PTV USER GROUP MEETING – 2016, GANDHINAGAR

# IMPACT OF IMPLEMENTING CONGESTION CHARGING USING DYNAMIC ASSIGNMENT IN VISSIM

## A CASE STUDY OF THIRUVANANTHAPURAM CITY


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# OVERVIEW

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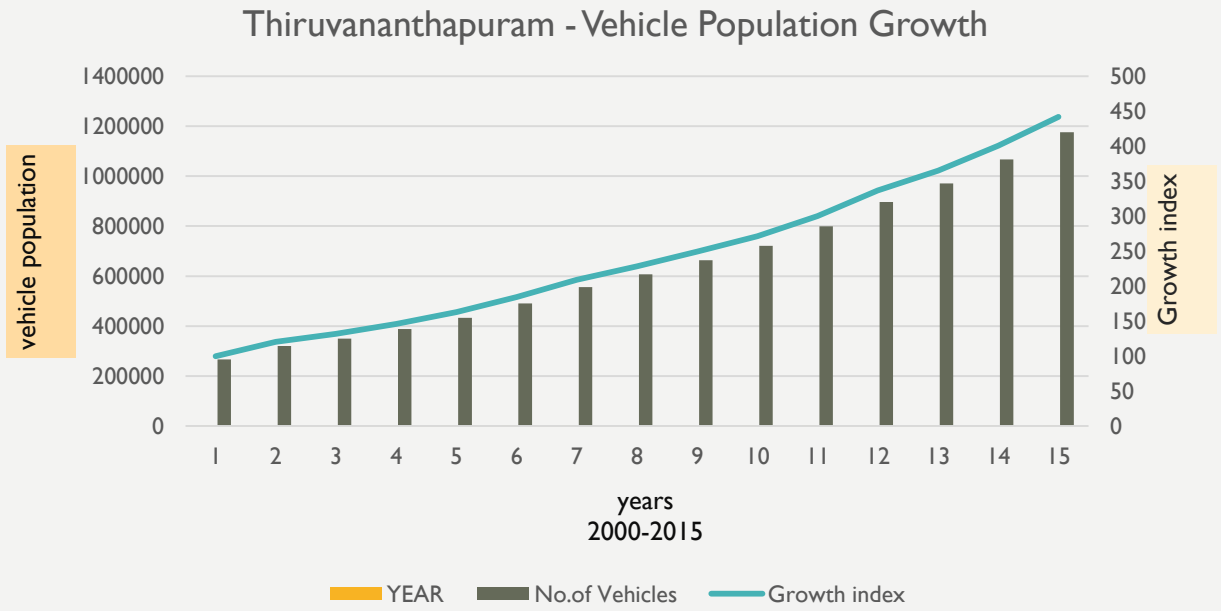
# INTRODUCTION

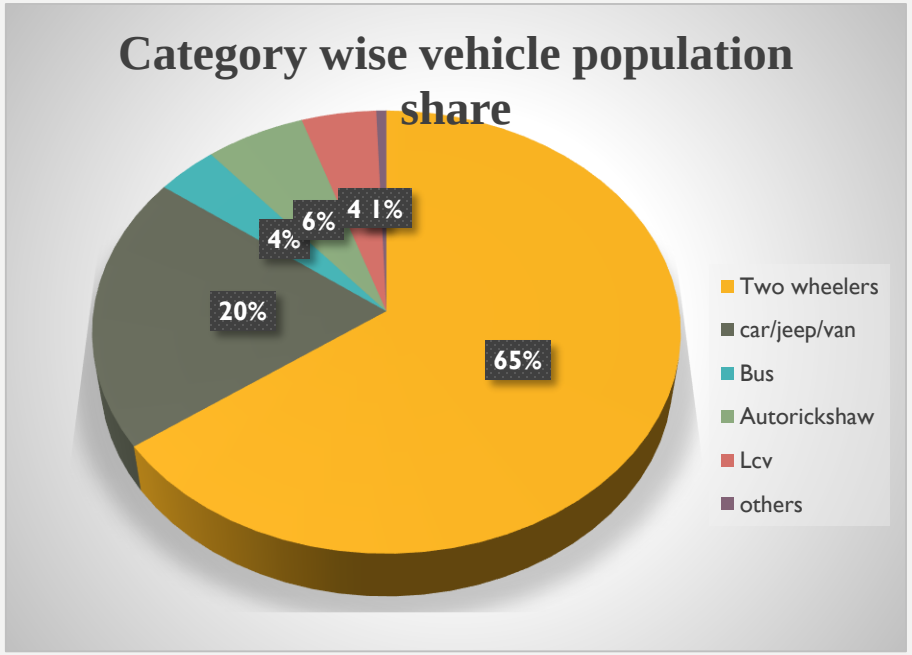
- **Congestion** causes frustrating and costly delays for drivers, urban and regional air pollution, national energy security concerns and global climate change.
- Mobility in medium and big cities is a huge challenge due to congestion during peak hours, which is mainly due to excessive use of private vehicles.
- **Congestion charging** addresses these issues by charging drivers for operating vehicles at highly congested times and locations to reduce travel times, improve air quality and decrease greenhouse gas emissions.
- It is a market or demand-based strategy designed to encourage a shift of peak period trips to: a). off-peak periods; b). to routes away from congested facilities or c). to alternative modes – high occupancy vehicles or public transit – during the peak demand periods.

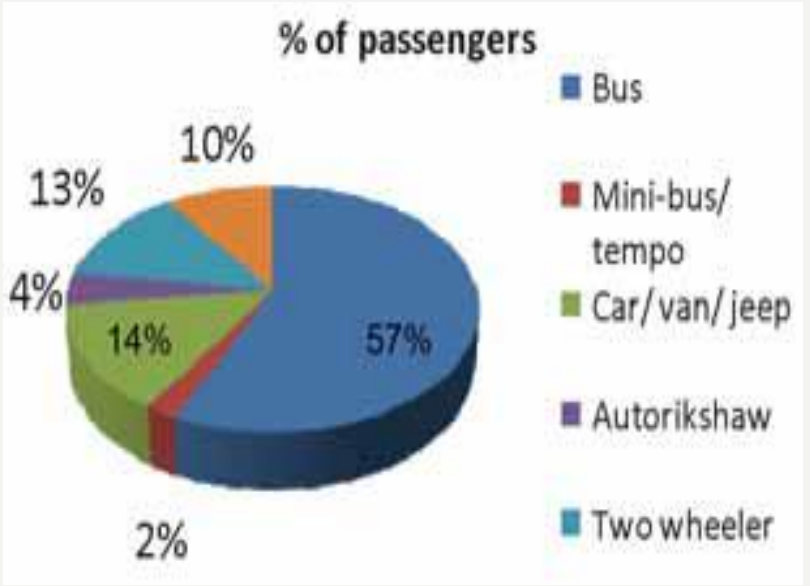
# GENERAL BACKGROUND

- Thiruvananthapuram is an emerging metropolitan city in the southernmost part of India and is the capital of Kerala.
- The fundamental objective of the study was to determine the impact of implementing congestion charging in Thiruvananthapuram city.
- The vehicle population in Thiruvananthapuram district has increased to nearly 4.41 times during the last 15 years – Growth rate of 12% per year.



# ANALYSIS OF VEHICLE POPULATION AND MODAL SPLIT




Source: NATPAC

## Some Peak Hour Visuals

Palayam jn


PMG

Vazhuthacaud

Pazhavangadi jn

Annie Mascrene square

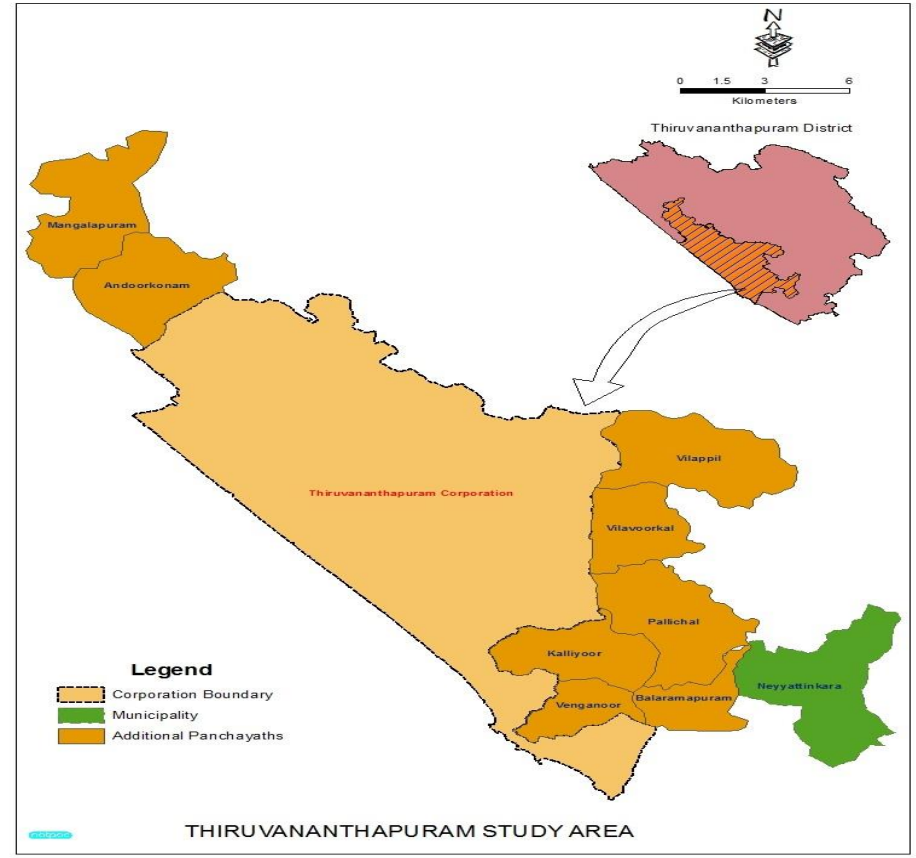
# OBJECTIVES

- Determine the congestion level in the study area.
- Establish the traffic pattern including OD.
- Device a methodology for implementing congestion charging.
- Determine the impacts of implementing congestion charging.

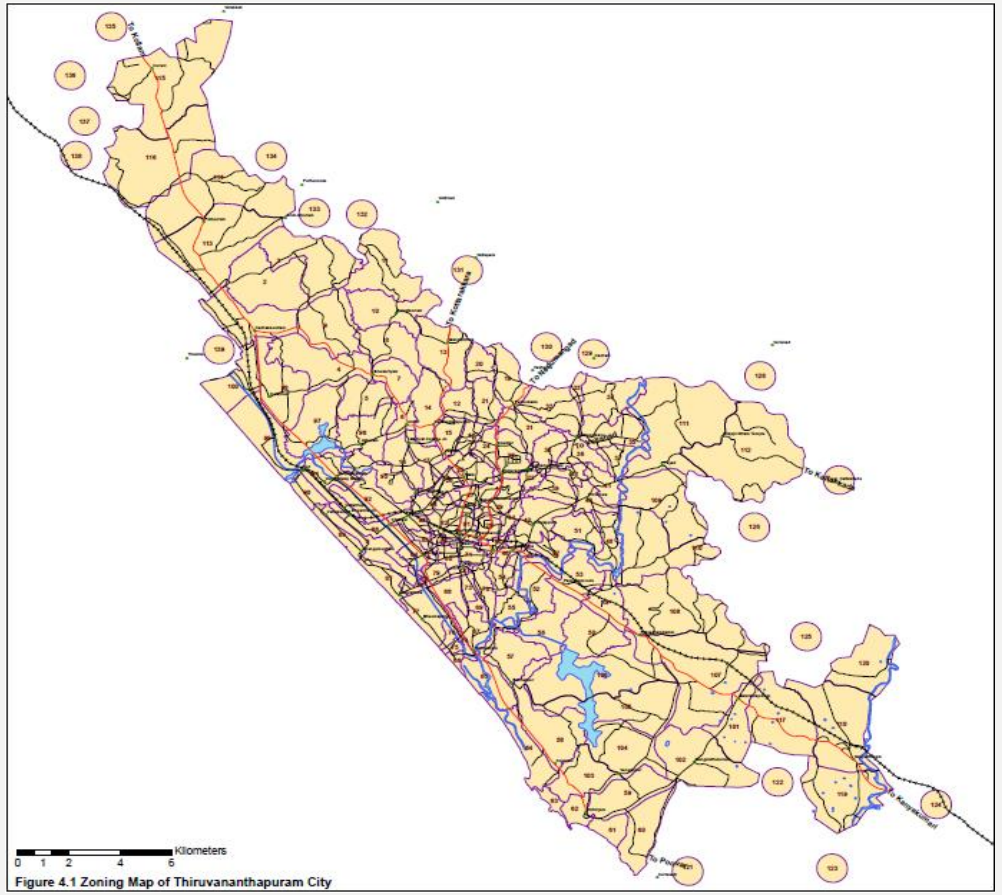
# SCOPE OF THE STUDY

Study area includes 100 wards of Thiruvananthapuram corporation, nearby wards of Neyyatinkara Municipality,and nearby 8 Panchayath .

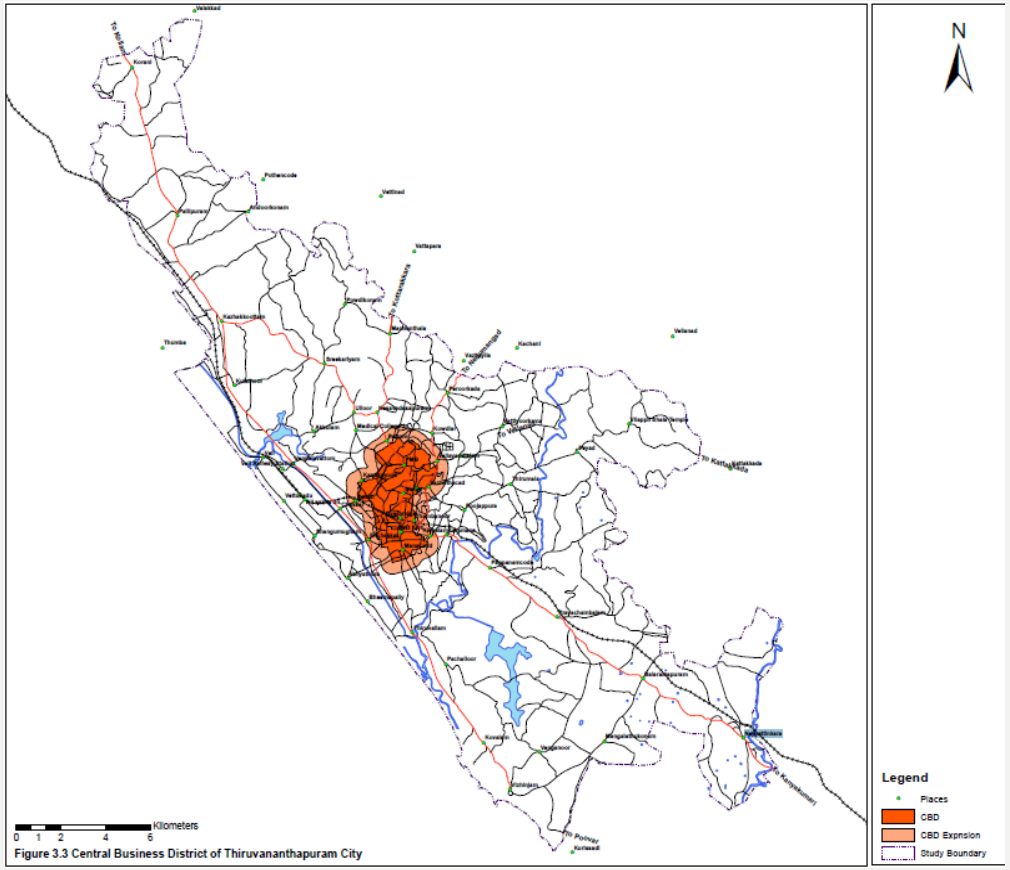
The total study area is divided into 140 zones



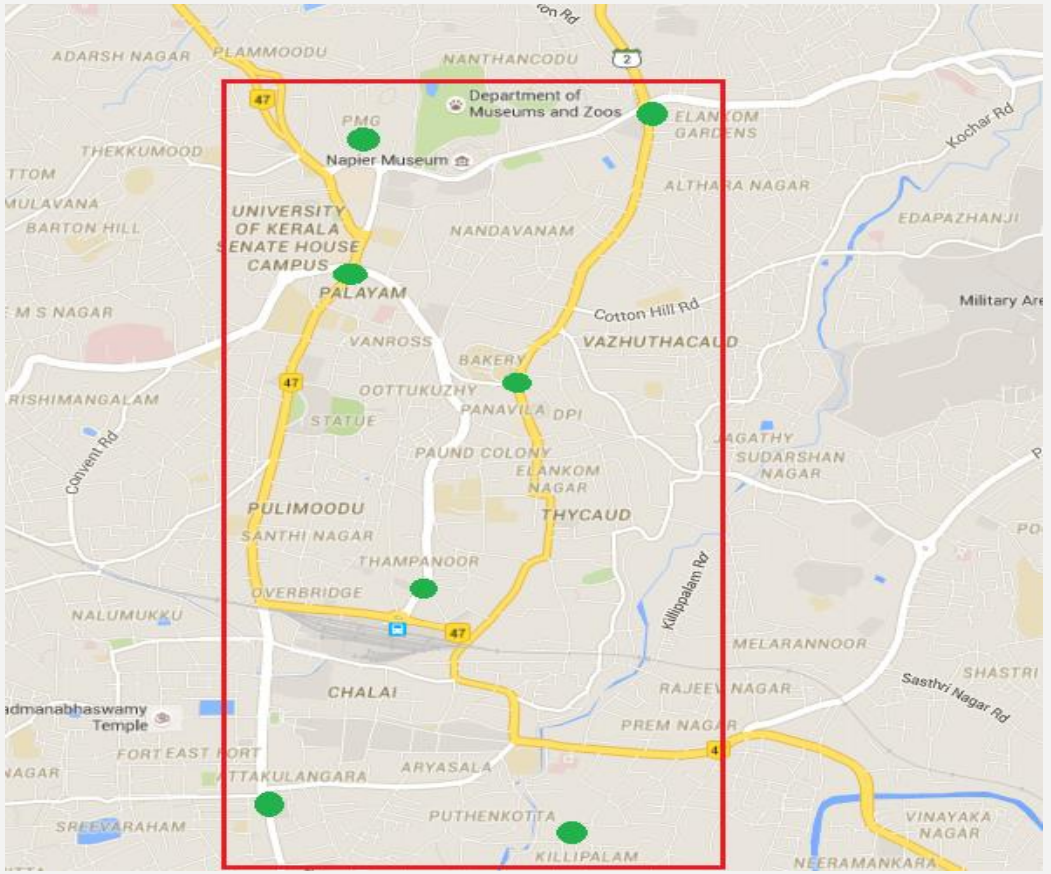

Thiruvananthapuram study area




Zoning Map




Thiruvananthapuram CBD area




The charging area covers :-

- ✓ MG road from PMG to Attakulangara.
- ✓ PMG to Vellayambalam.
- ✓ Vellayambalam to Killipalam.
- ✓ Killipalam to Attakulangara.
- ✓ Palayam to Thampanoor via bakery junction.

# LITERATURE REVIEW

| AUTHOR | FACTOR STUDIED | CONCLUSION |
|---|---|---|
| Sarkar (2009) | Traffic congestion and congestion pricing in Central Business District (CBD) of New Delhi | The external cost of congestion for road users was calculated and then through demand elasticity curves, the level of pricing required was identified. |
| Tina *et.al*(2015) | Identification of the most congested corridor of Thiruvananthapuram city and To determine an optimum congestion charge for car users which includes costs of delays, wasted fuel, and environmental costs. | Mahatma Gandhi road corridor between Attakulangara and LMS, which is the major travel corridor passing through the CBD area of Thiruvananthapuram has the highest travel time index value of 4.45 . The congestion price for car users obtained is Rs 14.50 per kilometer |

| AUTHOR | FACTOR STUDIED | CONCLUSION |
| --- | --- | --- |
| Chakrabartty *et.al* (2015) | Measured the external cost of congestion on the roads of kolkata. | The cost of congestion estimated for the city of kolkata indicates that there is a considerable monetary loss that is being incurred.Rs. 74,077.66 is lost in only two hours (i.E. 9 - 10 a.M. And 6 - 7 p.M.) In a day only on the few selected roads. So the loss for peak hour congestion in a month would be rs. 22, 22,329.8. |

# CASE STUDIES

Traffic effects

| | London | Singapore | Stockholm | Milan | Gothenburg | Rome |
|---|---|---|---|---|---|---|
| **Traffic volume** | -16% (2006)<br>-30% charge-able vehicles, +25% busses, +15% taxis, +49% bicycle<br>-21% (2002-2008) | -44% after ALS<br>-10%-15% after ERP compared to ALS<br>- 20%-30% for other extensions of the system | -20% across the cordon | -34%<br>(-49% in user of heavy polluting vehicles) | -10% across cordon,<br>-2.5% vehi-cle-km in Gothenburg | -20% over cordon<br>+15% motor-cycles |
| **Travel times** | -30% delays | speed criteria charge levels between 20-30 kph and 45-65 kph | -33% in delays | -17% in con-gestion<br>+7% bus speed, +4.7% tram speed | -10-20% reduction median travel time on cor-ridors | +4% in speeds<br>+5% speeds PT |
| **Public transit ridership** | +18% | n.a. | +5% | n.a. | +6% | +5% |

Environmental effects

| | London | Stockholm | Milan | Gothenburg | Rome |
|---|---|---|---|---|---|
| **CO2** | -16.4% | -13% | -22% | -2.5% (region) | -21% |
| **NOx** | -13.4% | -8% | -10% | Uncertain | n.a. |
| **PM2.5** | n.a. | n.a. | -40% | Uncertain | n.a. |
| **PM10** | -15.5% | -13% | -19% | Uncertain | -11% |

# DYNAMIC TRAFFIC ASSIGNMENT

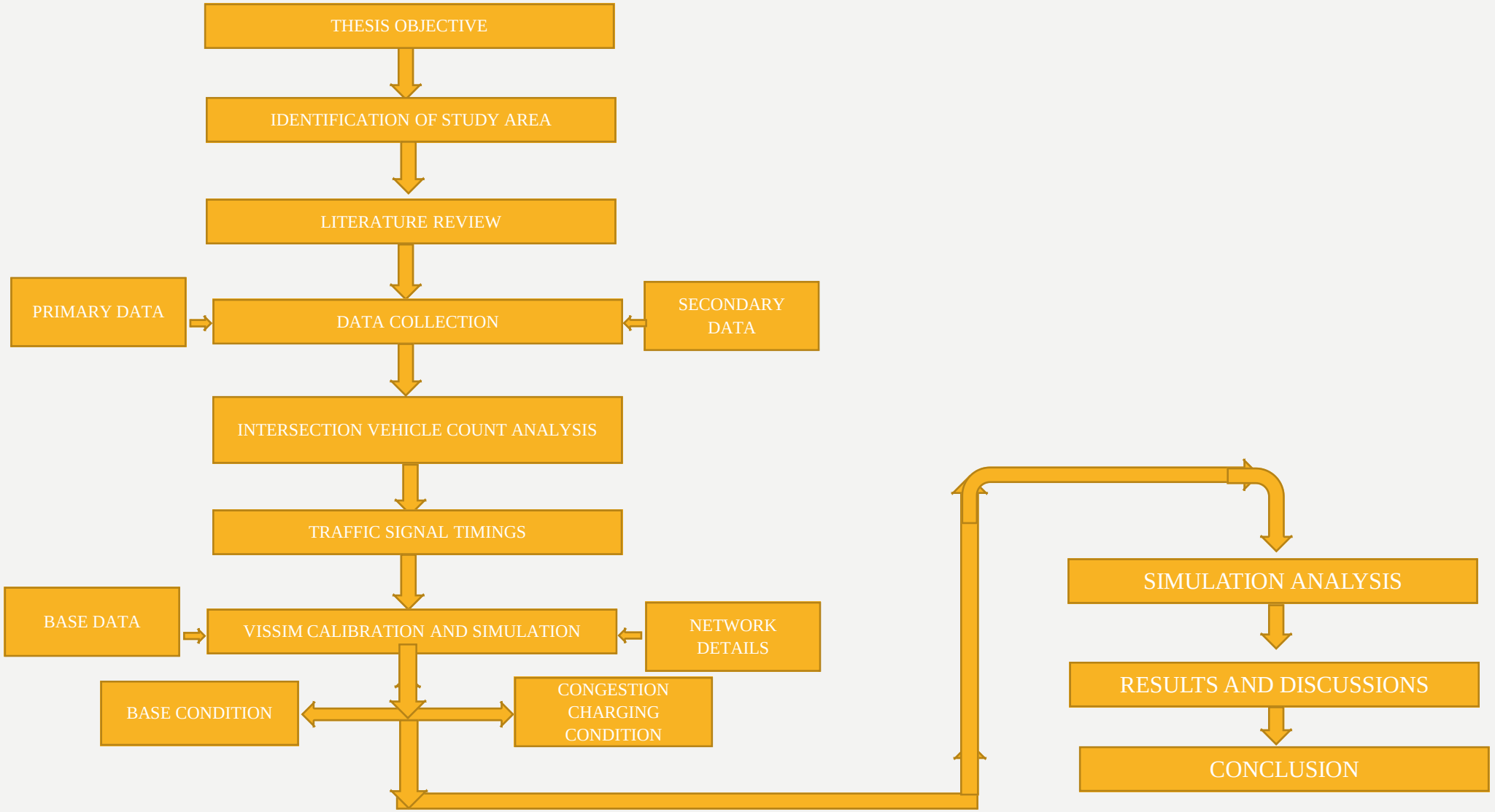
- A traffic assignment method to predict/estimate how trip-makers may shift to other routes in response to:

- ***Congestion***
- ***Pricing***
- ***Controls***
- ***Incidents***
- ***Improvements***

- Understand how individual travel decisions impact an entire region, by

- Time of day
- Origin-Destination (OD) zones
- Transportation modes

# METHODOLOGY



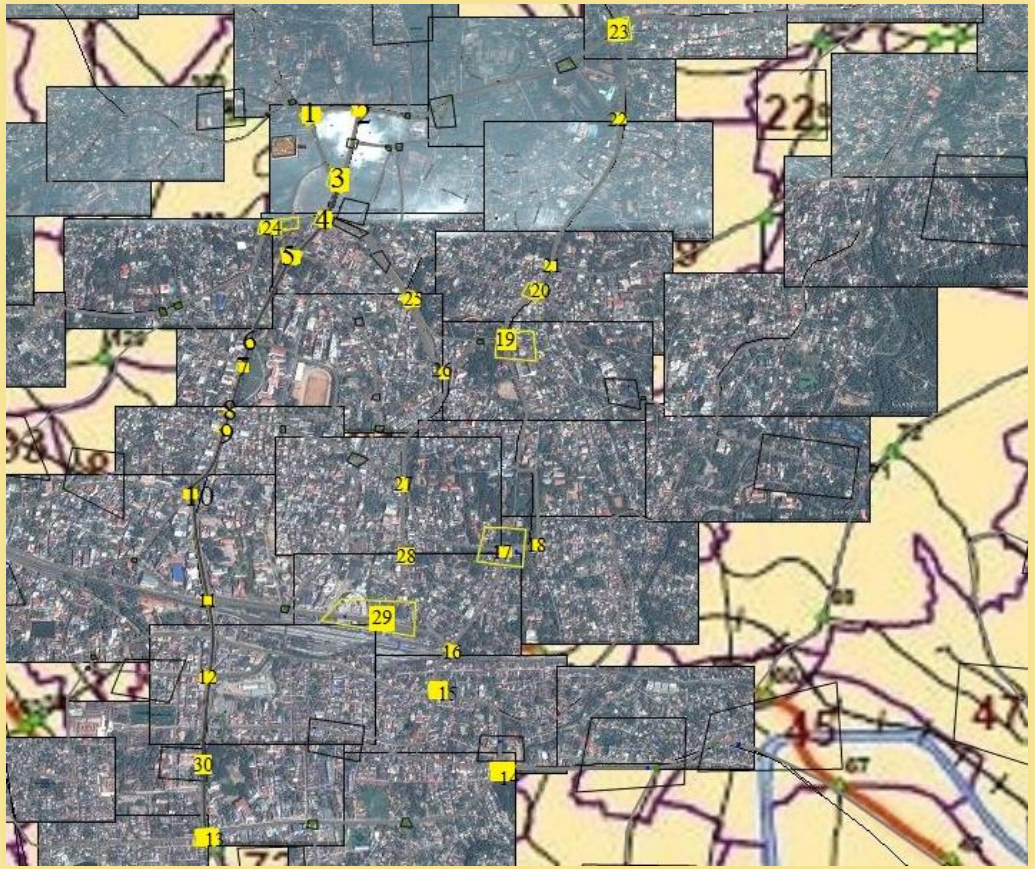
# DATA COLLECTION

## ❑ INTERSECTION TRAFFIC VOLUME SURVEY

- CBD area includes 30 intersections
- Video graphic survey carried out during 8.30am-10.30am ,Tuesday – Thursday
- Directional counts were carried out at all intersection arms by vehicle types – Two wheeler, three wheeler, Car/Jeep/Van, LCV and Bus.

Data collection at PMG


Data collection at LMS junction



Intersections within the CBD

| Location of survey | Direction of traffic | Bus | LCV | Car/Van/Jeep | Auto | 2W | Truck |
|---|---|---|---|---|---|---|---|
| LMS | Palayam - Sasthamagalam | 36 | 6 | 210 | 175 | 389 | 0 |
| | Sasthamagalam - Palayam | 29 | 5 | 150 | 129 | 352 | 2 |
| | Sasthamagalam - PMG | 4 | 9 | 131 | 61 | 208 | 0 |
| | PMG - Sasthamagalam | 6 | 2 | 146 | 68 | 225 | 0 |
| | PMG - Palayam | 58 | 1 | 20 | 73 | 60 | 0 |
| | Palayam - PMG | 1 | 0 | 6 | 0 | 6 | 0 |

Data collected from LMS jn

## ❑ TRAFFIC SIGNAL TIMINGS WITHIN THE CBD

- 21 signalised intersections.
- Set PMG as base signal point and offset to other signals for coordination determined.

Noting signal timing at Vellayambalam

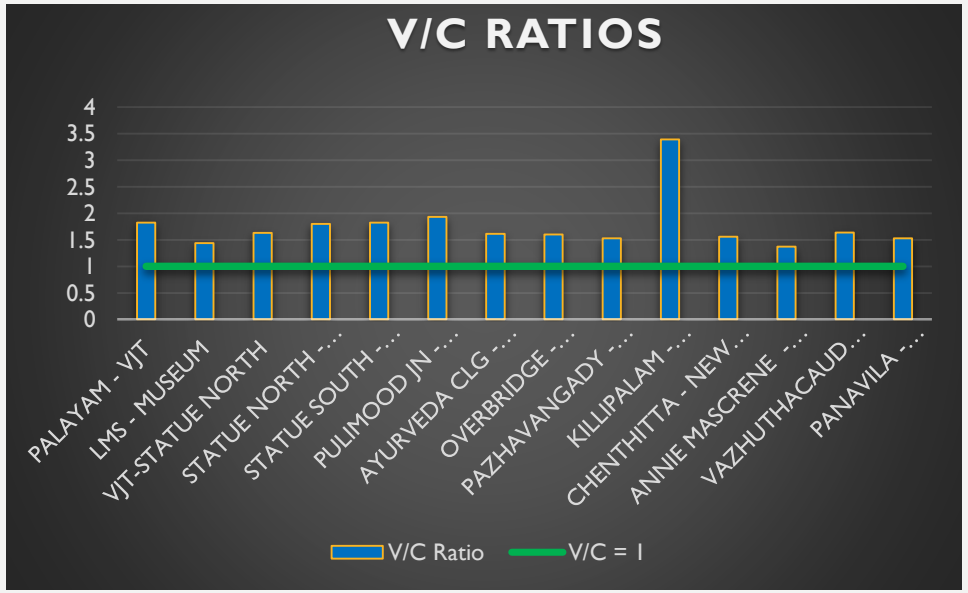
SIGNAL TIMINGS AND PHASE DIAGRAMS

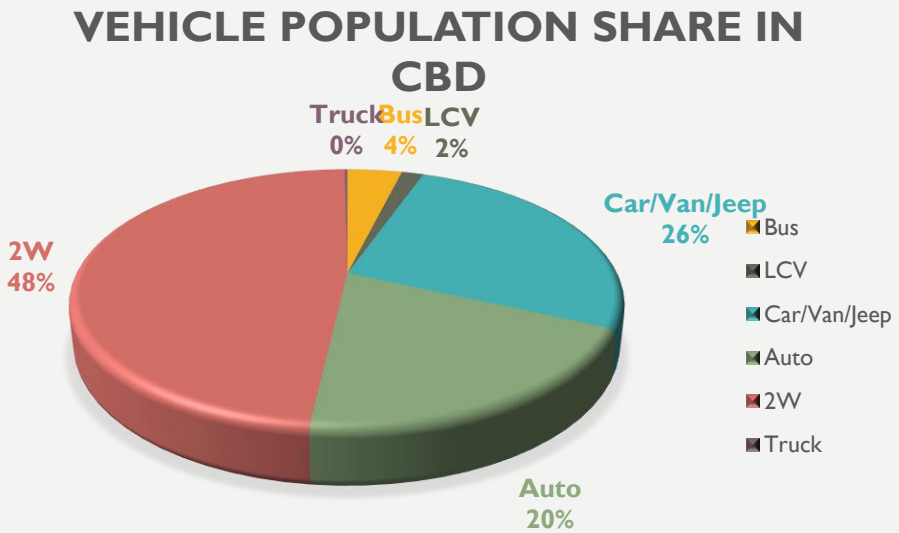
| otic | Name | Number of phase | Phase direction | Phase diagram | Red tir | Green tir | Amber t | total cycle duration | Offset |
|---|---|---|---|---|---|---|---|---|---|
| 1 | PMG | | | | | | | | |
| | | 4 | WM - PATTOM | | 31 | 85 | 3 | 119 | |
| | | | PATTOM-WM | | 71 | 46 | 3 | 120 | |
| | | | LMS-PATTOM | | 90 | 27 | 3 | 120 | |
| | | | WM - LMS | | 79 | 37 | 3 | 119 | |

Signal timings at PMG

# EXISTING CONGESTION LEVEL IN THE CBD

- Volume of traffic in PCU ,is calculated for one hour at midblock sections between two intersections to determine V/C ratio.
- . Capacity of the road stretch is taken as per IRC 86-1983

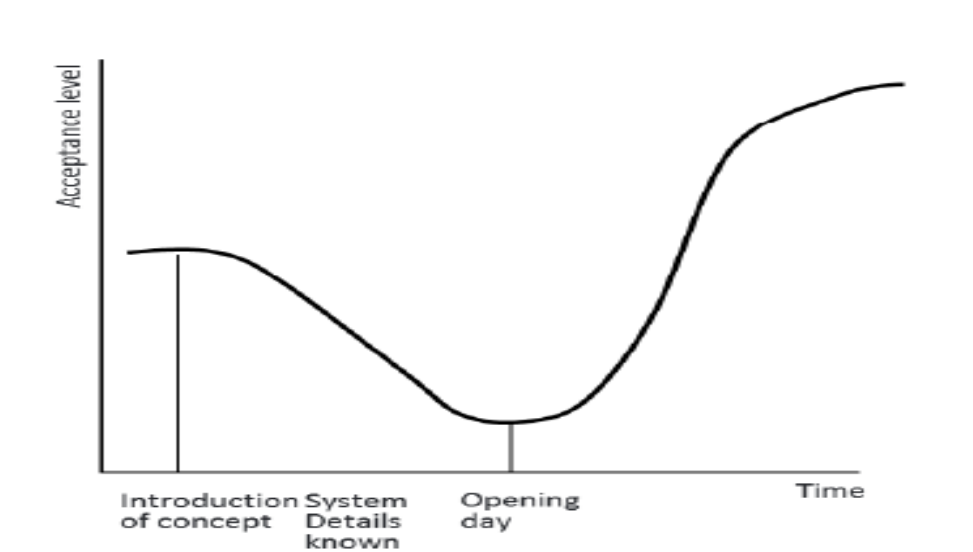


# CONGESTION CHARGING

- The term ‘congestion charging’ is used to describe a distance, area or cordon based road-user charging policy around congested city centres .
- Charging does not only eliminate traffic jams, but we are able to collect money perhaps for new buses and better roads.
- Congestion pricing is also known as value pricing, peak-period pricing, time-of-day pricing, and variable pricing.

➢ **POLITICAL AND PUBLIC ACCEPTANCE**

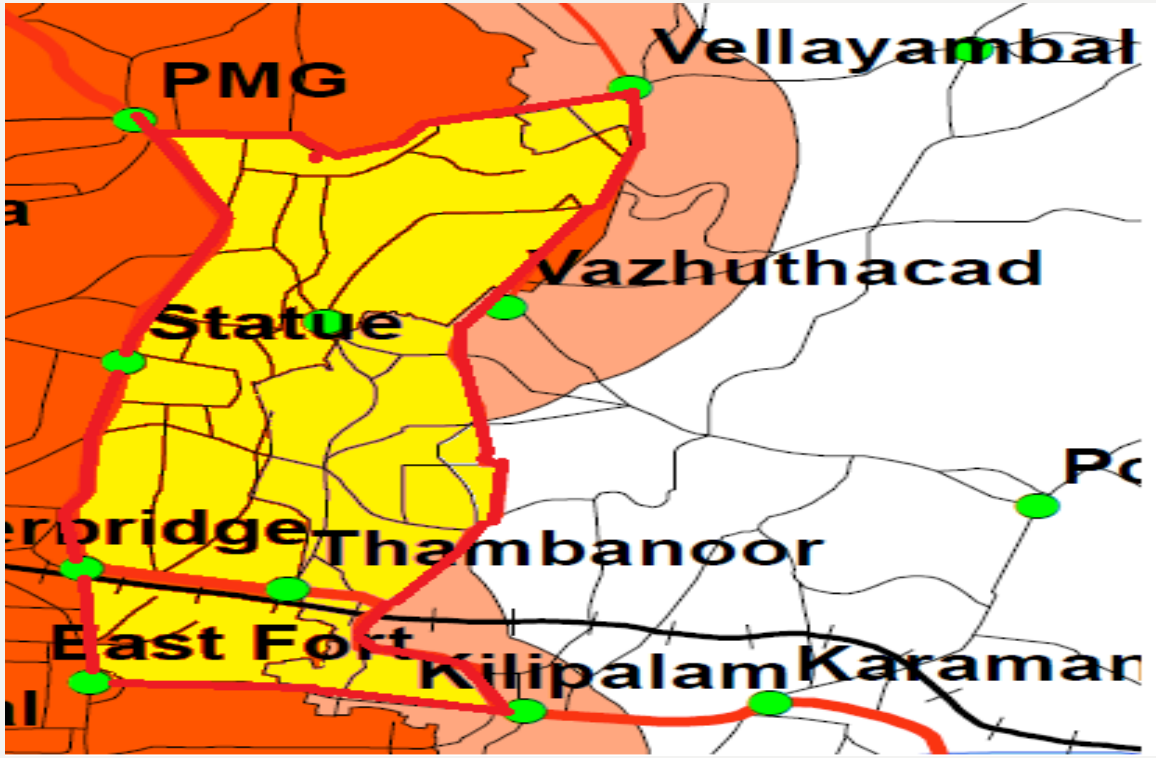



Public acceptance vs time

Source:Introduction to congestion charging,ADB

## PROPOSED CHARGING SCHEME

- **Combination of Area based and Zone/cordon based Congestion charging**
- Where people crossing the boundary of the zone/cordon; this can be inbound, outbound or both as well as within the area are charged.
- Peoples have to pay the charge for every trips they makes,
- Additional enforcement cameras (either stationary or mobile) will be needed inside the charging area.




Proposed Congestion charging area

## CHARGING PERIOD

- Charging period is only during morning peak hour 8.30 am – 10.30am.
- No charging is done during all other time of day.
- There is no charging during Saturdays, Sundays and public holidays.

## CHARGING TECHNOLOGY

- **Electronic Road Pricing system.**

Consists of three components:

✓ In-vehicle unit (IU) with or without a smart card called cash card.

✓ Erp gantries located at control points across the road and

✓ control centre .

- **In-vehicle unit**

✓ IU is a pocket dictionary-sized device powered by the vehicle battery and fitted permanently to the lower right hand corner of the vehicle's windscreen .

✓ IU has a slot for receiving a prepaid stored value contact smart card.

✓ **RFID** can be used as an alternative to IU.

In –vehicle unit

## Electronic Road Pricing (ERP) gantries

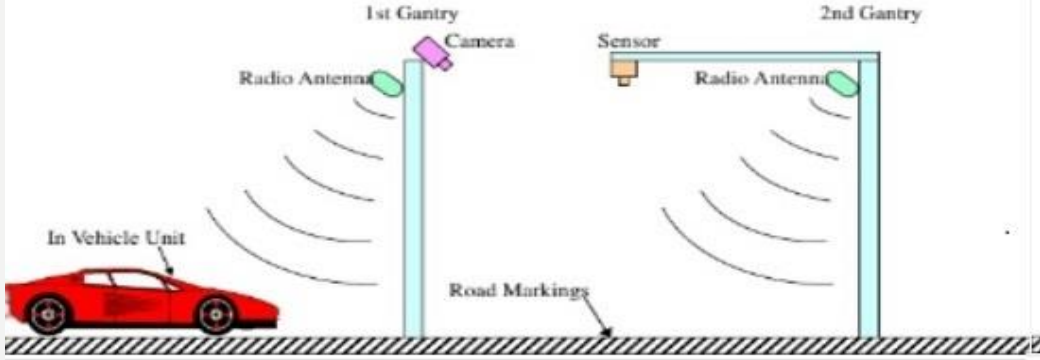
- Set of two overhead gantries mounted at each control point
- Generally at a height of 6.1 m above road level and placed about 12 – 15 m apart.
- The local controller transfers data continuously with a central computer at a control centre by using leased telephone lines.


ERP Gantries.

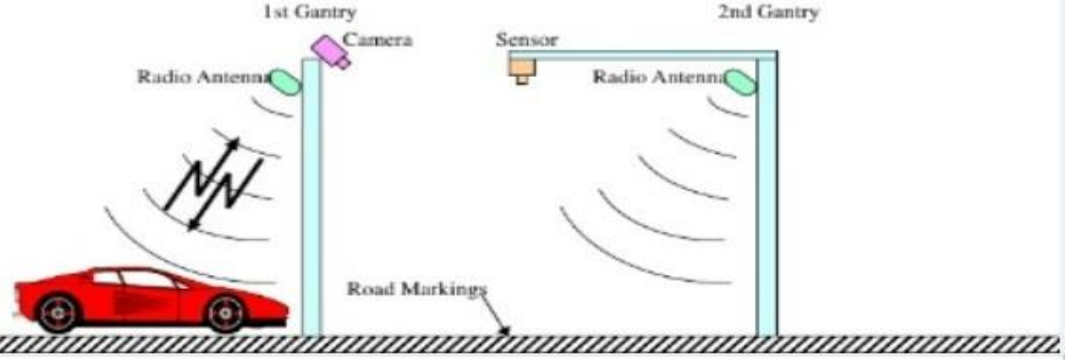
### CONTROL CENTRE

- Control centre houses the central computers and peripherals.
- Centre receives the records of all ERP transactions and records any faults in the equipment and digital images of violating vehicles.

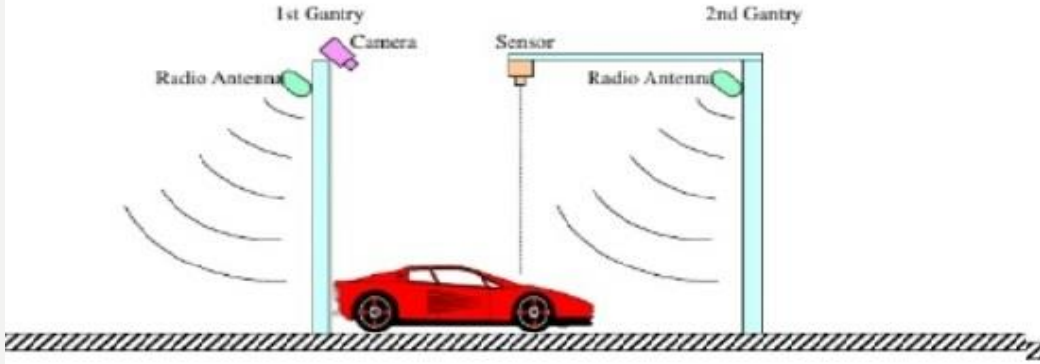
(1) Approach of Vehicle



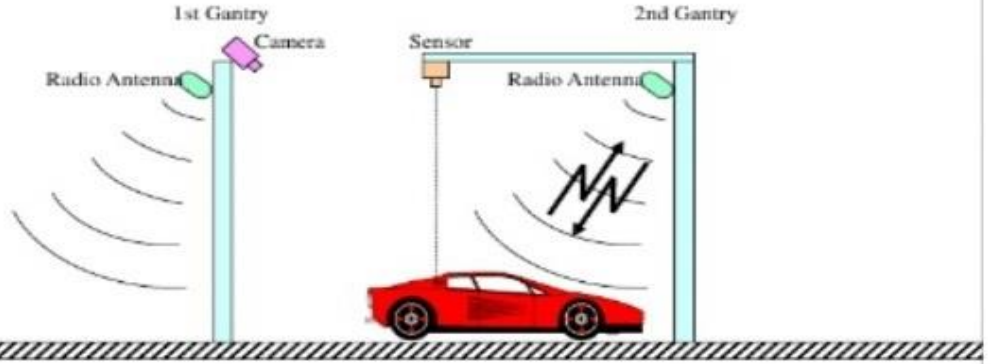

(2) Charging



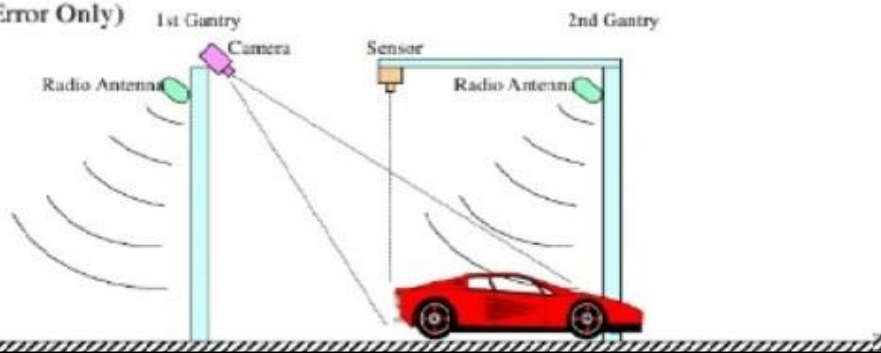

) Debiting
(IU-Cashcard)



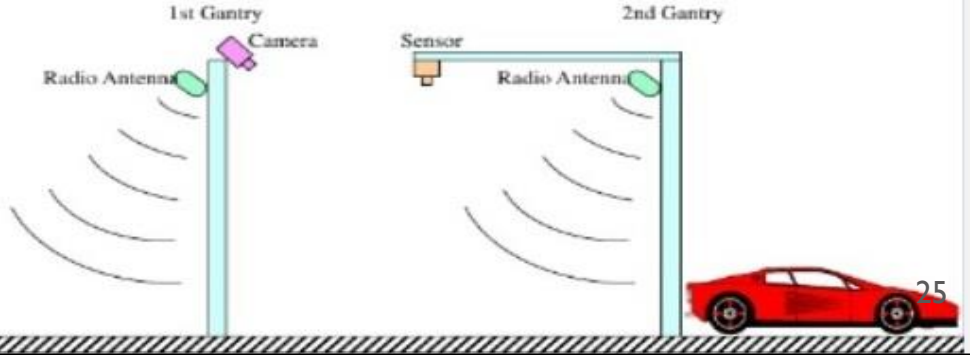

(4.1) Verification




(4.2) Capturing Photo (For Violation/Error Only)

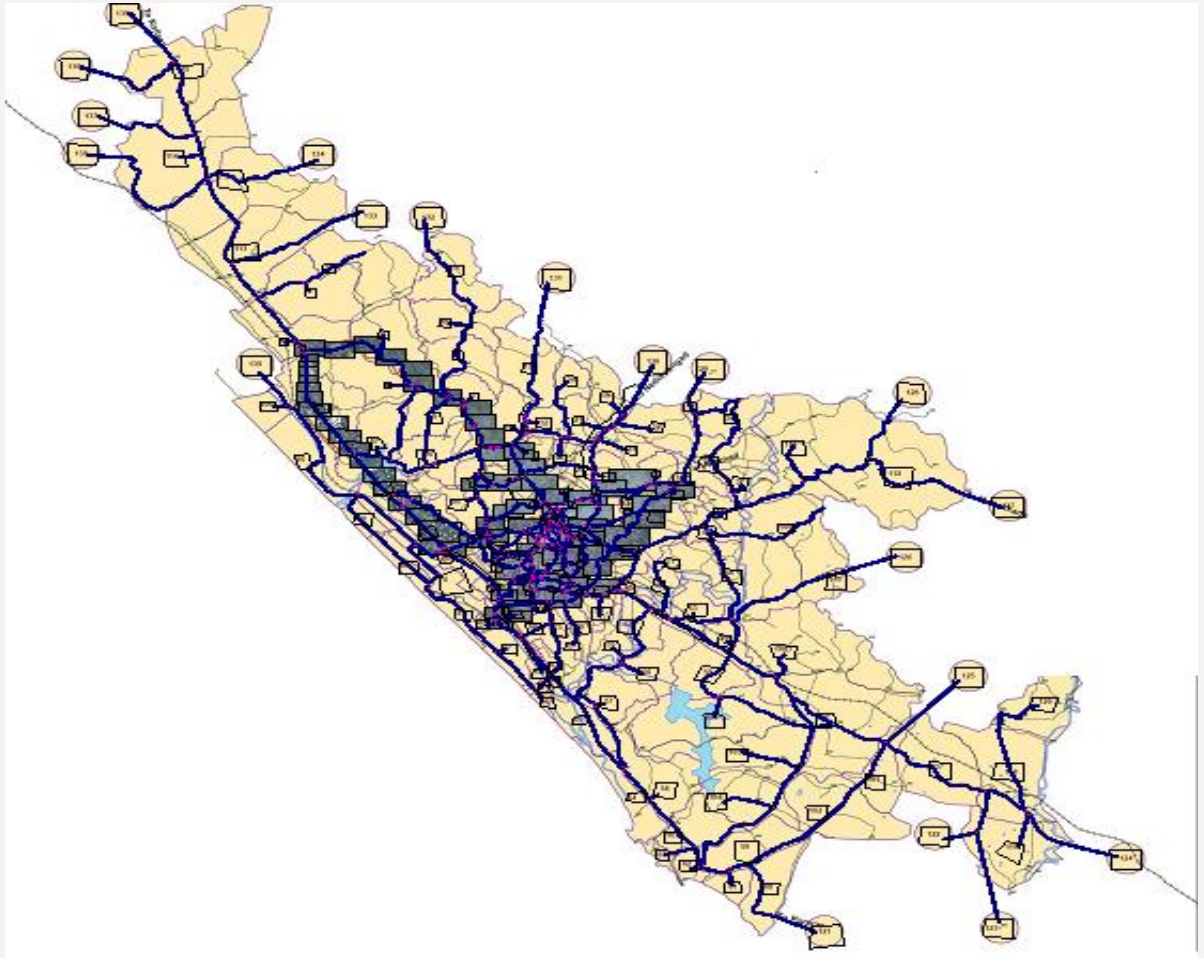



(5) Departure of Vehicle



# VISSIM SIMULATION

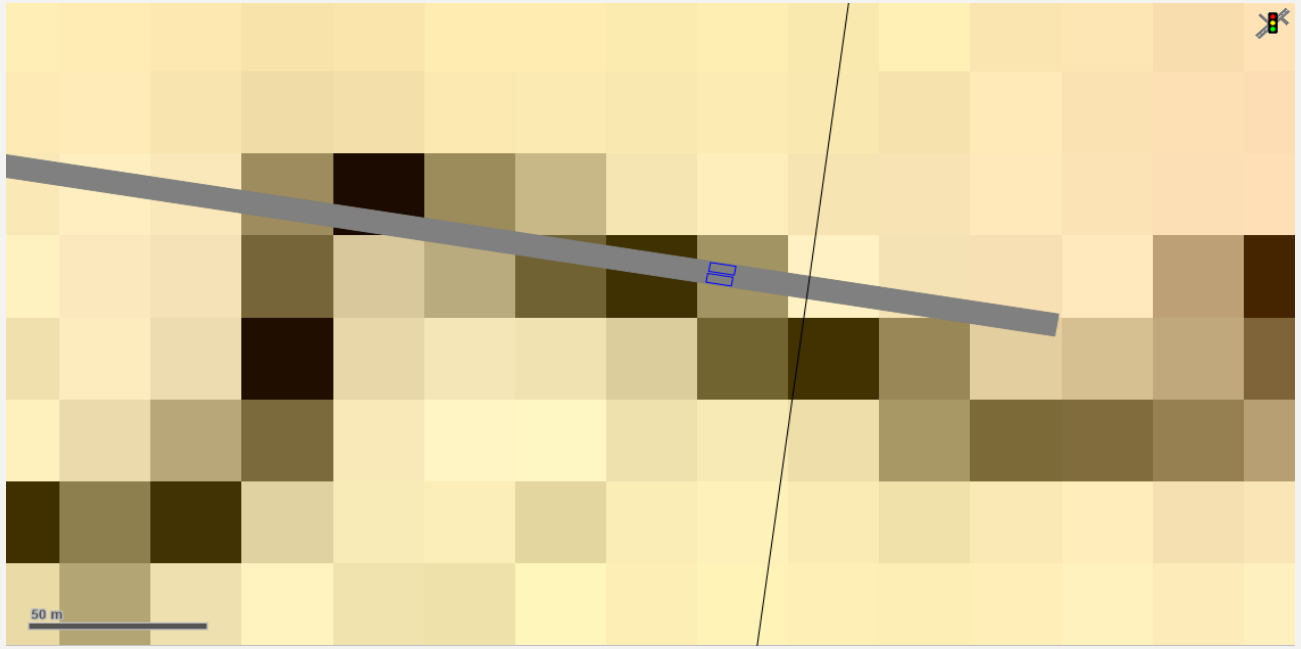
- Entire simulation is carried out using Vissim version 8.
- Simulation process consists of two conditions : - Present scenario & Congestion charging scenarios
- Congestion charging scenario is created by adding Link cost to the routes within the CBD



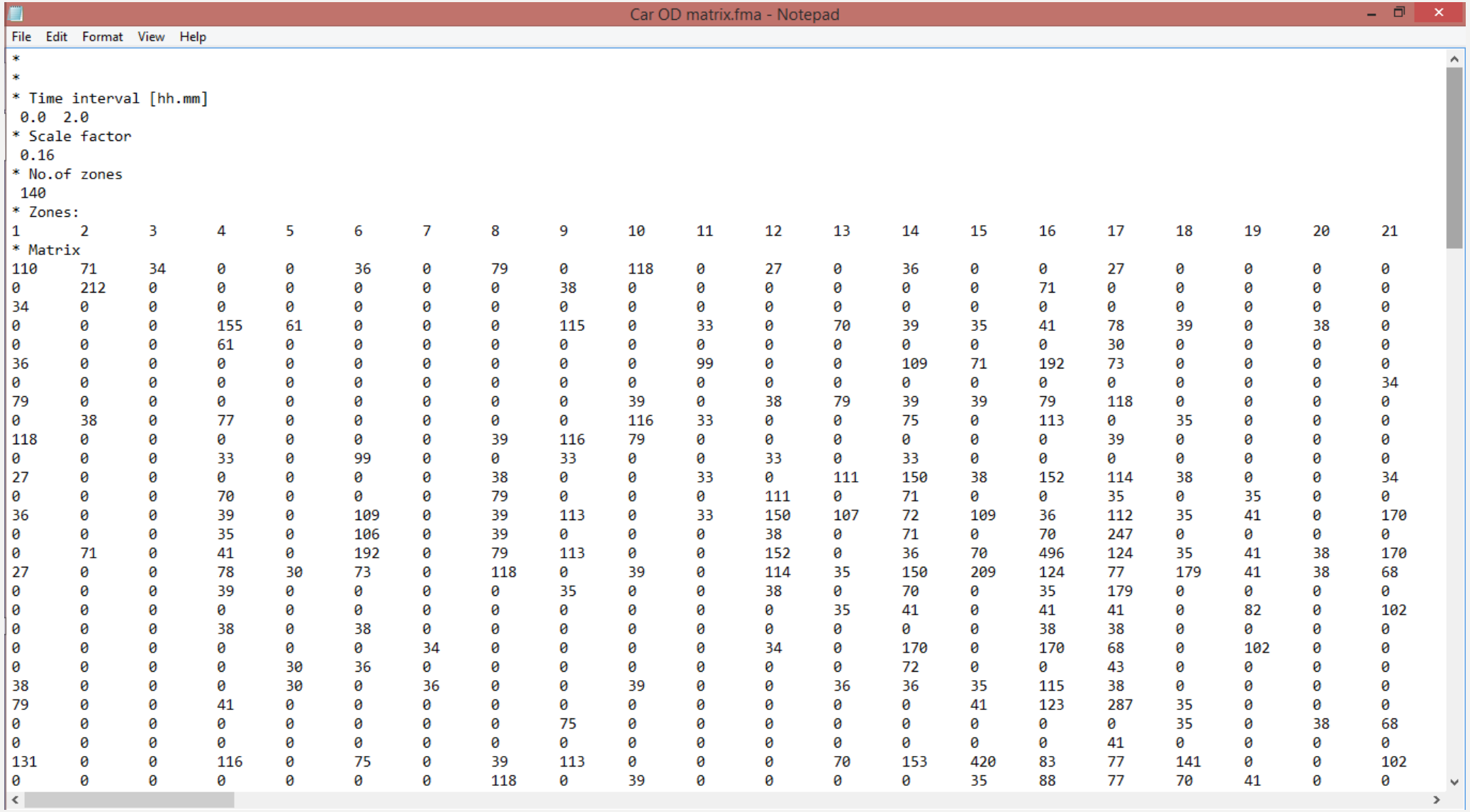
Snapshot of entire study area in PTV vissim 8

## DYNAMIC TRAFFIC ASSIGNMENT

- Dynamically assigning traffic flows as per the OD matrix.
- Individual OD matrix for each vehicle class has to be prepared .(140x140 matrix)
- Each zones has to be assigned as nodes in Vissim.
- Also nodes are created at all the junctions for dynamic assignment.
- Two Zone connectors(Parking lots) has to be added at each nodes for the generation and termination of vehicles.
- OD matrix should be in the .fma format .



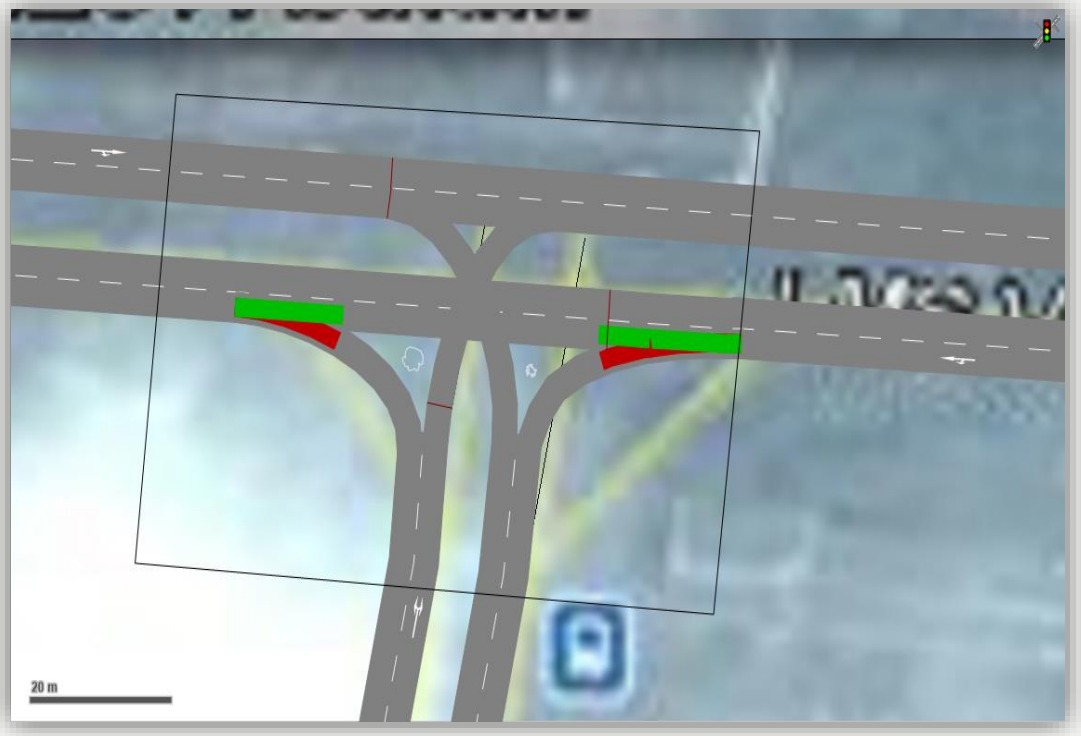

Zone connectors at node entry



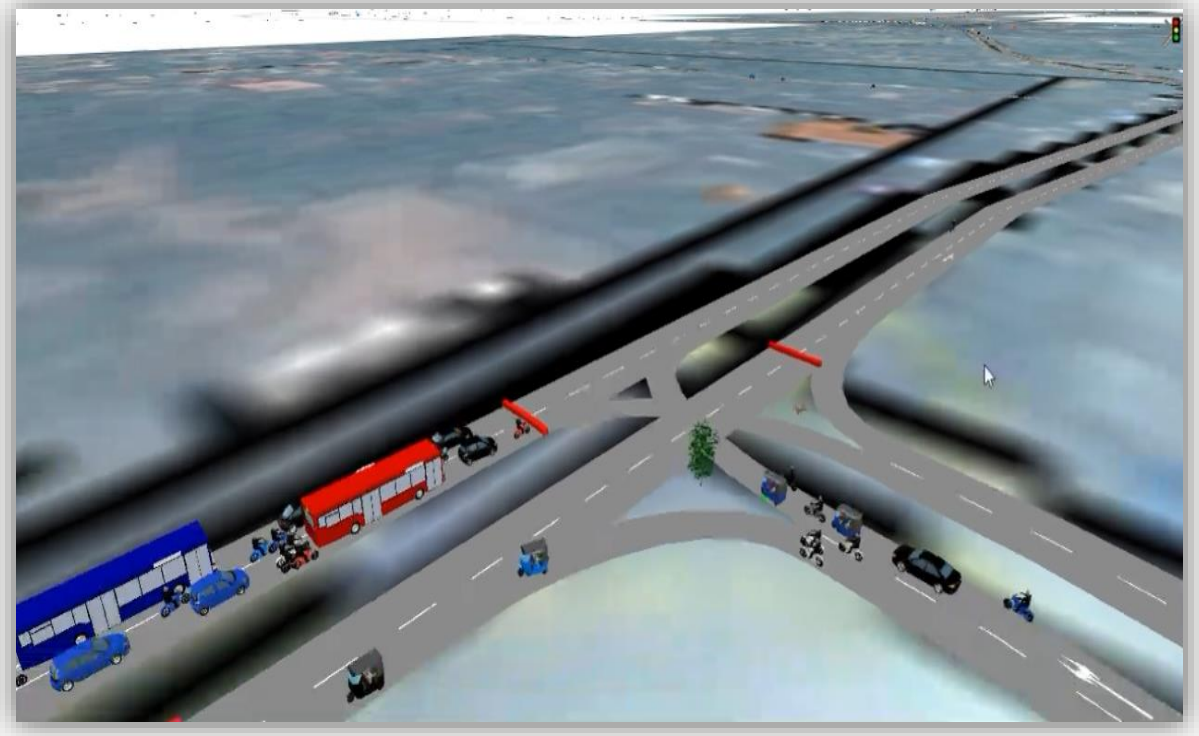

Car OD matrix file

## INTERSECTION REPRESENTATION

- The foremost aspect is to accurately represent the geometry defined by the number of approaches, width of each approach and turning space.



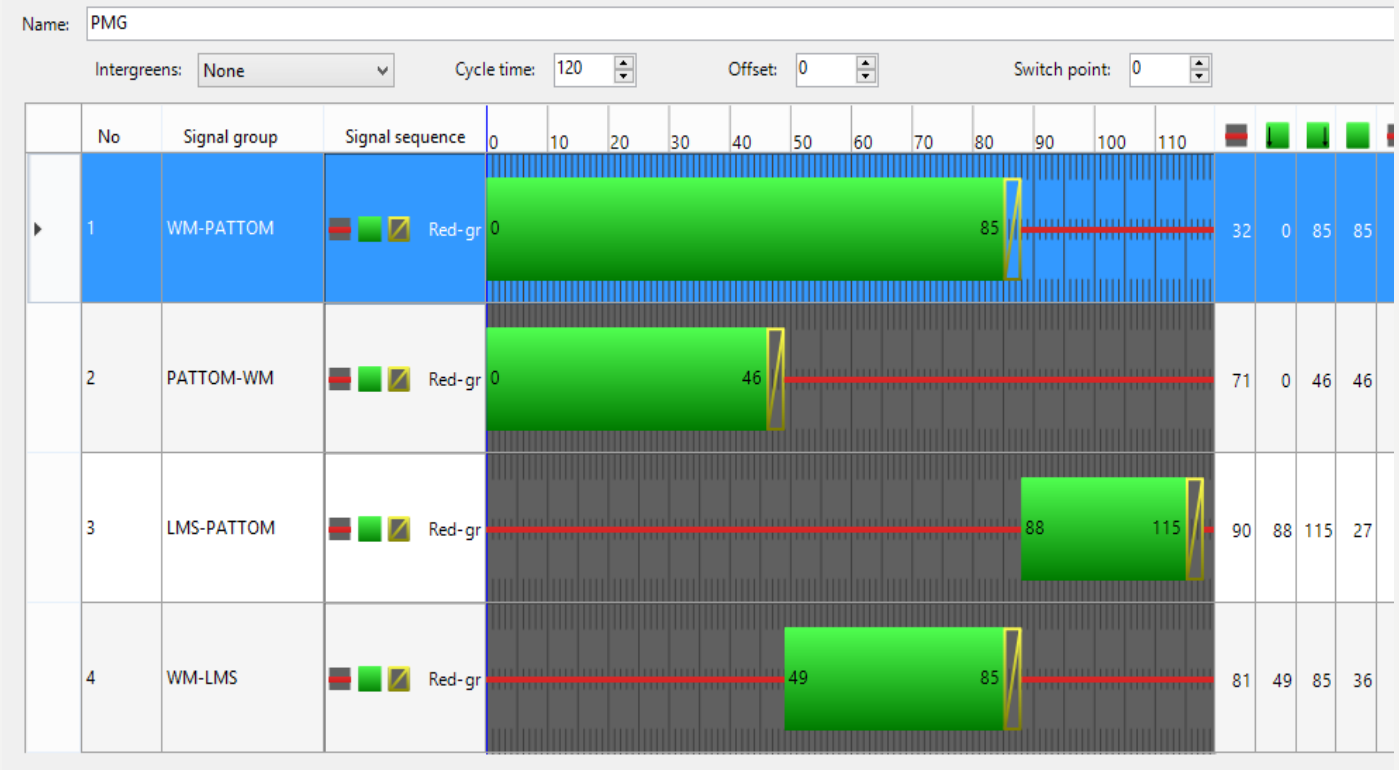

LMS junction



Realistic representation of LMS junction

# TRAFFIC SIGNAL CONTROLS

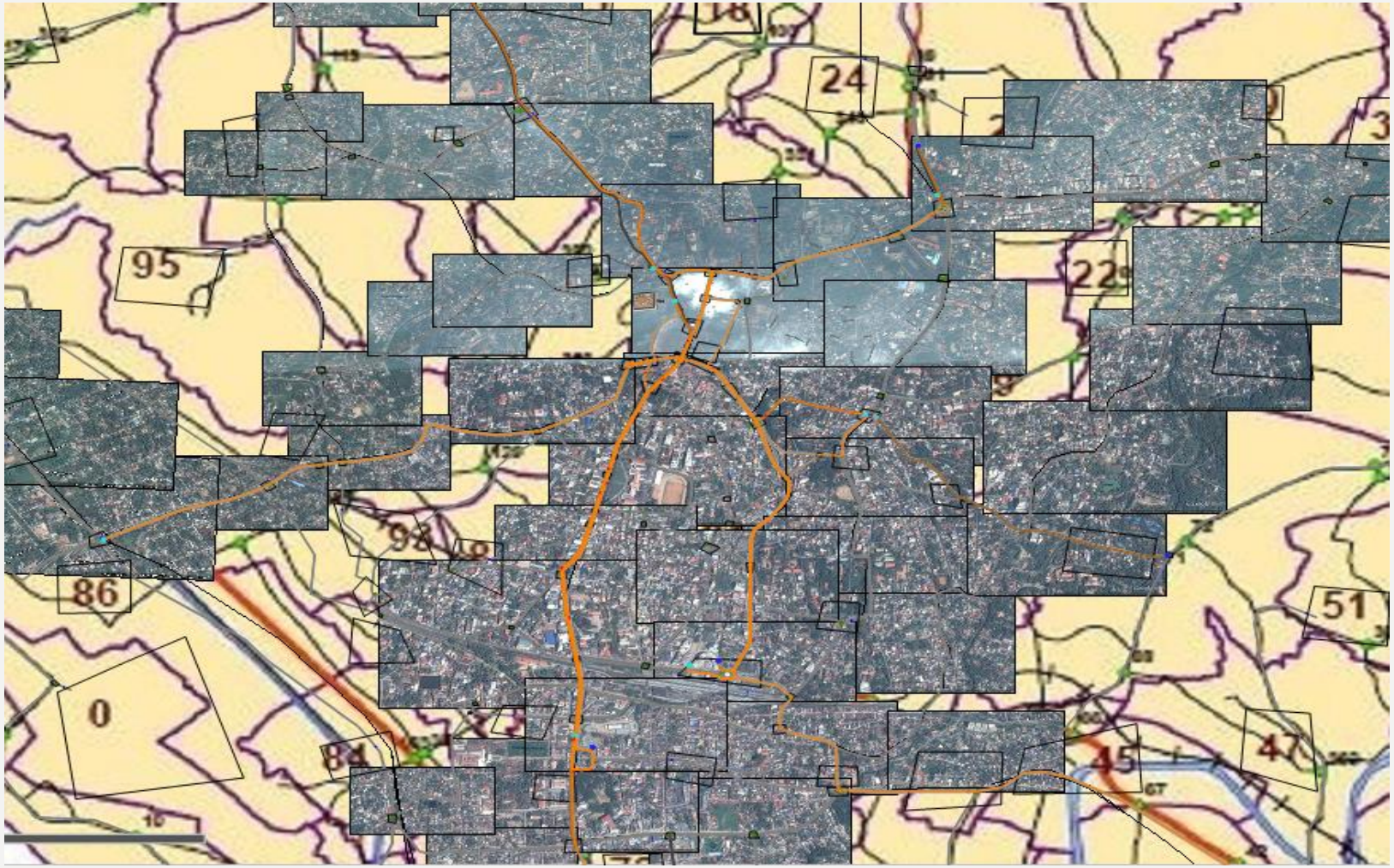
- In vissim each traffic signals are termed as signal controllers and each phase of a signal controllers as signal groups.
- Signal groups are the smallest control unit belonging to a signal controller assigned a unique id in vissim.
- All the 21 signals within the CBD are coordinated as in real by adding offsets



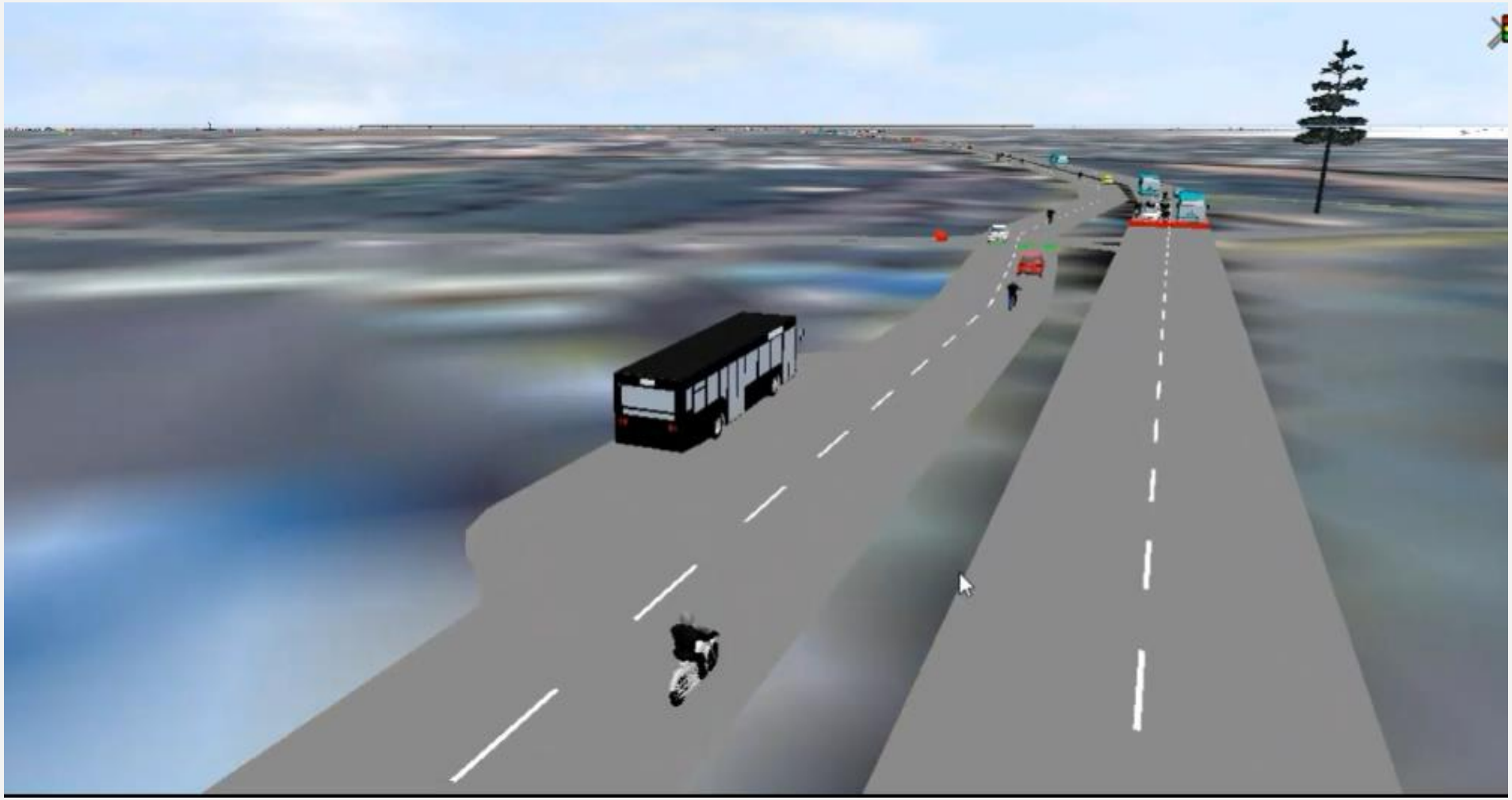

Signal groups at PMG junction

# PUBLIC TRANSPORT LINES AND STOPS

- 17 PT lines and 23 PT stops within CBD.
- Bus schedules during 8.00 am – 10.00 am is collected from KSRTC bhavan.




PT lines(orange coloured lines) within the CBD



Realistic representation of bus stopping at Saphalyam bus stop ,Palayam

# OVERALL NETWORK

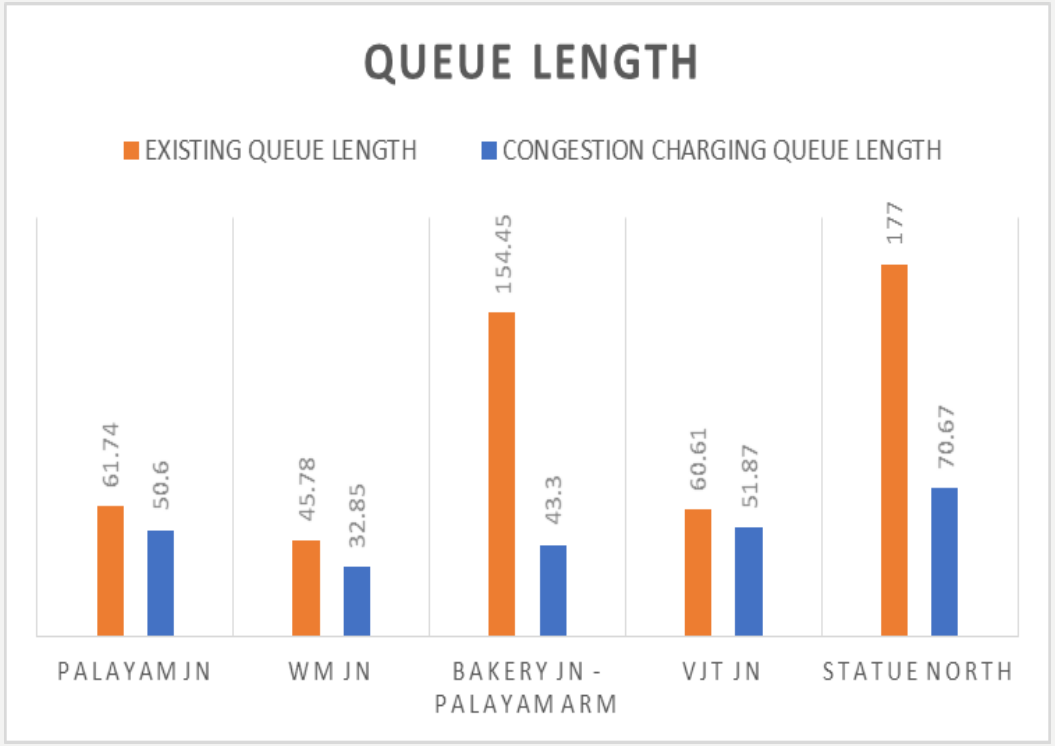
PMG - STATUE

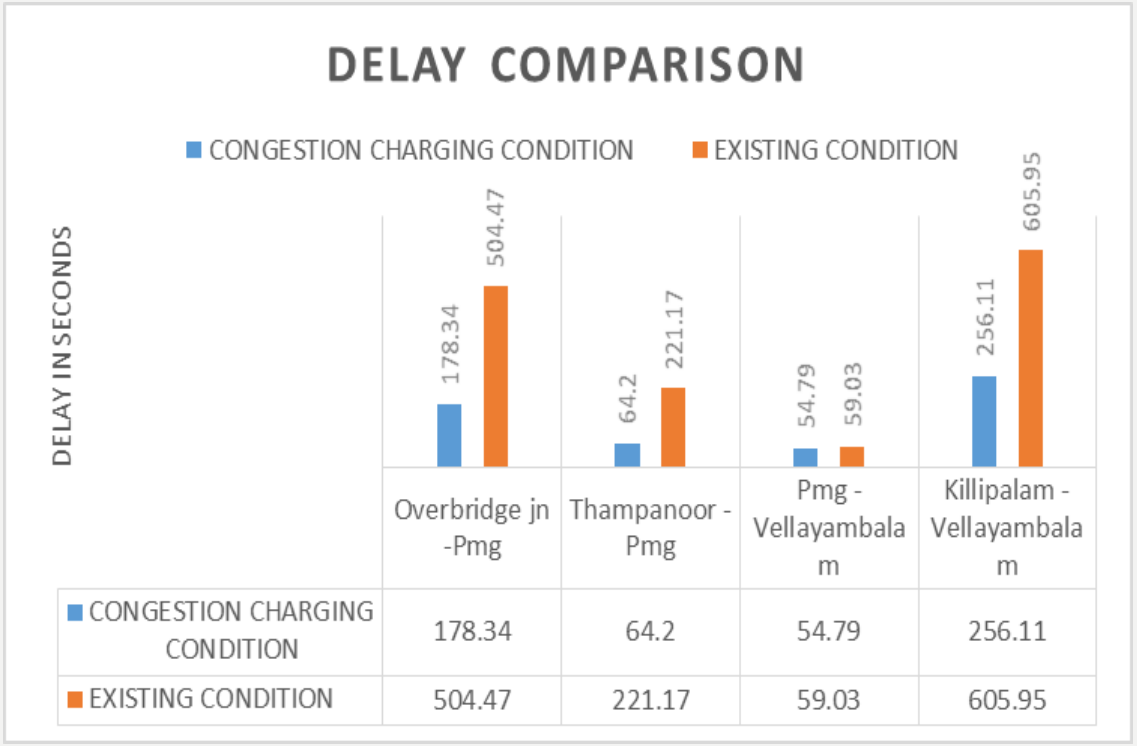
VELLAYAMBALAM - PMG

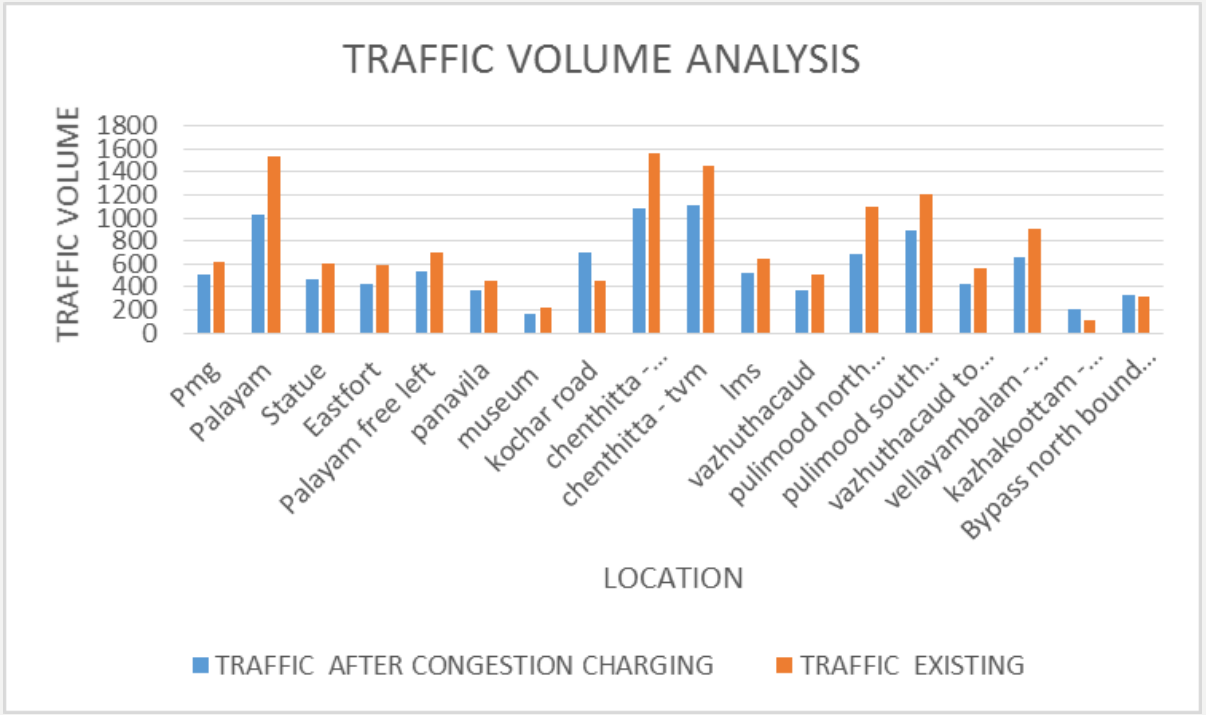
# THAMPANOOR - PALAYAM

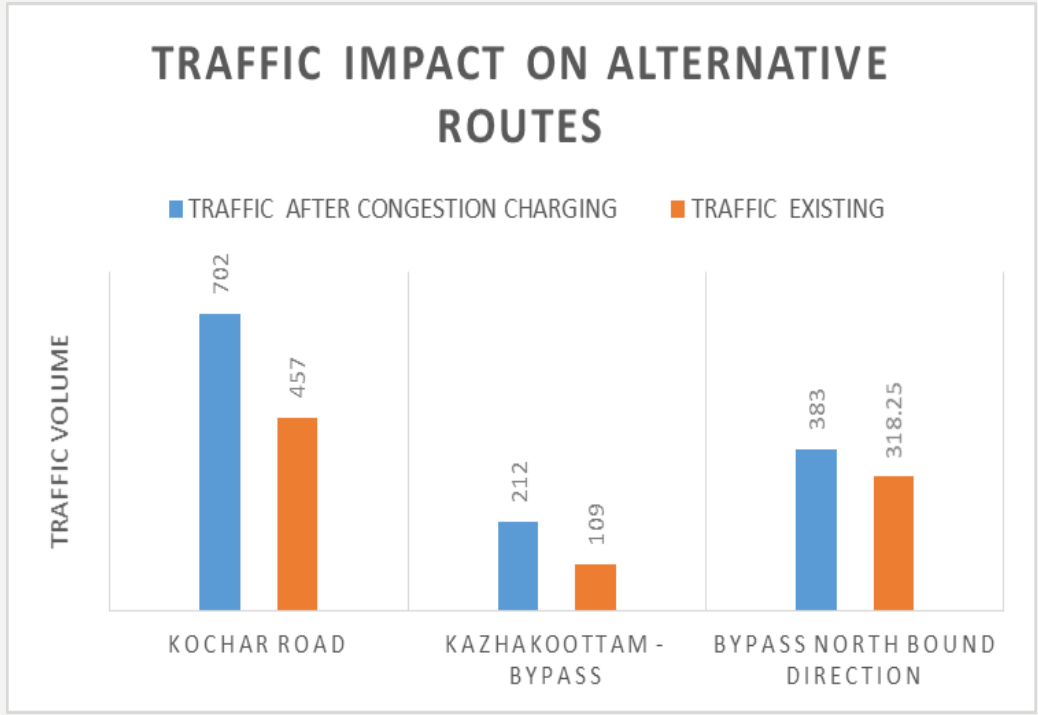
# SIMULATION RESULTS

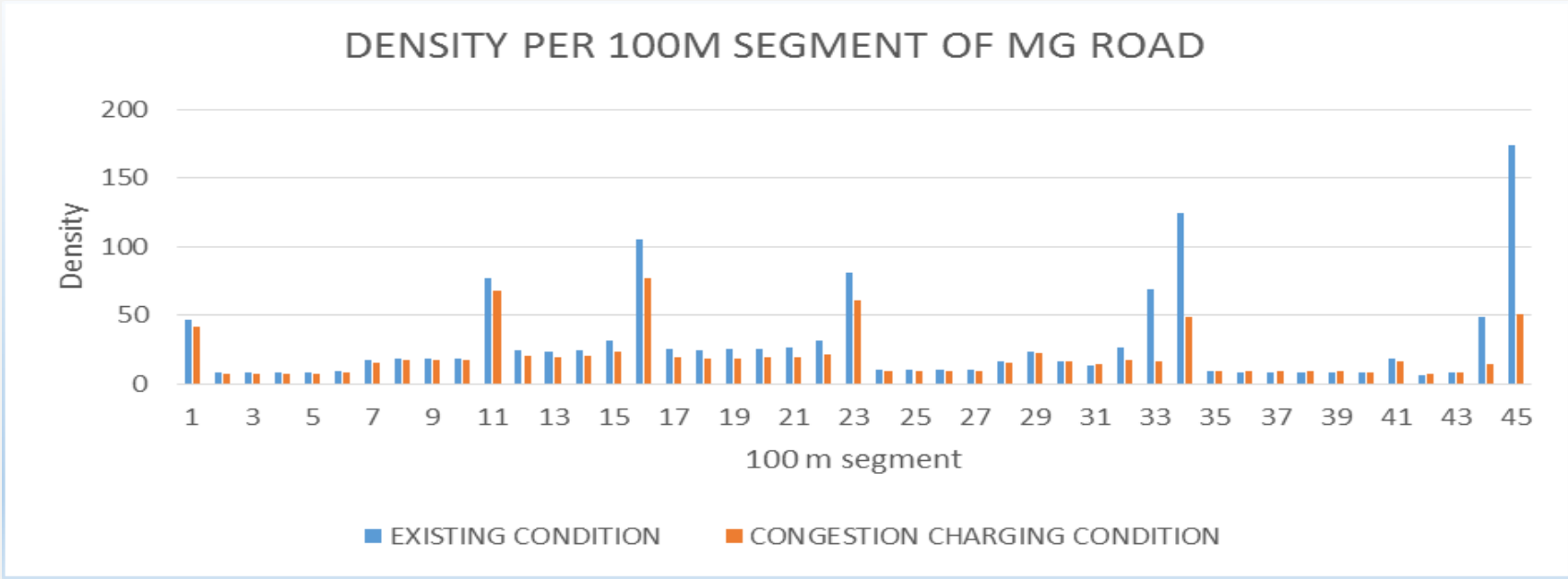
COMPARISON OF EXISTING CONDITION AND CONGESTION CHARGING CONDITION

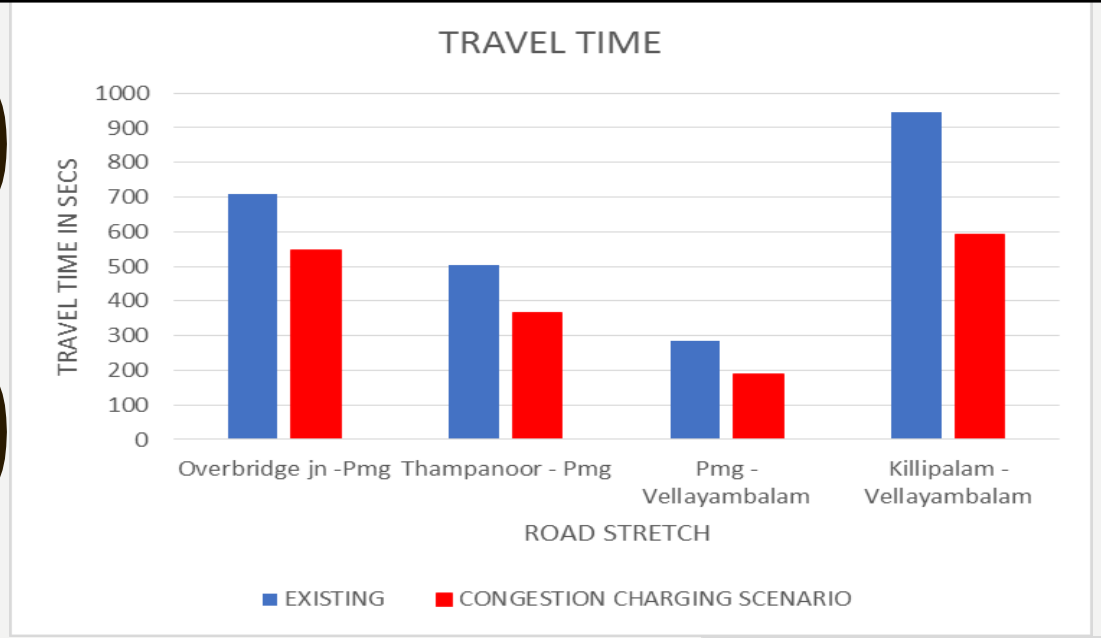


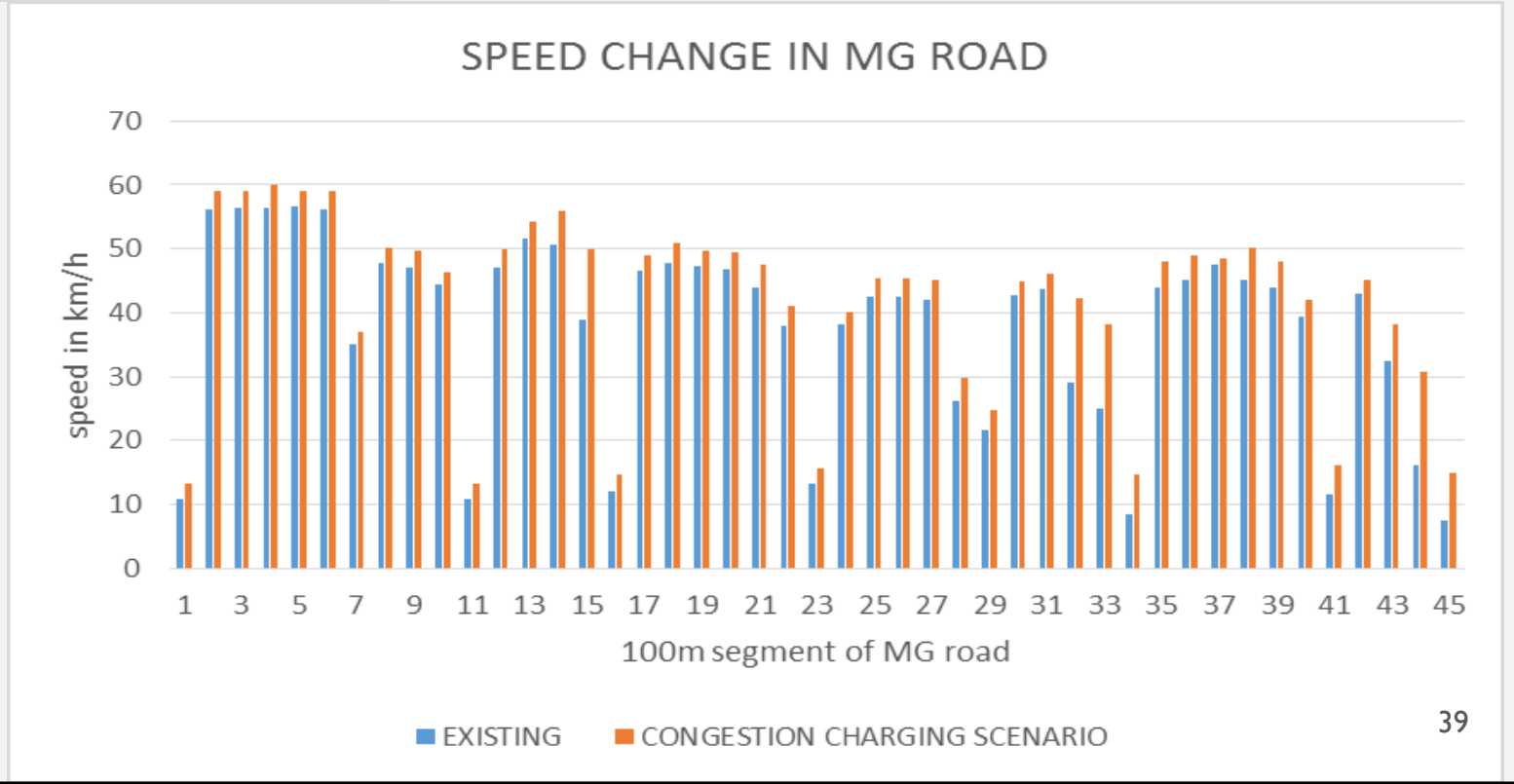



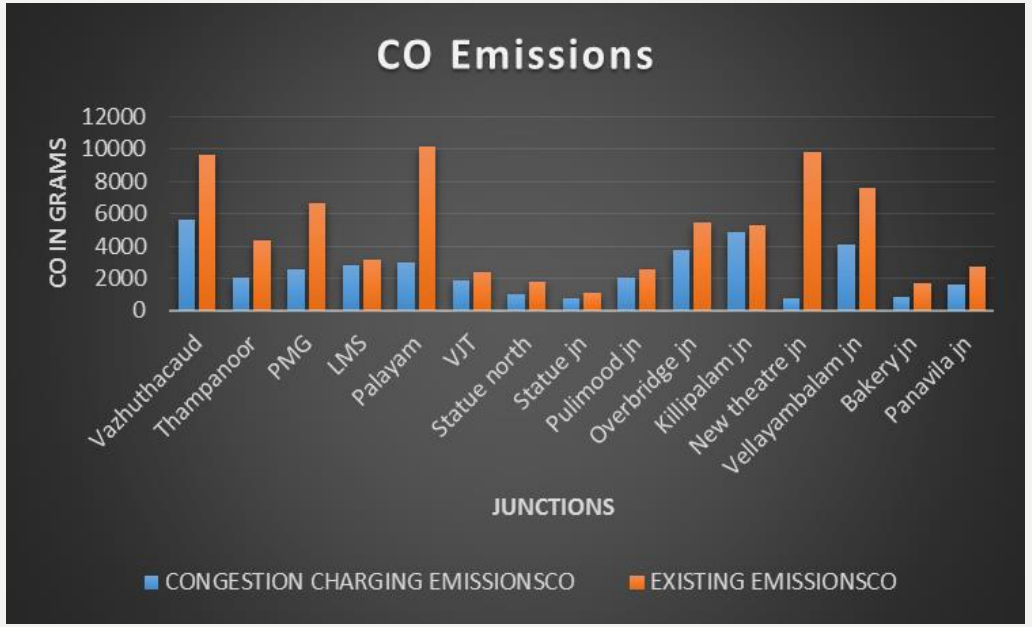

TRAFFIC VOLUME ANALYSIS
TRAFFIC VOLUME
1800
1600
1400
1200
1000
800
600
400
200
0
Pmg
Palayam
Statue
Eastfort
Palayam free left
panavila
museum
kochar road
chenthitta -...
chenthitta - tvm
lms
vazhuthacaud
pulimood north...
pulimood south...
vazhuthacaud to...
vellayambalam -...
kazhakoottam -...
Bypass north bound...
LOCATION
TRAFFIC AFTER CONGESTION CHARGING
TRAFFIC EXISTING

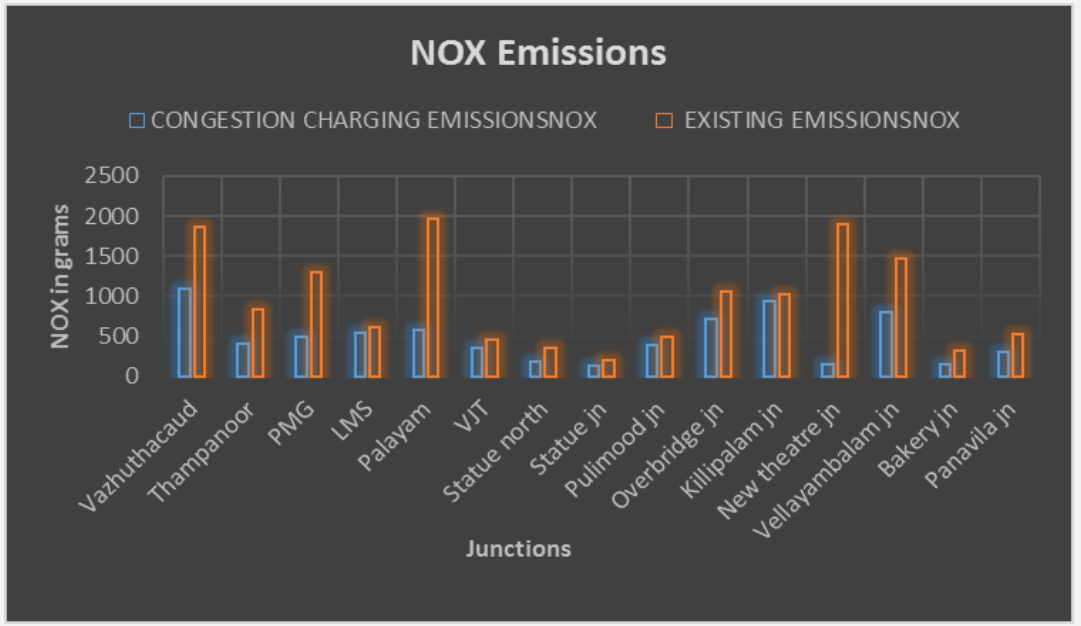

TRAFFIC IMPACT ON ALTERNATIVE ROUTES
TRAFFIC AFTER CONGESTION CHARGING
TRAFFIC EXISTING
TRAFFIC VOLUME
702
457
212
109
383
318.25
KOCHAR ROAD
KAZHAKOOTTAM - BYPASS
BYPASS NORTH BOUND DIRECTION

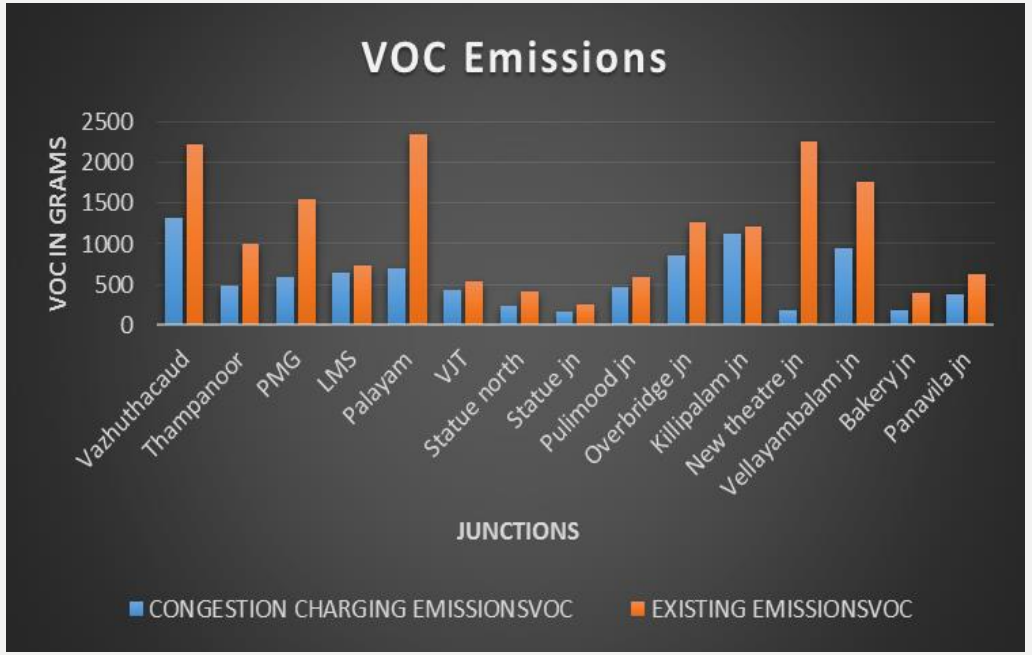

DENSITY PER 100M SEGMENT OF MG ROAD
Density
200
150
100
50
0
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
43
45
100 m segment
EXISTING CONDITION
CONGESTION CHARGING CONDITION

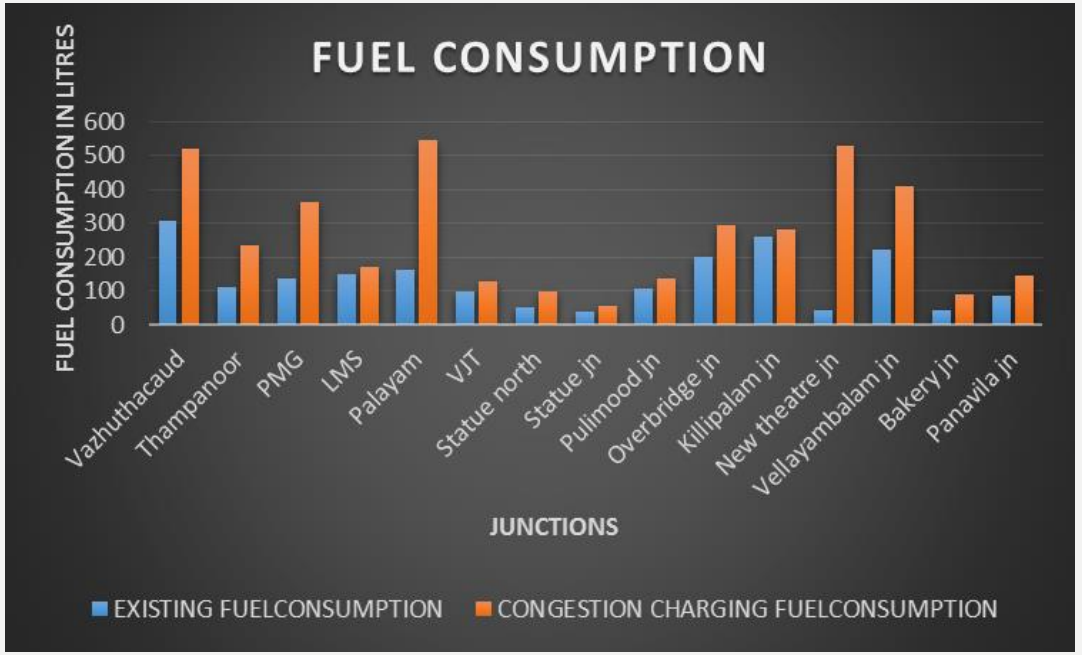

TRAVEL TIME
TRAVEL TIME IN SECS
1000
900
800
700
600
500
400
300
200
100
0
Overbridge jn -Pmg
Thampanoor - Pmg
Pmg - Vellayambalam
Killipalam - Vellayambalam
ROAD STRETCH
EXISTING
CONGESTION CHARGING SCENARIO


SPEED CHANGE IN MG ROAD
speed in km/h
70
60
50
40
30
20
10
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45
100m segment of MG road
EXISTING
CONGESTION CHARGING SCENARIO






# Above emission statistics are just for comparative study only. Actual values may vary

# CONCLUSIONS

- Congestion charging can be effectively implemented as a TDM strategy to reduce congestion and its ill effects.
- Study reveals that congestion and its ill effects can be effectively reduced to a great extent inorder to provide better mobility in Thiruvananthapuram city.
- As a result of congestion charging, queue lengths at major intersections get reduced by 38%
- Overall delay in CBD area get reduced by 44%.
- Overall traffic volume at intersections has been reduced by 25%.
- Kochar road had the major impact after congestion charging. Traffic at kochar road has been doubled.
- Density along mg road has been reduced by 15.3% .
- An overall travel time reduction of 48% has been observed in the cbd area.
- Speed of vehicles has been increased by 16%.
- Emissions within the cbd get reduced by 40%.Also significant reduction in fuel consumption observed

# RECOMMENDATIONS

- Use of models or tools  to forecast  and compare effects with respect to change in traffic participating congestion charging.
- Invest in alternative travel options
- Make sure people understand how to use the system.
- Focus on impacts

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# THANK YOU