условия, чтобы способствовать их возникновению. Поэтому задача формирования региональных и межрегиональных транспортных связей в привязке к развитию промышленных кластеров крайне актуальна.

Статья предлагает понятную логическую схему постановки задач и их решения. Вместе с тем вряд ли можно говорить о завершении разработки метода формирования сетевой структуры межрегиональных транспортных систем, о его полной практической применимости. Демонстрируются пока подходы к его теоретическому обоснованию, созданию работоспособной концептуальной методологической схемы.

Но учитывая важность поднятых вопросов, есть и поле для дискуссии. Ключевое значение учета потребностей в осуществлении грузовых перевозок на местном, региональном и межрегиональном уровнях требует более детального теоретического обоснования. Минимизация расстояний между заданными кластерами с учетом транзитных коридоров, что является, по сути, центральным пунктом статьи, – нужный способ и шаг к успеху, но недостаточный для формирования современной транспортной сетевой структуры.

Нужна апробация на реальных объектах, например, подтверждение допущения о двух третях объема транспортной работы, приходящихся на грузопотоки между кластерами на анализируемой территории, или на транзитные грузопотоки между узлами кластеров. Приведенные в таблице 2 участки пути для решения реальных задач целесообразно будет рассматривать как реально применяемые маршруты.

При дальнейшей разработке метода необходимо усиление математического аппарата. Например, задачу соединения узлов методом полного перебора целесообразнее решать путем нахождения минимального остова графа ввиду возможных трудностей полного перебора и невозможности его проведения из-за большой размерности задачи. Также, по нашему мнению, надо при этом учитывать и дополнительные условия реальной экономики, в чем-то упрощающие, а в чем-то усложняющие задачу. В ряде экономически успешных российских областей само число промышленных кластеров (несмотря на весомый вклад в региональные ВВП), понимаемых как совокупность компактно или удаленно расположенных предприятий, относящихся к одной отрасли и/или имеющих отлаженные кооперационные связи по выпуску продукции, может быть и небольшим, равно как и число их участников (локальных кластеров внутри региональной транспортной системы). Но и тогда имеются развитые связи с поставщиками и потребителями из других областей (перевозки комплектующих по транзитному коридору в локальный кластерный узел и генерация грузопотока из кластерного узла в направлении потребителей).

Понятно, что многие из вопросов, которые вызывают интерес или представляются пока спорными, не могли быть включены в журнальную статью, тем более посвященную отдельной теме, тем не менее сам факт их возникновения доказывает, что авторами сделан существенный шаг к исследованию действительно многогранной проблемы, дан повод к дискуссии. И это несомненное достоинство статьи.

NETWORK STRUCTURE OF INTERREGIONAL TRANSPORT SYSTEMS

Tararychkin, Igor A. *– D. Sc. (Tech), associate professor of V. Dahl Eastern-Ukrainian national university, Lugansk, Ukraine.*
Slobodianuk, Maxim E. *– Ph.D. (Tech), senior lecturer of V. Dahl Eastern-Ukrainian national university, Lugansk, Ukraine.*
Nechaev, Grigory I. *– D. Sc. (Tech), professor, head of the department of transport systems of V. Dahl Eastern-Ukrainian national university, Lugansk, Ukraine.*

ABSTRACT
The article studies organization of transport systems on the basis of clusters with account for industrial links emerging between them. The network structures are considered at local, regional and interregional levels. The authors propose approaches towards transport network organization, methods of managerial actions,

Table 1

Typical tasks arising at the stages of development and functional organization of transportation systems

List of problems relative to engineering and functional organization of transportation systems	Relevant stage of designing or functional operation, related to solution of the problem
Synthesis of multilevel transportation systems with the account for forecasted needs for traffic	Stage of designing and structuring of transportation network at the time of developing of new territories and regions
Analysis of conformity of existing transportation structure with regional needs for freight traffic	Stage of functioning of transportation system. The problem is solved in order to assess capacity and practicability of transportation system's optimization at different levels.
Provision with managerial tools of stage-by-stage (evolutional) development of transportation systems and of their conformity with changing demand for regional and interregional freightage.	Stage of reconstruction, modernization and enhancement of existing transportation systems.

demonstrate examples of structural decisions for variants of clusters located next to and at a distance from transit corridors.

ENGLISH SUMMARY

Background.

Transportation systems and infrastructure are created in order to satisfy existing demand for transportation. Organization and development of network structures within the mentioned systems are conditioned by volumes and features of regional production, existing stable links between enterprises, outlook on industrial zones' development.

Organization, maintenance, development of logistics systems require important funding and are conditioned in most cases by preliminary estimation of expected economic efficiency [1,2].

Objectives.

A list of typical tasks peculiar to engineering and organization of transport systems of different levels of complexity is shown in table 1 above. The solution of the problems, enlisted in the table, at the stages of designing, operation and reconstruction is related to the necessity to analyze the existing state of transport objects and substantiation of practicability of attendant managerial operations [3–5].

The leading subject here is to determine features of organization of network structure of transportation systems of different complexity, taking into account demand for freight carriage at local. Regional and interregional levels.

Methods. *The developed principle of shaping, engineering and organization of operation of interregional transport system is based on a synthesis of its structure taking into account a possibility of existence of several structural levels. To realize the study the authors use logistic principles and mathematical methods.*

Results.

1. Local structures. The existence of industrial links between local business enterprises supposes that regular freight traffic has existed for a long time. Namely, the stable links between economic entities condition need for engineering and development of transport systems at local level.

In practice solution of relevant tasks relates to engineering of industrial clusters and relevant network infrastructure.

In that case a cluster is perceived as a territory which aggregates space-localized business entities that can be characterized by existence of stable transportation links and freight traffic realized for a long period (not less than a year).

The authors assume that the feature of industrial cluster is that two thirds of all the volume of transportation operations within the dominated territory is executed within its borders.

So far the engineering of a system at local level is linked to the necessity to determine borders of mutual allocation of separate clusters, as well as to structure them, including creation of transport network and provision of links between existing business enterprises. The totality of the task supposes minimizing of transportation operations of local freight traffic.

2. Regional features

To follow up the declared approach, regional level of transport system represents an ensemble of industrial clusters interlinked by common regional network.

But procedure of formal uniting of traffic nodal centers of separate clusters into a whole structure can be considered by itself as an instrument of engineering of a regional network. It is explained by the fact that creating of rational network structure and effective interlinking of clusters can be importantly influenced by transit freightage volumes. This is the reason why the task of engineering of regional transportation network should be differentiated between the case of clusters located next to transit corridors and the case of clusters located at a distance form transport corridors.

2.1. Cluster at a distance from transit

The set of clusters, whose borders are not crossed by transit corridors and whose traffic nodal centers are not included into the above corridors, is considered to be a separate group, functioning independently of existing traffic flows.

A fragment of a regional transportation system, consisting of five clusters and composing a separate group, located at a remote distance from transport corridors, is shown in pic.1.

As the main transportation work at local level is executed within the borders of separate clusters and the volumes of freightage between clusters are relatively low, then the interlinking of clusters should be done in a manner that the total length of ways, linking them to each other, should be reduced to a possible minimum.

The principle of minimal total length of transportation ways at regional level is a preferential

one, because its realization allows reducing total costs of creation and maintenance of localized transport network.
So the condition of optimal system of transportation links between the centers of separate clusters, located at a distance from transit corridors, is expressed as follows:

$$\sum_i L_i \to \min,$$

where L_i is a distance between traffic nodal centers of separate clusters united into a common regional group.
An example of adjoining of nearly located clusters within a common group is shown in picture 2. Full and intermittent lines illustrate alternative variants of joining of nodal centers of separate clusters.
The considered variants of joining B1 and B2 differ as for the total length of linking routes. Variant B1 is deemed to be preferential as

$$\sum_i L_i^{B1} < \sum_i L_i^{B2} \text{ (table 2).}$$

Therefore the definite decision on engineering of optimal network structure for a group of clusters should be made after analyzing of different variants of joining of traffic nodal centers, taking into consideration the total length of linking routes.
2.2. Possibility to locate clusters closer to transit
One can proceed with studying of a fragment of a transportation system, which is limited by three transit corridors, passing by interregional traffic nodal centers (pic.3). The chart shows that some industrial clusters are crossed by corridors. At the same time the corridors determine the directions and ensure possibility to guide freight flows between regional traffic nodal points.
We assume that transit freight flows between such nodal points are prevailing and that they represent not less than two thirds of traffic flow along the considered corridor.
It is evident that, see considerable volumes of transit freightage, a practicability of inclusion of the nodal points of the clusters into the transit corridors that cross them should be considered, taking into account the condition of minimization of total time needed for freight to pass the corridors.
Minimization of time means that while engineering a corridor, consisting of N separate sections with average transit time of freight equal to T_i (i=1,2, ... N), it is necessary to be guided by the condition of minimization of the sum:

$$\sum_{i=1}^{N} T_i \to \min .$$

In other terms, the choice of road laying for transport corridor is determined not only by its length, but by conditions of its separate sections which are to provide minimization of delivery time (by rational process organization, sufficient number of traffic lanes, providing of maximum admissible traffic speed etc.).
The picture 4 shows variants of possible linking of nodal points of clusters K2, K4, K3, K6 и K10, located along a transit corridor.
If an average time of freight transit along the route, corresponding to variant B1, is less as compared to variant B2, then according to proposed approach the variant B1 is preferential. Comparing alternative variants of transit corridor laying, using the data of table 3, it is possible to come to a conclusion that the corridor should pass by nodal points A_1, A_2, A_4, A_5, A_6, A_7.
Accordingly, as it was declared previously, the developed principle of laying out, engineering and organization of operation of interregional transport system is based on a synthesis of its structure taking into account a possibility of existence of several structural levels.
Consequently, at a local level the engineering, structuring and functional organization of separate industrial clusters should be executed taking into consideration the condition of minimization of total transportation work.
At a regional level linking of nodal points of clusters and network developing should be realized taking into account the condition of minimization of total length of transportation ways.
While developing interregional system it is necessary to minimize time of transit of freight traffic along transport corridors.

Conclusions.

The authors have proposed a method of developing of network structure of interregional transport systems, based on logistics principles, providing necessity of:
– determining borders of industrial clusters, their structuring and optimal functioning at local level;
– substantiating of practicability of inclusion of near-by located clusters into a regional group and of creating of conditions for optimization of transport system's functioning at regional level;
– assessing of possibility of inclusion of separate nodal points of clusters, if the borders there-of are crossed by transport corridors, into transit corridor followed by optimization of transport system operation at interregional level.

Key words: transport, transportation, system, network, structure, freight flow, cluster, nodal point, traffic nodal center, region, management levels.

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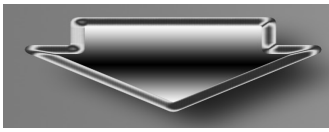

EDITORIAL RESUME

There is no doubt that the article deals with a problem of significant importance. Development of regional transport systems as well as of transport and logistics complexes (or hubs) is a point of immediate interaction between transport and economic systems. Transport and logistics complexes emerge in the regions of the presence of already existing industrial clusters or on the contrary the newly created transport and logistics complexes can contribute to creating of regional industrial clusters. Therefore the task of development of regional and interregional transport systems taking into consideration the development of industrial clusters is currently among most discussed topics.

The article offers comprehensible logic layout of declared problem setting and solution. Nevertheless it does not mean that we can speak about completed method of development of network structure of interregional transport systems, about its implementation capacity. Still approaches to its theoretical substantiation and to development of workable methodological concept have been elaborated.

But regarding the importance of raised issues, there is a field for discussion. For instance the key issue of consideration of demand for goods carriage at local, regional, interregional level needs more detailed inclusion in theoretical substantiation of the method. Minimization of distances between given clusters, which is the essential point of the article, is an important tool but it is still insufficient for development of full-scaled transport network structure.

The method should be probed at real examples. For instance, the assumed theses, that two thirds of transportation work is executed between the clusters within analyzed territory or in transit freight traffic between cluster nodal points, should be confirmed. The road sections in table 2 in order to solve real problems should be replaced with real routes.

Further development of the method should be followed by reinforcement of mathematical apparatus. For instance it is practicable to solve the problem of joining of nodal points by the methods of solving of minimum graph skeleton problem instead of complete enumeration method, as it is too difficult or probably even impossible to execute complete enumeration due to dimension of the problem.

In our opinion while solving the problem at real examples it is practicable to consider additional conditions of real economics, that can either facilitate or complicate the problem. In some economically successful Russian regions the quantity of industrial clusters itself is not great (regardless of its important contribution to regional economics), and they are comprehended as a set of manufacturing entities which are located closely or at a distance to each other, but are of the same industrial sector and/or have stable regular cooperative links regarding manufactured goods. The number of participants of industrial clusters (local clusters within regional transport system) could be little as well. But they have developed transportation links with suppliers and customers from other regions (supplies of components through transit corridor to local cluster traffic nodal point and generation of freight flow originated in cluster nodal point towards customers).

It is natural that many of the questions that excite interest or are deemed discussable, could not have been included into the journal article, devoted to a specific subject, but the fact that the article initiates those questions proves that the authors have made an important step in the study of the current problem and in further discussions. It is an indisputable merit of the article.

Координаты авторов (contact information): Тарарычкин И. А. (Tararychkin I. A.) – tabos@net.lg.ua, Слободянюк М. Э. (Slobodianuk M. E.), Нечаев Г. И. (Nechaev G. I.) – ts.snu.edu@gmail.com.

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