ТРАНСПОРТНЫЕ СИСТЕМЫ

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THE MODEL FOR SELECTING THE OPTIMAL INTERCITY SCHEME FOR PACKAGED CARGO DELIVERY WITH THE USE OF ROAD TRANSPORT

Ye. Nagornyi, Prof., D. Sc. (Eng.), V. Naumov, Prof., D. Sc. (Eng.), O. Shulika, T. Asst.,
Kharkiv National Automobile and Highway University

Abstract. *Planning and implementation of the process of packaged cargo delivery by road transport are based on the transport and technological schemes of delivery. The optimal scheme choice allows providing the maximal cumulative effect of all participants of the transport process. The total costs of the delivery process participants have been proposed as the criterion for determining the optimal transport and technological delivery scheme. The proposed approach to the formalization of the complete set of alternative variants of the packaged cargo delivery process in the intercity as a graph-model allows using the network optimization techniques.*

Key words: *delivery process, packaged cargo, intercity transportation, road transport.*

МОДЕЛЬ ВИБОРУ ОПТИМАЛЬНОЇ ТРАНСПОРТНО-ТЕХНОЛОГІЧНОЇ СХЕМИ ДОСТАВКИ ТАРНО-ШТУЧНИХ ВАНТАЖІВ АВТОМОБІЛЬНИМ ТРАНСПОРТОМ У МІЖМІСЬКОМУ СПОЛУЧЕННІ

Є.В. Нагорний, проф., д.т.н., В.С. Наумов, проф., д.т.н., О.О. Шуліка, асист.,
Харківський національний автомобільно-дорожній університет

Анотація. *Наведено результати аналізу підходів до формування альтернативних варіантів транспортно-технологічних схем доставки вантажів. Запропоновано критерій визначення оптимальної транспортно-технологічної схеми доставки. Надано модель вибору оптимальної транспортно-технологічної схеми доставки тарно-штучних вантажів у міжміському сполученні.*

Ключові слова: *процес доставки, тарно-штучні вантажі, міжміські перевезення, автомобільний транспорт.*

МОДЕЛЬ ВЫБОРА ОПТИМАЛЬНОЙ ТРАНСПОРТНО-ТЕХНОЛОГИЧЕСКОЙ СХЕМЫ ДОСТАВКИ ТАРНО-ШТУЧНЫХ ГРУЗОВ АВТОМОБИЛЬНЫМ ТРАНСПОРТОМ В МЕЖДУГОРОДНОМ СООБЩЕНИИ

Е.В. Нагорный, проф., д.т.н., В.С. Наумов, проф., д.т.н., О.А. Шулика, ассист.,
Харьковский национальный автомобильно-дорожный университет

Аннотация. *Приведены результаты анализа подходов к формированию альтернативных вариантов транспортно-технологических схем доставки грузов. Предложен критерий определения оптимальной транспортно-технологической схемы доставки. Представлена модель выбора оптимальной транспортно-технологической схемы доставки тарно-штучных грузов в междугородном сообщении.*

Ключевые слова: *процесс доставки, тарно-штучный груз, междугородные перевозки, автомобильный транспорт.*

Introduction

A technology of cargo delivery process we consider as a technique of implementation of the particular transportation process by breaking it with a system of consecutive and interlinked stages of operations that are performed more or less definitely and are implemented in order to achieve high efficiency of transportation process.

Planning and implementation of the process of the packaged cargo (PC) delivery by road transport are based on transport and technological schemes of delivery (TTSD) that are quite complex due to the specifics of transport process in the intercity. Thus, as a rule, an estimation of alternative delivery schemes for determination of optimal one for a certain request is not being implemented. The optimal scheme choice allows providing of maximal cumulative effect of all participants of the transport process.

Therefore, an important task while the implementation of an integrated process of the PC delivery in the intercity is to develop a model of choice of the optimal TTSD of PC by road transport.

Analysis of publications

The methods of choice of transport and technological schemes of PC delivery in the intercity have been examined in the researches of A. Vorkut, A. Velmozhin, L. Mirotin, N. Goryaev, Ie. Nagornyi, V. Naumov and other scientists. Papers [1, 2] have been devoted to the choice of intercity transportation schemes on the basis of technical and economic calculations of transport unit costs for compared alternative scheme variants. Wherein, in those papers an insufficient attention is paid to the accompanying forwarding operations.

In [3] algorithms that describe the sequence of operations feasibility were used for the formalization of forwarding process. However, the analysis has been carried out mainly with the position of freight forwarding companies and less attention was given to the detailed consideration of the delivery technology.

Papers [4,5] considerate the planning issues and the implementation features of containerized cargo delivery process and provides recommendations for development of the optimal scheme for each individual request on transport services. But the main attention has been paid to the choice of delivery process participants and combination of delivery transport modes without a detailed analysis of technological operations on a micro-level.

Paper subject and tasks

The paper aims to develop tools for improvement of the efficiency of PC delivery in the intercity by choosing the optimal transport and technological delivery schemes.

The object of research is the process of forming of transportation technology for packaged cargo delivery in the intercity, and the research subject is the process of choosing the optimal transport and technological packaged cargo delivery scheme.

The following tasks have been set in order to achieve the research subject: choice of the efficiency criterion, formalization of the research object, development of a methodology for choosing of the optimal TTSD by road transport for PC in the intercity.

Developing the model of choice of optimal transport and technological schemes

The purpose of the mathematical model development is to choose the optimal TTSD for PC in the intercity by road transport. Model input parameters are the parameters of the requests flow and the number of the group $\{N_{LC}\}$ which is defined by dispatchers of the enterprise and carries information about the client's needs regarding the transport package, the productive resources availability, the geographical location of the transport process participants and so on.

Analysis of existing criterions of efficiency has shown that the most reasonable criterion for the choice of PC delivery scheme was the overall costs for all the participants of delivery process as the elements efficiency criterion of logistic system (LS) of cargo delivery in the intercity. Given that one logistic supply chain (LSC) implements one owner application of the cargo consignment delivery suppose that total cost of all realized LSC is LS efficiency criterion. Efficiency criterion is as follows:

$$E_{LS}(Q,L,I) = \sum_{i=1}^{N_r} E_{LCi} \to \min, \qquad (1)$$

where Q – the consignment volume for the request, t; L – delivery distance, km; I – time interval between the moments of current request reception and the reception of the next request, hrs; N_r – number of serviced requests of shippers who participate in delivery process during certain period of time, requests / time period; $E_{LC\,i}$ – the costs of servicing of the i-th request, hrn / time period.

$$E_{LC} = \sum_{j=1}^{N_{FO}} E_{FOj} + \sum_{j=1}^{N_C} E_{Cj} + \sum_{j=1}^{N_{FF}} E_{FFj} + \sum_{j=1}^{N_T} E_{Tj}\ , \quad (2)$$

where E_{FO}, E_C, E_{FF}, E_T – costs for cargo owners (consignors – CR, and consignees – CE), carriers, freight forwarders and cargo terminals respectively, UAH / time period; N_{FO} – number of cargo owners, one; N_C – number of carriers; N_{FF} – number of freight forwarding companies (FFC); N_T – number of terminals involved to implement the application, one.

Outgoing model parameter is a variant of transport and technological scheme which is characterized by the optimal (minimum) value of the efficiency criterion.

Model of choice of the optimal TTSD could be represented as a system of "gray box" which consists of two interrelated processes: 1 – the process of forming set of alternative transport and technological packaged cargo delivery schemes $\{T_i\}$; 2 – the process of determining the effectiveness of alternative schemes and the choice of the optimal scheme (Fig. 1).

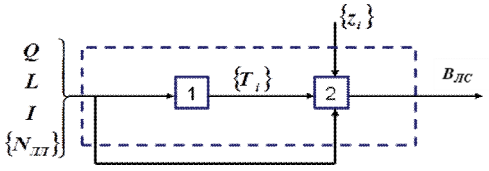

Fig. 1. Cybernetic model for choice of the optimal technological PC delivery scheme

The time of loading and unloading, packaging, labeling, temporary storage of 1 t cargo, vehicle speed, time to confirme the structure and choice LSC have been taken into account as external model factors $\{z_i\}$. For the choice of the optimal delivery scheme it is essential to resolve the problem of the set of alternative TTSDs determining. Basing on the analysis of existing approaches to the formalization of cargo delivery process the core list of elementary operations needed to deliver the PC in the intercity has been formed [6]. The options encoding for events due to the elementary process options has been introduced as follows: response (event) – code – a summary of the option (event) characteristics.

The following characteristics (event) have been considered: consultation with the FFC (a_1 – took place, a_2 – did not take place); evaluation of the self implementation (b_1 – took place, b_2 – did not take place); search at the logistics web site (c_1 – took place, c_2 – did not take place); placement on the logistics web site (d_1 – took place, d_2 – did not take place); analysis of alternatives (e_1 – took place, e_2 – did not take place); coordination of rates with the carrier (f_1 – took place, f_2 – did not take place); coordination of rates with the cargo owner (g_1 – took place, g_2 – did not take place); transportation characteristics (aa_1 – consignment as a single cargo, aa_2 – consignment as a cargo in the consumer packaging, aa_3 – consignment as a single cargo loaded on (in) a pallet (container), aa_4 – consignment as a cargo in the consumer packaging loaded on (in) a pallet (container)); availability of consumer packaging (ab_1 – is available, ab_2 – is not available); availability of packing means (ac_1 – is available, ac_2 – is not available); returns of shipping tare (ad_1 – took place, ad_2 – did not take place); availability of loading and unloading facilities (ae_1 – are available, ae_2 – are not available); the labeling apply (af_1 – is automated, af_2 – is manual); paperwork (ag_1 – is automated, ag_2 – is manual); reading the labels (ai_1 – is automated, ai_2 – is manual); the required vehicle body type basing on the cargo transport characteristics (ak_1 – van, onboard general purpose vehicle (tented), ak_2 – other); availability of the required vehicle (al_1 – is available, al_2 – is not available); the vehicle possible loading and unloading scheme (am_1 – from the rear side of the vehicle, am_2 – from the sides, am_3 – combined); required scheme for the vehicle loading (an_1 – from the rear side of the vehicle, an_2 – from the sides, an_3 – combined); required scheme for the vehicle unloading (ao_1 – from the rear side, ao_2 – from the sides, ao_3 – combined); availability of a cargo processing area (ap_1 – is available, ap_2 – is not available); packaging method (aq_1 – mechanized, aq_2 – manual); warehouse recycling (at_1 – no need, at_2 – consolidation of cargo units is required, at_3 – reconfiguring of the cargo unit is required, at_4 – disbanding of the cargo unit is required).

We represent the model of the full variants set of technological schemes of PC delivery in the in-

tercity by road transport as graphs for the considered in [6,7] four LSC variants (Fig. 2, 3).

Thus, the complete set of all paths from the top of the "Request is received" to "Request is serviced" can be obtained from the data graphs.

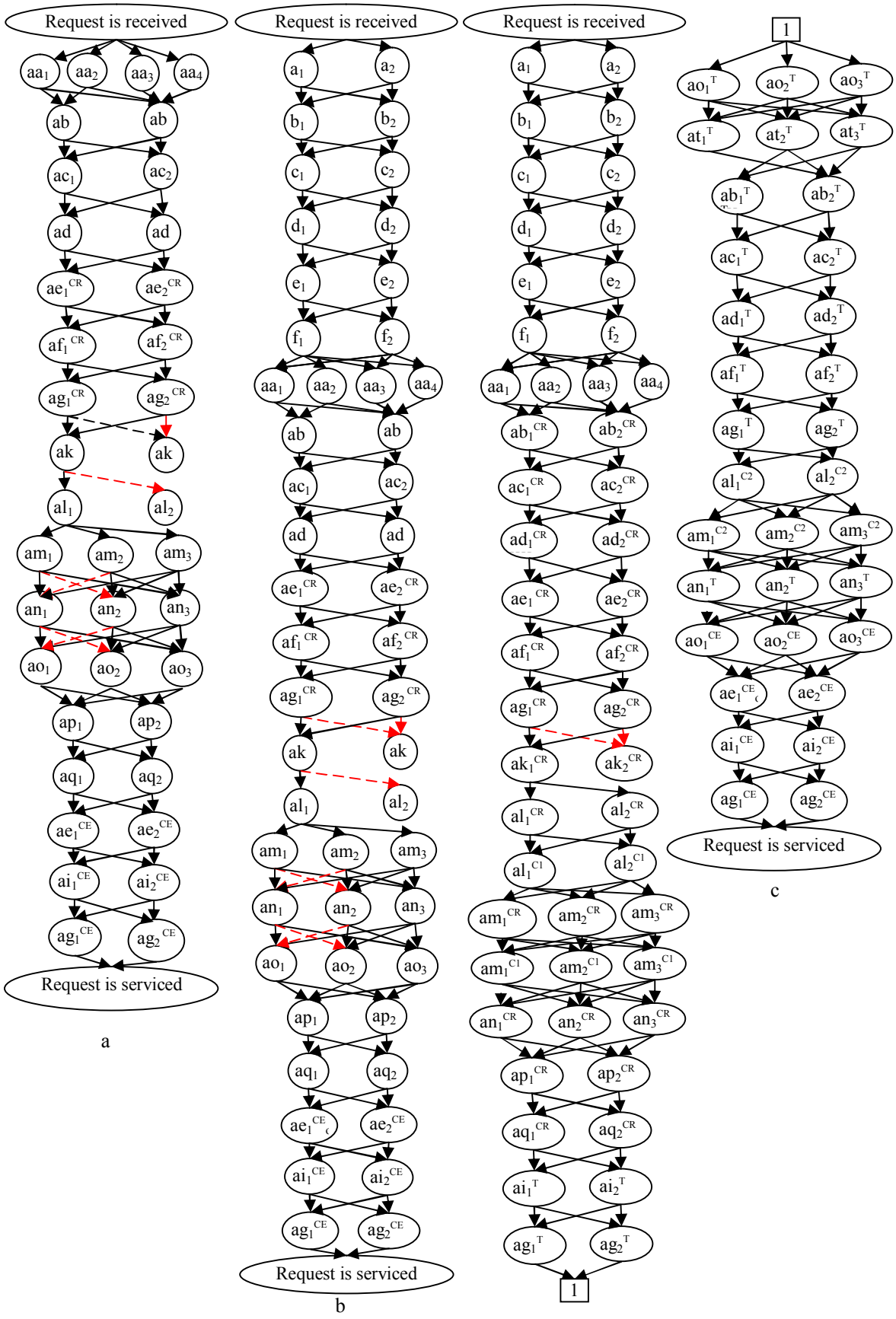

Fig. 2. Model for forming of the complete set of alternative PC schemes for the 1F-, 2F- and 1T- variants of LSC

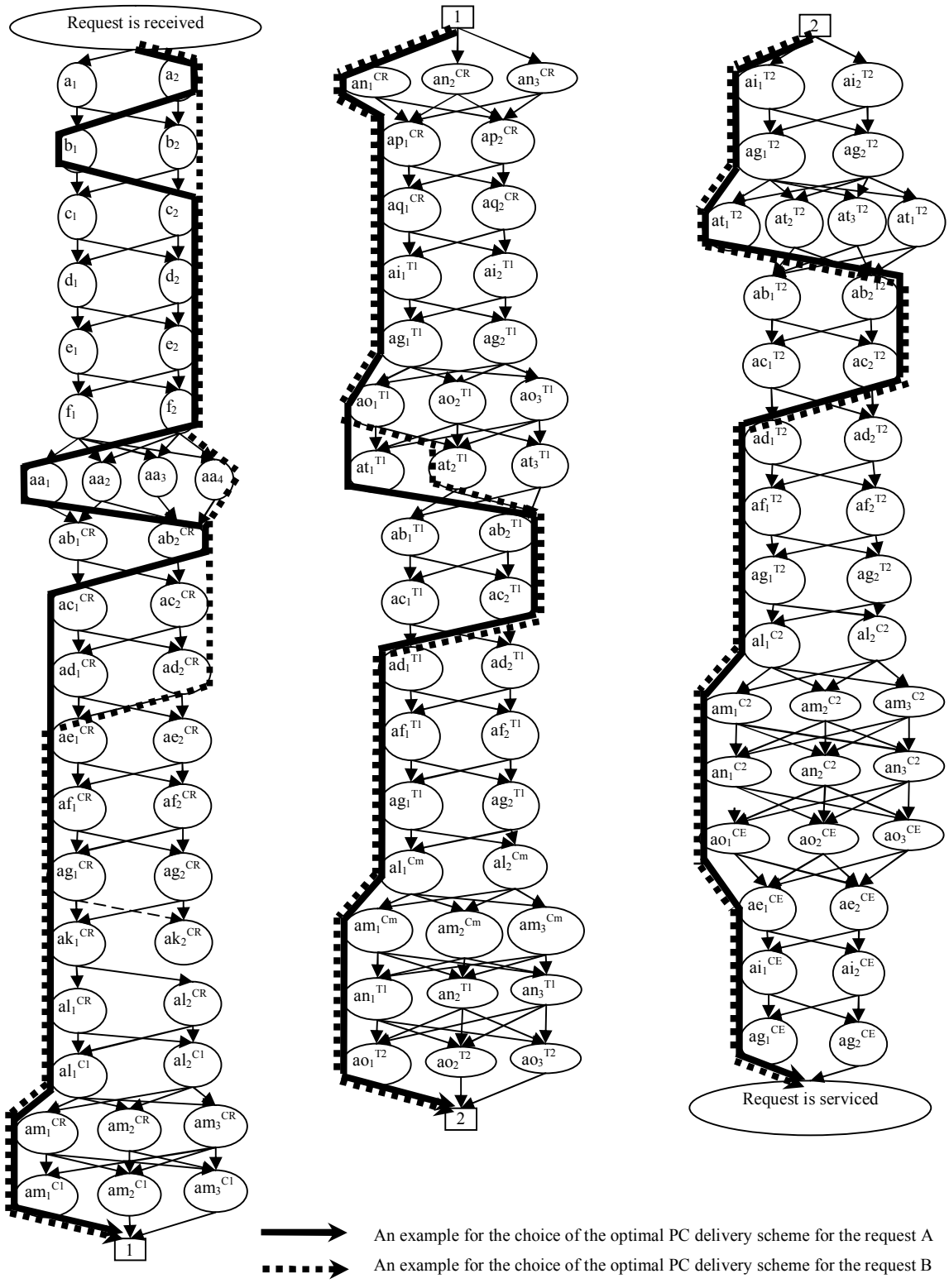

Fig. 3. Model for forming of the complete set of alternative PC schemes for the 2T- variant of LSC (with the marked examples of the optimal scheme choice)

Then it becomes possible to choose the optimum TTSD using based on Deikstra's method the shortest path. An example of graphical implementation of the optimal TTSD choice for two requests with different characteristics is shown at Fig. 3.

Conclusion

The conducted analysis of practical experience and scientific works in the field of improving the efficiency of road transport suggests that the most appropriate criterion for evaluation of the effectiveness of PC delivery in the intercity is the total costs of the delivery process participants.

The proposed approach to the formalization of the complete set of alternative variants of PC delivery process in the intercity as a graph-model allows using of the network optimization techniques.

In particular, the proposed models could determine the optimal variant of servicing technology by means of a method of finding the shortest path in the network.

Reference

1. Воркут А.И. Грузовые автомобильные перевозки / А.И. Воркут. – К.: Высш. шк., 1986. – 456 с.
2. Вельможин А.В. Грузовые автомобильные перевозки: учебник для вузов / А.В. Вельможин, В.А. Гудков, Л.Б. Миротин, А.В. Куликов – М.: Горячая линия, 2006. – 560 с.
3. Наумов В.С. Транспортно-экспедиционное обслуживание в логистических системах: монография / В.С. Наумов. – Х.: ХНАДУ, 2012. – 220 с.
4. Наумов, В.С. Модель вибору оптимальних транспортно-технологічних схем доставки вантажів в контейнерах/ В.С. Наумов, Н.С. Вітер // Вісник Східноукраїнського національного університету ім. В. Даля. – 2011. – Вип. 5(159). – Ч. 1. – С. 259–264.
5. Наумов В.С. Методика формування альтернативних транспортно-технологічних систем доставки вантажів / В.С. Наумов, Н.С. Вітер // Восточно-Европейский журнал передовых технологий: сб. науч. тр. – 2011. – Вып. 5/4(53). – С. 16–19.
6. Нагорний Є.В. Формування варіантів технології доставки тарно-штучних вантажів автомобільним транспортом у міжміському сполученні / Є.В. Нагорний, В.С. Наумов, О.О. Шуліка // Автомобильный транспорт: сб. науч. тр. – 2013. – Вып. 32. – С. 61–66.
7. Нагорний Є.В. Особливості формування схем доставки тарно-штучних вантажів автомобільним транспортом у міжміському сполученні / Є.В. Нагорний, В.С. Наумов, О.О. Шуліка // Автомобильный транспорт: сб. науч. тр. – 2013. – Вып. 33. – С. 77–81.

Reference

1. Vorkut A.I. Gruzovye avtomobil'nye perevozki. Kyiv, Vyssh. shk. Publ., 1986. 456 p.
2. Vel'mozhin A.V., Mirotin L.B., Gudkov V.A. Gruzovye avtomobil'nye perevozki: uchebnik dlja vuzov. Moskow, Gorjachaja linija Publ., 2006. 560 p.
3. Naumov V.S. *Transportno-jekspedicionnoe obsluzhivanie v logisticheskih sistemah*: Kharkov, KhNADU Publ., 2012. 220 p.
4. Naumov V.S., Viter N.S. Model' viboru optimal'nih transportno-tehnologichnih shem dostavki vantazhiv v kontejnerah. *Visnik Shidnoukr. nac. un-tu im. V. Dalja*, 2011, vol. 5(159), iss. 1. pp. 259–264.
5. Naumov V.S., Viter N.S. Metodika formuvannja al'ternativnih transportno-tehnologichnih sistem dostavki vantazhiv. *Vostochno-Evrop. zhurnal peredovyh tehnologij*: *sb. nauch. tr.*, 2011, vol. 5/4(53). pp. 16–19.
6. Nagornij E.V., Naumov V.S., Shulika O.O. Formuvannja variantiv tehnologiї dostavki tarno-shtuchnih vantazhiv avtomobil'nim transportom u mizhmis'komu spoluchenni. *Avtomobil'nyj transport: sb. nauch. tr.*, 2013, vol. 32. pp. 61–66.
7. Nagornij E.V., Naumov V.S., Shulika O.O. Osoblivosti formuvannja shem dostavki tarno-shtuchnih vantazhiv avtomobil'nim transportom u mizhmis'komu spoluchenni. *Avtomobil'nyj transport*: *sb. nauch. tr.*, 2013, vol. 33. pp. 77–81.

Рецензент: П.Ф. Горбачёв, профессор, д.т.н., ХНАДУ.

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