Study and analysis of A Vehicular Traffic Intersection Point, For Traffic and Congestion Control in Amolapatty, Dibrugarh, Assam.

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Abstract

This study addresses the growing concern of traffic congestion in urban areas, focusing on Dibrugarh town in Assam, India. With the rapid increase in vehicular traffic due to factors such as population growth, urbanization, and economic expansion, there has been a noticeable deterioration in the efficiency of the transportation infrastructure. The necessity of transportation for individual livelihoods, economic activities, and social integration underscores the importance of addressing these challenges.This paper selected a critical traffic intersection in Dibrugarh , Amolapatty, for detailed analysis. The majority of the data for the intersection point for the simulation came from observations. Observations were made with the help of a Drone camera as well as a static camera. Some of the observations were made with the help of manual observation. A simulation model was developed for each junction using the PTV VISSIM thesis license version. This study aims to identify the factors contributing to traffic congestion at this intersection and propose viable solutions for mitigating the traffic congestion.

Keywords: Urbanization ,Traffic congestion, Traffic simulation, Traffic intensity, Simulation model

1. Introduction

Traffic simulation studies have emerged as powerful tools for analyzing and evaluating transportation networks in urban areas. These studies utilize computer models to simulate and replicate real-world traffic conditions, allowing researchers to assess the performance of existing systems and explore potential improvements. By simulating various scenarios and testing different interventions, policymakers can make informed decisions that optimize traffic flow, reduce congestion, enhance safety, and promote sustainable transportation. With the high computational power available today, simulated environments can generate results much faster than real environments[1]. Therefore, experiments conducted in simulated mediums can provide results significantly ahead of real-world experiments.Traffic studies in India are essential for infrastructure planning, safety assessment, traffic management, public transportation planning, environmental impact assessment, and future projections. By collecting and analyzing relevant data, authorities can make informed decisions and implement measures to enhance traffic efficiency, safety, and sustainability in the country[2,3].

India's rapid urbanization and population growth have resulted in increased traffic congestion. Traffic studies help in understanding traffic patterns, identifying bottlenecks, and planning infrastructure developments such as roads, bridges, flyovers, and public transportation systems to alleviate congestion and improve traffic flow. India has a high rate of road accidents, and traffic studies play a crucial role in assessing safety risks and identifying accident-prone areas. By analyzing traffic volumes, speeds, and crash data, authorities can implement measures to enhance road safety, such as installing traffic signals, speed breakers, road signs, and pedestrian crossings. Effective traffic management is crucial to ensure smooth traffic flow and reduce congestion[4]. Traffic studies provide valuable data on traffic volume, peak hours, travel patterns, and origin-destination flows. This information helps authorities in implementing strategies like signal timings, lane configurations, one-way systems, and traffic diversions to optimize traffic management. With the increasing demand for public transportation, traffic studies assist in determining the most suitable routes, frequency of services, and capacity requirements. This data helps in optimizing bus and metro routes, ensuring efficient connectivity, and improving the overall public transportation system. Traffic studies enable the evaluation of the environmental impact of transportation systems. By analyzing traffic emissions, fuel consumption, and congestion levels, authorities can develop strategies to minimize pollution, promote eco-friendly transportation alternatives, and encourage sustainable urban development. Traffic studies involve forecasting future traffic demands based on population growth, economic trends, and urban development plans. These projections aid in long-term planning for transportation infrastructure, ensuring that cities and regions can handle the anticipated increase in traffic volume[5].

Table 1: India traffic growth from 1951 to 2019

As on 31st March	Two wheelers	Cars, Jeeps and Taxis	Buses	Goods vehicles	Other Vehicles	Total (Lakhs)
	(as %age of total vehicle population)					
1951	8.80	52.00	11.10	26.80	1.30	3.00
1961	13.20	46.60	8.60	25.30	6.30	7.00
1971	30.90	36.60	5.00	18.40	9.10	19.00
1981	48.60	21.50	3.00	10.30	16.60	54.00
1991	66.40	13.80	1.50	6.30	11.90	214.00
2001	70.10	12.80	1.20	5.40	10.50	550.00
2002	70.60	12.90	1.10	5.00	10.40	589.00
2003	70.90	12.80	1.10	5.20	10.00	670.00
2004	71.40	13.00	1.10	5.20	9.40	727.00
2005	72.10	12.70	1.10	4.90	9.10	815.00
2006	72.20	12.90	1.10	4.90	8.80	896.00
2007	71.50	13.10	1.40	5.30	8.70	967.00
2008	71.50	13.20	1.40	5.30	8.60	1053.00

2009	71.70	13.30	1.30	5.30	8.40	1150.00
2010	71.70	13.50	1.20	5.00	8.60	1277.00
2011	71.80	13.60	1.10	5.00	8.50	1418.00
2012	72.40	13.50	1.00	4.80	8.30	1595.00
2013	72.70	13.60	1.00	4.70	8.00	1760.00
2014	73.10	13.60	1.00	4.60	7.70	1907.00
2014	73.50	13.60	1.00	4.40	7.50	2100.00
2016	73.50	13.10	0.80	4.60	8.10	2300.00
2017	73.90	13.30	0.74	4.84	7.27	2530.00
2018	74.40	13.37	0.71	4.69	6.85	2726.00
2019	74.80	12.99	0.69	4.65	6.85	2958.00

Source (road transport year book, Ministry of road transport and highways transport research wing, Govt. of India)

According to a survey conducted by the Transport Research Wing of the Ministry of Road Transport and Highways, Government of India, there has been a substantial increase in the number of vehicles in India over the past few decades. This surge in vehicular population is poised to have significant implications for the nation's traffic system as a whole. Employing simulation studies to enhance the traffic system will be crucial in effectively addressing these challenges in the near future[6,7].

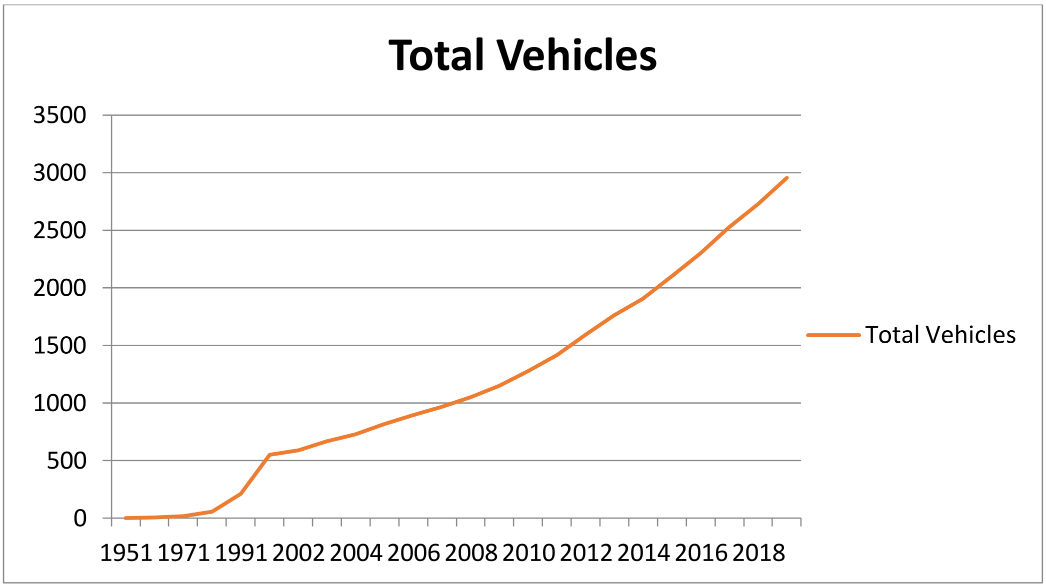

Figure 1: Rapid growth of vehicles in India

As India is an emerging economy, it is highly likely to experience a more significant surge in vehicle ownership compared to developed countries. The World Road Statistics report of 2018, published by the International Road Federation in Geneva, highlights that only 32 out of every 1,000 individuals in India own a vehicle. In contrast, this figure stands at 804 in the United States. Considering India's status as a developing economy coupled with its position as a hub for automobile production, the current figure of 32 vehicles per 1,000 individuals could escalate rapidly. Consequently, traffic management may emerge as one of the most formidable challenges for the Indian government over the next decade[7,8,9].

Table 2: Total no of Accidents: Fatalities and persons injured during 2016 to 2021

Year	Accidents	Change over previous period(%)	Fatalities	Change over previous period (%)	Persons Injured	Change over previous period(%)
2016	4,80,652	-	1,50,785	-	4,94,624	-
2017	4,64,910	-3.28	1,47,913	-1.9	4,70,975	-4.78
2018	4,67,044	0.46	1,51,417	2.37	4,69,418	-0.33
2019	4,49,002	-3.86	1,51,113	-0.2	4,51,361	-3.85
2020	3,66,138	-18.46	1,31,714	-12.84	3,48,279	-22.84

2021	4,12,432	12.64	1,53,972	16.9	3,84,448	10.39

Source (road transport yearbook, Ministry of road transport and highways transport research wing, Govt. of India)

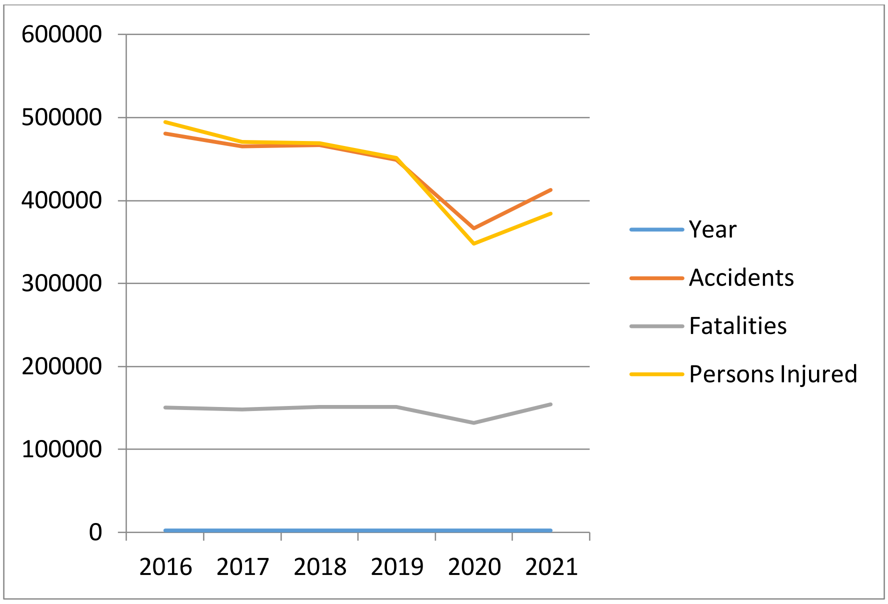

Figure 2: Plot for the total no of accidents, fatalities and persons injured from 2016 to 2021

2. Research gap

The novelty of the traffic simulation study in Dibrugarh, Assam, lies in its potential to address the unique traffic challenges faced by this particular region. Dibrugarh, located in northeastern India, is a rapidly growing city with increasing urbanization and economic activities. As a result, its road networks have experienced significant congestion and traffic management issues. By employing advanced traffic simulation models, such as microsimulation or agent-based modelling, researchers can replicate the city's road network, traffic flow, and behaviour of different road users. This helps in identifying the most efficient and cost-effective solutions tailored to Dibrugarh's unique traffic conditions. Overall, the novelty of the traffic simulation study in Dibrugarh, Assam, lies in its focus on addressing the city's distinct traffic challenges and providing evidence-based solutions that can enhance traffic management, reduce congestion, and improve the overall transportation system in the region[8,9,10,11]. Furthermore, Using PTV VISSIM in a traffic simulation study in Dibrugarh, Assam, India, would bring several novelties and advantages to the study. Here are some potential novelties:

3. Objectives of the present work

From our review of existing literature on traffic congestion studies, we have pinpointed several issues. In an effort to address these issues, we have devised specific objectives for our current research. The principal objectives of our study are outlined below.

Objective 1: To conduct an analysis of the implications of incorporating an additional road into the existing network and assess its impact on traffic flow and congestion.

Objective 2: To scrutinize the consequences of converting an existing road into a one-way (unidirectional) street and how it affects traffic patterns and efficiency.

Objective 3: To ascertain traffic-related metrics, such as vehicle delays, formation of queues, and waiting times in the current system, as well as forecast these metrics under the assumption of a 30% increase in future traffic volume.

4. Methods and materials

4.1 Study area and layout

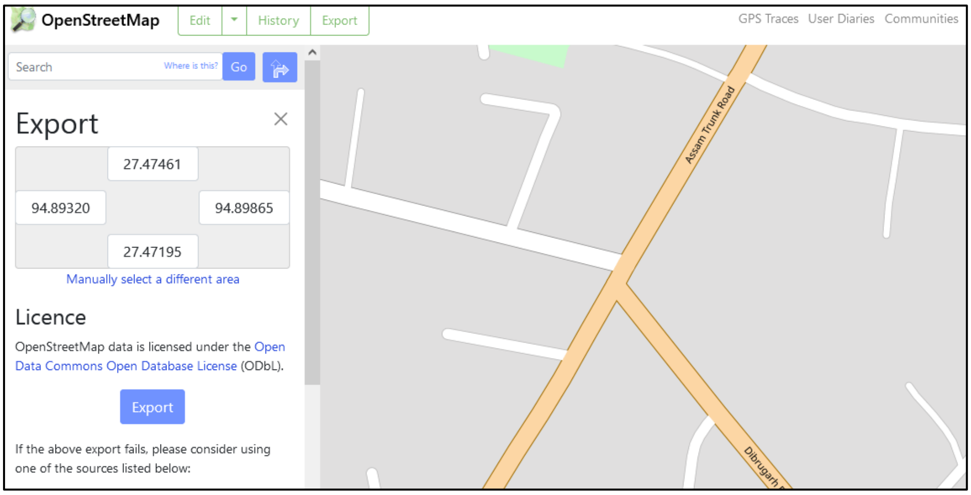

Figure 3: The longitude and altitude of the study area from open street map

The OSM file acquired from OpenStreetMap represents an advanced approach in the field of traffic simulation research. It serves as a valuable input for various sophisticated traffic simulation software. Specifically, the OSM file pertaining to the Amolapatty traffic intersection has been extracted, containing coordinates within the range of (94.89200-94.89865) and (27.47461-27.47195).

4.2 Data Collection and Observation

Traffic movements at that particular traffic point were documented over a period of 31 days in December 2021. Each day, a total of 3 hours of data was captured, with 1 hour in the morning, 1 hour in the afternoon, and 1 hour in the evening. The data collection process involved the use of two stationary video recorders strategically placed at different locations to ensure simultaneous coverage of the entire point. Additionally, a drone camera was utilized to capture an axial view of the traffic.

Figure 4: Observation of data using Static camera

Figure 5: Observation of data using Drone camera

4.3 Data interpretation and analysis

The recorded videos were subject to analysis through both manual and automated methods .Sample data analysis of the Amolapatty intersection point from the traffic observation sheet. From this analysis Vehicle input, vehicle composition, vehicle flow ratio per hour can be estimated.

Table 3: Sample traffic data analysis of Amolapatty intersection

Time (10:00 - 10:10)			**Direction from**	**To the direction**	**To the direction**	**To the direction**	**To the direction**
Vehicle Type	Total vehicle	Vehicle Composition	Dibrugarh Town	Dibrugarh Town	Dibrugarh University	Chowkidingee	Mohanaghat
HGV/TRUCK	5	0.035461		0	5	0	0
Car	40	0.283688		0	30	8	2
BUS	6	0.042553		0	6	0	0
Bike	63	0.446809		0	33	21	9
DI/Magic	11	0.078014		0	8	2	1
Rickshaw	7	0.049645		0	5	1	1
Auto ricshaw	9	0.06383		0	7	1	1
total Vehicle	141			0	94	33	14
route composition				0	0.66666667	0.23404255	0.09929078

5. Model preparation and validation

A simulation model for the intersection was prepared with the help PTV Vissim thesis version license. The following steps were performed for the preparation of the model[11-17]:

Intersection Selection: Begin by navigating to the network editor menu in PTV VISSIM to pinpoint and choose the intersection of interest. The network editor furnishes with the capability to select any real-world traffic junction with an accurate layout

Network Configuration: Next, set up the network according to the observations made during the data collection phase.

Link Properties Configuration: For the intersection inputted link size was 3.5 meters, and the link behaviour as the urban motorized driving condition is on the left-hand side

Conflict Areas and Priority Rules: In this step, Identification of the conflict areas and establishment of priority rules were made. For instance, in this simulation, priority should be accorded to the AT road (National Highway No. 37) traversing the intersection

Vehicle Input Configuration: In this step, the volume of vehicles was inputted in the different lanes. This step is vital as the volume of vehicles is a key parameter in this study.

Vehicle Route Definition: In this step, the route for each vehicle within each lane was defined. Vehicles will navigate according to the routes assigned to their respective lanes.

Vehicle Composition Customization: In this step, the Formulation of a vehicle composition list was performed to mirror real-world traffic conditions. For example, rickshaws, auto rickshaws, and DI/LGV were added to the vehicle class while excluding others like trams. One can create distinct vehicle compositions for each lane and remove vehicles not permitted in specific lanes using this function.

Vehicle Classification: The vehicles traversing the intersection were classified into seven different categories.

Relative Flow Determination: The relative flow of each vehicle was determined by a critical analysis of the observed data, as discussed earlier in the data analysis section.

Signal Head Design for Signalized Intersections: In this step, the signal head was designed according to the existing system. Latersignal head timings can be modified or optimized during the analysis phase.

Nodes and Data Collection Points Setup: Finally, the various nodes, data collection points, were placed for the collection of various data to facilitate subsequent result analysis.

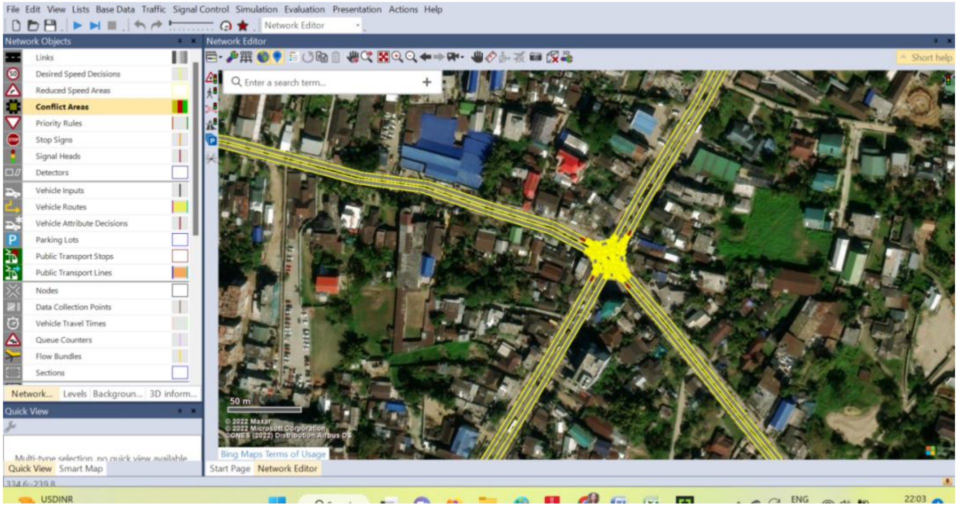

Figure 6: Simulation model of the Amolapatty intersection

Following steps were performed to validate the model:

The model that was prepared underwent a validation process using real-world data. Observations were conducted across all intersections for a duration of seven days. The outcomes derived from the simulation demonstrated a high degree of accuracy when compared to the newly acquired empirical data.

6. Result and Discussion

In the first phase of analysis, the Present volume of this intersection was inputted as an input volume in the simulation model. The traffic intersection can handle this volume. After the simulation run, the link segment result of the simulation is shown in the table below.

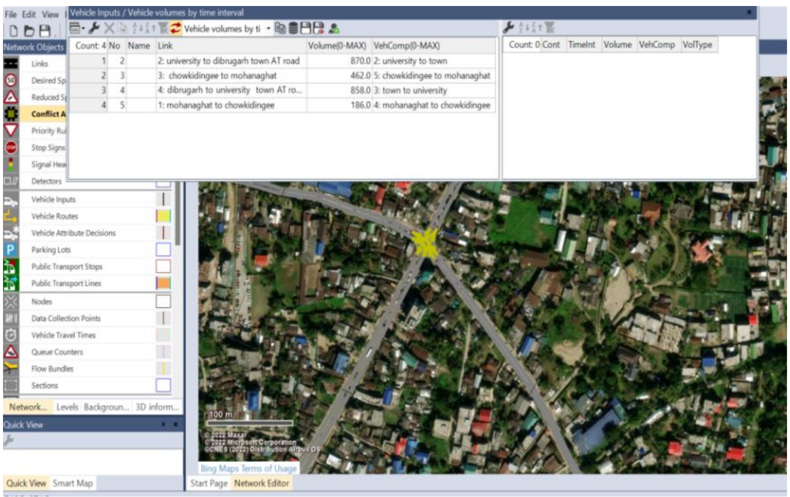

Figure 7: Present traffic volume inputted in the simulation model

Link Segment Results

Count: 2670	SimRun	TimeInt	LinkEvalSegment	Density(All)	DelayRel(All)	Speed(All)	Volume(All)
106	1	0-3600	2: university to dibrugarh town AT road -...	25.97	20.53 %	20.92	543.40
107	1	0-3600	2: university to dibrugarh town AT road -...	25.73	22.40 %	20.82	535.60
108	1	0-3600	2: university to dibrugarh town AT road -...	25.25	22.58 %	19.73	498.11
109	1	0-3600	2: university to dibrugarh town AT road -...	26.00	21.38 %	19.16	498.11
110	1	0-3600	2: university to dibrugarh town AT road -...	24.36	17.84 %	19.64	478.38
111	1	0-3600	2: university to dibrugarh town AT road -...	21.93	13.59 %	20.65	452.83
112	1	0-3600	2: university to dibrugarh town AT road -...	21.93	13.44 %	20.65	452.83
113	1	0-3600	2: university to dibrugarh town AT road -...	21.08	12.62 %	20.33	428.61
114	1	0-3600	2: university to dibrugarh town AT road -...	19.97	14.07 %	20.40	407.55
115	1	0-3600	2: university to dibrugarh town AT road -...	19.12	18.47 %	20.32	388.52
116	1	0-3600	2: university to dibrugarh town AT road -...	18.22	21.12 %	19.88	362.26
117	1	0-3600	2: university to dibrugarh town AT road -...	17.74	16.25 %	20.42	362.26
118	1	0-3600	2: university to dibrugarh town AT road -...	16.79	12.44 %	21.57	362.26

Figure 8: Link segment results for present traffic volume obtained from the simulation model

The point when traffic intensity becomes more than one Link evaluation data changes which are given bellow.

Link Segment Results

Count: 4005	SimRun	TimeInt	LinkEvalSegment	Density(All)	DelayRel(All)	Speed(All)
1888	5	0-3600	2: university to dibrugarh town AT road -...	76.67	51.36 %	12.93
1889	5	0-3600	2: university to dibrugarh town AT road -...	82.69	54.98 %	11.97
1890	5	0-3600	2: university to dibrugarh town AT road -...	75.22	50.50 %	13.07
1891	5	0-3600	2: university to dibrugarh town AT road -...	75.19	50.66 %	13.00
1892	5	0-3600	2: university to dibrugarh town AT road -...	63.46	41.68 %	15.32
1893	5	0-3600	2: university to dibrugarh town AT road -...	66.04	44.47 %	14.63
1894	5	0-3600	2: university to dibrugarh town AT road -...	72.76	49.86 %	13.22
1895	5	0-3600	2: university to dibrugarh town AT road -...	67.97	46.61 %	14.06
1896	5	0-3600	2: university to dibrugarh town AT road -...	61.85	41.61 %	15.43
1897	5	0-3600	2: university to dibrugarh town AT road -...	69.31	48.17 %	13.71
1898	5	0-3600	2: university to dibrugarh town AT road -...	67.21	47.00 %	14.11
1899	5	0-3600	2: university to dibrugarh town AT road -...	65.38	45.70 %	14.50
1900	5	0-3600	2: university to dibrugarh town AT road -...	62.34	43.01 %	15.16

Figure 9: Link segment results for at the time when traffic intensity becomes more than one from the simulation model

Corresponding traffic volume for the link evaluation is given below:

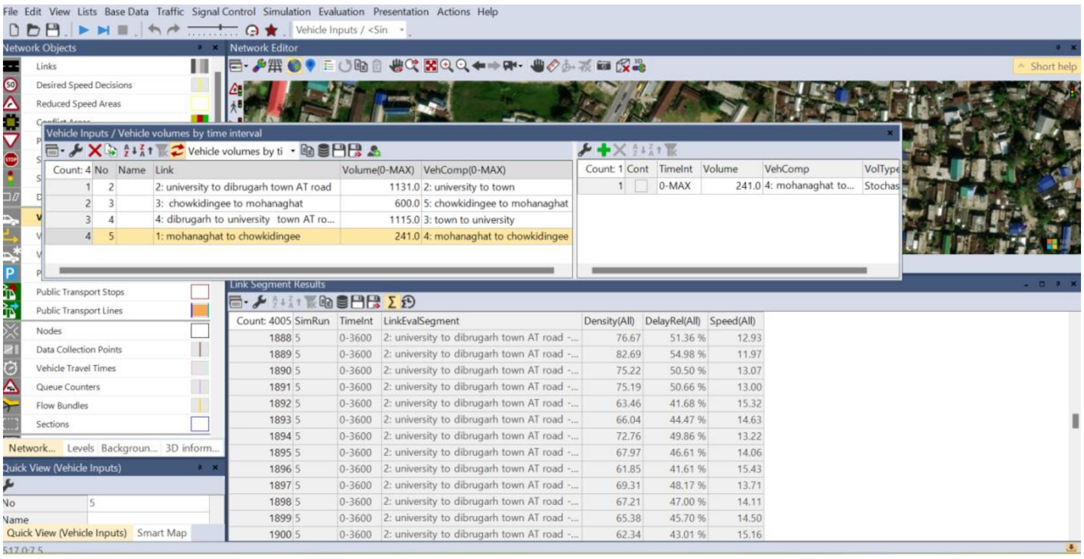

Figure 10: Screen shoot of traffic volume from the simulation model when intensity become more than one

When the traffic volume increases by 30%, the traffic intensity becomes greater than one for this Amolapatty intersection, indicating that the number of vehicles exceeds the system's capacity. After one hour of simulation, there were eight vehicles remaining in the system, which prevented the simulation from being completed. This situation leads to a traffic system failure at the intersection, implying that the intersection is unable to handle the increased traffic demand and cannot function properly. Furthermore, the simulation run reveals that the increase in traffic volume has several other consequences. The density of vehicles on the road increases from a range of 20-30% to 60-80%. The significant rise in density signifies that the road becomes much more congested due to the increased traffic, resulting in a higher number of vehicles occupying the available space. Additionally, the delay experienced by drivers also increases as a result of the heightened traffic volume. The delay, which was previously in the range of 20-30%, now falls within the 40-50% range. In summary, the 30% increase in traffic volume leads to a failure of the traffic system at the intersection, as it becomes overwhelmed by the higher traffic intensity.

In this phase, an attempt is made to study the effect of the addition of a new lane on the existing intersection. For this, we have prepared a model with an extra lane; for the Amolapatty intersection, the new lane was assumed to be added in the university to the Dibrugarh town direction. The simulation results revealed significant improvements in traffic parameters such as average delay, queue length, and average waiting time, with a notable decline in traffic congestion. In the previous model, increasing traffic volume by 30% resulted in the traffic intensity exceeding a value of one, indicating that eight vehicles remained within the system even after an hour of simulation. In contrast, when the enhanced model with an additional lane was subjected to a 30% increase in traffic volume, the system managed to sustain the traffic without forming an endless queue.

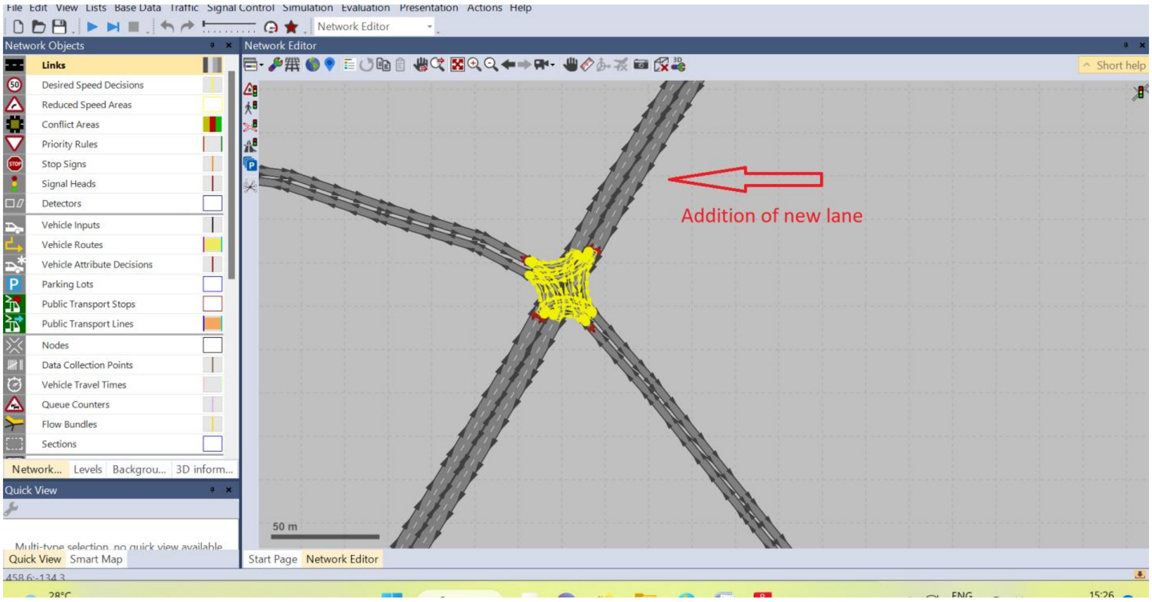

Figure 11: Addition of a new lane

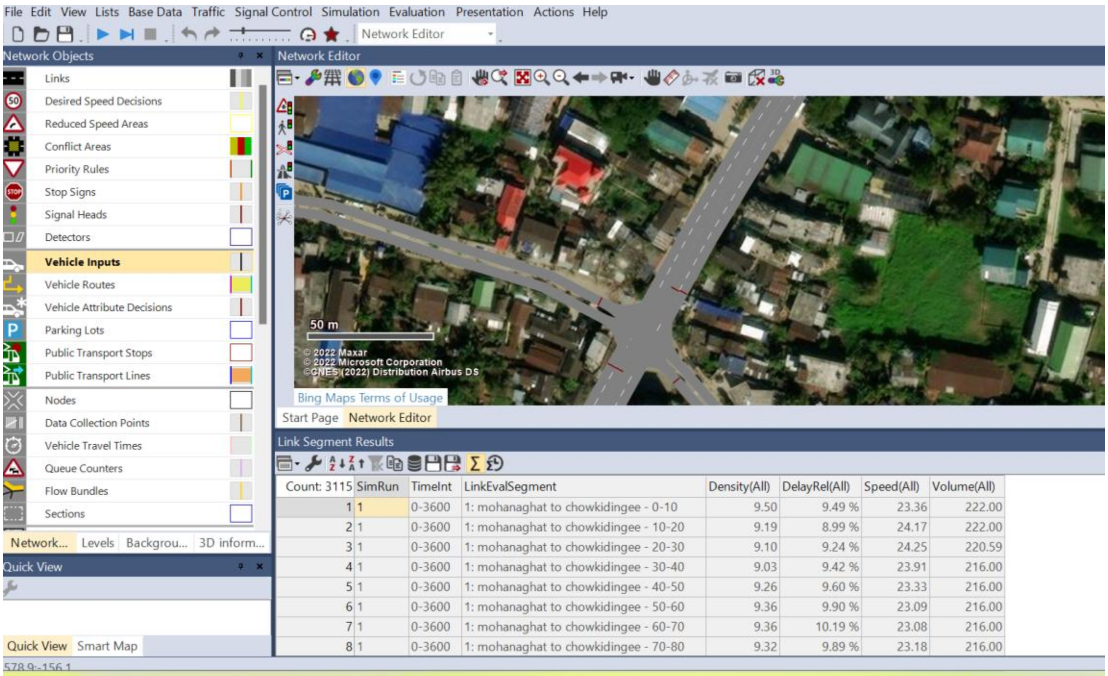

Figure 12: Link evaluation result with 30% increase in traffic volume.

In the last phase of the study, an attempt is made to study the potential impacts of transitioning a lane to a unidirectional format (one-way). For the Amolapatty intersection, we have one national highway (NH37); practically, it will not be possible to make it unidirectional. The lane in the direction of Mohanaghat is a single lane connecting the area, so it will not be possible to make it unidirectional. However, the lane heading towards the Chowkidingee intersection could be transitioned to a unidirectional layout. It would be possible to restrict vehicle movement towards Chowkidingee. The effect of increases in 30% volume in this modified condition will be useful. A comparison between these two scenarios – before and after the proposed changes has been conducted, and distinctive models for each scenario have been created

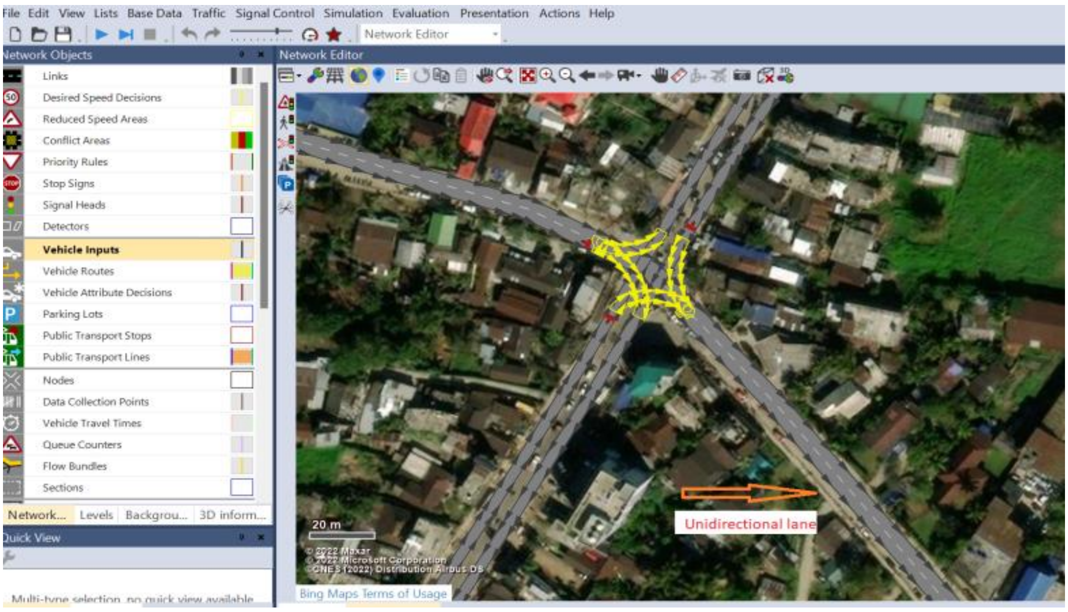

Figure 13: one-way movement amolapatty to chowkidingee only

In the first scenario, the traffic flow is restricted to only allow vehicles to move from Amolapatty to Chowkidingee, keeping the present traffic condition fixed. No vehicles are permitted to travel back to the Amolapatty intersection. Implementing this restriction will bring significant benefits to the Amolapatty intersection. Consequently, the evaluation of the model reflects similar outcomes, with noticeable decreases in traffic volume, density, and delays.

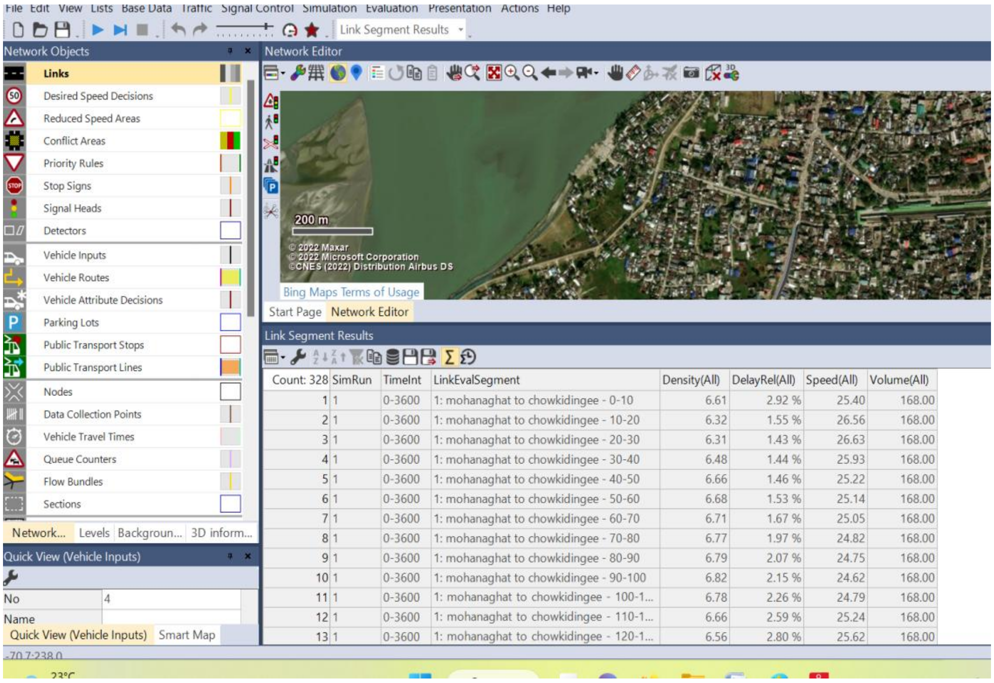

Figure 14:Link evaluation at present volume

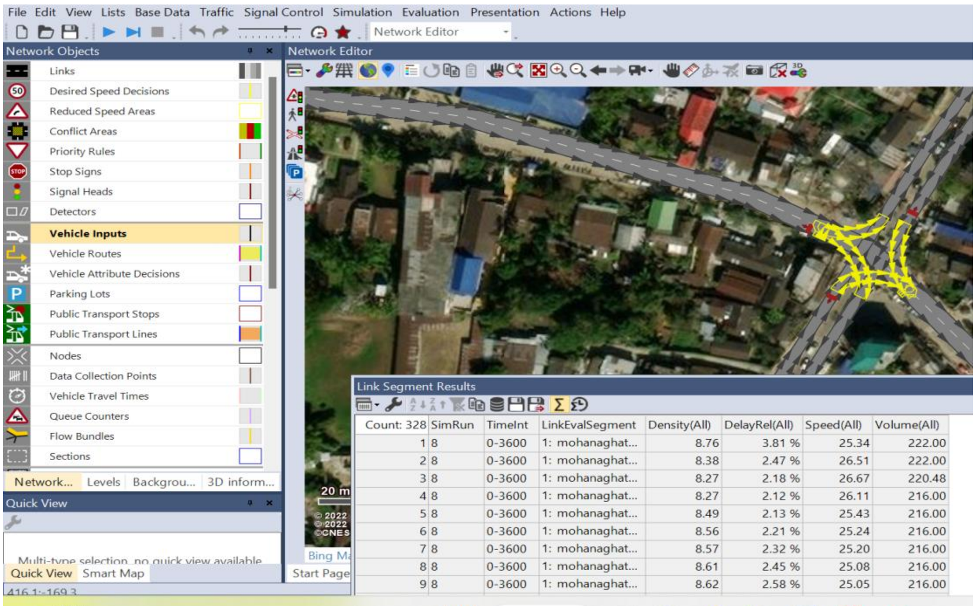

Figure15:Link evaluation by increasing 30% volume.

The findings indicate that even with a 30% increase in traffic volume, the impact on various parameters remains relatively low; traffic can run without congestion. But this alteration can hamper the capacity of nearby traffic intersections. Conducting a comparative study on the effects of this alteration on nearby intersections and finding an optimal solution can enhance the overall traffic conditions of the town.

7. Conclusion

The prediction of the traffic volume level at which the system can form an infinite queue is an important aspect of future traffic control; this will necessitate the need for alternative solutions for the traffic system. A traffic intensity value greater than 1 indicates that the system is unable to handle the incoming volume, leading to congestion, delays, and potential system failure. The study aims to predict the traffic volume level at which the traffic intensity exceeds 1. This serves as a threshold point where the system becomes overloaded, leading to the formation of long queues and decreased traffic flow efficiency. Upon identifying the system failure point, the study emphasizes the necessity for alternative solutions to address traffic congestion and long queue formation. This may involve considering infrastructure expansion, implementing traffic management measures, enhancing public transportation, or exploring intelligent transportation systems (ITS) solutions. The study shows that an increase of 30 % in traffic volume can cause a traffic system failure at the intersection. The addition of a new lane or making a lane one-way can increase the capacity of the intersection. But this alteration can hamper the capacity of nearby traffic intersections. Conducting a comparative study on the effects of this alteration on nearby intersections and finding an optimal solution can enhance the overall traffic conditions of the town.

8. Future prospect

Future research could focus on the nearby intersections, analyzing how changes at one affect others. A crucial aspect of further study could be exploring the impact of traffic congestion on fuel consumption and engine emissions. By understanding these relationships, we can build a comprehensive picture of traffic patterns and their environmental implications, providing a basis for more efficient and eco-friendly traffic management strategies.

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