kmph (m)	Standing 0.2 , Driving 1	Standing 1, Driving 1
Signal Control			
10	Behaviour at Amber Signal after end of red	Continuous Check	One Decision
11	Behaviour at Amber Signal after end of Green	Go	Stop

It was also observed that the network was over saturated, and hence the no of vehicles in traffic flow could not be completed in any run, only 50% vehicles were generated and run on network, it was also observed in the error log generated after each simulation that many vehicles were diffused after waiting time of 60 seconds, whereas in actual vehicles tend to wait for ever, till they get chance to change lane or move ahead on road. Thus to overcome this issue, the waiting time before diffusion point no 4 in list above is been changed to 120 seconds. The saturated network also pose the hazard of not having complete vehicle generation that's because many vehicle may not be able to exit network with 3600 seconds, to overcome this issue simulation runs were performed for minimum 3 hours, i.e 10800. It was noted in earlier studies that error between 10 to 20% is acceptable so the same is been achieved by the iterative trial and run error. Comparison of observed, default and calibrated values of travel time and northbound traffic flow are shown in figures 8 and 9 and tables 2 and 3 show how the error values are been reduced by calibration.

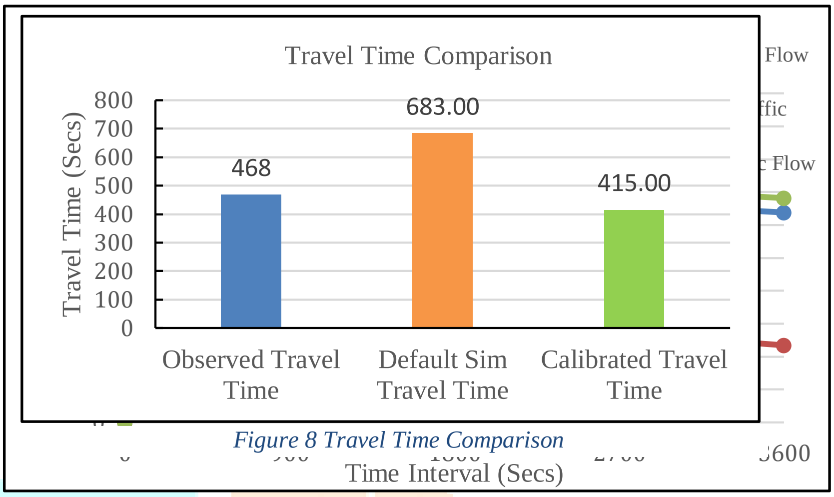


Figure 8 Travel Time Comparison

Figure 9 Traffic Flow Comparison

Table 2 Traffic Flow Error Estimation

Time Interval	Observed Traffic Count	Default Traffic Count	%age Error	Calibrated Traffic Count	%age Error
900	445	134	69.89	353	20.67
1800	433	127	70.67	318	26.56
2700	333	136	59.16	355	-6.61
3600	319	117	63.32	341	-6.90
Mean Average Percentage Error =			**65.76**		**8.43**

Table 2 Travel Time Error Estimation

Observed Travel Time	Default Simulation Travel Time	Calibrated Simulation Travel Time
468	683	415
Mean Average Percentage Error =	**-45.94**	**11.32**

After successful calibration, model is to be validated if its working fine, for this purpose, a different data set from some other day is taken and is fed into model. If the travel time and traffic flow results remain in the same range of error, the model is called successful validated. This was done by using data of other peak hour studied. Validation results also came in line within 13 % error and hence model is ready for further scenario analysis.

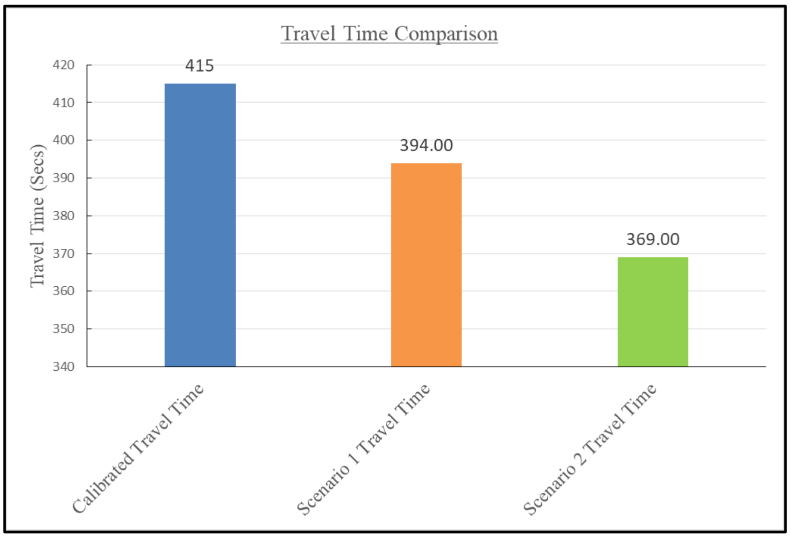


Figure 11 Scenario Analysis Travel Time Comparisons

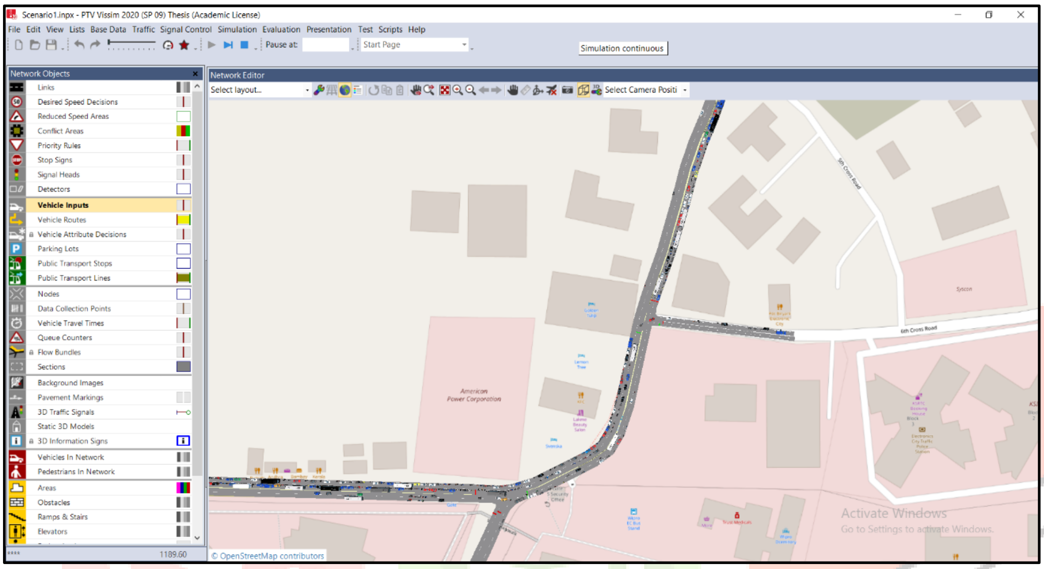


Figure 10 Snapshot of Simulation Run Showing Reduced Congestion during Scenario analysis

VII. SCENARIO ANALYSIS

The traffic congestion issue could be resolved by many measures like road widening, creating freeways, creating parallel new roads to cater to existing demands, creating exclusive heavy vehicles lanes etc. for the purpose of this research, two scenarios have been studied, they are 1) increasing road widths throughout the corridor, 2) creating exclusive through traffic lane on Wipro avenue by giving through traffic zero stopping on Wipro and Golden Tulip junction. The scenario 1 analysis reduced the calibrated travel time from 415 seconds to 394 seconds, i.e a reduction of 5%. But when we remove the traffic signal heads from the north bound through traffic lanes at Wipro Junction and Golden Tulip Junction, the travel time is reduced to 369 Seconds, this is 11 % less than the actual calibrated travel time. The travel time comparison is shown in Fig 11.

During both scenario analysis, the traffic flow count is observed under permissible error limit of 12%. It was also observed that the error log of Simulation run reduced a lot, as increase in width of roads allowed accumulation of more no. of vehicles on them and free traffic flow movement for them, thus reducing the number of vehicles left for simulation run that means the vehicle inputs could be completed by simulator. A typical simulation run snapshot is seen in Fig 10 for Wipro Junction and Golden Tulip Junction.

VIII. CONCLUSION

While the research gave clear understanding of steps and difficulties associated with developing a complete over saturated urban corridor in PTV Vissim, the following conclusions are drawn from it:

1. It was concluded based on the scenario analysis in PTV Vissim, that the current network condition is Over Saturated, wherein the traffic volume has exceeded the capacity of roads in the network.
2. It was noted that a simulation run of 1 hour is not enough to represent over saturated traffic conditions, as the vehicles input cannot be completed, due to vehicles being stuck in network.
3. It was further found that in over started conditions, simulation runs should be made for minimum 3 hours and could be made for 6 hours too, to make the model replicate the ground conditions.
4. Other than the Wiedemanns car following parameters, one more parameter should also be changed for Indian conditions, that is waiting time before diffusion, this is needed because in reality vehicles wait unconditionally for their turn to change lane or move forward on the network.

5. Scenario analysis have proved that it is advisable for widening of existing road widths to provide much needed space for the vehicular traffic, this will result in lesser travel time on corridor and will save time, fuel and money of the facility user.
6. Scenario analysis also proved that the reduction in travel time is also achieved by creating freeway corridor, and limit the number of intersections on it. This can be achieved by making exclusive lane for through traffic and following the same on road.
7. It was also observed while modelling that lot of through moving traffic gets stuck behind vehicles waiting for right turns, this creates un-necessary delay in peak hours. This problem can be sorted by making lane discipline to be followed strictly on road by the help of appropriate traffic signage, lane marking, and delineators and last by human intervention of traffic wardens.

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