Методика. Теоретические методы: теоретико-методологический и научно-теоретический анализ литературы по исследуемой проблеме, моделирование, прогнозирование. Эмпирические методы: исследование и обобщение педагогического опыта применения системного подхода в образовательных профессиональных организациях, включенное наблюдение, анкетирование, экспертная оценка.

Результаты. Разработаны концептуальные положения создания безопасной информационной среды в образовательной организации, раскрывающие её сущность, представленные в форме целей управления. Установлено, что реализация представленных в исследовании подходов эффективного управления образовательной организацией обеспечивает выделение необходимых условий комфортной профессиональной подготовки будущих специалистов в вузе. Для педагогических работников разработан курс „Информационная безопасность образовательной организации", целью которого является повышение квалификации в области обеспечения информационной безопасности работников образовательных организаций.

Научная новизна. Уточнено понятие „инфобезопасная среда образовательной организации", рассматриваемое как динамичный показатель качества управления образовательной организацией. Определены перспективные направления инновационных преобразований в системе управления образовательной организацией. Обоснованы основные параметры безопасной информационно-образовательной среды по цели, результатам и управлению педагогическими системами, обеспечивающие эффективное применение системного подхода как основы конструирования системы управления образовательной организацией.

Практическая значимость. Использование полученных результатов позволяет повысить качество инновационного развития системы управления образовательной организацией и тем самым поднять на новый уровень результат профессиональной подготовки будущих специалистов.

Ключевые слова: *информационная безопасность, качество управления, инфобезопасная среда образовательной организации, профессиональная переподготовка*

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METHODOLOGICAL ASPECT OF SUBSTANTIATING THE FEASIBILITY OF INTERMODAL TECHNOLOGY FOR DELIVERY OF GOODS IN THE INTERNATIONAL TRAFFIC

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МЕТОДОЛОГІЧНИЙ АСПЕКТ ОБҐРУНТУВАННЯ ДОЦІЛЬНОСТІ ІНТЕРМОДАЛЬНОЇ ТЕХНОЛОГІЇ ДОСТАВКИ ВАНТАЖІВ У МІЖНАРОДНОМУ СПОЛУЧЕННІ

Purpose. Development of methods for determining the efficiency of piggy-backed cargo delivery in the international traffic.

Methodology. The choice of the rational range of piggyback delivery of goods in international traffic is based on the analytical method and mathematical modeling.

Findings. The method of choosing the rational range of piggyback delivery of goods in international traffic is proposed, based on the determination of the equilibrium value of the distance of transportation for alternative options: delivery by road transport through service and piggyback delivery. Criterion of the effectiveness of intermodal technology for the delivery of goods in international traffic under conditions of a certain location of production and consumption is substantiated, which is the unit cost of delivering the goods from the point of departure to the destination subject. On the basis of a detailed analysis of individual elements of alternative technologies, the costs of all elements of alternative options are formalized: delivery by road transport through service and piggyback delivery.

Originality. Mathematical models of the process of delivering goods in international traffic have been developed for alternative options: road transport through service and piggyback delivery. The models are based on the system approach and take into account the costs of all technological elements of the delivery process, subject to the limitation of the delivery time.

Practical value. The application of the proposed methodology makes it possible to select a rational intermodal technology for the delivery of industrial and technical goods in the international traffic. The developed mathematical models allow simulating the process of cargo delivery for alternative variants, including in the maintenance of mining enterprises, metallurgical and machine-building complexes, which makes it possible to operatively estimate the unit costs depending on the values of price and technological parameters.

Keywords: *intermodal technology, multimodal system, international communication, piggyback transportation, mathematical model, criterion of effectiveness*

Introduction. The globalization of the economy, the use of innovative technologies in the production sector and in the transport sector, the increase in the level of informatization, the expansion of foreign economic relations have led to a significant increase in the volume of international transportation. Therefore, increasing the efficiency of functioning of the transport and logistics system is very topical today.

In addition, in the context of creation of transport and logistics clusters and joint ventures [1], the concentrated work of interacting entities specializing in the provision of transport and logistics services and ensuring competitive advantages of respective territories is needed.

When servicing the enterprises of the mining industry, metallurgical and machine-building complexes, the ever-increasing role of motor transport is observed both for intra-plant shipments of industrial and technical goods [2], and for the transportation of export products, especially rolled metal products and hardware.

The main trends of the development of freight transportation in international traffic are associated with the increased use of multimodal transport systems and an increase in the share of intermodal technologies. This trend is primarily due to the integration of Ukraine's transport infrastructure into the world transport system, which contributes to the development of a network of existing transport corridors and to the competitiveness of national transport companies in the global transport services market.

Analysis of the recent research and publications. Researchers pay significant attention to the existing problems of the transport sector, with special attention given to multimodal transport systems of interregional and international nature [3].

It is noted that the development of multimodal delivery systems is based on the organizational and technological interrelation of all links of the transportation process, contributes to the socio-economic development of not only individual regions but also the country as a whole [4]. In turn, the interaction of participants of the delivery process in complex transport and logistics delivery systems causes a synergistic effect [5].

Scientists consider multimodal technologies as the main trend of increasing the efficiency of managing the processes of cargo delivery [6, 7]. At the same time, the choice of optimal delivery technology from a variety of alternatives should be carried out using optimization models that underlie the operator's interactive tool when deciding on the most efficient operation of the transport system [8]. Multifactor models that take into account the specifics of the described process and the availability of restrictions allow real-time operational control and coordination of the participants in the delivery process within the framework of an innovative transport system [9, 10].

The choice of the transport-technological system for the delivery of goods is based on taking into account the features of the functioning of technological elements in the organization of transport, storage and reloading processes. When researching complex production and transport systems, it is proposed to select a rational technology for their functioning, considering technical, economic and operational indicators based on the logistic approach [11, 12].

One of the forms of multimodal transport technologies for delivery of goods is intermodal transportation [7].

Most often, intermodal technologies are used with containers of different carrying capacity, removable car bodies, and contrailers [13]. In Western Europe, intermodal transport through piggyback technologies is becoming more common today. Pipeline transportation is organized in 20 countries of Europe, as well as in the USA, Canada and Australia, herewith costs saving of delivering goods reaches 10–17 % [14], reducing harmful emissions discharged into to the environment up to 75 %. For Ukraine, the most promising among intermodal transportations in international traffic is piggybacking, carried out in land transport international corridors [4].

Thus, among a variety of alternative intermodal technologies, special attention should be given to piggyback transportation as the most promising trend for development of the transport complex of Ukraine. At the same time, it is of interest to determine the scope of the effectiveness of piggyback cargo delivery in the international traffic, which has not been adequately reflected in the studies carried out.

Objectives of the article. The purpose of the given publication is to develop a methodology for determining the scope of the effectiveness of piggy-backed cargo delivery in the international traffic.

Objectives of the study include substantiation of the criterion of the effectiveness of intermodal technology for the delivery of goods in the international traffic; formalization of costs for all elements of alternative delivery options; development of models for the process of international cargo delivery for alternative options; development of methods for determining the rational range of piggyback traffic in international traffic.

Methods. The choice of a rational intermodal delivery system is, as a rule, reduced to establishing the economic feasibility of the spheres of application of a particular system [15].

For modeling at the initial stage it is proposed to use an analytical method that does not require a large amount of systematized statistical data.

Explanation of scientific results. Intermodal technologies, as a kind of multimodal delivery process, involve the systematic cooperation of different modes of transport in the organization of transport chains and are based on the firm agreement and correspondence of technical and technological aspects of interaction of all the participants of the delivery process.

Cooperation of the participants of the delivery process contributes to:

- improving the efficiency of transport management;
- redistribution of cargo flows, optimizing the route;
- ensuring the rational use of resources;
- full satisfaction of consumers' needs for transport services.

The main forms of coordination and interaction of different types of transport for intermodal transportation of goods, aimed at increasing the overall synergetic effect, include:

- coordinated work of transport modes at transport hubs and other buttress points on the basis of a single technological process;
- formation of mutually agreed schedules for organizing the delivery along the whole route of cargo transportation involving several modes of transport;
- synchronization of the rolling stock supply at transshipment points;
- concentration of cargo operations at terminal complexes and transport and distribution centers;
- cooperated use of loading and unloading mechanisms by different types of transport during cargo transshipment at junction points;
- operational planning of transportation and rolling stock supply at junction points of different modes of transport;
- automation of document registration, settlement payments between the participants responsible for the delivery of goods, the use of electronic document management;
- information support of cargo transportation in international and domestic traffic;
- application of complex automated systems to control the intermodal transport system;
- logistics services to improve the quality of customer service in the organization of transport, storage and reloading processes;
- harmonization of the economic interests of the participants in the delivery of goods and the use of an established mechanism for income distribution among the participants;
- application of unified through rates of payment for transportation and introduction of flexible tariff policy;
- unification of parameters and standards for the technology and technical means of transportation;
- application of uniform legal norms.

To integrate the piggyback traffic with the European multimodal network (TEN-T), it is necessary to create legal, economic and organizational and technical conditions in Ukraine.

It has been determined that one of the most important criteria for choosing a rational transport and technological delivery system for cargo delivery from the point of view of the consumer of transport services is the unit cost for cargo delivery.

Alternative transport and technological systems of cargo delivery were chosen: piggyback delivery and delivery by road transport according to the direct variant. In this case, the technological situation for each of the systems is presented as a set of technological operations $(u_{g_m g_{m+1}}, u_{a_m a_{m+1}}, \ldots, u_{g_n n}, u_{a_n n})$, required to perform the cargo delivery from point 1 to point n (Table).

The total time for delivery of the goods can be expressed as follows

$$t(\Theta_i) = \sum_{i=1,n} t_i(u_{m,m+1}); \quad u \in \Theta,$$

where $t_i(u_{m,m+1})$ is the time of executing the technological operations during the transition from state m to state $m+1$ for cargo delivery according to the i system; Θ is a set of delivery technologies according to alternative systems.

However, as a rule, the option of cargo delivery with the least amount of time is not economically viable. Hence, it is expedient to take into account the unit costs

$$C\left[\Theta_i\right] = \sum_{i=1}^{n} C_i(u_{m,m+1}); \quad u \in \Theta,$$

where $C[\Theta_i]$ stands for unit costs for the delivery of goods according to the i-system; $C_i(u_{m,m+1})$ stands for unit costs, associated with the execution of technological operations in the transition from the state m to the state $m+1$ for delivery through the i system.

The replacement of intermodal delivery technology r by j leads to a change in unit costs and time for delivery of the goods, i. e.

$$\begin{cases} t_r(\Theta_i) = t_j(\Theta_i) \pm \Delta t(\Theta_i) \\ C_r(\Theta_i) = C_j(\Theta_i) \pm \Delta C(\Theta_i) \end{cases},$$

where $\Delta t(\Theta_i)$, $\Delta C(\Theta_i)$ are absolute changes in time and unit costs for the delivery of cargo when replacing intermodal delivery technology r by j.

With this in mind, unit costs for the delivery of goods from the point of departure to the destination subject to

Table

Alternative delivery systems

Paradigm of the system	Technology
Piggyback service	$\Theta_{con} = \left\{u_{1g_1}; u_{g_1 g_2}; \ldots; u_{g_m g_{m+1}}; \ldots; u_{g_n n}\right\}$
Cargo delivery by road transport	$\Theta_{avt} = \left\{u_{1a_1}; u_{a_1 a_2}; \ldots; u_{a_m a_{m+1}}; \ldots; u_{a_n n}\right\}$

the limitation of the delivery time are chosen as a criterion for the optimality of the sphere of effective application of piggyback delivery at a certain location of production and consumption.

The objective function takes the following form

$$R_c = \min C[\Theta_i].$$

When comparing the delivery options for alternative intermodal technologies, it is necessary to take into account the variable costs:

- for transportation of goods to the point of transfer to the main mode of transport;
- related to environmental pollution;
- for capital investment into the rolling stock and permanent equipment;
- for performance of loading and unloading operations;
- for cargo transportation under the considered intermodal technology;
- costs associated with passing a checkpoint across the state border;
- costs associated with the exclusion of the cargo mass from the turnover.

It should be noted that the same time elements of costs are not considered when choosing the delivery option.

On the basis of the analysis of the process of functioning of individual elements of alternative intermodal technologies and the establishment of analytical dependences of the costs of all elements, a mathematical model of the process of delivering goods by road transport according to a direct option in the international traffic has been obtained

$$R_{avt} = (T_{avt} \cdot L + C_{pr} \cdot t_{pr}^{dr})\frac{1}{q_c} + \frac{U_h \cdot 2L \cdot H_{100} \cdot C_{1l}}{100 \cdot q_c} + \\ + E_p \cdot \frac{(C_v + C_b) \cdot t_r}{24 \cdot 365 \cdot \gamma \cdot t_d \cdot \alpha \cdot \beta \cdot q_c \cdot V_{tech}} + \\ + \frac{C_c \cdot \gamma \cdot q_c \cdot \frac{t_{tr} + t_r}{24} \cdot i}{365} \cdot \frac{1}{q_c} \to \min, \quad (1)$$

where T_{avt} is the tariff for the transportation of goods by car, UAH/km; $L$is the distance of cargo transportation, km; C_{pr} is the cost of one hour of road-train idle time, UAH/h; t_{pr}^{dk} is idle time when passing the state border, h; q_c is mass of consignment, t; U_h is normative value of the volume of emissions of harmful substances discharged into the atmosphere for a vehicle of the corresponding brand, m^3/l; H_{100} is the rate of fuel consumption of the car, l/100 km; C_{1l} is the rate of payment for emissions of harmful substances discharged into the atmosphere, UAH/m^3; E_p is the normative coefficient of efficiency of capital investments; C_v is the cost of the vehicle, UAH; C_b is the cost of production and technical base, attributed to one car, UAH; t_r is the time of one ride, h; 365 is the number of days in a year, days; γ is the coefficient of utilization of the semi-trailer load capacity; t_d stands for the time of the vehicle on duty, h; α is the vehicle fleet production ratio; $\beta$is mileage utilization factor; V_{tech} is technical speed, km/h; C_c stands for cost of 1 ton of transported goods, UAH; t_{tr} is time expenditure for trips, maintenance, repairs, refueling, etc. h; i is the interest rate on deposits, share.

The restriction to the model (1) is:

- limitation due to the physical meaning of the values

$$\gamma,\ t_d,\ \alpha,\ \beta,\ q_c,\ V_{tech} > 0;$$

- execution condition of cargo delivery time T

$$t_{pr}^{dk} + t_{tr} + t_r \le T.$$

A mathematical model of cargo delivery by piggybackers in the international traffic is proposed

$$R_{pig} = (T_{avt} \cdot L_{avt} + C_{pr} \cdot t_{pr}^{st} + C_{pr} \cdot t_{l-unl}^{st} + \\ + T_{pig} \cdot L_{pig} + C_{pr} \cdot t_{pr}^{pas})\frac{1}{q_c} + \\ + E_p \cdot \frac{(k_{rlok} N_{loc} C_{loc} + k_{rpl} N_{pl} C_{pl}) \cdot t_{turn}}{365 \cdot 2 \cdot \gamma \cdot q_c \cdot S} + \\ + \frac{C_c \cdot \gamma \cdot q_c \cdot t_{rail} \cdot i}{365} \cdot \frac{1}{q_c} \to \min, \quad (2)$$

where L_{avt} is the distance from the consignor to the railway station, km; t_{pr}^{st} is the time of road trains accumulation at the railway station and waiting for loading on the platform, h; t_{l-unl}^{st} is the time for loading and unloading of road trains at departure and destination stations, h; T_{pig} is tariff for cargo transportation by piggybackers, UAH/km; L_{pig} is the distance of railway transportation, km; t_{pr}^{pas} is the idle time when passing through the state border by train, h; N_{loc}, N_{pl} is the number of locomotives and platform in the train respectively; C_{loc}, C_{pl} are the cost of the locomotive and platform respectively, UAH; k_{rlok}, k_{rpl} are the coefficients that take into account the reserve of rolling stock; t_{turn} is the turnover time of rail transport, days; 2 is the number of semi-trailers on the platform; S is the number of platforms while a part of the train; t_{rail} is the time of road train transportation by rail, days.

Restrictions to the model (2) are:

- the restriction that takes into account the physical meaning of the quantities

$$\gamma,\ q_c,\ S > 0;$$

- the condition for executing the term of delivery of goods T

$$t_{pr}^{st} + t_{l-unl}^{st} + t_{pr}^{pas} + t_{rail} \le T.$$

The choice of a rational range for intermodal technology of cargo delivery of goods in the international traffic is carried out on the basis of the equality of unit costs

$$R_{avt} = R_{pig}.$$

Conclusions. The conducted research testifies to a wide spectrum of possibilities for applying the intermodal technologies of delivery of cargoes of industrial and technical purpose, especially metal rolling and hardware stock, when servicing the enterprises of the мining industry, metallurgical and machine-building complexes.

The following results were obtained during the research:

- the criterion of efficiency of intermodal technology of cargo delivery in the international traffic is grounded. The efficiency criterion for determining the rational range of piggyback traffic is the unit cost of delivery, taking into account the time limit for delivery;
- the costs of all elements of alternative delivery options are formed in an analytical form on the basis of a detailed analysis of individual elements of alternative technologies;
- there were developed mathematical models of the process of goods delivery in the international traffic for alternative options that are based on the system approach and take into account the costs of all the technological elements of the delivery process;
- there was offered a method of choosing the rational range for the piggyback technology of goods delivery in the international traffic, based on the determination of the equilibrium value of the transportation distance for alternative options.

Further research should be aimed at modeling the international cargo delivery process for alternative intermodal technologies and determining the rational range of piggyback cargo transportation.

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Мета. Розробка методики визначення сфери ефективності контрейлерної доставки вантажів у міжнародному сполученні.

Методика. Вибір раціональної дальності контрейлерної доставки вантажів у міжнародному сполученні базується на аналітичному методі й математичному моделюванні.

Результати. Запропонована методика вибору раціональної дальності контрейлерної доставки вантажів у міжнародному сполученні, заснована на визначенні рівноважного значення відстані перевезення для альтернативних варіантів: доставки автомобільним транспортом у прямому сполученні й контрейлерної доставки. Обґрунтовано критерій ефективності інтермодальної технології доставки вантажів у міжнародному сполученні в умовах певного розміщення виробництва й споживання, в якості якого виступають питомі витрати на доставку вантажу від пункту відправлення до пункту призначення. На основі детального аналізу окремих елементів альтернативних технологій формалізовані витрати всіх елементів альтернативних варіантів: доставки автомобільним транспортом у прямому сполученні й контрейлерної доставки.

Наукова новизна. Розроблені математичні моделі процесу доставки вантажів у міжнародному сполученні для альтернативних варіантів: доставки автомобільним транспортом у прямому сполученні й контрейлерної доставки. Моделі ґрунтуються на системному підході та враховують витрати всіх технологічних елементів процесу доставки за умови обмеження терміну доставки.

Практична значимість. Застосування запропонованої методики дозволяє здійснювати вибір раціональної інтермодальної технології доставки вантажів виробничо-технічного призначення в міжнародному сполученні. Отримані результати дозволяють моделювати процес доставки вантажів для альтернативних варіантів, у тому числі при обслуговуванні підприємств гірничодобувної промисловості, металургійного й машинобудівного комплексів, що дозволяє оперативно оцінювати питомі витрати в залежності від значень цінових і технологічних параметрів.

Ключові слова: *інтермодальна технологія, мультимодальна система, міжнародне сполучення, контрейлерне перевезення, математична модель, критерій ефективності*

Цель. Разработка методики определения сферы эффективности контрейлерной доставки грузов в международном сообщении.

Методика. Выбор рациональной дальности контрейлерной доставки грузов в международном сообщении основан на аналитическом методе и математическом моделировании.

Результаты. Предложена методика выбора рациональной дальности контрейлерной доставки грузов в международном сообщении, основанная на определении равновесного значения расстояния перевозки для альтернативных вариантов: доставки автомобильным транспортом в прямом сообщении и контрейлерной доставки. Обоснован критерий эффективности интермодальной технологии доставки грузов в международном сообщении в условиях определенного размещения производства и потребления, в качестве которого выступают удельные затраты на доставку груза от пункта отправления к пункту назначения. На основе детального анализа отдельных элементов технологий формализованы затраты всех элементов альтернативных вариантов: доставки автомобильным транспортом в прямом сообщении и контрейлерной доставки.

Научная новизна. Разработаны математические модели процесса доставки грузов в международном сообщении для альтернативных вариантов: доставки автомобильным транспортом в прямом сообщении и контрейлерной доставки. Модели основываются на системном подходе и учитывают затраты всех технологических элементов процесса доставки при условии ограничения срока доставки.

Практическая значимость. Применение предложенной методики позволяет осуществлять выбор рациональной интермодальной технологии доставки грузов производственно-технического назначения в международном сообщении. Полученные результаты позволяют моделировать процесс доставки грузов для альтернативных вариантов, в том числе при обслуживании предприятий горнодобывающей промышленности, металлургического и машиностроительного комплексов, что позволяет оперативно оценивать удельные затраты в зависимости от значений ценовых и технологических параметров.

Ключевые слова: *интермодальная технология, мультимодальная система, международное сообщение, контрейлерные перевозки, математическая модель, критерий эффективности*

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