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Transportation Research Procedia 20 (2017) 277 – 282

Transportation Research Procedia

www.elsevier.com/locate/procedia

12th International Conference "Organization and Traffic Safety Management in large cities", SPbOTSIC-2016, 28-30 September 2016, St. Petersburg, Russia

Method Considering Traffic Stream Variability over Time when Determining Multiprogram Control Modes at Signaled Intersections

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Abstract

This paper demonstrates the relevance of application of multiprogram control at signaled intersections and a method considering variability of traffic streams over time for the purpose of increasing traffic efficiency.
Recommendations are suggested as to considering daily and hourly traffic stream variability when determining the parameters of multiprogram control modes at signaled intersections. The analysis of effectiveness of applying the suggested recommendations has been carried out.
Application of the recommendations as to considering daily and hourly traffic stream variability allows reducing intersection traffic delays up to 17-28% during a day.

Peer-review under responsibility of the organizing committee of the 12th International Conference “Organization and Traffic Safety Management in large cities”

Keywords: traffic stream variability, daily variability, hourly variability, traffic signalization, multiprogram control, traffic delay.

1. Main part

Deficiencies of widely used fixed single-program control may be eliminated by using fixed multiprogram control, i.e. determining moments in time to change traffic-signal control modes during a day, a week or a year depending on the amount of traffic streams and their distribution throughout travel directions at the intersection during the above stated periods. Multiprogram control allows taking traffic stream variability into account. Multiprogram control is

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Peer-review under responsibility of the organizing committee of the 12th International Conference “Organization and Traffic Safety Management in large cities”
doi:10.1016/j.trpro.2017.01.022

cost-effective, can be implemented quickly and allows for reduction of intersection traffic delays for 10 to 35% during a day as compared with single-program control [Petrov (2007)]. However, no recommendations on determining parameters, moments of changing and duration of multiprogram control modes exist and are practically used in Russia.

Traffic stream variability indices during both a day and an hour considered when setting parameters of traffic-signal control at isolated intersections allow improving intersection efficiency by reducing traffic delays.

In view of all mentioned above, the objective of this paper is to develop a method of determining parameters of multiprogram control modes to take traffic stream variability into account and improve efficiency of signaled intersections.

To achieve the stated objective, the following tasks have been solved:

1. Determine the characteristics of daily and hourly traffic stream variability and analyze the factors influencing the formation of traffic stream variability.
2. Substantiate recommendations as to considering traffic stream variability over time when determining parameters of multiprogram traffic-signal control modes.
3. Substantiate a generalized criterion and analyze effectiveness of the recommendations on setting parameters of multiprogram traffic-signal control modes with account of traffic stream variability over time.

For the purpose of making a list of recommendations as to considering traffic stream variability when determining parameters of multiprogram traffic-signal control modes, a respective experimental study has been conducted based on the recommendations of the well-known researchers [Braylovsky and Granovsky (1975), Pechersky and Khorovich (1976), Drew (1972), Rankin et al. (1981)], an extensive multifactor experiment has been carried out which has allowed to determine the traffic stream intensity in the areas of signaled intersections in some Russian large cities (Moscow, Saint Petersburg, Novosibirsk, Omsk, Khabarovsk etc.).

Mean deviation of the number of vehicles which passed the intersection within 5-minute intervals from the mean hourly intensity [Kashtalinsky and Petrov (2014)] was used as an index of hourly variability:

$$\Delta\lambda_j = \frac{\sum_{i=1}^{12}\left|k \cdot \lambda_i^{5\min} - \lambda_j^{hour}\right|}{12}, \text{ units per hour,} \quad (1)$$

where $\Delta\lambda_j$ – traffic stream variability index for j-th hour period, units per hour; $\lambda_i^{5\min}$ – number of vehicles which passed the intersection within the i-th 5-minute interval of the j-th hour period, units per hour; λ_j^{hour} – hourly intensity of the traffic stream during the j-th hour period, units per hour; k – factor of 5-minute interval traffic intensity reduction to hourly intensity, k=12.

Based on the experimental data, the following relationship between the mean traffic intensity deviation $\Delta\lambda$ and the traffic intensity value λ and traffic stream composition has been obtained:

$$\Delta\lambda = -4{,}181 + 0{,}123\lambda + 139{,}1l + 0{,}037\lambda l - 0{,}000084\lambda^2 - 145{,}14l^2 . \quad (2)$$

where λ – specific traffic intensity, units per hour; l – part of cars in the traffic stream.

Fig. 1 shows the graphical interpretation of Expression (2). The results of detailed analysis of the above relationship are set forth in the article [Kashtalinsky and Petrov (2016)].