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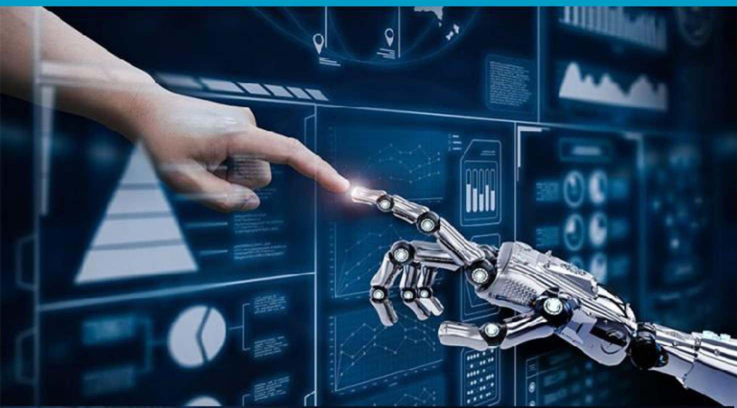

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Four-Step Transportation Modeling: An Attempt for Identification of Problems in a Transportation System

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ABSTRACT: In any urban transportation planning process, travel forecasting plays a very vital role. Different travel forecasting models are conveniently adopted for projecting the future traffic scenario. It forms the foundation for analysis of probable road capacities, changes in transit services along the new changes in pattern and policies for the land use. As far as the Travel Demand and modeling is concerned it involves the mathematical model series for attempting the simulation of the traveling behavior of human beings. The solution to travel decisions is generally obtained if the models are done in sequence. Many attempts are made to simulate the variety of choices made by travelers as a part of a response to a particular highway system, related transit system, and connected policies. For this purpose number of assumptions are considered regarding the decisions made by the people, factors considered by them, and their reaction as a response to the alternatives available in the transportation system. Generally, the process of travel simulation follows trip generating at the trip generation zone and moves through different links of the network and nodes. It ultimately ends at the trip attraction zone. The simulation method is known as Traditional Four Steps Transportation Modeling, and it includes the four basic models namely Trip Generation, Trip Distribution, Mode Choice, and Traffic Assignments. This paper it is tried to focus on the process of this traditional four- step transportation modeling system. The modeling method calculates a simplified transportation network from the city of Ulhasnagar, India. All of the models are based on information about the travel system's pattern and behavior.

KEYWORDS: Travel simulation, four steps transportation modeling, Mathematical model, Ulhasnagar city.

I. INTRODUCTION

Passenger transportation is vital to the city's operation, and transportation is the backbone of the urban management system for day-to-day activities. One of the most important factors is transit planning and infrastructure growth, which is particularly important in major metropolitan areas with high and rapid population growth [1]. It is essential to have a clear understanding of current travel patterns to identify and represent a diverse traffic problem [16]. To manage, develop, evaluate, and regulate transportation and supply chain networks, precise forecasts of total passenger and freight demand, as well as efficient and comparable transportation connections, are needed [11]. The main objective of transportation planning and management is to strike a balance between transportation supply and travel demand. Transportation planning implements a decision-making process for future road infrastructure improvements in a region. As decision-making is one of the most important processes, different programming tools and manuals have been aimed to help in the process. [2]. The two probable alternatives available are,

1. Simulations for calculating travel demand for the four-step planning phase.
2. Measurements of transport costs that provide details on regional congestion in the city.

Travel demand analysis methods are used for the four-step urban planning process [17]. To rising in regional development and road network supply, travel forecasting models are used to estimate changes in traffic patterns and the operation of the transportation system. Identifying travel demand is a difficult task, but it is important for good transportation planning and study. [1]. This paper it is tried to gain a clearer knowledge of the traffic situation in the city of Ulhasnagar, Maharashtra, on a zonal basis. It is also tried to improve network Assignment by using Urban Transport Modeling System.

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II. STUDY AREA

For data collection, the city corporation area of Ulhasnagar is selected [5]. Ulhasnagar town, Thane district, Maharashtra has 5 camps. The city is divided into 20 zones and 78 wards. Here 6 zones from Ulhasnagar camp no. 4 have been selected for the traffic analysis zone.

Figure 1: Ulhasnagar city municipal Corporation (study area)
Source: Ulhasnagar Municipal Corporation

METHODOLOGY

To achieve the planning goals in this paper, the traditional four-step transportation modeling system is used. Before venturing into what transportation modeling is, it is very essential and important to learn the basic and broad key steps in transportation planning. It will help generate an understanding of how transport modeling fits into the overall transportation planning [8]. Figure1. Represents the standard sequence of stages to be implemented in transportation planning.

III. IMPLEMENTATION STEPS

Figure 1: Basic Implementation steps in the transportation planning process.

Study area: To choose a study area, you must first consider the community's various problems, such as transportation, economics, and land-use issues. Identifying the research area as well as the purpose of the analysis can be taken into consideration.

Define goals, objectives, and criteria: Transportation service efficiency, environmental effect, and cost goals are all set. A good planning effort will define the exchange between such factors by alternative explicitly and clearly to allow decision- making.

Data collection is needed to learn about the current state of the transportation system and its use. This may include traffic updates, public transit ridership numbers, census results, and household travel habits interviews. Land use, population trends, environmental conditions, and financial resources are all studied. This will help define the problem as well as develop methods for predicting future travel trends. This is important because the transportation planning process requires detailed data at all times.

Forecasts: Travel demand models are used to forecast future travel based on data from previous trips. This requires calculations of population, land use, and economics, as well as an understanding of how people would like to travel. Forecasting usually requires a large amount of data and is predicated on several assumptions.

Develop alternative: Land use and transportation system forecasting results are used to determine the advantages of various possibilities. This is required to determine the effectiveness of alternative scenarios in terms of achieving aims, objectives, and requirements.

Implementation: After decisions have been taken, proposals have to be prepared and should be further formulated and modified to be implemented. This may involve the research for planning and operation, similar to the study designed to set above. It's a technique for performing at a macro level [6].

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After this in next stage, it is necessary to complete the following conventional four steps for transportation modeling:

A. Trip Generation

Trip generation is the first step in the conventional four-step transportation planning model, which is widely used to forecast travel demand. It predicts the number of trips departing or arriving at a particular traffic analysis zone [3]. Trips are calculated based on the number of people in the household and the number of vehicles available. Usually, the number of employees in a period is used to calculate trip attractions. After ten years (2021), this stage describes trip production and attraction (the base year 2011). To proceed, 10-year growth rates are used to measure real trip production and attraction parameters(figure 2). These rates of growth are calculated on a regional basis [4].

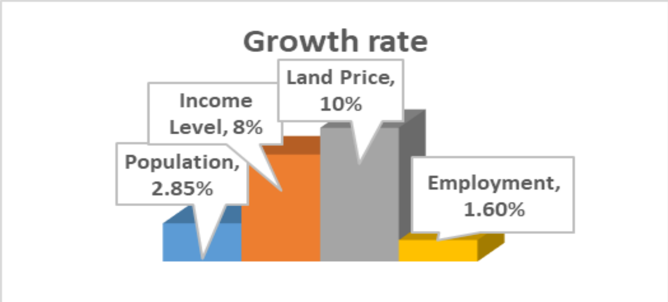

Figure 2 shows the growth rate for a 10 year

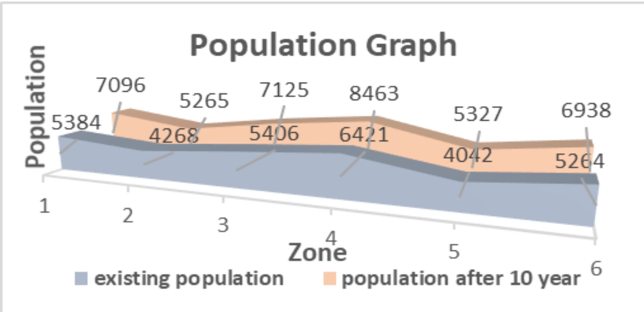

Figure 3 Existing and after 10-year population

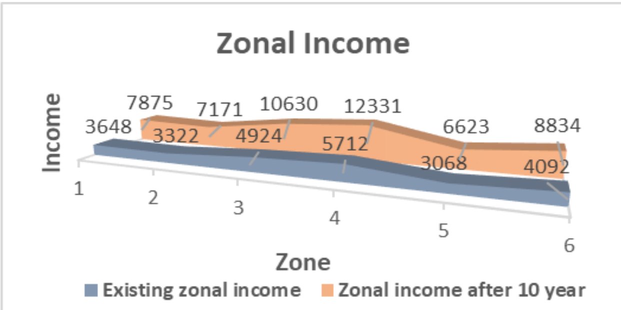

Figure 4 Existing and after 10-year zonal income

For trip production analyses, the population, and zonal income is used

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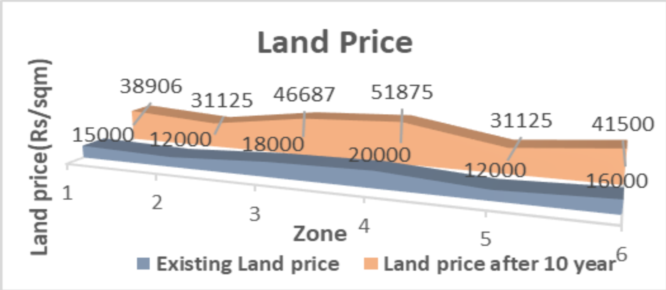

Figure 5 Existing and after 10-year land price (Rs/sqm)

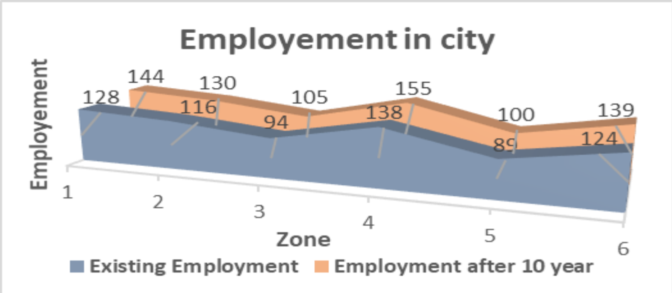

Figure 6 existing and after 10-year employment details

For trip attraction analyses, the employment and land price information is used.

Calculation process for future forecasting ***(2031): - Existing values* (1+growth rate) ^ projected year***

As a result, similar formulas are used to measure forecasted values for both trip production and attraction variables. After ten years, two regression equations for trip production and trip attraction are identified from the calculated variables [2]. Two more regression equations have been discovered

For the production of the trip:

$$Y_{Production} = 4.251743 - 0.02181 * X_1 + 0.3285 * X_2$$

For trip attraction:

$$Y_{Attraction} = 3.88933 - 0.0571 * X_1 + 0.03863 * X_2$$

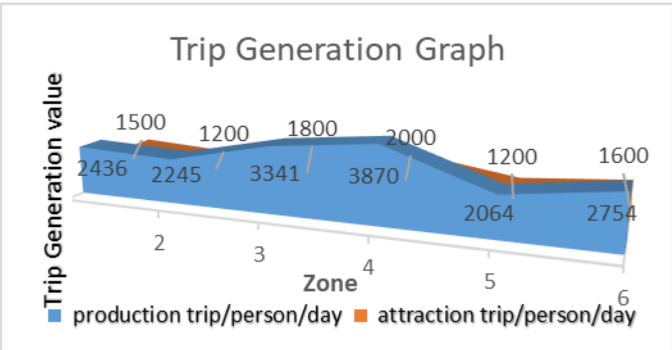

Figure 7. forecasted Production and attraction/person/day

These regression equations are then used to develop travel simulations for both trip production and attraction growth for future planning as shown in figure 7. After identifying possible productions and attractions, the stage of trip generation comes to an end.

B. Trip Distribution

Enable the collection of trip productions and trip attractions, the next step is to arrange the productions and attractions to evaluate how trips created in one zone are divided across all other zones. To put it simply, it's the

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method of predicting how people will choose their ultimate destinations. There are a variety of reasons why one location is preferred over another. In general, traffic distribution is a function of [8]

1. Population socioeconomic characteristics,
2. Transportation facility type and extent, and
3. Land-use pattern, including position and intensity.

The first step in the trip distribution process will be to develop

Table 1: O-D matrix

O-D	Zone 1	2	3	4	5	6	Total
Zone 1							2436
2							2245
3							3341
4							3870
5							2064
6							2754
Total	1500	1200	1800	2000	1600	1200	9300

Total trip production value is 16705 and total trip attraction is 9300, Therefore trip Production > trip Attraction. The adjustment factor is used to create trip attraction equivalent to trip production [2].

$$Adjustment\ factor = \frac{Trip\ production}{Trip\ attraction} * Trip\ attraction\ value$$

Table 2: Adjusted O-D matrix

O-D (Zone)	Zone 1	2	3	4	5	6	Total
Zone 1							2436
2							2245
3							3341
4							3870
5							2064
6							2754
Total	2700	2160	3240	3600	2160	2880	19920

It is difficult to switch from one node to another in a network due to path overload. While 'Link Impedance' can be expressed in terms of time for modeling purposes, travel time or apparent costs are usually more accurate steps. After creating a cost matrix, the table is built by calculating the cost of travel from one zone to the next. In the trip distribution stage, the gravity model is used.

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Table 3: Cost matrix table (C ij)

O-D	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Zone1	10	15	20	18	20	22
Zone2	15	10	18	20	16	18
Zone3	20	18	10	15	16	20
Zone4	18	20	15	10	22	18
Zone5	20	16	16	22	10	12
Zone6	22	18	20	18	12	10

$$Impendence\ factor = e^{-\beta * c_{ij}}$$

Table 4: Impedance factor values

O-D	Zone1	Zone2	Zone3	Zone4	Zone5	Zone6
Zone1	0.368	0.223	0.135	0.165	0.135	0.111
Zone2	0.223	0.368	0.165	0.135	0.202	0.165
Zone3	0.135	0.165	0.368	0.223	0.202	0.135
Zone4	0.165	0.135	0.223	0.368	0.110	0.165
Zone5	0.135	0.202	00.202	0.111	0.368	0.302
Zone6	0.111	0.165	0.135	0.165	0.302	0.368

Therefore, the total impendence factor is 7.35 and the total trip is 9300. The trip to every zone with different zones is now calculated using the formula below.

$$Trip\ of\ any\ zone = \frac{Total\ trip}{Total\ impendence\ factor} * Impendence\ factor\ for\ the\ particular\ zone$$

Table 5: Trip distribution for future forecasting

O-D	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Total
Zone1	465	282	171	209	171	140	1438
Zone2	282	465	209	171	255	209	1591
Zone3	171	209	465	282	255	171	1553
Zone4	209	171	282	465	140	209	1476
Zone5	171	255	255	140	465	382	1668
Zone6	140	209	171	209	382	465	1576
Total	1450	1590	1540	1470	1670	1580	9300

Now, comparing Tables 2 and 5, it is clear that the trip productions and trip attractions are vastly different from what they should be. Although the overall number of trips is the same, there are variations in total output and attraction between zones. This indicates that the inter-zonal distribution is incorrect.

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Table 6: Adjusted trip distribution after 10 years

O-D	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Total
Zone1	406	449	363	381	426	411	2436
Zone2	436	271	368	559	209	402	2245
Zone3	508	344	627	556	723	832	3341
Zone4	483	540	804	752	362	929	3870
Zone5	476	180	497	521	173	217	2064
Zone6	391	376	581	831	267	338	2754
Total	2700	2160	3240	3600	2160	2880	19920

Adjusted trips from various zones are found to solve the problem. After 10 years, this is the final O-D matrix for trip distribution among different zones. Finally, trip distribution from one zone to different ends at the result.

C. Mode choice

A modal split is a method of separating people's trips depends on the mode of transportation. Generally, modal split refers to trips taken by private car rather than public transportation. The mode selection process is an integral part of the travel demand modeling process [16]. The 'Logit' model is regularly adopted for mode split [2]. This step provides an O-D matrix for calculating the utilities for two modes of transportation: car and rickshaw. Furthermore, utility functions are assumed for these two modes.

The following are the utility functions [4]:

$$U_{Car} = -0.06 Travel\ Time - 0.04 Travel\ Cost$$

$$U_{Auto} = 1.2 - 0.06 Travel\ Time - 0.04 Travel\ Cost$$

The table shows utility matrix tables for various modes of transportation.

Table 7: Utility matrix for car

O-D	Zone1	Zone2	Zone3	Zone4	Zone5	Zone6
Zone1	-1.2	-1.7	-2.08	-1.8	-2.08	-2.32
Zone2	-1.7	-1.2	-1.88	-2.08	-1.68	-1.88
Zone3	-2.08	-1.88	-1.2	-1.62	-1.76	-2.08
Zone4	-1.8	-2.08	-1.62	-1.2	-2.32	-1.88
Zone5	-2.08	-1.68	-1.76	-2.32	-1.2	-1.44
Zone6	-2.32	-1.88	-2.08	-1.88	-1.44	-1.2

Table 8: Utility matrix for auto- rickshaw

O-D	Zone1	Zone2	Zone3	Zone4	Zone5	Zone6
Zone1	0.32	-0.3	-0.8	-1.02	-0.92	-1.36
Zone2	-0.3	0.32	-0.42	-0.56	-0.34	-0.72
Zone3	-0.8	-0.42	0.32	-0.48	-0.4	-0.92
Zone4	-1.02	-0.56	-0.48	0.32	-0.88	-1.02
Zone5	-0.92	-0.34	-0.4	-0.88	0.32	-0.6
Zone6	-1.36	-0.72	-0.92	-1.02	-0.6	0.32

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Using the formulas below, the probability of various modes (Table 9-10) is measured using tables 7-8.

$$\mathit{Probability}_{car} = \frac{e^{U_{Car}}}{e^{U_{Car}} + e^{U_{Auto}}} \qquad probability_{auto} = \frac{e^{u\,auto}}{e^{u\,car} + e^{u\,auto}}$$

O-D	Zone1	Zone2	Zone3	Zone4	Zone5	Zone6
Zone1	0.47	0.70	0.75	0.64	0.73	0.77
Zone2	0.70	0.47	0.73	0.77	0.69	0.70
Zone3	0.75	0.73	0.47	1	0.70	0.73
Zone4	0.64	0.77	1	0.47	0.82	0.66
Zone5	0.73	0.69	0.70	0.82	0.47	0.62
Zone6	0.77	0.70	0.73	0.66	0.60	0.47

Table 10: Probability matrix for rickshaw

The modal share is now calculated by multiplying the number of trips from one zone to another (as calculated by the trip distribution) by the probability. The following equation is used to measure this:

Modal share for any mode = $Trip_{i-j} * Probability_{i*j}$

	0.52	0.29	0.24	0.35	0.26	0.22
	0.29	0.52	0.26	0.22	0.30	0.29
	0.24	0.26	0.52	0.49	0.29	0.26
	0.35	0.22	0.49	0.52	0.17	0.33
	0.26	0.30	0.29	0.17	0.52	0.37
	0.22	0.29	0.26	0.33	0.37	0.52

Table 11: Modal share matrix for car

Finally, the modal distribution tables 11-12 for the two vehicles are arranged. This is the end outcome of the modal selection stage. We can see how many trips are made between zones using various modes of transportation.

D. Trip Assignment

The traveler's route option to the total or part of a network is specified by the traffic assignment method. The inter-zonal modal trips are allocated to the different routes of each mode in the final step of the travel estimation process. At least four factors influence people's decision to take one path over another. They are as follows:
1 Duration of travel 2 Travel expenses
3 Convenience and Service level (volume/capacity)
The most commonly used considerations are travel time and travel cost.
Generalize, Road network diagram as shown below

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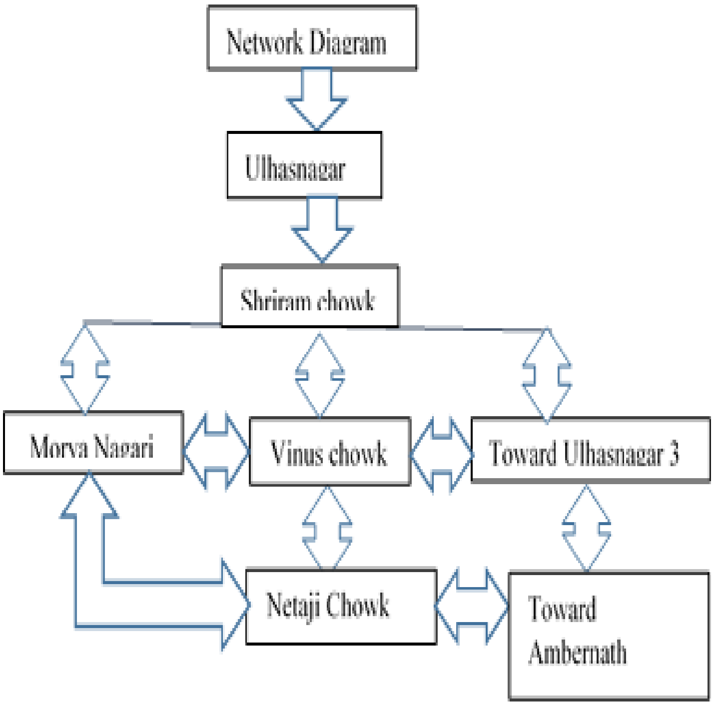

O-D	Zone1	Zone2	Zone3	Zone4	Zone5	Zone6
Zone1	216	133	90	133	112	94
Zone2	130	142	98	127	65	118
Zone3	126	91	320	270	211	217
Zone4	170	123	390	394	64	306
Zone5	125	54	145	95	90	82
Zone6	88	111	152	274	100	177
O-D	Zone1	Zone2	Zone3	Zone4	Zone5	Zone6
Zone1	192	315	272	247	314	317
Zone2	306	128	269	431	145	280
Zone3	380	252	298	556	511	614
Zone4	312	416	804	357	142	621
Zone5	351	125	351	431	90	135
Zone6	302	264	428	550	160	160

Figure 8 Flow diagram to show the road network

The process starts with determining the shortest route. Each O-D pair's trips are then allocated to the minimum path's links, and the trips are counted for each connection [2]. To determine if the connection is congested, the allocated trip volume is compared to the link's capacity. If there is When a connection becomes congested, its

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speed must be decreased, resulting in a longer travel time. As travel times change, the shortest path can change as well. As a result, the entire process is repeated several times until travel demand and supply are in balance. Trips on overcrowded routes will be rerouted to traffic-free routes before this equilibrium is reached. The most difficult calculation in the travel modeling series is traffic assignment.

Dijkstra's Method is now used to measure the shortest distance in terms of GTC between source and destination for various modes. An all-or-nothing assignment is used to calculate the traffic flow for different modes from one node to another [16]. The Generalized Travel Cost factor for each mode is determined after assuming a network. The steps for calculating GTC are given below [1].

$$GTC = TC + \left(\frac{a_1}{a_2}\right) * TT$$

Table 13: Generalized Travel Cost for car and Auto

O-D	Zone 1		Zone 2		Zone 3		Zone 4		Zone 5		Zone 6	
	Car	auto	car	auto	car	auto	Car	auto	car	Auto	Car	auto
1	30	22	37	37	52	50	45	63	52	38	58	64
2	42	37	28	22	47	40	52	47	42	39	47	48
3	52	50	47	40	30	22	40	37	44	40	52	53
4	45	55	52	44	40	42	30	22	58	52	47	55
5	52	53	42	38	44	40	40	52	30	22	33	45
6	58	64	47	48	52	53	47	47	33	45	28	22

Table 14 displays the traffic flow from one node to another during peak hours for various modes of traffic

Table 14: Total trips in each link

Link	Flow for car	Flow for auto
Sriram to Morya(1-2)	423	496
Sriram to Venus(1-3)	672	714
Sriram to UNR3(1-4)	416	457
Venus to Netaji(2-5)	534	610
Morya to Netaji(3-5)	468	502
Netaji to Ambernath (5-6)	627	674
Venus to UNR 3(2-3)	416	468
Morya to Venus(2-4)	521	580
UNR 3 to Ambernath (4-6)	418	482

The average number of people that occupy a vehicle is referred to as its occupancy. According to the Ulhasnagar corporation survey [5], the occupancy for a car 1.85, and an auto-rickshaw is 1.85. The number of cars and auto-rickshaws that flow in the peak time in different links is estimated using these occupancy values. The total vehicle number for a particular mode calculated as given below:

Vehicle number= Flow for vehicle / Occupancy for vehicle

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Table 15: Total number of modes in each link

Link	Flow	occupancy	Number	Flow	occupancy	Number
1-2	423	1.85	228	496	1.63	304
1-3	672	1.85	363	714	1.63	438
1-4	416	1.85	224	457	1.63	280
2-5	534	1.85	288	610	1.63	374
3-5	468	1.85	252	502	1.63	307
5-6	627	1.85	338	674	1.63	413
2-3	416	1.85	224	468	1.63	287
2-4	521	1.85	281	580	1.63	355
4-6	418	1.85	225	482	1.63	295

The traffic assignment details reflect the distance travel on each path in the network with a given transportation system at some point in the future. Congestion levels, travel times, travel speeds, and vehicle kilometers traveled are all direct outputs of the modeling process. For plan evaluation, connection traffic volumes are often used to assess other travel results.

Thus, the existing transport modeling process is carried out step by step, as detailed in this paper, while collecting data for the 6 zones of the Ulhasnagar City municipal Corporation for research purposes.

IV. CONCLUSION

Transportation modeling is used to solve and analyze "absolute" problems by combining theory and implementation. For future planning, four conventional models are developed Trip generation is developing to estimate the total number of trips created to and attracted from different zones in the study areas. The trip matrix is required to define the trip distribution pattern by Using the gravity model and the growth factor
equation. Mode selection decides the number of trips taken by people who use a specific mode of transportation. In this approach, the Logit model is applied. Travelers will choose the direction with the shortest route by applying this model with their trip. One of the most important ways to improve model accuracy and value is to develop a successful collection of recent data to measure the models that provide for evaluation. Travel demand management, employer-based trip reduction schemes, pedestrian and cycling programmers, shifting population age structures, and land-use policies may not be solved with this approach. Several important points should be considered for implementation to make the conventional transportation modeling system more meaningful and effective.

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