THE INFLUENCE OF ROAD CONDITIONS AND SPEED DISTRIBUTION ON THE REGULARITY OF PUBLIC TRANSPORT OPERATION

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Abstract: The article analyses the issues related to ensuring the regularity of public passenger transport services. The distribution of bus travel speeds, the condition of road infrastructure, traffic flow patterns at intersections, and the causes of congestion formation are examined. It was identified that the uneven distribution of traffic flow speeds negatively affects the adherence of public transport vehicles to scheduled headways. Based on the results obtained, practical recommendations have been developed to improve the regularity of public transport services.

Keywords: public transport; service regularity; speed distribution; road infrastructure; traffic flow; Navoi Street, Kokand city

ВЛИЯНИЕ СОСТОЯНИЯ ДОРОГ И РАСПРЕДЕЛЕНИЯ СКОРОСТИ НА РЕГУЛЯРНОСТЬ РАБОТЫ ОБЩЕСТВЕННОГО ТРАНСПОРТА.

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Аннотация: В статье анализируются вопросы обеспечения регулярности работы общественного пассажирского транспорта. Рассматриваются распределение скоростей движения автобусов, состояние дорожной инфраструктуры, схемы транспортного потока на перекрестках и причины образования заторов. Выявлено, что неравномерное распределение скоростей транспортного потока негативно влияет на соблюдение запланированных

интервалов движения транспортных средств общественного транспорта. На основе полученных результатов разработаны практические рекомендации по повышению регулярности работы общественного транспорта.

Ключевые слова: общественный транспорт; регулярность обслуживания; распределение скоростей; дорожная инфраструктура; транспортный поток; улица Навои, город Коканд

Introduction

At present, the stable and efficient operation of urban public passenger transport systems plays a crucial role in ensuring the mobility of the population. Service quality in public transport — particularly service regularity — directly affects passengers' waiting times, travel reliability, and overall satisfaction with the transport system. When service regularity deteriorates, waiting times increase, headways become unstable, and, as a result, the share of private car usage tends to grow significantly [1–3].

In the scientific literature, the factors influencing public transport service regularity are generally grouped into internal and external categories. Internal factors include vehicle technical condition, driver competence, operational regime, and organisational management practices. External factors, meanwhile, comprise road–transport infrastructure, congestion levels, traffic signal control, socio-economic conditions, and urban planning structure [2,4,5]. In particular, instability in traffic flow speed distribution and fluctuations in flow density have been shown to exert a strong negative impact on service reliability and headway regularity [6,7].

Furthermore, the loss of service regularity may result in bus bunching and the progressive disruption of scheduled headways. This phenomenon not only distorts timetable stability, but also reduces passengers' willingness to use public transport services [8–10]. Therefore, ensuring service regularity and analysing the interaction between traffic flow speed distribution and operational control strategies represent key research priorities in the field of urban public transport.

From this perspective, the present study investigates the distribution of traffic flow speeds along Navoi Street in the city of Kokand using experimental observation methods, and evaluates its influence on the service regularity of public bus operations. Based on the obtained results, scientifically grounded conclusions and practical recommendations aimed at improving speed stability and optimising public transport operations have been developed.

Materials and Methods

The study object comprised vehicles operating in the traffic stream along Navoi Street in the city of Kokand, a section along which public bus routes No. 20, 24, 42 and 82 also operate. Two measurement locations were selected along this street to capture both free-flow and signal-influenced speed conditions: (i) a free-flow segment located approximately 20 metres downstream of the signalised pedestrian crossing situated near the Kokand branch of the Tashkent State Transport University, and (ii) a section located 150 metres upstream of the same traffic signal, where vehicles are subject to deceleration prior to the stop line.

Vehicle speeds were recorded using direct field observation combined with photographic and video documentation, consistent with the experimental observation methodology applied throughout the broader research programme on this route network [11]. Individual vehicle speeds were determined for a representative sample of the traffic stream at each measurement location and grouped into 5 km/h speed-range intervals to construct frequency (density) distributions.

For each measurement location, the speed data were summarised using both interval-based percentage distributions and cumulative percentage distributions. From the cumulative distribution curves, the 15th, 50th (median), 85th, and 95th percentile speeds were extracted, following standard traffic engineering practice for characterising free-flow and constrained speed variability. The variation range of speeds (the difference between the 85th- and 15th-percentile values) was calculated for each location to allow direct comparison of speed dispersion between the free-flow and signal-influenced sections. No additional or alternative measurement methods beyond those described here were employed.

Results

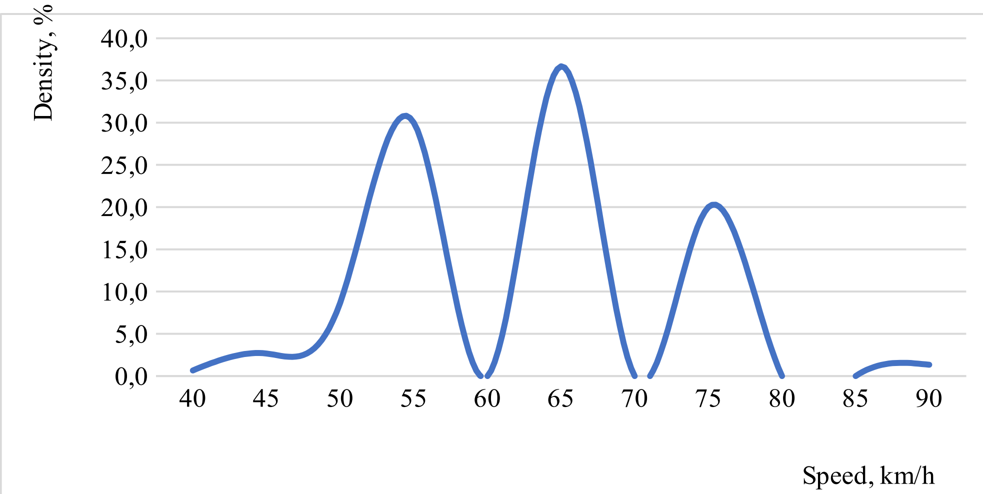

Figure 1 illustrates the percentage distribution of vehicle speeds under free-flow traffic conditions on Navoi Street.

The research findings reveal several specific characteristics of traffic speed variation (Figure 1). The modal speed of the traffic flow corresponds to the 60–65 km/h range, where 36.7% of the vehicles were recorded. This indicates that the road conditions along the considered section allow vehicles to travel freely without major constraints.

The second largest group is observed in the 50–55 km/h range, accounting for 30% of the vehicles. This suggests that traffic movement along the section is generally smooth.

Furthermore, 20% of vehicles were recorded travelling at 70–75 km/h, which is considered relatively high for an urban street. This implies that a certain proportion of drivers significantly exceed the typical operating speed.

The share of vehicles travelling within the 45–50 km/h range amounts to 8.7%.

In contrast, the proportion of vehicles moving at 35–45 km/h and 85–90 km/h is extremely small, ranging between 0.7% and 2.7%. These ranges mainly represent either very slow-moving vehicles or those exceeding normal speed limits.

It is also noteworthy that no vehicles were observed within the 55–60 km/h, 65–70 km/h and 75–85 km/h speed ranges, i.e., the density in these intervals is 0%.

The obtained results show that the speed distribution of the traffic flow on Navoi Street is highly non-uniform. Such instability in speed not only negatively affects road safety, but also has a significant impact on the regularity of bus operation.

The three pronounced peaks observed in the graph indicate that traffic speeds tend to cluster around three distinct levels. This phenomenon is difficult to explain solely by traffic composition, since the majority of the flow consists of passenger cars. If traffic composition were the only influencing factor, the speed distribution would not be so sharply stratified. However, field measurements demonstrate the opposite.

The formation of this situation is mainly associated with the pedestrian traffic signal located near the Kokand branch of the Tashkent State Transport University. Experimental measurements were carried out 20 metres downstream of this signalised crossing, on a free-flow segment. Vehicles that had previously stopped at the signal accelerate at different rates once the green phase begins, which leads to speed differentiation within the flow.

Vehicles with higher acceleration capabilities quickly increase speed and move to the front of the stream, while those with weaker dynamics remain behind. Buses, due to their larger mass and dimensions, are more limited in choosing an appropriate speed regime and often remain in the slower part of the stream during acceleration. As a result, deviations from the planned headway schedule may occur.

Slow-accelerating vehicles begin to constrain the movement of buses, forcing them to operate below their potential cruising speed along this section.

The variation range of speeds on this road segment is determined as follows.

$$R = V_{max} - V_{min} = 90 - 35 = 55\, km/h$$

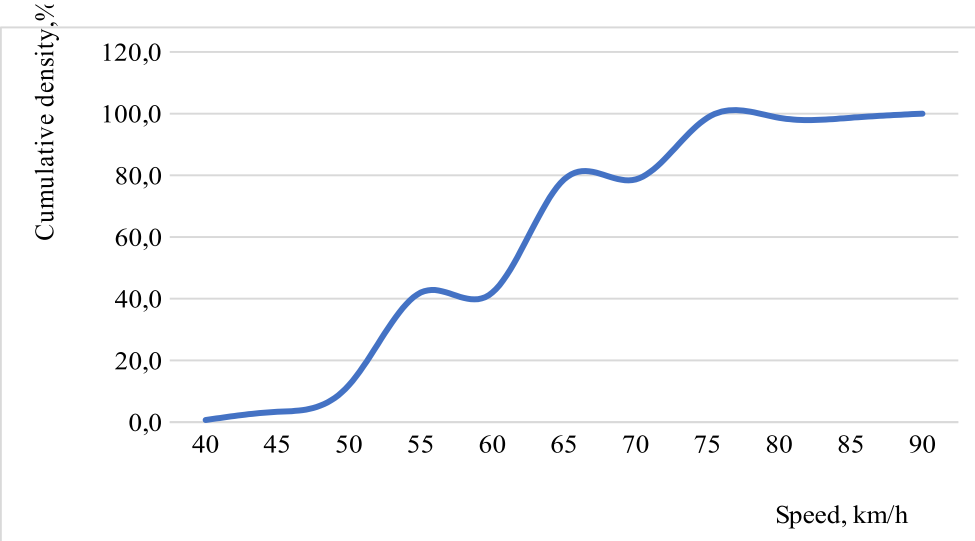

Figure 2. Cumulative curve of free-flow speed distribution on Navoi Street.

The cumulative curve illustrates the distribution of vehicle speeds in the traffic stream in terms of cumulative percentage. As can be seen from the cumulative curve, the 15th-percentile speed of the traffic flow is equal to 45 km/h. The 50th-percentile (median) speed is 60 km/h, the 85th-percentile speed is 72 km/h, and the 95th-percentile speed is 74 km/h. These results indicate that vehicle speeds along the analysed road section are generally relatively high, and confirm that vehicles with higher dynamic performance tend to travel at speeds significantly exceeding the posted limits along this segment. The variation range for this free-flow section is 27 km/h (72 − 45 km/h).

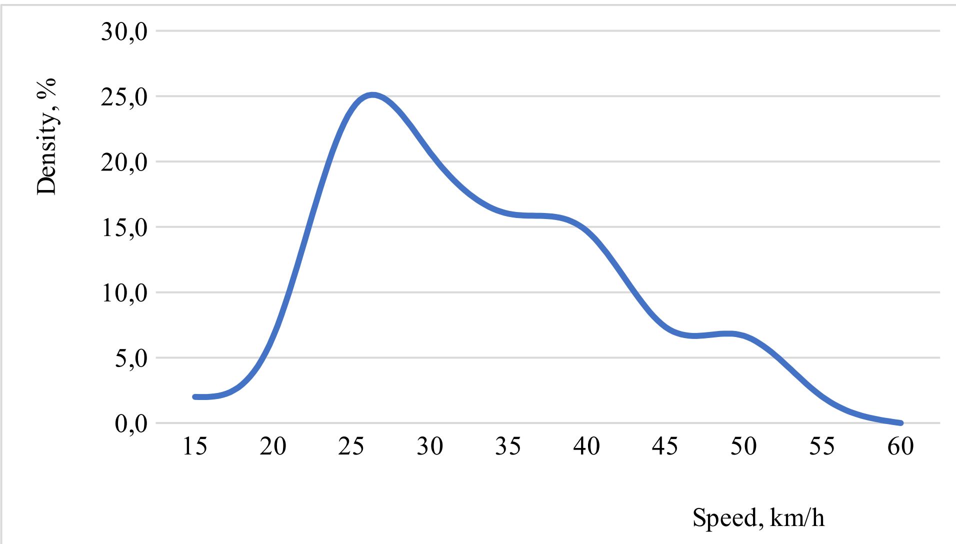

Figure 3. Distribution of vehicle speeds near the traffic signal on Navoi Street (150 m before the signal).

Figure 3 illustrates the distribution of vehicle speeds within the traffic stream approaching the signal. The modal speed of the traffic flow falls within the 20–25 km/h range, where the density reaches 24%. This indicates that a large proportion of vehicles reduce their speed when approaching the traffic signal. The next highest density is observed in the 25–30 km/h range, accounting for 20.7%. Thus, a total of 45% of vehicles are concentrated within these two low-speed intervals. Beyond these ranges, the density decreases sharply: the density in the 45–50 km/h range is 6.7%, while in the 50–55 km/h interval it amounts to only 2%. The research findings demonstrate that the traffic signal has a considerable influence on the overall speed of the traffic stream, reducing the prevailing speed down to 20–25 km/h.

As vehicles approach the traffic signal, the reduction in speed may decrease the capacity of the road network and, consequently, lead to congestion. The variation range of speed on this section is determined as follows:

$$R = V_{max} - V_{min} = 60 - 10 = 50\, km/h$$

This distribution indicates the need to optimise traffic operations, reconsider the signal timing plans, or introduce intelligent traffic control systems.

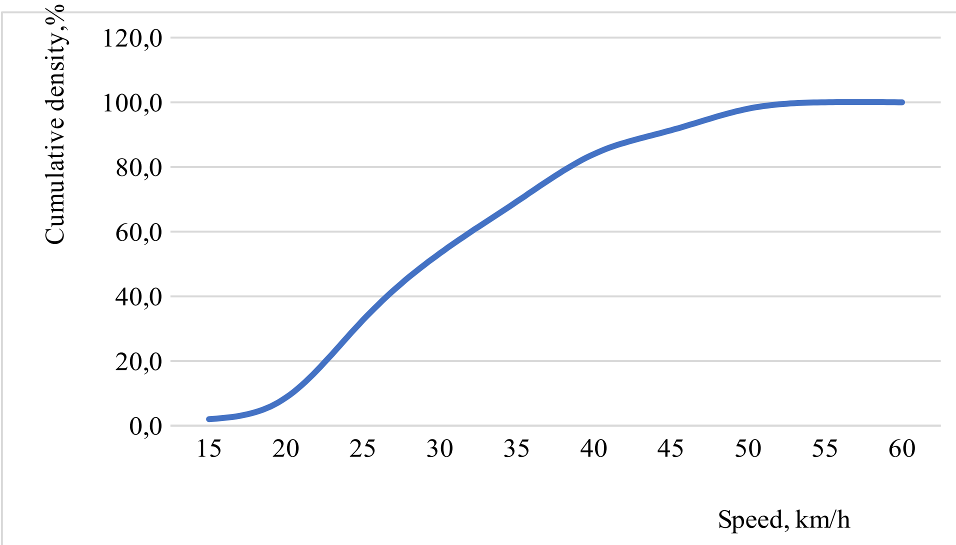

Figure 4. Cumulative speed distribution of vehicles 150 metres before the traffic signal on Navoi Street.

At the beginning of the cumulative curve, the proportion of vehicles travelling at 15 km/h is very small, with the cumulative density amounting to approximately 2%. According to the cumulative curve analysis, the 15th-percentile speed of the traffic stream is 15 km/h, the 50th-percentile speed is 25 km/h, the 85th-percentile speed is 35 km/h, and the 95th-percentile speed is 45 km/h. The variation range for this section is 20 km/h (35 − 15 km/h), which is narrower than the 27 km/h range recorded in the free-flow section, indicating that speeds stabilise in the deceleration zone even as their absolute level decreases.

Discussion

The findings of this study are consistent with the international literature on the relationship between speed variability and public transport service reliability. Gibson, Bunker and Ferreira [6] similarly demonstrated that variability in running speed along a route segment is a significant determinant of bus service reliability, while Turnquist [7] showed that fluctuations in link travel time propagate directly into headway instability. The pronounced 55–60% reduction in modal speed observed near the Navoi Street signal (from 60–65 km/h under free-flow conditions to 20–25 km/h at the signal approach) illustrates precisely this mechanism: buses, constrained by their lower acceleration capability relative to passenger cars, are disproportionately affected by signal-induced deceleration, which increases the likelihood of headway deviation consistent with the bunching dynamics described by Daganzo [10].

The observation that the acceleration-zone speed distribution (variation range of 27 km/h) is wider than the deceleration-zone distribution (20 km/h) suggests that signal control paradoxically exerts a homogenising effect on vehicle speeds, even as it lowers their absolute level — a pattern that has practical implications for signal-timing coordination. This is broadly consistent with the guidance provided in the TCQSM [3] and TCRP Report 215 [4], both of which identify intersection and signal-related delay as a principal, controllable source of schedule deviation.

From a practical standpoint, these findings suggest that dedicated bus lanes, signal priority for public transport vehicles, or adjustment of signal-cycle timing at the Navoi Street crossing could reduce the disproportionate deceleration burden placed on buses, thereby improving headway regularity. The results also imply that speed-limit harmonisation along the free-flow segment could reduce the wide variation range observed there, further contributing to smoother, more predictable bus operation.

This study is limited by its focus on a single street segment and a single set of field observations; the extent to which these findings generalise to other signal-controlled corridors in Kokand or other cities of the Fergana region has not been established. Future research should extend this analysis to multiple corridors and observation periods, and should quantitatively link the observed speed-distribution patterns to measured headway coefficients of variation for the routes operating along Navoi Street.

Conclusion

The results of the experimental studies show that the distribution of traffic flow speed along Navoi Street differs significantly across various sections of the road. Under free-flow conditions, the majority of vehicles travel within the 60–65 km/h speed range, which indicates the dominance of relatively high speeds in this area. However, the wide variation in speeds also reflects a lack of stability within the traffic stream.

In the vicinity of the traffic signal, vehicle speeds decrease sharply, with the modal speed forming within the range of 20–25 km/h. This confirms that the operation of the traffic signal has a strong influence on the traffic flow, and that acceleration and deceleration processes result in noticeable differentiation of speeds. It was also identified that in sections where speed reduction occurs, the distribution of speeds becomes relatively more stable, whereas in areas where speeds increase, a larger variation range is observed, indicating lower flow stability.

The research results demonstrate that such variability in traffic speeds has a negative impact on the service regularity of public passenger transport. Increasing speed differences raise the likelihood of deviations from scheduled headways, and reduce the stability of passenger waiting and travel times.

Overall, ensuring more uniform speed conditions within the traffic flow is a key factor in improving the regularity of public transport services. Therefore, optimisation of traffic signal control regimes, coordination of traffic conditions, and mitigation of factors causing sharp speed variations are considered necessary.

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