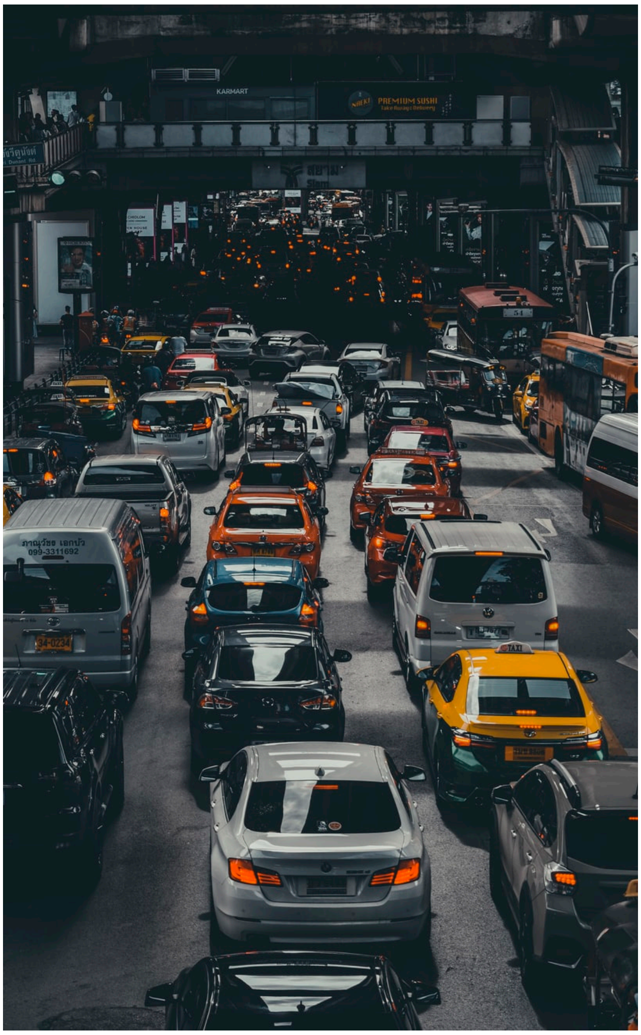
ENGINEERING DESIGN- II PROJECT REPORT

Traffic Flow Modelling



Group 8, Team C

June 2022

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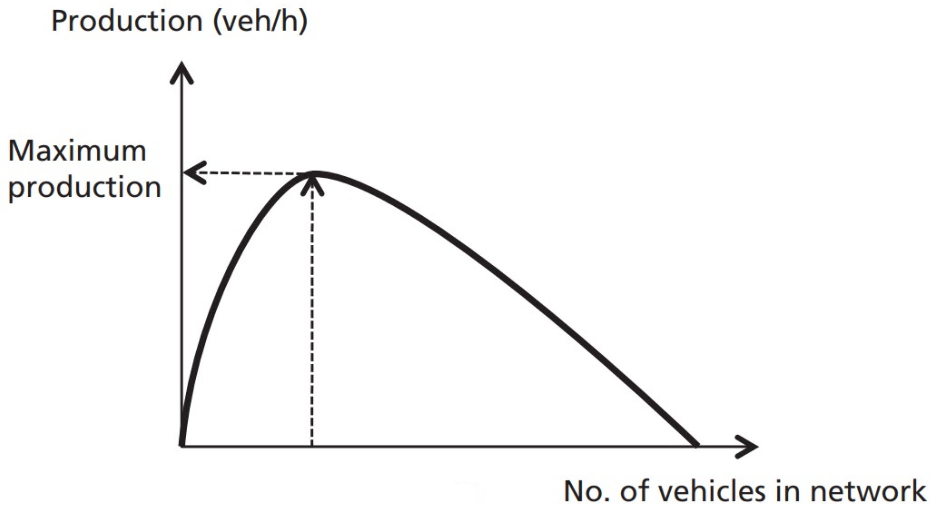
Motivation

- Not everything is solved by the development of public transport. In our city, it is planned to build a subway for 20 years, but the zones of the city are developed according to their own laws without taking into account the plans laid down for the metro, and therefore part of the dug canals under the ground do not meet today's needs. Similarly, with the development of cycling and pedestrian zones.
- In countries with sharply continental weather in the cold season, it is unlikely that the city dweller will choose a bicycle instead of his personal car while the temperature's below 20 °C. Bus routes can have a certain effect, but again, dedicated lanes are needed (consider adjustments to the law and traffic regulations) and the replacement of a fleet for more comfortable trips as well as more developed routes. Inspection of road regulation(the police) is not as much interested in solving the problems of traffic congestion.

- The main indicator of the success of their work is the minimum number of accidents and victims on the roads. Therefore, the lower the traffic flow rate or its "standing", the calmer. Thus, what solution can really be implemented in cities where there are no autonomous and flying cars, where the budget is not enough to build monorails and tunnel stations (junctions) to connect metro, buses and other vehicles in rooms with comfortable conditions.

Summary of ED-I

- Traffic flow theory and modeling are important in order to design comfortable and safe roads, to solve road congestion problems and to design adequate traffic management measures, amongst other things.
- In traffic flow theory a basic distinction is made between microscopic and macroscopic traffic flow variables. Microscopic traffic flow variables focus on individual drivers. Macroscopic traffic flow variables reflect the average state of the traffic flow.
- The fundamental diagram in traffic flow theory describes a statistical relation between the macroscopic flow variables of flow, density and speed. The basic premise underlying the fundamental diagram is that under similar traffic conditions drivers will behave in a similar way.
- Traffic flow models can be used to simulate traffic, for instance to evaluate ex ante the use of a new part of the infrastructure. Models can be categorized based on, firstly, representation of the traffic flow in terms of flows (macroscopic), groups of drivers (macroscopic) or individual drivers (microscopic) and, secondly, underlying behavioral theory, which can be based on characteristics of the flow (macroscopic) or individual drivers (microscopic behavior).
- The overall dynamics of a traffic network can be described using a remarkably simple relation, referred to as the macroscopic or network fundamental diagram (NFD). This relation shows one of the most important properties of network traffic operations, namely that their performance decreases when the number of vehicles becomes greater.

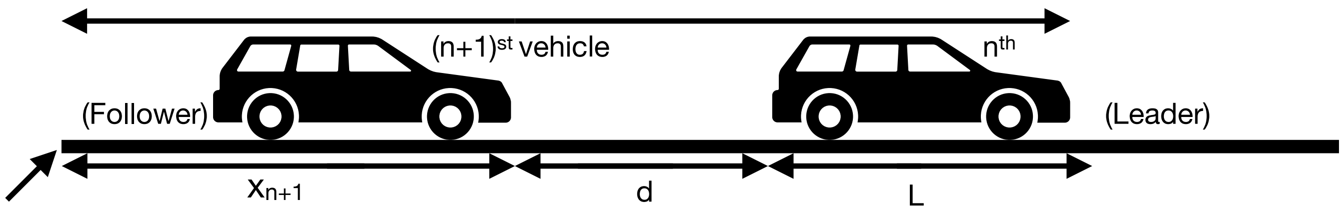


Example of the network fundamental diagram

Work Description

This model is based on “Follow the leader” theory.
Following another vehicle on a single lone highway with no passing allowed has been characterise as one of the driving takes by R W Rothery.

Let suppose:



Assume it to be the starting point (x=0)

We can write;

$\mathbf{x_n(t) - x_{n+1}(t) = L + d}$ .....(1)

Where,

d = distance between 2 vehicles (also known as headway)

L = length of vehicle

If road length = L_r

Number of vehicles on road = N_r

Then,

$$L_r = (L + d)N_r$$

$$N_r = (L_r / (L + d))$$

$$N_r / L_r = 1 / (L + d) = \varrho \text{ (density)}$$

As we know;

$$x_n(t) - x_{n+1}(t) = L + D$$

$$\varrho = (1 / (x_n(t) - x_{n+1}(t)))$$

Follow the leader Concept :

Response = Stimulus . Sensitivity

Response → acceleration/ deceleration of Driver

Stimulus → Relative distance between follower and leader

Or

Difference in speed

Or

Speed of leading car

Sensitivity →Parameter (vary as per model)

Mathematically,

If $x_n(t)$ is position of a n^{th} vehicle at time t

Then dx_n/dt is speed of a n^{th} vehicle at the t

And d^2x_n/dt^2 is acceleration of :

$$(d^2x_{n+1}(t)) / (dt^2) = -K_p (dx_{n+1}(t)/dt - dx_n(t)/dt)$$

Acceleration/ Deceleration of follower vehicle

Sensitivity parameter (Dimension of K_p is per unit time)

Stimulus → speed difference between n^{th} or $(n+1)^{th}$ vehicle

$$(d^2x_{n+1}(t)) / (dt^2) = -K_p (dx_{n+1}(t)/dt - dx_n(t)/dt)$$

If $dx_n/dt > dx_{n+1}/dt$

i.e. leader is fast then follower could naturally accelerate,

$\Rightarrow (d^2x_{n+1} / dt^2) > 0$

$\Rightarrow K_p < 0$

If $dx_n/dt < dx_{n+1}/dt$

i.e. follower decelerate,

$\Rightarrow (d^2x_{n+1} / dt^2) < 0$

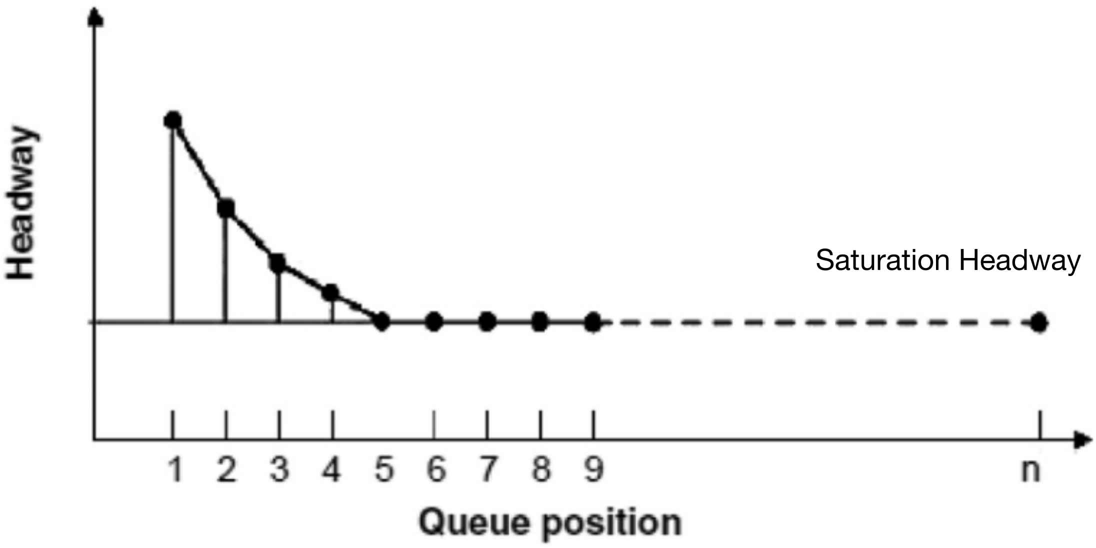
$\Rightarrow K_p > 0$

So $K_p \rightarrow$ keeps on changing

$$\mathbf{(d^2x_{n+1}(t)) / (dt^2) = -K_p (dx_{n+1}(t)/dt - dx_n(t)/dt)}$$

Put n = 1,2,3,... N where N is number of cars on the road section under conditions. We get a system of N 2nd order ordinary differential equations and further they are coupled.

Discharge Headways



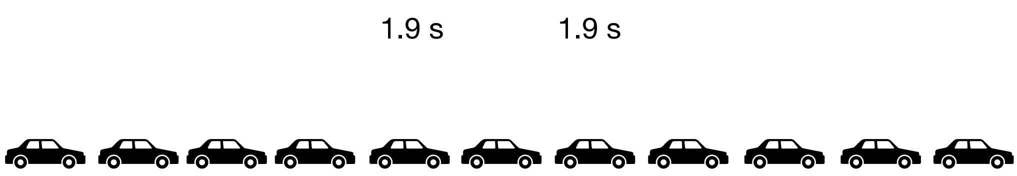
Headway between front of the queue are greater than the middle of the queue.

Start of green	Vehicle 1	3.2 sec	Start up condition
Vehicle 1	Vehicle 2	2.9 sec	
Vehicle 2	Vehicle 3	2.6 sec	
Vehicle 3	Vehicle 4	2.2 sec	
Vehicle 4	Vehicle 5	1.9 sec	Saturation Headway
Vehicle 5	Vehicle 6	1.9 sec	
Vehicle 6	Vehicle 7	1.9 sec	
Vehicle 7	Vehicle 8	1.9 sec	

Saturation Headway

It is the average headway measured in seconds per vehicle that can be achieved by a saturated stable moving queue passing through a signal (and in this case that's 1.9 sec per vehicle)

(1) Assume that the signal is always green and never red and a stable queue that is infinity long.



Saturation flow rate; (Vehicles per hour of green per lane)

3600/1.9 = 1895 Vphgpl

→ We can see that a lane has capacity to service 1895 V per hour of green time.

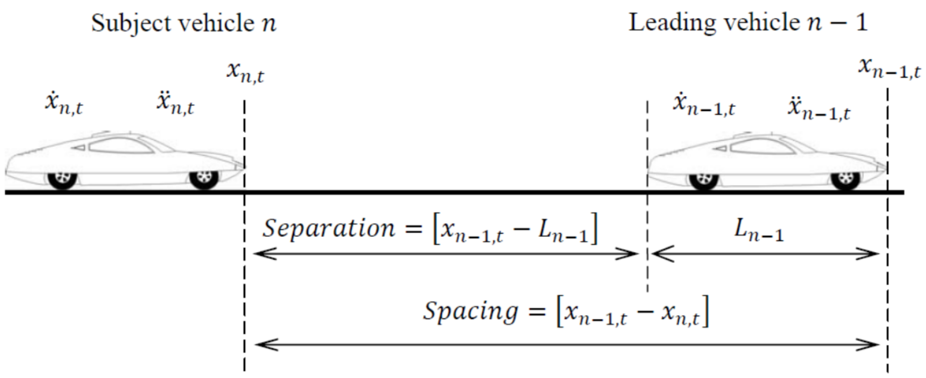
(2) But in reality, signal sometime greens or sometimes red.

→ Now assume that the lane is green only just 33% of the hour.

Saturation flow rate; 0.33 * 1895 = 625 Vphgpl

→ Capacity = 625 vehicles per hour

Analysis of Design



x_{n-1} is the position of a leading vehicle n-1 at time t.
x_n is the position of following vehicle n at time t.
x'_{n-1},t is the speed of a leading vehicle n-1 at time t.
x'_n,t is the speed of the following vehicle n at time t.
L_{n-1} is the length of the leading vehicle.
$[x_{n-1}-x_n]$ is the spacing between the two vehicles at time t.
$[x_{n-1}-x_n]$-Ln-1 is the separation between the two vehicles at time t.

Models we tried to implement are as follows:

1.) Pipes Model:-

$x_{n-1}=x_n+[b+Tx'_n]+L_{n-1}$

Where:
b is the distance when vehicles are at standstill in feet.
T is a time constant in sec (T=1.023sec)

Minimum vehicle separation distance will be:

$$d_{min}=[x_{n-1}-x_n]=c+Tx'_n$$

Where:
$c=b+L_{n-1}$ is a constant.

But Pipe's model predicts that roadway capacity occurs when speed is infinite, which is unrealistic.
And the driver reaction time component was not considered.
So, the next model came to solve this problem.

2.) Forbe's Model:-

The model assumed that a driver of a subject vehicle maintains minimum safe time headway at least equal to the driver reaction time. This time headway is the summation of the driver reaction time and the time taken to travel a distance equivalent to the length of a leading vehicle.

$$h_{min}=\triangle t+(L_{n\text{-}}1/x'_n)$$

Where:
t is the driver reaction time.
L_{n-1} is the length of the leading vehicle.
h_{min} is the minimum headway.

Field results indicated considerable variations between the actual field measured and that obtained from Forbe's model and for different drivers.

3.) By introducing driver response time lag:-

In this model, the spacing between two consecutive vehicles in the queue is expected to depend on velocities of vehicles. For simplicity, the model assumed a linear function of the following the form:

$$[x_{n-1,t-\triangle t} - x_{n,,t-\triangle t}] = \beta x''_{n,t}$$

The model was further improved by assuming that vehicle separation is proportional to both speed of the subject vehicle and the leading vehicle. The developed model has the following form:

$$[x_{n-1,t-\triangle t} - x_{n,,t-\triangle t}] = \alpha [x''_{n-1,t-\triangle t}]^2 + \beta_1 [x'_{n,t}]^2 + \beta_2 [x'_{n,t}] + b$$

Where:
β_1 and β_2 are constants and other notations.

But still stimulus and Response were not considered.

The model assumes similar acceleration and deceleration response aggressiveness, which is unrealistic. Drivers' behavior for acceleration and deceleration responses may be different because the need for acceleration and deceleration are different.

4.)Stimulus-Response Models:-

Response = f (Sensitivity, Stimuli)

$$x''_{n,t} = \alpha[x'_{n-1,t-\triangle t} - x'_{n,t-\triangle t}]$$

Where:

t is the driver response time lag.

$x''_{n,t}$ is the acceleration/deceleration of a subject vehicle n at time t.

$x'_{n-1,t-\triangle t}$ is the speed of a leading vehicle n-1 at time t-△t.

$x'_{n,t-\triangle t}$ is the speed of subject vehicle n at time t-△t.

$[x'_{n-1,t-\triangle t} - x'_{n,t-\triangle t}]$ is the relative speed between the two vehicles at time t-△t.

α is the driver sensitivity parameter.

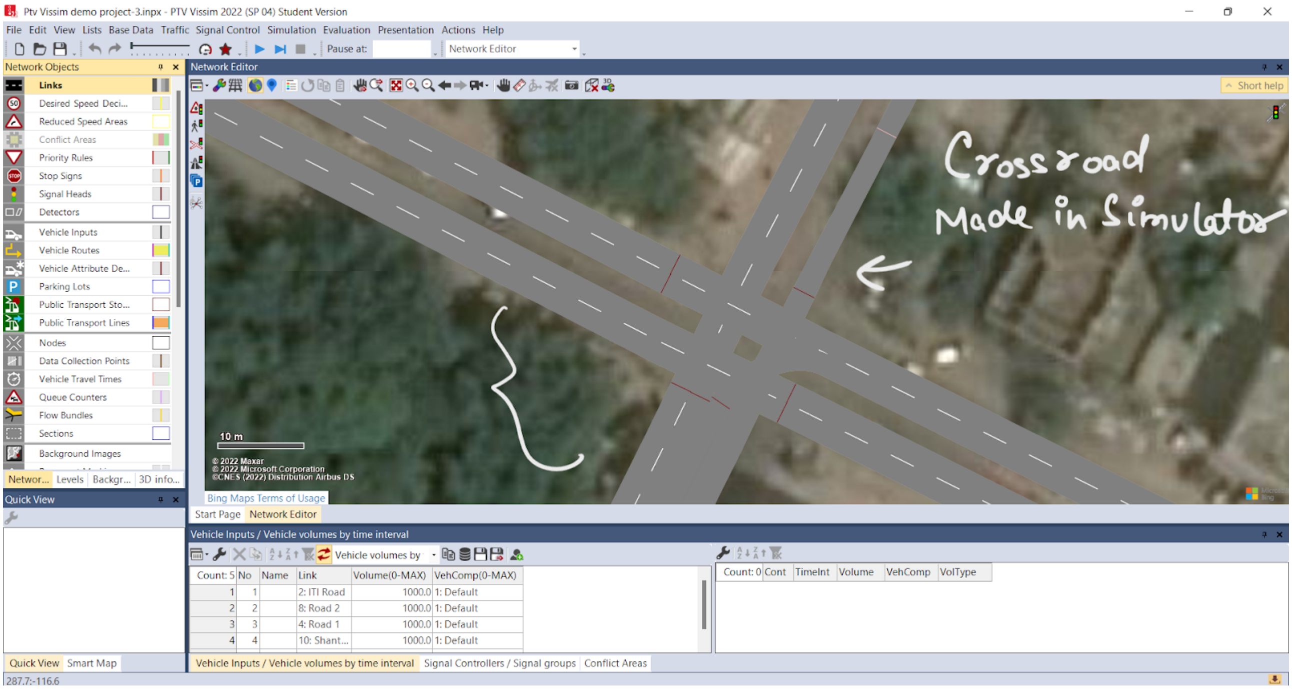
After some more improvements we finally reached our model which is described in the Work Description.

Conclusion:

Our model basically depends on variables of speed, flow, and concentration. These relationships are mainly concerned with uninterrupted traffic flow, primarily found on freeways or expressways.
[1] Flow conditions are considered "free" when less than 12 vehicles per mile are on a road. "Stable" is sometimes described as 12–30 vehicles per mile per lane. As the density reaches the maximum flow rate (or flux) and exceeds the optimum density (above 30 vehicles per mile), traffic flow becomes unstable, and even a minor incident can result in persistent 'stop-and-go driving' conditions. "Breakdown" condition occurs when traffic becomes unstable and exceeds 67 vehicles per mile.
[2] "Jam density" refers to extreme traffic density associated with completely stopped traffic flow, usually in the range of 185–250 vehicles per mile per lane.
However, calculations within congested networks are more complex and rely more on empirical studies and extrapolations from actual road counts. Because these are often urban or suburban in nature, other factors (such as road-user safety and environmental considerations) also dictate the optimum conditions.

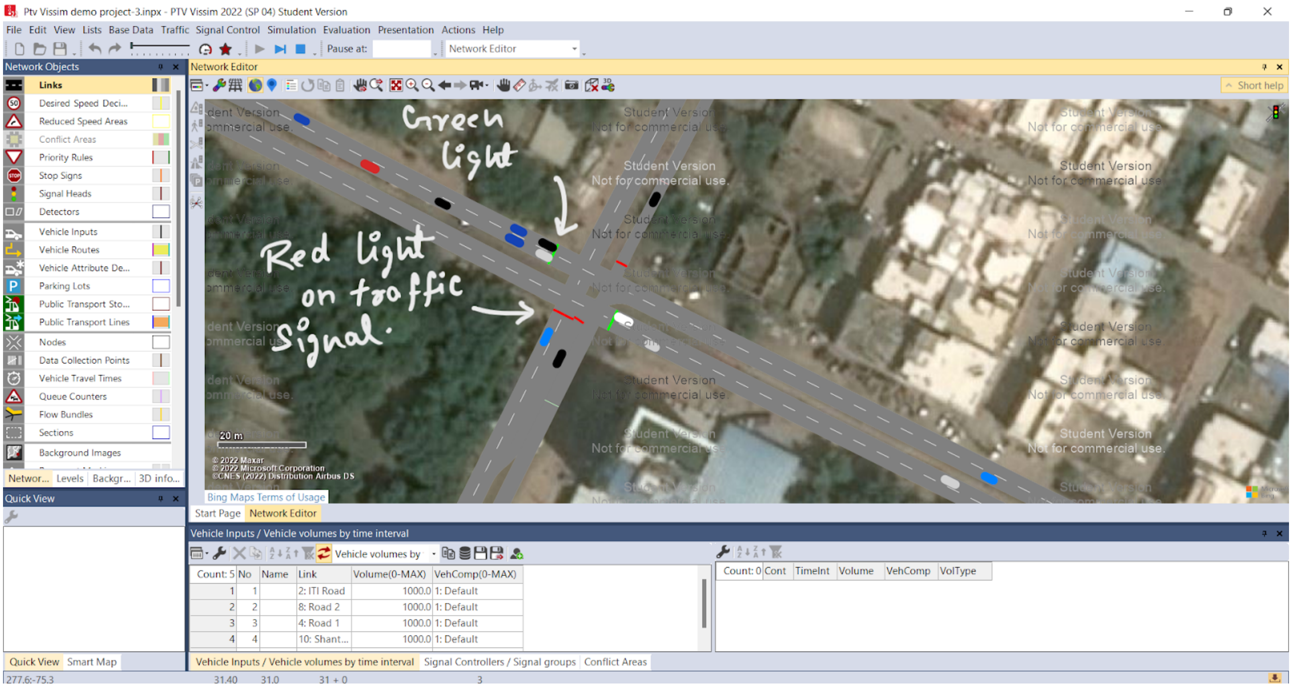
Modeling and Simulation

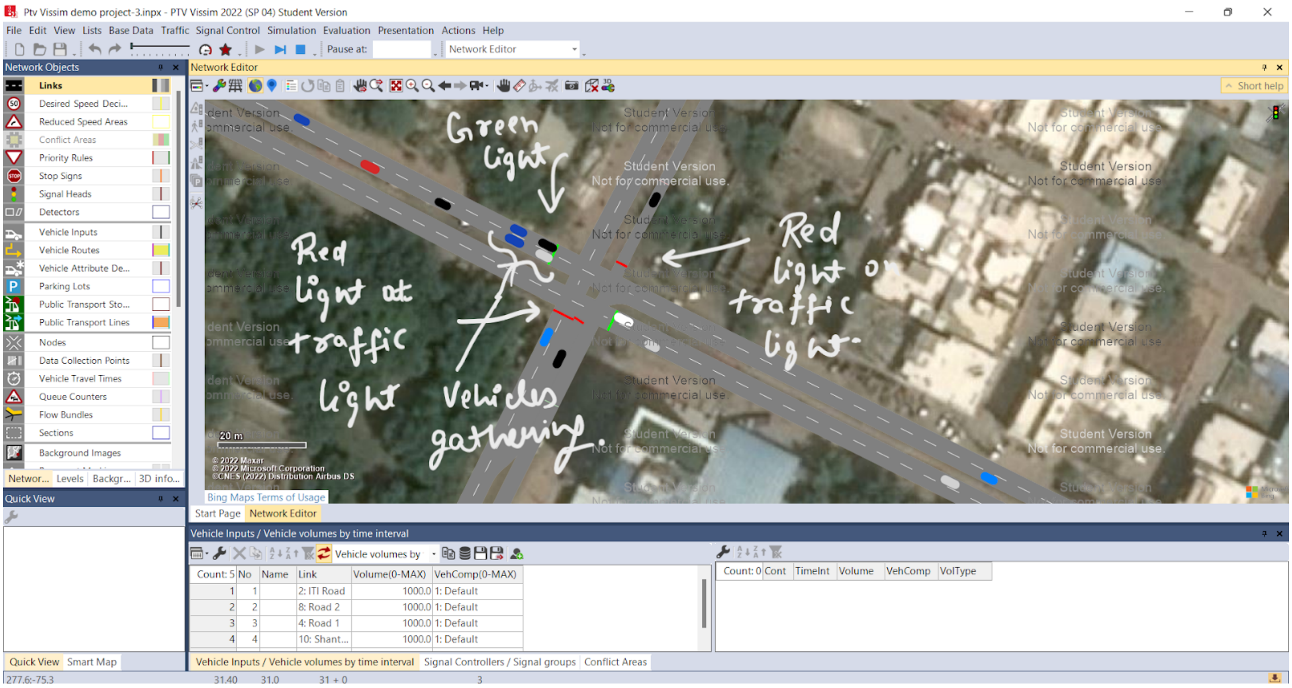
- To understand the working of traffic and how traffic gets affected by different parameters, we used a traffic simulator , **Ptv Vissim**.

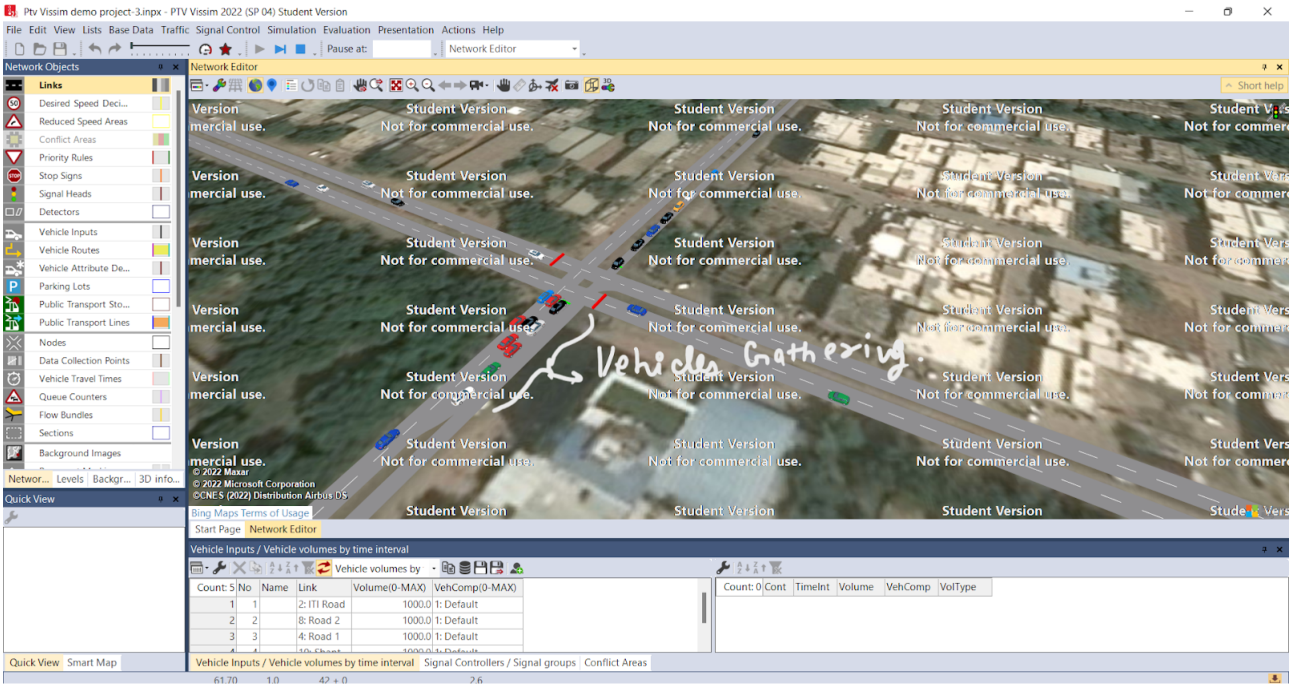


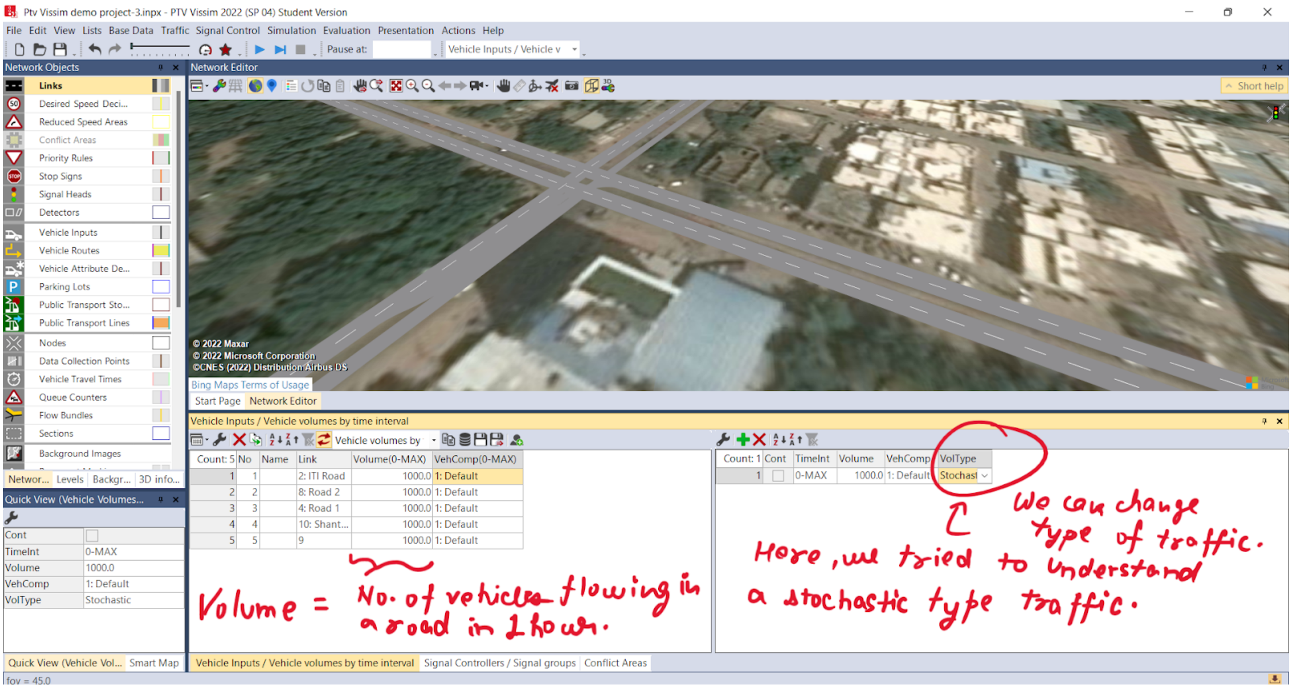
- We first created a simple crossroad in the simulator. Added vehicles to it. And tried to understand the effects of all the parameters in the traffic, through simulation.

- We tried to change intervehicular distance , vehicle type ,vehicle volume , type of traffic like Stochastic or exact and observed the differences , which helped us to do better research and get better and optimized solutions.


Ptv Vissim demo project-3.inpx - PTV Vissim 2022 (SP 04) Student Version
Green light
Red light on traffic signal.


Ptv Vissim demo project-3.inpx - PTV Vissim 2022 (SP 04) Student Version
Green light
Red light at traffic light
Vehicles gathering.
Red light o traffic light.





- Here Volume = Number of vehicles passing through a road per hour.
- We also tried to understand Stochastic type traffic through the simulator.

Refinement

While doing the prototype, we made several assumptions. We considered a single lane. We took the inter vehicular distance between the vehicles to be the same. We considered all the vehicles to be the same and we took the velocity of all the vehicles to be constant. Like these we took many assumptions for the prototype.

But in real life, these assumptions cannot be considered for implementing our prototype. We need to include several parameters like sensitivity. We need to consider multi-lane systems taking vehicles to be different with vehicles having acceleration and deceleration. We should take the inter variable distance to be different. We need to improve all these and refine our prototype to actually make our prototype to work in real traffic and system.

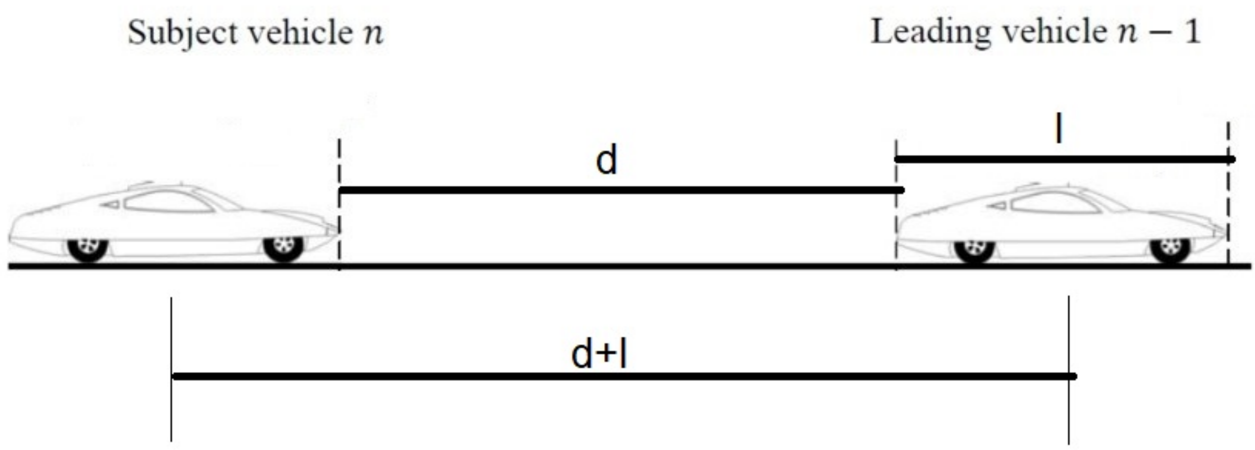
Demonstration of Final Design

Optimizing ‘d’:

This can be achieved by reducing the time gap once saturation is achieved. The following assumptions are also to be made:

1. Velocity of all vehicles once saturation is achieved is the same and is equal to ‘v’.

2. Vehicles are of similar lengths equal to ‘L’



Now, $t_{sat} = (d+L)/v$ and $N=3600/ t_{sat}$

Here, ‘N’ is the no. of vehicles crossing the green light in one hour (after saturation)

Ideally, $d = 0$ and thus, $t_{sat}= L/v$

Obviously, this situation is impossible in real life as there are other factors that need to be taken into consideration, which are the response time of the driver and a safe inter-vehicular distance to be maintained.

So basically, $t_{sat}= L/v$ acts as a lower limit for the real life $t_{sat.}$

$$\text{Thus, } (t_{sat})_{real} >= (t_{sat})_{ideal} = L/v \qquad \text{and} \qquad d_{real} > 0$$

Real life scenario:

Let 'T' be the response time.

Now, for safety purpose, $d >= (T)_{max} * v$

$$\therefore\ d_{optimum} = T_{max} * v$$

$$\therefore\ \text{Optimum } t_{sat} = ((T_{max} * v) + L)/v = T_{max} + L/v$$

Thus, at saturation : $N_{optimum} = 3600 / (T_{max} + L/v)$

The final design, is a simulated prototype for traffic flow optimisation utilities that further form the basis of automated traffic systems.

the very basis of any car following model is that whenever the following vehicle has speed not equal to the leading vehicle, the following driver will react in such a way to make its speed equal to the leader.

We have modelled this behaviour using the saturating exponential function with the power coefficient equivalent to the sensitivity term that we have discussed before.

This model is used as a reference simulation of natural traffic flow where drivers are not assisted by a recommendation system.

We shall contrast its output with that of a model in which, an external system instructs the drivers to speed up or speed down, depending on their initial inter vehicle distance, with the aim of achieving constant optimal headway separations equal to the initial separation during red time.

The response of the behaviour to the instructions given by the system is again modelled using response stimulus model.

The driver tends to speed up/down by an acceleration depending on the stimulus (which is the inter-vehicular distance in this case) and the sensitivity parameter.

Source Code

Natural System

```
import pygame
import time
import math
import random
eff=0

black = (0, 0, 0)
white = (255, 255, 255)
red=(128,0,0)
green=(0,128,0)
gexit = False
flag=0
to0=to = time.time()

def t():
    """ universal time """
    return time.time() - to

class car:
    global l
    def __init__(self,n,d):
        self.n=n
        self.delt=random.uniform(0,0.85)
        self.d=d
        global x
        self.x=800-self.n*self.d
        self.y=300
    def v(self):
        if self.n == 0:
            if signal()==red:
                return 0
            return 80 * (1 - math.exp(-2*t()))
        else:
            if t()-sum(lags[1:self.n])<lags[self.n]:
                return 0
            else:
                return l[-1+self.n].v()*(1-math.exp(-t()))

def signal():
    global flag
    global to
    if t()<5 and flag==0:
```

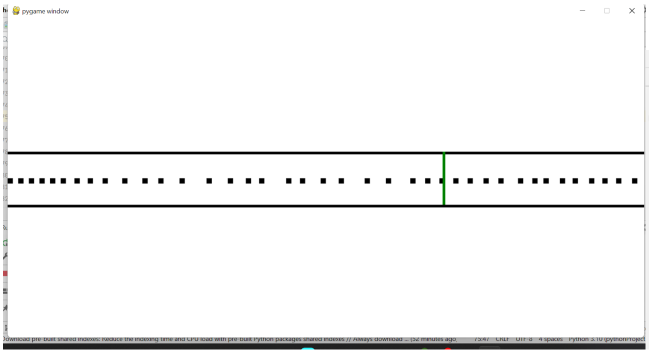
```
        return red
    flag=1
    if to==to0:
        to+=5
    return green
l=[]
for i in range(65):
    l.append(car(i,20))
lags=[c.delt for c in l]

pygame.init()
screen = pygame.display.set_mode((1200, 600))
clock = pygame.time.Clock()
currt = t()
dt=0

while not gexit:
    currt = t()
    for ev in pygame.event.get():
        if ev.type == pygame.QUIT:
            gexit = True
    screen.fill(white)
    for c in l:
        pygame.draw.rect(screen, black, [c.x,c.y, 10, 10])
        c.x+=c.v()*dt
        if c.x>=820:
            eff+=1
    # road
    pygame.draw.rect(screen, black, [0, 250, 1200, 5])
    pygame.draw.rect(screen, black, [0, 350, 1200, 5])
    # sign
    pygame.draw.rect(screen, signal(), [820, 250, 5, 100])

    dt = t() - currt
    if t()>40:
        print(eff/10000)
        print(2*math.atan(eff/10000)/math.pi)
        break
    pygame.display.update()
    clock.tick(5000)

pygame.quit()
quit()
```

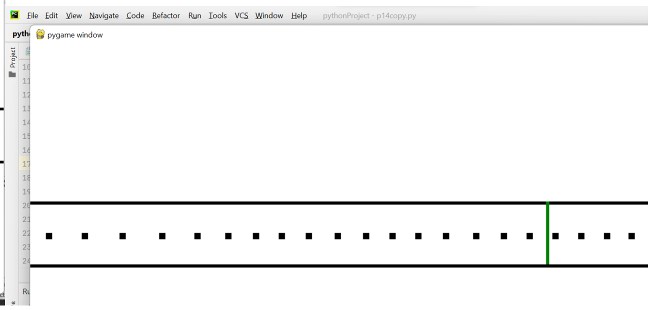
Assisted system

```
import pygame
import time
```

```
import math
import random
eff=0

black = (0, 0, 0)
white = (255, 255, 255)
red=(128,0,0)
green=(0,128,0)
gexit = False
flag=0
to0=to = time.time()

def t():
    """ universal time """
    return time.time() - to

class car:
    global l
    def __init__(self,n,d):
        self.n=n
        self.delt=random.uniform(0,0.85)
        self.d=d
        global x
        self.x=800-self.n*self.d
        self.y=300
    def stim(self):
        if self.n>1:
            return l[self.n-1].x-l[self.n].x-20
        else:
            return 0
    def v(self):
        if self.n == 0:
            if signal()==red:
                return 0
            return 80 * (1 - math.exp(-2*t()))
        else:
            if t()-sum(lags[1:self.n])<lags[self.n]:
                return 0
            else:
                return l[-1+self.n].v()*(1-math.exp(-t()))

def signal():
    global flag
    global to
    if t()<5 and flag==0:
        return red
    flag=1
    if to==to0:
```

```
        to+=5
    return green

l=[]
for i in range(65):
    l.append(car(i,20))
lags=[c.delt for c in l]

pygame.init()
screen = pygame.display.set_mode((1200, 600))
clock = pygame.time.Clock()
currt = t()
dt=0

while not gexit:
    currt = t()
    for ev in pygame.event.get():
        if ev.type == pygame.QUIT:
            gexit = True
    screen.fill(white)
    for c in l:
        pygame.draw.rect(screen, black, [c.x,c.y, 10, 10])
        c.x+=(c.v()+c.stim()*0.27)*dt
        if c.x>=820:
            eff+=1
    # road
    pygame.draw.rect(screen, black, [0, 250, 1200, 5])
    pygame.draw.rect(screen, black, [0, 350, 1200, 5])
    # sign
    pygame.draw.rect(screen, signal(), [820, 250, 5, 100])

    dt = t() - currt
    if t()>40:
        print(eff/10000)
        print(2*math.atan(eff/10000)/math.pi)
        break
    pygame.display.update()
    clock.tick(5000)

pygame.quit()
quit()
```





p14

```
pygame 2.1.2 (SDL 2.0.18, Python 3.10.1)
Hello from the pygame community. https://www.pygame.org/contribute.html
56.732121828741
0.9896323982321664

Process finished with exit code 0
```

p14copy

```
pygame 2.1.2 (SDL 2.0.18, Python 3.10.1)
Hello from the pygame community. https://www.pygame.org/contribute
64.6325
0.9901509460340745

Process finished with exit code 0
```

	A	B	C	D
2	N(vehicles per green time)	value of efficiency function	N(vehicles per green time)	value of efficiency function
3	56.7371	0.9887	62.6554	0.9898
4	57.1435	0.9888	63.8327	0.99
5	57.5656	0.9887	61.4832	0.9896
6	55.9825	0.9886	62.8954	0.9898
7	56.2357	0.9886	62.6892	0.9898
8	57.9325	0.989	62.3259	0.9897
9	57.5698	0.9889	61.3925	0.9896
10	58.2365	0.989	63.205	0.9899
11	56.7536	0.98857	62.4876	0.98981

Annexure (Individual Contributions)

The Team

Harsh V. Singh	B21CS032
Karanam Preethi	B21EE032
Khushi Katara	B21ME032
Praveen Kumar	B21Cl032
Rushi Shah	B21AI032
Srishti Singh	B21MT032
Srivats J	B21CH032
Tanishq Kankerwal	B21BB032

Harsh V. Singh (B21CS032)

As an undergraduate student In Computer Science and Engineering, I have provided my inputs for Algorithm design and explored the various tools which we could possibly use for simulating the virtual world environment for visualization.

After gaining some hands-on experience with languages like Python, I have contributed towards implementing the design.
I have demonstrated the working of the utility in the video. I have looked after the practical aspect as an addition to the research work done by the team, for instance modeling sensitivity into the velocity functions preserving equivalence with its appearance in differential equations

Karanam Preethi (B21EE032)

I am a student of electrical engineering and working on a traffic flow model.After completing the final decision on the idea of the project, I didn't know much about this project. But I got to know everything about this project slowly and it is very interesting to learn about it. We faced many problems in understanding some of the technical terms and after watching many videos and reading articles in youtube we got more clarity in this project. My team members also helped me in understanding many concepts and I attended the session with the Head of Civil Department, Dr. Ranju Mohan who is specialized in traffic flow and got to know more about this project. I worked on the theory part of this project like solving mathematical equations . By working on this mathematical equations we got to know more clarity on some terms like sensitivity etc. I did my research on car following models and helped my team regarding this project. I did some of the coding part required for this project but mostly i did theoretical equations in this project.I am happy to work with my team members regarding this project and happy to learn new things. This project was a great opportunity as I got to work in a bigger team and collaborate with other people. I was involved in presenting our weekly progress. We also held multiple sessions to discuss the implementation of our theme to maintain uniformity. I also thank my teachers who guided me during the class and also helped us to think in a much deeper way in our project and cleared our doubts.

Khushi Katara (B21ME032)

I am an undergraduate student of the Mechanical Engineering branch and working on Traffic Flow Model.

Harsh, one of our team members, suggested this idea. It is quite interesting.I got to know more about it from the internet and by reading the research papers, Prof.Ranju gave to us. I contributed to explore this idea more.

I took help from some online platforms like youtube,Researchgate and read some other research papers to get more clearance about this model. Mostly I contributed to the mathematics part of this model. I prepared notes for the mathematical part and discussed them with my team members.

Praveen Kumar (B21CI032)

I am an undergraduate student in Civil and Infrastructure Engineering department. I contributed to this project in many ways.

I learnt Ptv Vissim and handled it single handedly. I made a demo project and simulated the whole traffic in it . Through it I was able to understand how traffic is affected by different parameters, like intervehicular distance, velocity of cars , vehicle density, etc. I then presented all information related to it in the meets and made understand other members as well about it.

Apart from this , I also read some of the research papers like , "*Parametric study of stimulus-r ametric study of stimulus-response behavior incorporating vehicle heterogeneity in car-following models* " and "*Chandler Research Paper*" in order to understand different aspects of traffic like response time, sensitivity, etc. and finally reach to the final solution.

I optimized the d (intervehicular distance) parameter and found out its optimized value needed for the optimum scenario.

I also tried to give some suggestions in python code , which our team made from scratch in order to mimic traffic

I used to attend all our team meetings and used to give my inputs. Whatever new things I used to explore and find something new I used to make a note of it and also shared my ideas in our discussion meetings. I also helped my team to make this final report and video.

Rushi Shah (B21AI032)

As a student of the Artificial Intelligence and Data Science branch, I got to learn many new things from this course. According to me, the most important one was the correct approach one should follow when doing something innovative. One should keep in mind that only problem solving would not be enough. One should also know how to identify the problem or sub-problems in order to come up with a solution which is feasible as well as helpful. My group was very interactive and helpful. As to the problem we are currently targeting, I, along with Harsh, took up the task of organizing and planning i.e. what to do and when to do. I
also provided my inputs in the interpretation part of the research we did. Usually we used to meet in a video call and discuss and learn together. I took up the task of leading the explanation part in the ED classes and also contributed in helping my team understand the concepts which Khushi, Harsh and Tanishq put forward to the group.I attended the session with the Head of the Civil Department, Dr. Ranju Mohan, who specializes in traffic flow and shared my interpretation of some subtle problems that came to our minds after that lecture with my group members. I also helped Harsh in figuring out the solutions to some problems we came across in the PyGame part of the project.

Srishti Singh (B21MT032)

As a student of Metallurgical and Materials department, my contribution to this project is specifically on background research on how the input data can be fed to the system. Research was done by me for finding reliable sources and case-studies that match the solution of our problem. During literature review and research, the content found facilitated our group in providing a well-researched and logical solution report. I analysed the sources provided by other members of the group and gave my input to that also, which facilitated our group to have a broader view of thinking.

I took part in all of the group discussions and provided appropriate feedback to other members in order to increase collaborative efficiency.

Furthermore I was responsible for the compilation and editing of the final report.

I am very thankful to all my team members for their collaborative support and would like to thank the professors for their constant guidance, and the institute for such an innovative course.

Srivats J (B21CH032)

I am an undergraduate student of Chemical Engineering and my project for this year's Engineering design course was on the topic of 'Traffic Flow Modelling'

Even though my branch of choosing didn't play much of a role in this project, I still helped with inputs on detailed research of Car following models and Signal detection theory, which gave rise to the reaction time variable in our project and thus helped us better optimize our equations.

I have also attended the interactive sessions scheduled in the month of January by Dr. Ranju Mohan on 'Transportation Flow Systems' and 'Response Stimuli'.

On top of this, I mostly contributed a major part to the final documentation of the report and compilation of the final video together for this project.
I would like to thank my professors for giving me this opportunity to expand my knowledge beyond my horizons.

Tanishq Kankerwal (B21BB032)

I am pursuing a Bachelor's degree in Bioscience and Bioengineering from IIT Jodhpur and I along with my teammates worked on the Traffic Flow Model.

It was my pleasure to have attended this course which helped me in developing a research mindset. Our Indian school curriculum is not that research-oriented so this course was an invaluable experience.

Regarding my contribution towards our project, I have helped the team by doing research and study about Headways (Both Discharge and Saturation) and applying the said idea.

Furthermore I researched about the Basic Model of Saturation Flow and its applications. And the idea of traffic flow happening in phases.

I had read different research papers and different Car and Traffic Flow models. I studied the relations between inter-vehicle distance, time, speed and acceleration. I analyzed all the Traffic Models and checked all the differential equations used before finally applying it.

I mostly contributed to the Analysis of Design