ASSESSING LEVEL OF SERVICE AT RAJSHAHI RAILWAY STATION INTERSECTION: A TRAFFIC VOLUME SURVEY APPROACH

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ABSTRACT

A traffic volume survey (TVS) is a systematic study performed to quantify and evaluate the volume and movement characteristics of traffic on a particular route or network of roads. The study offers useful information on the volume of vehicles traveling through a specific area, their types (such as cars, trucks, and motorbikes), and their patterns of movement. The study's objective is to investigate the behavior of mixed traffic flow at the intersection of Rajshahi Railway Station which is a crucial transportation hub situated in the heart of Rajshahi city, a major urban center in Northwestern Bangladesh. This intersection is composed of three legs which indicate three roads and six lanes. A field TVS was done to evaluate the degree of service at the railway station intersection (RCC). Level of service (LOS) was calculated using the volume capacity ratio, peak hour factor (PHF) technique, and speed-based method. The outcomes of this research will serve as a valuable resource for transportation planners, policymakers, and traffic engineers in devising effective strategies to enhance the LOS and overall traffic management at the Rajshahi Railway Station intersection.

Keywords: *TVS, intersection, LOS, V/C method, PHF method, Speed based method, PCU.*

1. INTRODUCTION

Transportation system of an area is the most sensitive and intellectual procedure maintaining some rules and regulations. The transparency of the transport system can provide insight into how comfortable people are in their daily lives and activities where transports are the main objects in the system. Various vehicles and pedestrians are known as the moving objects of the transportation system. Other fixed facilities are the road, sidewalk, etc. Some control system is also included to maintain the rules as mentioned where all systems are expected to run effectively. The vehicles used by people can be categorized into two types: public transport and private transport. According to different viewpoints, there are more public transit options than private ones. Expect all of that; a better sustainable transport system ought to exist. By converting products and services, transport is an essential tool for growing the economy (Olabasi & Umar,2020). As it is known that the population of our country is increasing. A greater number of automobiles are required to cooperate with the extra people. If the state of these vehicles' circulation is not monitored, there may be an issue. To convey the scenario in a certain location, a traffic volume survey (TVS) is required for this consideration. In certain unique circumstances, any route's movement can alter with time. An intersection is the point where two or more roads meet, intersect, diverge, or converge simultaneously. Vehicles are moved through the intersection in a variety of routes to reach their goal. This section shows a variety of roads and automobiles that are used to transport people for different reasons. The objective of the study is to examine the behavior of mixed traffic flow to assess Level of Service (LOS) at the Rajshahi Railway Station intersection, using three analytical methods: V/C ratio, Peak Hour Factor, and Speed-Based Method, and subsequently propose targeted interventions for enhancing traffic management and reducing congestion.

A TVS can obtain some highly visible information for any type of development. Any given vehicle's volume can aid in organizing a specific discipline to circulate these in an obligatory manner. In this case, one of the most important metrics for determining the amount of traffic in the transportation system is the passenger car unit (PCU). PCU computes the impact on traffic variables by contrasting passenger automobiles with other modes of transportation. It turns the traffic from being heterogeneous to being homogeneous. In this survey, traffic movement is observed. The flow of traffic determines the level of passenger security. It is also essential for people to move about conveniently. Additionally, it may result in some chaotic circumstances if the flow is observed to be significantly high. The most economically advanced metropolis in Bangladesh, Dhaka, is experiencing terrible traffic conditions as a result (Sabbir, 2022). To facilitate subsequent analysis, the movement's direction is noted together with the vehicles' known characteristics. As already mentioned, excessive traffic is ruining people's lives and squandering a lot of time on business-related activities. The transportation system, which is the primary focus of the traffic volume study, was shown to be the most important aspect of regionalization when determining the impact and intensity of earned money for each given area. Based on the preceding requirements, it is evident that a TVS is among the most important tools for lowering economic barriers and improving a variety of features. Furthermore, a good transportation system is the result of an intellectual TVS which is compared as the vessels to make an area economically repleted.

2. LITERATURE REVIEW

A TVS plays a vital role in quantifying and assessing the characteristics of traffic movement within a particular route or network of roads (Mohan et al., 2020). It provides valuable insights into the volume of vehicles, their types, and patterns of movement, thereby aiding in the understanding of mixed traffic flow behavior (Li et al., 2019). In the case of the Rajshahi Railway Station intersection, a significant transportation hub in Northwestern Bangladesh, a field TVS was conducted to evaluate LOS (Islam et al., 2021).

The concept of LOS is widely used in transportation engineering to measure the quality of traffic flow and the effectiveness of transportation infrastructure (Garber & Hoel, 2017). LOS is typically determined by various factors, including the volume capacity ratio, peak hour factor (PHF) technique, and speed-based method (Shen et al., 2018). These methodologies help in assessing the efficiency and performance of transportation systems, specifically at intersections (Hassan et al., 2017).

Transportation planners, policymakers, and traffic engineers heavily rely on the outcomes of TVSs and LOS evaluations to devise effective strategies for enhancing traffic management and the LOS at specific intersections (Amini et al., 2019). The results of the survey conducted at the Rajshahi Railway Station intersection will serve as a valuable resource for these stakeholders, enabling them to make informed decisions regarding traffic planning, optimization of infrastructure, and implementation of appropriate measures (Wu et al., 2020).

In conclusion, the TVS conducted at the Rajshahi Railway Station intersection will provide crucial information on the volume and movement characteristics of traffic, enabling a comprehensive evaluation of the LOS. The methodologies employed in this survey, such as the volume capacity ratio, PHF technique, and speed-based method, will contribute to a deeper understanding of mixed traffic flow behavior. The findings of this research will prove beneficial for transportation planners, policymakers, and traffic engineers, aiding them in formulating effective strategies to enhance the LOS and overall traffic management at the Rajshahi Railway Station intersection.

3. METHODOLOGY

3.1 Study Area

The Rajshahi Railway Station Intersection is a vital transportation hub, serving as a major connection point for both road and rail transport. Due to its strategic location, the intersection experiences significant traffic congestion, especially during peak hours. The study area for this research paper focuses on the Rajshahi Railway Station Intersection in Rajshahi, Bangladesh. The intersection consists of six lanes and operates as a three-leg intersection.

Figure 1: Study Area

From the figure we can see that, there is a three-legged unsignalized intersection where each leg has 2 lanes. The lanes are: Rail gate to Station mor, Station mor to Vodra Mor, Station mor to Rail gate, Vodra Mor to Station mor, Sagorpara to Station mor, Station mor to Sagorpara. And the six lanes along with their width, median, and footpath width are given below the table.

Table 1: Road Geometry

	Lane width		Median	Footpath width	
Road Name	**Right**	**Left**		**Right**	**Left**
Rail gate to Station mor	26	26	4	10	10
Station mor to Vodra Mor	26	26	4	10	10
Station mor to Rail gate	26	26	4	10	10
Vodra Mor to Station mor	26	26	4	10	10
Sagorpara to Station mor	14	14	No median	8	8
Station mor to Sagorpara	14	14	No median	8	8

3.2 Layout Plan

Figure 2 shows the layout plan of Rajshahi Railway Station intersection, where we can see that, from where a vehicle can come, and go to its destination. Determining the LOS at an intersection at Rajshahi Railway Station is the main objective of this study. The modal composition of different modes of travel, including the size and geometry of the roads, is essentially linked to LOS. Every mode of transportation has advantages in terms of cost, speed, accessibility, frequency, safety, comfort, and other factors; these are all highlighted by its modal composition.

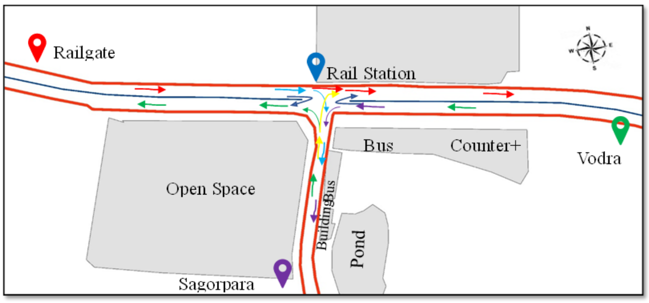

Figure 2: Layout Plan

Table 2: LOS Measurement and Description

Level of service	V/C ratio	Peak Hour Factor	Speed Based Method (Km)	Detailed Description
LOS A	<0.6	≤ 0.7	≥ 40	Exceptional service with minimal delays and high travel speeds.
LOS B	0.6-0.7	0.7-0.8	30-40	Good service with some minor delays and moderate travel speeds.
LOS C	0.7-0.8	0.8-0.85	25-30	Satisfactory service with noticeable delays, reduced travel speeds.
LOS D	0.8-0.9	0.85-0.9	15-25	Poor service with significant delays and low travel speeds.
LOS E	0.9-1.0	0.9-0.95	≤ 15	Very poor service with severe delays, extremely low travel speeds.
LOS F	>1.0	≥ 1.0		Unacceptable service with extreme delays and almost non-existent travel speeds.

To calculate the LOS, we conducted a geometric feature analysis and a TVS to count mixed vehicles manually. The three phases of traffic data collection were morning (8–10 am), afternoon (12–2 pm), and evening (4–6 pm), each with a two-hour peak on 18th and 21st May, 2023. To find the existing road capacity, a geometric feature study was done. To calculate the present supply and capacity conditions at different intersections, taking into account factors like the number of legs, shoulder, highway length, carriageway width, footpath, median, and control system. Another method used to collect data was field surveys. PCU computation is an important aspect in analysing mixed or heterogeneous traffic, and PCU is a simplification that translates diverse types of vehicles into an equivalent number of passenger cars. To estimate the LOS of the intersection three useful methods have been applied. The volume-capacity ratio is first method which is one of the most popular and useful metrics for evaluating traffic conditions in urban areas is the volume capacity ratio (V/C), measures the mobility and quality of travel of a facility or a portion of a facility. V is the total number of vehicles that pass a given point in an hour, and C is the maximum number of vehicles that can pass through a given point under normal traffic conditions. It does a comparison between the roadway demand (vehicle volumes) and the roadway supply (carrying capacity). The V/C method is associated with LOS to determine the performance of a roadway. This measure can alert transportation providers to those areas where traffic mitigation measures must be considered. The V/C ratio has been calculated by equation (1):

Volume Capacity Ratio = (Total Hourly PCU)/Capacity, C = (Highest Design Capacity * Effective Width)/12 **(1)**

The second method is to compute the LOS using the Peak Hour Factor (PHF). Traffic engineers pay more attention to the volume of traffic during peak hours to assess capacity and other crucial factors. Since notable short-term changes frequently transpire over the course of an hour, the assessment of service quality relies on the highest flow rates that transpire during peak hours. Typically, a 15-minute peak flow rate is employed (Number of Reading=4). The relationship between the total hourly volume and the peak 15-minute flow rate is described by the peak-hour factor or PHF. In metropolitan regions, peak-hour factors often fall between 0.80 and 0.98. Peak-hour values greater than 0.95 are frequently a sign of heavy traffic. PHF was evaluated by equation (2):

Peak Hour Factor = Average PCU 1 hour/(15 Minutes Highest PCU*Number of Reading) **(2)**

The third one is Speed based method. When conducting TVSs, one popular technique for estimating the number of cars that pass through a certain location on a route is the speed-based method. This approach depends on calculating the average speed of moving vehicles to calculate the flow of traffic.

Traffic Volume = Total Distance / Average Speed **(3)**

The total distance is the length of the survey section, and the average speed is calculated by summing up the speeds of all vehicles measured and dividing it by the total number of vehicles.

4. DATA ANALYSIS

In Rajshahi, the transportation system comprises various modes of vehicles with different passenger carrying capacities. The PCU values mentioned in table 3 are unique to Rajshahi and are derived from the standard values found in the Rajshahi Metropolitan Development Plan (RMDP). These figures aid in determining the relative effects of various vehicle categories on city traffic flow.

Table 3: PCU Values

MODE	Truck	Bus	CNG	Utility	Car	Auto	Auto Rickshaw	Motor Cycle	Bicycle	Cycle Rickshaw
PCU (RMDP)	3	3	1	1	1	2	2	0.75	0.5	2

4.1 Modal Variation of 6 Existing Lane

To assess modal variations in traffic across all six lanes, we selected both a weekend day (Thursday) and a weekday (Sunday) to examine differences in traffic volume on these two distinct days.

Thursday:

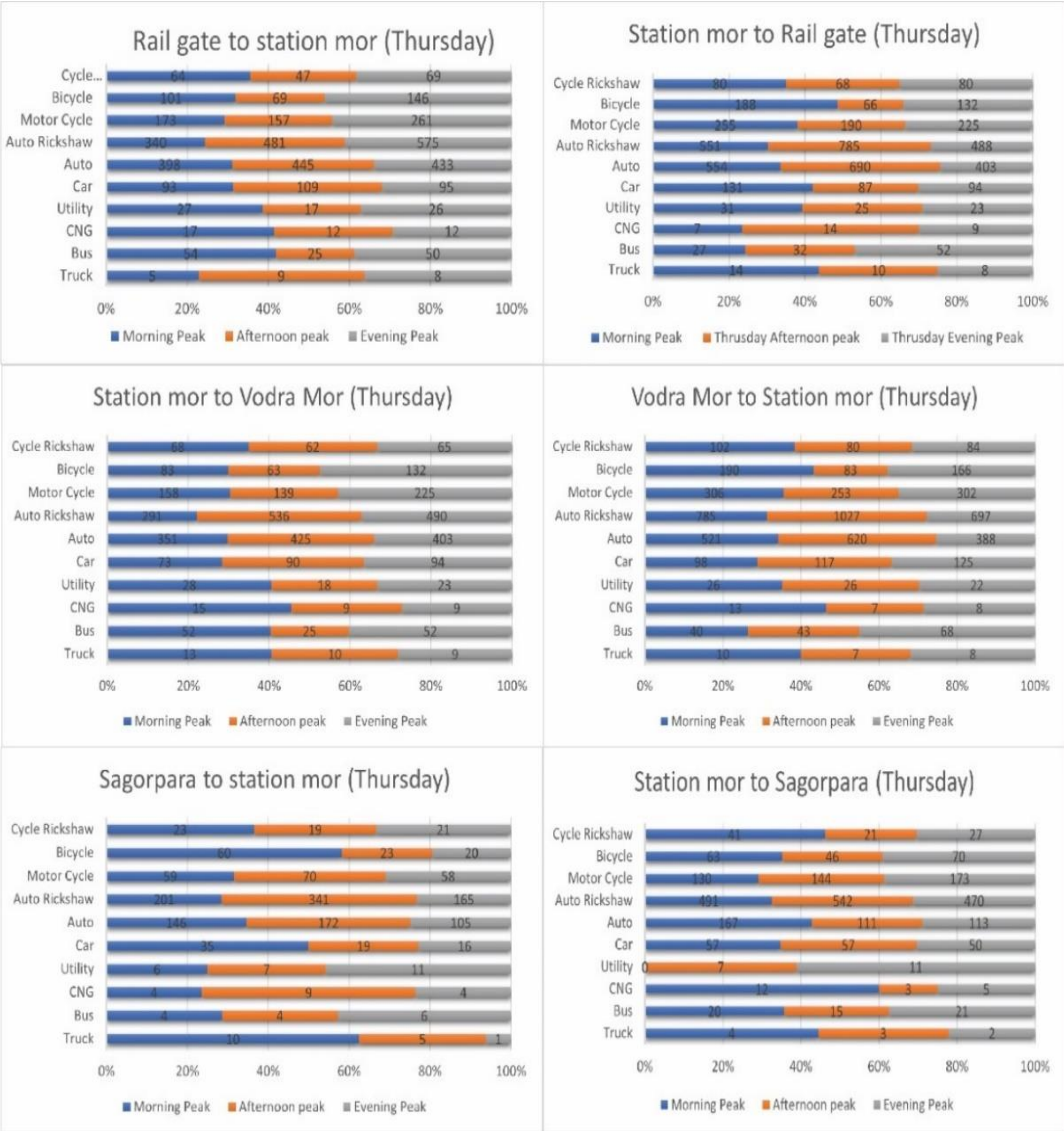

Figure 3: Modal Variation on Thursday

During Thursday peak hours at the Rail gate to Station mor, mornings see autos leading with 398 vehicles, while afternoons have auto rickshaws at 481 and evenings also see auto-rickshaws dominating with 575. From Station mor to Rail gate, mornings peak with autos at 554, afternoons with auto-rickshaws at 785, and evenings with auto-rickshaws at 488. From Station mor to Vodra Mor, mornings observe autos at 351, afternoons see auto-rickshaws at 536, and evenings maintain auto-rickshaws as the highest. From Vodra Mor to Station mor, mornings highlight auto-rickshaws at 785, afternoons peak with auto-rickshaws at 1027, and evenings with auto-rickshaws at 697. Sagorpara to Station mor morning shows auto-rickshaws at 201, afternoons peak with auto-rickshaws at 341, and evenings with auto-rickshaws at 165. Station mor to Sagorpara mornings feature auto rickshaws at 491, afternoons with auto-rickshaws at 542, and evenings with auto-rickshaws at 470.

Sunday:

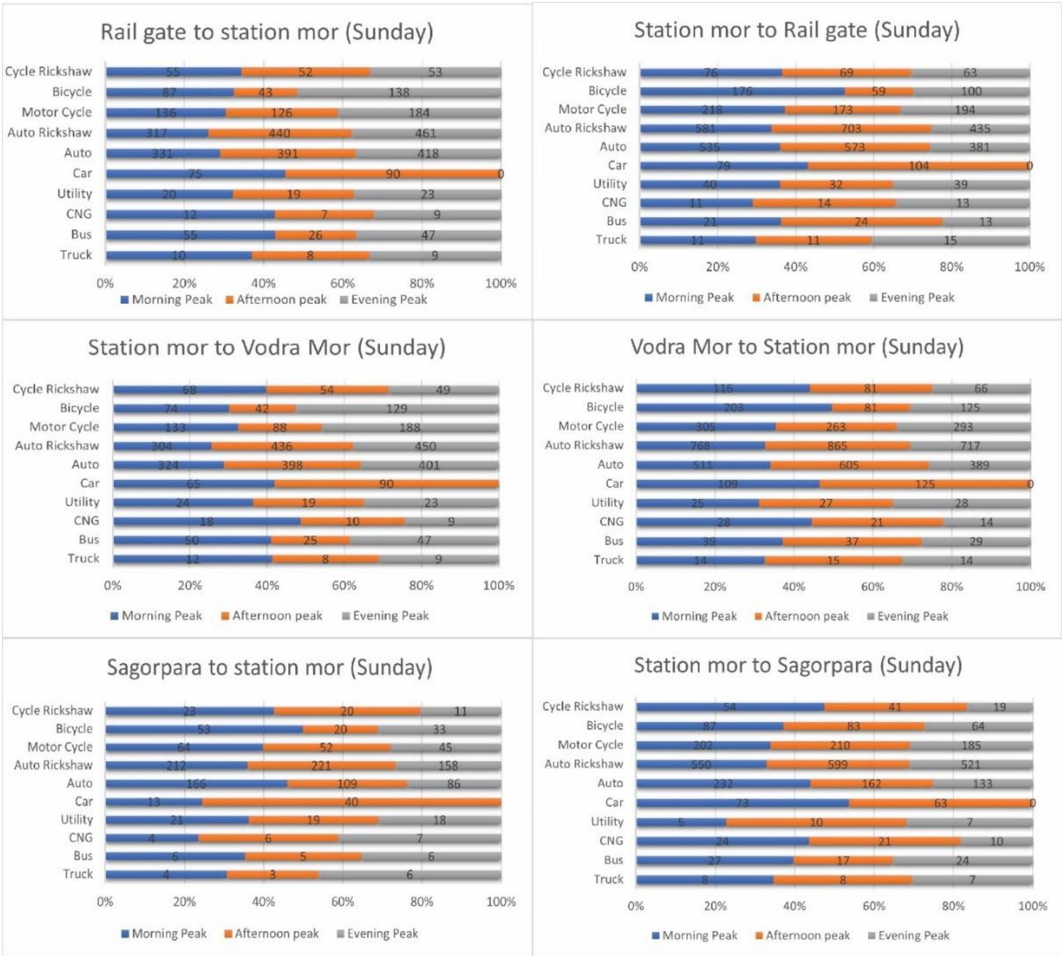

Figure 4: Modal Variation on Sunday

On Sunday at Rail gate to Station mor, mornings peak with autos at 331, afternoons see auto-rickshaws at 440 and at evening auto-rickshaws also counted highest among all other transports. From Station mor to Vodra Mor, Sunday mornings highlight autos at 324, afternoons maintain auto-rickshaws at 436, and evenings continue with auto-rickshaws at 450. From Vodra Mor to Station mor, mornings showcase auto-rickshaws at 768, afternoons with auto-rickshaws at 865, and evenings with auto-rickshaws at 717. Sagorpara to Station mor has mornings with auto-rickshaws at 212, afternoons with auto-rickshaws at 221, and evenings with auto-rickshaws at 158. Station mor to Sagorpara peak with auto-rickshaws at 550 in the morning, 599 in the afternoon, and 521 in the evening.

After all six lanes' data was analysed, it was found that autos and auto rickshaws had the largest volume of any kind of vehicle. Because they are affordable and easy to manoeuvre, these vehicles are common urban transportation options. With the exception of Sagorpara Road, where motorcycle usage is significantly higher than that of other lanes, motorcycles and bicycles were determined to have a modest traffic volume after auto rickshaws and vehicles. For short-distance commutes, these forms of transportation are frequently utilised. Car and cycle rickshaws were observed to have a lower medium range of traffic volume. Finally, Ultimately, the lowest traffic volumes were identified for trucks, buses, CNG cars, and utility cars.

4.2 Temporal Variation of 6 Existing Lane

The given analysis provides data on the total PCUs per hour during different peak periods of the day.

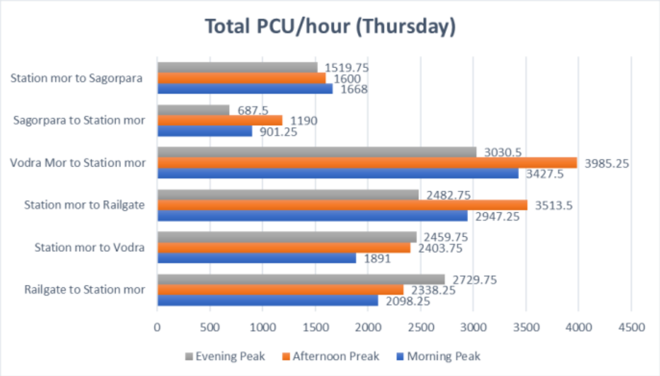

Figure 5: Total PCU/hour (Thursday)

PCUs per hour were used to quantify the traffic volume in Rajshahi city. From Vodra Mor to Station Mor, the maximum PCU figure was recorded at 3427.5 PCUs. With 2947.25 PCUs, the Station mor to Railgate route had a substantial amount of traffic, but the Railgate to Station mor route had 2098.25 PCUs during the Morning Peak.. The greatest PCU value in the Afternoon Peak rose to 3985.25 between Vodra Mor to Station Mor, highlighting Station Mor's importance as a transportation hub. There were variations in the Evening Peak; the highest PCU was 2729.75 from Railgate to Station Gate. All things considered, the data highlights the crucial role that Station Mor plays in travel, especially during rush hour, which helps to explain the higher PCU values that are seen around the city.

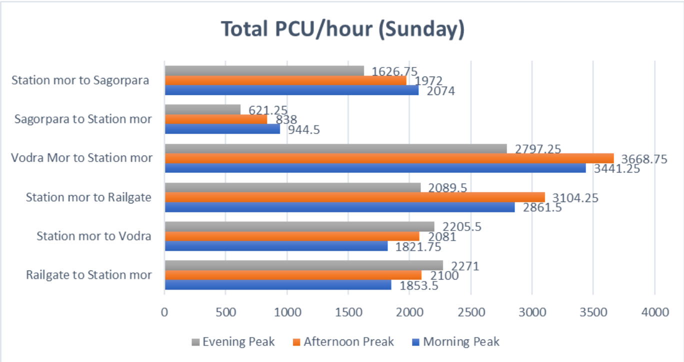

Figure 6: Total PCU/hour (Sunday)

The same output had been generated on Sunday as well, with Vodra Mor to Station having the highest PCU value of 3668.75.

4.3 Level of Service (LOS)

4.3.1 V/C Ratio Method

LOS analysis stands for Level of Service analysis, which is a method used to assess the quality of traffic conditions on a roadway. It divides traffic conditions into several groups, from A (best) to F (worst), according to variables like volume, capacity, and the volume-to-capacity ratio (V/C ratio). The more congested the road, the higher the V/C ratio. The LOS for the analysed lanes ranges from F (worst) during all three peak periods. This suggests that traffic is heavy compared to the lanes' capacity, resulting in congested situations.

Table 4:LOS of different lanes by V/C ratio method on Thursday

Thursday					
Morning peak					
LANE Name	**Volume (PCU/h)**	**Capacity**	**V/C Ratio**	**LOS**	
Rail gate to Station mor	2098.25	1950	1.07603	F	
Station mor to Vodra Mor	1891	1950	0.96974	E	
Station mor to Rail gate	2947.25	1950	1.51141	F	
Vodra Mor to Station mor	3427.5	1950	1.75769	F	
Sagorpara to Station mor	901.25	700	1.2875	F	
Station mor to Sagorpara	1668	700	2.38286	F	
Afternoon peak					
LANE Name	**Volume (PCU/h)**	**Capacity**	**V/C Ratio**	**LOS**	
Rail gate to Station mor	2338.25	1950	1.1991	F	
Station mor to Vodra Mor	2403.75	1950	1.23269	F	**F**
Station mor to Rail gate	3513.5	1950	1.80179	F	
Vodra Mor to Station mor	3985.25	1950	2.04372	F	
Sagorpara to Station mor	1190	700	1.7	F	
Station mor to Sagorpara	1600	700	2.28571	F	
Evening peak					
LANE Name	**Volume (PCU/h)**	**Capacity**	**V/C Ratio**	**LOS**	
Rail gate to Station mor	2729.75	1950	1.39987	F	
Station mor to Vodra Mor	2459.75	1950	1.26141	F	
Station mor to Rail gate	2482.75	1950	1.27321	F	
Vodra Mor to Station mor	3030.5	1950	1.5541	F	
Sagorpara to Station mor	687.5	700	0.98214	E	
Station mor to Sagorpara	1519.75	700	2.17107	F	

Based on table 4, most routes between different lanes have a "LOS F" in the morning, afternoon, and evening. However, the Sagorpara to Station mor route has a slightly better "LOS E" in the evening, while the Station mor to Vodra Mor route has a little better "LOS E" in the morning. Overall, it can be concluded that Thursday's LOS at the intersection is marked as "LOS F," which is the lowest level.

Table 5: LOS of different lanes by V/C ratio method on Sunday

Sunday					
Morning peak					
LANE Name	**Volume (PCU/h)**	**Capacity**	**V/C Ratio**	**LOS**	
Rail gate to Station mor	1853.5	1950	0.950513	E	
Station mor to Vodra mor	1821.75	1950	0.934231	E	
Station mor to Rail gate	2861.5	1950	1.467436	F	
Vodra mor to Station mor	3441.25	1950	1.764744	F	
Sagorpara to Station mor	944.5	700	1.349286	F	
Station mor to Sagorpara	2074	700	2.962857	F	**F**
Afternoon peak					
LANE Name	**Volume (PCU/h)**	**Capacity**	**V/C Ratio**	**LOS**	
Rail gate to Station mor	2100	1950	1.076923	F	
Station mor to Vodra mor	2081	1950	1.067179	F	
Station mor to Rail gate	3104.25	1950	1.591923	F	
Vodra mor to Station mor	3668.75	1950	1.88141	F	

Sagorpara to Station mor	838	700	1.197143	F
Station mor to Sagorpara	1972	700	2.817143	F
Evening peak				
LANE Name	**Volume (PCU/h)**	**Capacity**	**V/C Ratio**	**LOS**
Rail gate to Station mor	2271	1950	1.164615	F
Station mor to Vodra mor	2205.5	1950	1.131026	F
Station mor to Rail gate	2089.5	1950	1.071538	F
Vodra mor to Station mor	2797.25	1950	1.434487	F
Sagorpara to Station mor	621.25	700	0.8875	D
Station mor to Sagorpara	1626.75	700	2.323929	F

Table 5 shows that the travel times between Rail gate and Station mor, as well as between Station mor and Vodra Mor, are comparatively longer than the other routes during the Sunday morning peak. The LOS rating for these routes is E, which denotes moderate congestion.
Travel times between several places, such as Rail gate, Station mor, Vodra Mor, and Sagorpara, are constantly scored as LOS F throughout the afternoon and evening peaks, indicating substantial congestion and prolonged travel times.
It's worth noting that the travel time from Station mor to Sagorpara during the evening peak has a slightly better LOS rating of D, indicating relatively lighter congestion compared to the other routes during that time period. So, we can conclude that the LOS of the intersection is “LOS F” on Thursday as it is the worst.

4.3.2 Peak Hour Factor Method

The peak hour factor is a measure of traffic congestion during peak hours compared to the free-flow conditions.

Table 6: LOS of different lanes by Peak Hour Factor Method on Thursday

Thrusday				
	Road Name	**Peak hour factor**	**LOS**	
Morning peak	Railgate to Station mor	0.944	E	
	Station mor to Vodra	0.936	E	
	Station mor to Railgate	0.707	B	
	Vodra Mor to Station mor	0.760	B	
	Sagorpara to Station mor	0.865	D	
	Station mor to Sagorpara	0.896	D	
Afternoon peak	Railgate to Station mor	0.929	E	
	Station mor to Vodra	0.872	D	
	Station mor to Railgate	0.769	B	**F**
	Vodra Mor to Station mor	0.788	B	
	Sagorpara to Station mor	0.762	B	
	Station mor to Sagorpara	0.918	E	
Evening peak	Railgate to Station mor	0.806	C	
	Station mor to Vodra	0.792	B	
	Station mor to Railgate	1.049	F	
	Vodra Mor to Station mor	1.082	F	
	Sagorpara to Station mor	1.153	F	
	Station mor to Sagorpara	0.844	C	

The given data appears in table 6 represents the LOS and peak hour factor for several road segments in the morning, afternoon, and evening peak hours. As a result, the morning peak (LOS B, C, D, and E) exhibits comparatively lower levels of congestion than the afternoon and evening peaks (LOS B, C, D, E, and F). The road segment "Sagorpara to Station mor" has the highest peak hour factor (1.153, LOS F) during the evening peak, suggesting the highest level of congestion, while the segment "Station mor to Railgate" has the lowest peak hour factor (0.707, LOS B) during the morning peak.

Table 7: LOS of different lanes by Peak Hour Factor Method on Sunday

Sunday				
	Road Name	**Peak hour factor**	**LOS**	
Morning peak	Railgate to Station mor	0.951	F	**F**
	Station mor to Vodra	0.934	E	
	Station mor to Railgate	0.648	A	
	Vodra Mor to Station mor	0.713	B	
	Sagorpara to Station mor	0.694	A	
	Station mor to Sagorpara	0.708	B	
Afternoon peak	Railgate to Station mor	1.077	F	
	Station mor to Vodra	1.067	F	
	Station mor to Railgate	0.676	A	
	Vodra Mor to Station mor	0.716	B	
	Sagorpara to Station mor	0.786	B	
	Station mor to Sagorpara	0.797	B	
Evening peak	Railgate to Station mor	1.165	F	
	Station mor to Vodra	1.131	F	
	Station mor to Railgate	1.125	F	
	Vodra Mor to Station mor	1.096	F	
	Sagorpara to Station mor	0.994	E	
	Station mor to Sagorpara	1.030	F	

According to the road network studies, there is more traffic and a lower quality of service during afternoon and evening peaks, particularly on Sundays. With substantial traffic during all peak hours and a steady LOS of F, Railgate to Station Mor consistently has the highest peak hour factors. However, Station mor to Railgate and Sagorpara to Station mor exhibit comparatively lower peak hour factors during the morning peak, which results in better LOS. The afternoon and evening peak hours are when the road network is often busiest, with Railgate to Station Mor being the most traveled route during the day.

4.3.3 Speed Based Method

The speed-based method can be used to evaluate the LOS in a traffic volume study. This method comprises calculating the average speed, and travel time of vehicles in which data were manually collected by traveling with various frequently seen vehicles on the road.

Table 8: LOS of different lanes by Speed based Method

Speed Based Method					
Different Lanes	**Distance (Km)**	**Travel Time (Hour)**	**Speed**	**Thursday**	**Sunday**
Rail gate to Station mor	1.5	4 Minutes	22.5	LOS D	LOS D
Station mor to Vodra Mor	1.5	4 Minutes	22.5	LOS D	LOS D
Station mor to Rail gate	.35	1 Minutes	21	LOS D	LOS D
Vodra Mor to Station mor	.35	1 Minutes	21	LOS D	LOS D
Sagorpara to Station mor	.85	3 Minutes	17	LOS D	LOS D

Station mor to Sagorpara	.85	3 Minutes	17	LOS D	LOS D

Table 8 shows that all of the current roads fall under the LOS D category since their speeds vary from 15-25 km/h. This suggests there is bad service and severe delays on all of the roads. With only one lane, the Station Mor to Sagorpara route has the slowest speed of all the roads (17 km/h). As a result, traffic congestion is most common on this road.

Table 9: LOS of different lanes by all Methods

Overall								
V\C ratio method			**Peak hr factor method**			**Speed based method**		
Different Lanes	Thurs day	Sun day	Different Lanes	Thurs day	Sun day	Different Lanes	Thurs day	Sun day
Railgate to Station mor	LOS F	LOS F	Railgate to Station mor	LOS B	LOS A	Railgate to Station mor	LOS D	LOS D
Station mor to Vodra	LOS F	LOS E	Station mor to Vodra	LOS B	LOS A	Station mor to Vodra	LOS D	LOS D
Station mor to Railgate	LOS F	LOS F	Station mor to Railgate	LOS B	LOS A	Station mor to Railgate	LOS D	LOS D
Vodra Mor to Station mor	LOS F	LOS F	Vodra Mor to Station mor	LOS B	LOS B	Vodra Mor to Station mor	LOS D	LOS D
Sagorpara to Station mor	LOS F	LOS F	Sagorpara to Station mor	LOS B	LOS A	Sagorpara to Station mor	LOS D	LOS D
Station mor to Sagorpara	LOS F	LOS F	Station mor to Sagorpara	LOS C	LOS B	Station mor to Sagorpara	LOS D	LOS D

For all three approaches, there are clear distinctions between Thursday and Sunday. Based on data analysis, it appears that the V/C ratio approach regularly displays heavy congestion (LOS F) on all lanes on Thursdays and Sundays. The consistency of service levels varies on certain routes, but not on others. Railgate to Station mor, Station mor to Vodra, and Station mor to Sagorpara LOS improvements are predicted by the peak hour factor approach for Sunday. Since every route in the LOS D category—which denotes poor service and moderate to severe traffic congestion—shows a similar pattern, the speed-based technique also exhibits comparable patterns across all roads. Based on these variations, it appears that Sunday has generally better levels of traffic and congestion than the other day.

5. RECOMMENDATION

Recommendations for improving the Rajshahi Railway Station intersection's LOS and general traffic control, where the LOS value is F::

1. Optimise the Timing of Traffic Signals: The intersection's signal timings at Rajshahi Railway Station should be adjusted to improve traffic flow and lessen congestion. Apply a signal timing strategy that is optimized based on the field survey data on traffic volume, incorporating a signal coordinator. By doing this, the intersection's overall LOS will be improved and delays will be reduced (Transportation Research Board, 2010).
2. Increase Intersection Capacity: To handle the heavy traffic at the Rajshahi Railway Station intersection, think about expanding the intersection or adding more lanes. For all users of the road, this extension will serve to improve the LOS, lessen delays, and ease congestion (Transportation Research Board, 2010).
3. Intelligent Transportation Systems (ITS): To improve traffic management and give drivers access to real-time information, install intelligent transportation systems, such as traffic surveillance cameras, dynamic message signs, and traffic signal coordination systems.
4. Public Transportation Promotion: Encourage the use of public transportation options, such as buses or trains, to reduce the number of private vehicles on the road.

5. Implement Traffic Management Strategies: Develop and implement effective traffic management strategies to enhance the flow of vehicles at the intersection. This may involve techniques like lane assignment, designated turning lanes, and sophisticated intersection control technology (e.g., adaptive signal control systems) to optimize traffic movements and reduce conflicts (Garber et al., 2009).
6. Pedestrian and Cyclist Facilities: To ensure that non-motorized users may navigate around the intersection safely and effectively, upgrade the facilities for cyclists and pedestrians. This could entail installing bike lanes, crosswalks, and sidewalks in addition to the proper signage and traffic signals.

6. CONCLUSION

This research delved into the intricate dynamics of the Rajshahi Railway Station intersection and assessed the traffic conditions by doing a comprehensive analysis of both modal and temporal variations. Through the utilization of three different methods: Volume/Capacity Ratio, Peak Hour Factor, and Speed-Based methods, a nuanced picture of the intersection's LOS was obtained. During peak hours, our results regularly showed a prominent LOS F, indicating significant traffic congestion. The predominance of auto-rickshaws and autos was highlighted by the modal and temporal analysis, underscoring the necessity of targeted interventions. This research holds significant implications for urban planning, which not only highlights important traffic problems at the Rajshahi Railway Station intersection but also offers practical solutions; suggestions include intersection enlargement and signal optimization, as well as the promotion of public transit and the use of Intelligent transportation systems. These tactics aim to improve traffic flow and reduce congestion. Even though this study significantly improves Rajshahi's traffic management, it has several drawbacks, such as its reliance on manual data collection. However, the knowledge gathered serves as a foundation for further research on urban transport and is an invaluable resource for both scholars and decision-makers. In addition to pointing out existing problems, this study provides the stage for long-term, practical solutions in the field of urban transportation planning.

REFERENCES

Amini, A., Jalayer, M., Bhat, C. R., & Mesbah, M. (2019). Level of service: concepts, classification, and measurement methods. Transportation Research Record, 2673(3), 222-235.

Garber, N. J., & Hoel, L. A. (2009). Traffic and Highway Engineering (4th ed.). Stamford, CT: Cengage Learning.

Garber, N. J., & Hoel, L. A. (2017). Traffic and highway engineering. Cengage Learning.

Hassan, Y., Yaman, M., & Torkelson, B. (2017). Level of service (LOS) of signalized intersections: An overview. KSCE Journal of Civil Engineering, 21(1), 431-439.

Islam, M. S., Hossain, M. R., & Islam, R. (2021). Field Traffic Volume Survey and Level of Service Evaluation at Major Intersection in Rajshahi City. Transport, 36(2), 271-283.

Li, R., Shi, X., & Xia, J. (2019). Methodology of traffic volume survey for complex urban intersection: a case study in Beijing, China. IOP Conference Series: Earth and Environmental Science, 352(1), 012058.

Mohan, D., Mohanty, M., & Kumar, M. (2020). Evaluation of traffic volume survey techniques for estimation of passenger car equivalent. Journal of Traffic and Transportation Engineering (English Edition), 7(4), 398-414.

Sabbir, S. M. (2022). Traffic Volume in Dhaka City at Selected Priority Junctions. HBRP PUBLICATION, Volume 3 Issue 1.

Shen, J., Li, H., & Liao, H. (2018). Capacity estimation for at-grade intersections with mixed traffic conditions: A spatio-temporal speed-based method. Journal of Traffic and Transportation Engineering (English Edition), 5(3), 216-229.

Transportation Research Board. (2010). Highway Capacity Manual (HCM). Washington, D.C: National Academies Press.

Umar Obafemi Salisu, O. O. (2020). Traffic Survey Analysis: Implications for Road Transport Planning In Nigeria. Sciendo.

Wu, Y., Wang, X., Sun, C., & Zhang, W. (2020). Impact of road traffic flow heterogeneity on the performance of adaptive traffic signal control at a congested intersection. Transportmetrica A: Transport Science, 16(6), 1525-1548.