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Analysing Capacity and Delay Parameters for Signalised Arterials with Freight Delivery for the Ratanpole Corridor of Ahmedabad City through a Microsimulation Model

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Abstract
Freight deliveries on signalized city roads frequently result in lane blockages, exacerbating urban traffic congestion. This issue has gained prominence as traffic engineers and city planners strive for sustainable solutions amidst constrained road capacities. This study's core aim is to evaluate a model tailored to assess the impact of freight deliveries on both capacity and delay along signalized city roads in Ahmedabad. Modeled after the methodology delineated in the Highway Capacity Manual (HCM2010), this research endeavors to shed light on the application of analytical tools in urban freight delivery policies. The investigation delves into estimating delay and vehicle capacity, factoring in variables like delivery locations, durations, and their differential effects across lanes. Leveraging machine learning techniques, particularly Support Vector Machines and Artificial Neural Networks, this study predicts vehicle capacity and estimates delays. The findings illustrate a strong concurrence between our predictions and actual observations, signifying the efficacy of the employed methodologies in assessing and managing freight-related traffic impacts in urban settings.
Keywords: Freight delivery, blocked street , Capacity, delay time .Ahmedabad; microsimulation model

1. Introduction

Urban freight deliveries on signalized roads frequently result in lane blockages along their designated routes. The escalating concern over traffic congestion stemming from these deliveries has garnered substantial attention in recent years. Balancing burgeoning demand with limited road capacity poses a formidable challenge for traffic engineers and urban planners alike. Anemerging discourse emphasizes the implementation of policies aimed at incentivizing off-peak hour deliveries to mitigate the detrimental impact on traffic congestion. A seminal study examining the influence of heavy vehicles on the traffic network was outlined in NCFRP Report 31, penned by Dowling et al. in 2014. This report provides detailed insights into the effects of trucks on the speeds of mid-block arterials, proposing enhanced methodologies for calculating truck-passenger car equivalent factors. These advancements are aimed at enhancing the capacity analysis of signalized intersections."

Nomenclature

Ssr,dl = average saturation rate for shared right turn lane
Csr capacity of shared right turn lane
Ct capacity of through lane
C cycle length
ddl delay time with freight delivery
T duration of analysis period
td duration of blockage
G effective green time
Er equivalent no of through cars for a protected right turn.
G green time
Nsr no of lane in the shared right turn Lane
Nt no of lane in the through Lane.
lt phase lost time
Pr proportion of the right turning vehicle in the shared lane
AR red time
Cdl= revised lane group capacity
Vdl revised vehicle arrival rate
Ssr saturation flow rate for the shared right lane
St saturation flow rate of a through lane
v vehicle arrival rate
Y yellow time

Existing methodologies inadequately tackle the challenges posed by parked trucks causing obstructions. Keegan and Gonzales (2016) underscored the hurdles associated with freight deliveries in urban settings, notably the impediment to traffic flow leading to diminished street capacity and increased vehicle delays. In response, researchers have turned to the 'All or Nothing' model and Kinematic wave theory to evaluate freight delivery impacts on traffic and devise effective policies. Benekohal and Zhao (2000) delved into the concept of passenger car equivalents, offering a means to quantify the disparate effects of heavy vehicles on traffic flow operations. Given their size and slower acceleration/deceleration capacities, heavy vehicles have the potential to significantly disrupt traffic performance at intersections.

In 2006, Holguín-Veras and his team conducted an extensive investigation into policies promoting off-peak hour deliveries within urban environments. Their study delved into the essential prerequisites for fostering agreements between receivers and carriers regarding off-hour deliveries, as well as the efficacy of various policies in facilitating such shifts, particularly in competitive markets. In 2008, Holguín-Veras reiterated the significance of incentivizing off-hourdelivery programs as a strategy for alleviating traffic congestion. The analysis predominantly centers on the insights and perspectives of governmental agencies and delivery drivers, who stand to benefit from navigating less congested roadways during off-peak periods.

In their 2004 discourse, Crainic and his team examined the challenge of ensuring recipients' adherence to off-hour delivery schedules, often requiring store staff presence for proper acceptance and handling. This entails recipients remaining available post regular business hours or arranging prior delivery accommodations in the absence of designated receivers. Holguin-Veras et al. (2016) delved into the intricacies of agent interactions within supply chains, highlighting the significant influence of supply receivers on delivery timing and methods. Their findings advocated for Residential Loading Zone (RLC) programs, foreseeing substantial benefits for large urban areas, including reduced freight vehicle miles traveled and alleviated congestion levels. Yannis et al. (2006) conducted a study on the impact of restricting vehicle movements associated with urban delivery operations during peak hours. Their conclusions suggested that limiting deliveries to specific business types during peak hours could yield favorable effects on traffic and the environment. Additionally, research focused on analyzing city freight deliveries and parking facilities aimed to optimize urban freight transportation systems, proposing a mobile check-in-based parking system for freight vehicles to streamline delivery processes. Leveraging advancements in computing technologies, machine learning models, as emphasized by Vakharia et al. (2017), have emerged as valuable tools for data classification, prediction, and forecasting. These models offer decision-makers real-time insights and data estimations, enabling the evaluation of individual driver behavior to tackle traffic congestion issues and anticipate future traffic flow patterns based on historical data.

After conducting a comprehensive literature review and recognizing the imperative need to assess traffic conditions within smart cities, it became apparent that there was a significant gap in the research related to the utilization of machine learning models for predicting and validating capacity and delay times associated with freight deliveries on both obstructed and unobstructed streets.

In the present research, we undertook an experimental inquiry utilizing the 'All or Nothing' model, a methodology derived from the Highway Capacity Manual of 2010. Subsequent to computing positions and delay times.

2.Experiments conducted

Ahmedabad has emerged as one of India's fastest-growing cities in recent years, experiencing significant industrial and commercial expansion. With this rapid development, addressing traffic congestion has become a top priority. It is crucial not only for optimizing transportation capacity but also for improving economic performance, mobility, and environmental sustainability, all of which directly impact the city's residents.

The central focus of this study revolves around the challenges posed by urban freight deliveries within Ahmedabad, often leading to traffic obstructions, decreased street capacity, and vehicle delays. The research encompasses an examination of three key intersections within the city: starting from Kalupur market, passing through Kalupur railway station, and concluding at Sarangpur junction. Of these intersections, two face notable traffic congestion primarily due to freight deliveries, while Kalupur railway station experiences relatively unimpeded traffic flow owing to the absence of such deliveries.

In our investigation, we employed the 'All or Nothing' model, a methodology outlined in the Highway Capacity Manual, to analyze both unblocked streets and those affected by freight deliveries. The results of our study, including total capacity and delay times for both unblocked and blocked streets, are detailed in Table 1 and Table 2.

The saturation flow rate for the shared right lane is determined by...

$$Ssr = St/(1 + \Pr(Er - 1)) \quad (1)$$

The capacity of each road group is determined by accounting for various factors such as the saturation flow rate and signal timing. In cases involving pre-timed traffic signals, the capacity for both the through lane and the shared right-turn lane can be derived from the guidelines provided in the 2010 edition of the Highway Capacity Manual. This manual serves as a comprehensive resource for traffic engineers, offering standardized methodologies and equations to evaluate road capacities under different traffic conditions and signal settings. By utilizing the prescribed procedures outlined in the manual, traffic analysts can accurately assess the capacity of road segments, facilitating informed decision-making in transportation planning and management.

$$Ct = StNtg/C \quad (2)$$

The determination of the shared right-turn lane's capacity follows a specific methodology and analysis process.

$$Csr = Ssr\ Nsr\ g\ /C \quad (3)$$

The evaluation of control delay at the intersection is performed individually for each lane group, ensuring a comprehensive analysis of traffic flow dynamics.

d= (0.5c(1-g/C) ^2)/ (1-((min {1, v/c) g)/C)) (4)

The computation of capacity in the context of freight delivery, employing the All or Nothing model, proceeds in the subsequent manner.:"

Ssr, dl=Ssr(1- td/T) (5)

The methodology for determining the capacity of the shared right-turn lane is outlined as follows:

Csr,dl=Ssr,dl g/C (6)

The process of calculating delay concerning freight delivery, utilizing the All or Nothing model, is established as follows:

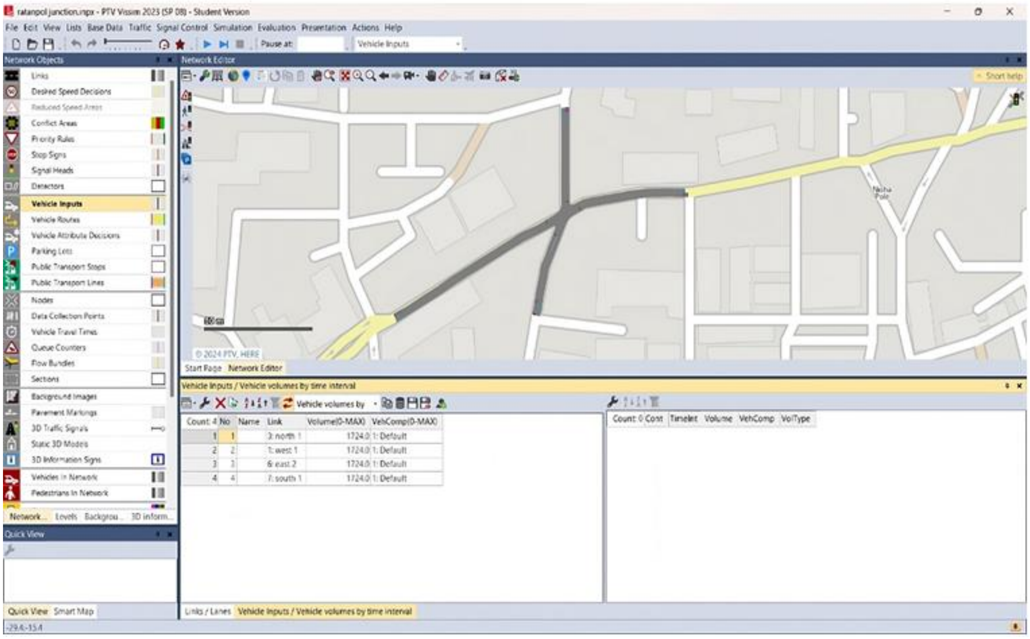
ddl=0.5 (C(1-g/C) ^2)/(1-min{1, vdl/cdl} g/C) (7)

Table 1 Total capacity, delay time and spot speed values for blocked location

No	Blocked location	Capacity (veh/hr)		Total Capacity	Delay time(sec)	Spot speed (km/hr)
		through lane	Shared right turn lane			
	Ratanpole cross road	756	534	1290	17.91	31.16

Table 2 Measurement and Analysis of Heterogeneous Vehicle parameters for Following Behavior on Urban Freeways

Parameter	Default	Min	Max	
Average Standstill Distance	2	0.35	2.8	2.00
Waiting time before diffusion	60	10	72	60.11
Min headway (Front/Rear)	0.5	0.1	0.8	0.50
Distance Standing (0 kmph)	1	0.2	1.15	0.93
Distance driving (50 kmph)	1	0.6	1.3	1.00



Figur 1: Link Generated for Ratanpole Corridor through Vissim Software.

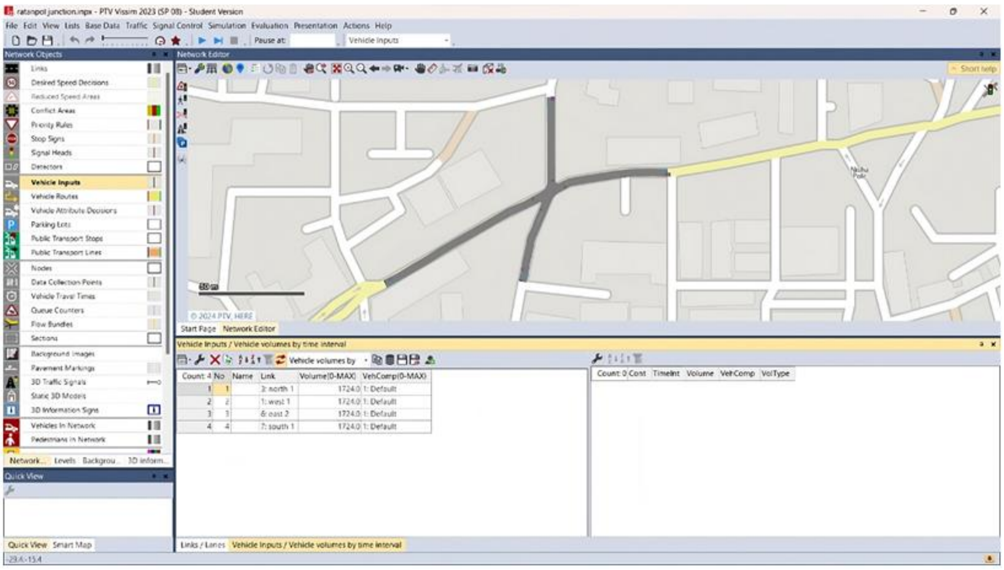


Figure 2: Traffic Volume Input in Vissim Software.

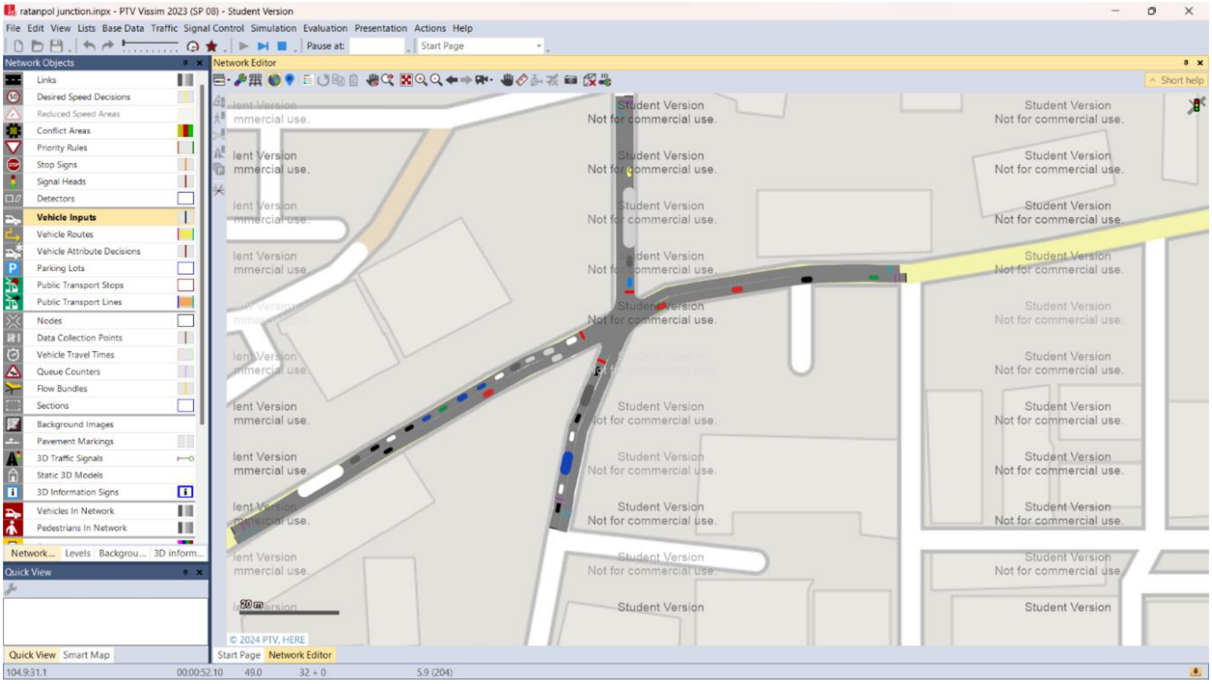


Figure 3: Micro simulation model run through Vissim Software

2. Results and Discussion

In this study, an ALL or Nothing model was employed to assess the capacity and delay times of both unblocked streets and streets obstructed by freight delivery. The findings indicate a significant reduction in road capacity when the street is blocked due to freight delivery, leading to increased delay times. The focal point of this study revolves around the challenge posed by urban freight deliveries that disrupt traffic flow within urban settings, resulting in diminished street capacity and subsequent vehicle delays. Despite the increasing discourse surrounding urban freight in scholarly works, there persists a necessity for quantitative approaches to evaluate how the obstruction caused by delivery vehicles impacts the performance of signalized roads. Delivery operations are not confined to specific locations along a block; rather, they can occur intermittently, often extending over several minutes, thus hampering the ability to effectively serve diverse road user demographics. Through the development of a microsimulation model, this research endeavors to shed light on how this conceptual framework manifests in real-world street dynamics. As fright deliveries take place, it increases delay time and decreases road capacity as well as speed is being decreases. With the addition of this parameters for analyzing heterogeneous traffic based on car following theory indicates average standstill distance has been maintaining but waiting time before diffusion is being increase due to more congestion.

3. Conclusion

This research addresses the issue of urban freight deliveries obstructing traffic flow in urban environments, leading to reduced street capacity and causing delays for vehicles. Despite the growing attention given to urban freight in literature, there remains a need for quantitative methods to assess the impact of delivery vehicles blocking lanes on signalized road performance. Delivery activities can take place at various points along a block, with durations often spanning several minutes, thereby impeding the capacity to cater to different road user groups. By developing a microsimulation model, this study aims to provide insights into how this theoretical framework translates to real-world street conditions.

References

[1] Benekohal, R. F., and Zhao, W. ,2000. Delay-based passenger car equivalents for trucks at signalized intersections.Transportation Research Part A: Policy and Practice 34.6,437-457.

[2] Crainic, T. G., Ricciardi, N., and Storchi, G.

,2004.Advanced freight transportation systems for congested urban areas.Transportation Research Part C: Emerging Technologies 12.2,119–137.

[3] Dowling, R., List, G., Yang, B., Witzke, E., Flannery, A., 2014. Incorporating truck analysis into the Highway Capacity Manual.DOI: https://doi.org/10.17226/22311.

[4] Holguín-Veras, J., Wang,Q.,Xu,N.,Ozbay,K., Cetin,M.,Polimeni,J.,2006.The impacts of time of day pricing on the behavior of freight carriers in a congested urban area: Implications to road pricing.Transportation Research Part A: Policy and Practice 40 (9),744-766.

[5] Holguín-Veras, J.,2008. Necessary conditions for off-hour deliveries and the effectiveness of urban freight road pricing and alternative financial policies in competitive markets.Transportation Research Part A: Policy and Practice 42,392-413.

[6] Holguín-Veras, J., Sánchez-Díaz, I. and Browne, M. ,2016. Sustainable Urban Freight Systems and Freight Demand Management.Transportation Research Procedia 12,40-52.

[7] Keegan, A. and Gonzales, E. ,2016.Evaluating Capacity and Delay for Signalized Arterials with Freight Deliveries.Transportation Research Procedia 15,161-175.

[8] Manual, H. (2010) HCM 2010 Highway Capacity Manual. National Academy of Sciences.

[9] Mrazovic, P.,Eravci,B.,Larriba-Pey,J.L.,Ferhatosmanoglu,H.,Matskin,M.,2017. Understanding and Predicting Trends in Urban Freight Transport.18th IEEE International Conference on Mobile Data Management DOI: 10.1109/MDM.2017.26

[10] Singh, S. and Kumar,N.,2015.Rotor Faults Diagnosis using Artificial Neural Networks and Support Vector Machines. International Journal of Acoustics and Vibrations 20.4, 153-159.

[11] Upadhyaya, R., Manglick, A., Reddy, D.K., Padhy, P.K., Kankar, P.K., 2015.Channel optimization and nonlinear feature extraction for Electroencephalogram signals classification. Computers and Electrical Engineering.45,222-234.

[12] Yang, X.,Sun,Z.,Ban,X.J.,Veras,J.H.,2014.Urban Freight Delivery Stop Identification with GPS Data. Transportation Research Record: Journal of the Transportation Research Board 2411(December),55–61.

[13] Yannis, G., Golias, J. and Antoniou, C. (2006) Effects of urban delivery restrictions on traffic movements, Transportation Planning and Technology 29.4,295-311.