METHODOLOGY OF TRANSPORT SYSTEM RESEARCH

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In this article transport system is analysed as a complex system∗ with all the indications characteristic of this system, that allows determining on the application of methods of systematic and operational analysis in the course of research of national transport system and its elements. Objectives of the research of transport complex systems’ theory are discussed here as well. Classification of these systems is presented together with their characteristics. Classification of transport complex systems consists in distinct determination of these systems as management objects. Such classification has to be grounded by certain technological and theoretical indications to which as well should be attributed the indications of differentiation of system management issues determined by the time co-ordination with the hierarchy of management, which arises from the hierarchic structure of complex systems. Another objective of the classification is a clear definition of main external and internal relations of transport complex systems, the relations being generally expressed by systematization of prior and searched information, necessary for management of interaction of these complex systems by territorial and time aspects. Certain scientific and methodical objectives of transport systems are presented in the article. Also there is given a description of methods of systematic analysis applied during the course of research of development of Lithuanian freight transport system.

Keywords: transport system network, traffic plans

1. Introduction

Main characteristics of the transport system are the following: transport system network; flows of transport means in the network; flows of freight or passengers in the network; capacity of terminals and quantity of interactive transport means in the terminals. From the point of view of the theory of systems – the national transport system is a complex system [1].

The structure of national transport system consists of numerous elements of system and their interrelation. Main characteristics of this system are:
- freight and passenger flows (applications for transportation, their distribution according to time and location);
- transport network and the fleet of units of separate transport types;
- traffic plans of separate transport type units (their distribution in the transport network, traffic timetables), interaction of transport modes in the terminals.

Scientific research of transport may be efficient and useful from the practical point of view, on condition that it is based on the factors determining the development of transport system, as well as on its natural conception and the knowledge of analytical (methodological) instruments offered by the specialists of transport engineering, transport economics, management science, mathematics, statistics and other sciences.

National transport system is being developed and improved in two directions: quantitative – the development of industrial transport capacities; and qualitative – improvement of technical level of transport infrastructure, acceleration of transportation speed, cutting transport expenses, etc.

Research of transport system has to be carried out in three aspects:
- functional – determination of the role of every transport mode within a territory (district), between separate territories and on the international scale.
- sectorial – relations between separate transport modes on the national and regional scale, basing on the general sectorial structure of transport system;
- territorial – assessment of the regional peculiarities of general transport system and the forms of territorial transport organisation.

Research of the general transport system permits performing of the following works: complex development of all transport modes; improvement of co-ordination of activities of different modes and

∗ Complex system – a managed system of great scale, consisting of sub-systems united by the aim of effect. It comprises people, vehicles, nature with its material, energetic, informative relations. Theoretical issues of the complex systems are solved by the theory of systems; while the planning, designing, construction and operation are dealt with by the systemo-technics.
rational distribution among all transport modes; solution of important national economical issues related to enhancement of public production efficiency; determination of reasonable economic relations within and between regions; development of national external economical relations; determination of expedient development of transport modes taking into account their technical economical parameters and the demand for public transport services.

Further we shall concentrate solely on theoretical-fundamental research, which should be analysed by the methodology of theory of transport system.

In the course of the analysis of the general transport system, when multimodal transportation is carried out in the common network, and this transportation is based on the principles of logistic system, from the point of view of the theory of transport system, the following issues are the prioritative ones [1].

- Strategy, analysis and synthesis of the development of transport system.
- Assessment of transport system as of a dual system.
- Research of characteristics of transport system.
- Research of controlled variables and management criteria.
- Research of interaction of transport modes and technological processes in terminals.
- Terminal co-ordination centre, its theoretical principles.
- Theoretical research of interaction of logistics and transport systems and their mutual supplementation.
- Theoretical research of general transport networks: roads, railways, inland and sea waterways.
- Air transport and that of pipelines may be excluded from the network of the general transport system because of their specific character and small amounts of transportation. However, issues of the synthesis of transport networks have to be worked out, such as designing of transport networks, basing on the aspects of optimal functioning of logistic systems.
- Research of multimodal transport flows in the general transport network.
- Research of technological schemes in the multimodal network and in terminals.
- Research of transportation processes and their cost price in terminals.

For the estimation of the work of transport system, the estimation of transport process has to be done as well. Essential feature of transportation process is its duality. Duality exists in the cycle of the transportation process: 1) turnover of transport means; 2) freight delivery time. In the first case the process of transportation is estimated from the positions of a transport enterprise, i.e. better usage of transport ability, operation. In the second case the process of transportation is estimated from the freight owner’s point of view, priority being focused on commercial operation, economic and juridical problems. The dual treatment of the transportation process decides upon its many-sided estimation. Here we encounter two different time categories, which have their own particular problems of organisation, technology, operation and economy. Nevertheless, these features are closely connected.

Therefore, further we shall analyse national transport systems from the point of view of methodology of complex systems.

2. Transport as a complex system

Functioning of territorial transport network covers a great variety of objectives from mathematical and technical to economic and social political. Let us analyse these objectives from the point of view of the theory of management of complex systems. Cybernetics as a science, forms a principally new attitude towards reality around us, towards its cognition and it may trigger off the development of numerous trends of science. Particularly important to the transport science are such provisions of cybernetics, which develop the principles of management of complex systems and the information theory. It is because of the fact that in transport there exist firmly established systems corresponding with the definition of the complex systems, therefore the systematic research of transport becomes particularly important.

Transport complex systems may be analysed as systems of particular type because of their specific nature. Their essence is defined by a concrete combination of the man – vehicle – environment, their hierarchy, sustainable development, community of interests, complex totality and connections of system elements attaching to it a new quality in the sense of principal opportunity of qualitative cognition of the system. To the main characteristics of such systems are attributed the following: development in the course of time within the limits of certain restrictions, lots of non-linear dependencies, probability of the character of parameters and influences, adaptation, playback, verification of functionality.

Complex transport systems comprise many-sided, particularly work consuming and capital consuming sector of national economy with especially diverse and complex objectives of management. There is no doubt, that for a rational management of this national economy sector, which becomes more
and more complex during the course of its development, there is necessary the application of new ways and methods, such as advanced information technologies and other technical management means.

Transport management and reasonable development of national transport system, based on principles of the theory of management of complex systems, may reveal a number of qualitatively new ideas, virtually allowing to increase transport efficiency and to realise not yet utilised its economical and technological progress reserves. The objective of management of transport complex systems may be formulated as a planned and sustainable development – from a long-term forecasting to the effective management inclusively.

3. Objectives of research of management theory of transport complex systems

In our opinion, the management theory of transport complex systems covers four main and co-related trends of research:

1) classification of transport complex systems by defining their structure, external and internal relations, management tasks and their composition, objectives of management of the external and internal relations in various time aspects;
2) research of common and different development features of various transport modes;
3) methodological basis for accumulation of necessary and reliable information for management of transport systems, for creation of the means of information transfer, processing and application;
4) scientific basis for creation of transport complex systems’ management means and methods; formation of generalised methods of efficient management of such systems, where optimal co-ordination of various management means and methods in territorial and time aspects is necessary. The complex of this research has to make a foundation for a principal improvement of transport operation, designing, planning and forecasting.

Classification of transport complex systems reveals itself by definition of these systems as of objects of management. Such classification has to be based on certain technological and theoretical indications. To them should be attributed the indications of differentiation of management objectives of these systems according to the time co-ordinated with the management hierarchy occurring from the hierarchic structure of the complex systems.

Another objective of classification – to define clear principal internal and external relations of transport complex systems. These relations generally are expressed by systematising the primary and searched information necessary for the management of the interaction of these complex systems by various theoretical and time aspects.

Research of common and different characteristics of the development of various transport complex systems, besides the aforesaid main aim to substantiate the independence of their management theory, has a particularly important significance. Only after a sufficient analysis of the characteristics of the object of management it is possible to formulate the creation of its rational management system. In the course of research of complex systems and their characteristics, for their further investigation it is necessary to create corresponding means. However, their creation is possible only in such cases, when there are known the requirements for these means, arising from aprioritative knowledge of characteristics of the systems and of opportunities of influence. Apprehension of quantitative characteristics and creation of necessary means for their research and management is a non-formalised iteration process, which may be perfected by highly erudite specialists profoundly understanding the designing, operation and planning of these systems.

Information on the variety of all aspects of a system is the foundation for formation of efficient management, because without qualitative information the system can not function properly. The following principal issues are analysed here: 1) classification of necessary information according to its truthfulness and formation peculiarities aiming at the management of systems in different periods of time; 2) creation of the methodology of obtaining unified information, which is especially important for technical economic information; 3) guaranteeing the process of obtaining of authentic information and improvement of systematic information, as well as of the process of its receiving; 4) formation of scientific foundations for the creation of means of information accumulation, transfer, processing, application and analysis.

The final objective should be considered the creation of the complex of rationally and sustainably functioning systems, where a strict hierarchical structure manifests itself by abatement of information and growth of its value in the course of transition from lower management standards to the higher ones.

Creation of perfect management methods and means for transport complex systems is one of the most important objectives of management. They may be divided into three groups:
1) mathematical models, with application of which most management functions may be carried out by using informational technical means of management;

2) electronic and automatic means, with application of which the automated systems may be created: a) management of transport technologic processes; b) acquirement of information, transfer of information and processing of information;

3) organisational, i.e. economical, administrative, moral management methods and means, determining the effective relations and organisation of work groups involved in the functioning and management of the system.

Rational management of transport, as of a complex system, has to be optimally co-ordinated in the aspects of hierarchy (technological, territorial) and time. Also it must be kept in mind, that complex systems make an organic combination of persons, vehicles and surrounding nature. It may be concluded that the complex system functions (develops) by influencing the vehicle and the man. The management process of great complex of transport complex systems should be estimated as a constantly specified planning process, finding optimal solutions by the application of methods of consequent approximations.

4. Classification of transport complex systems

According to the technological indication there may be distinguished the following main transport complex systems: 1) general state transport network, as a principal transport system covering main elements and relations of general national transport economy and synthesising different transport modes in the new economic and technical-technological quality; 2) general railway network; 3) general network of road transport; 4) general air transport network; 5) general network of inland water transport; 6) general pipeline transport network; 7) networks of urban electric transport.

All these systems are divided according to the territorial principle (state-town-region-large transport terminals) with several interacting transport modes and form a general hierarchically structured totality of vertically and horizontally arranged automatically functioning complex systems. Territorial classification of transport complex systems is quite complicated, since it is necessary to ground the synthesis of the vertical and horizontal hierarchy of these systems. We can not maintain that these systems are forming according only to a vertical line, i.e. as those strictly modal. Actually there are particularly strong relations of horizontal transportation, that are objectively determining the existence of horizontal transport systems on the national-urban-regional terminal levels.

Each modal system makes certain regional sub-systems according to specific indications of development. Meanwhile, transportations carried out by modal systems are widely interchangeable among themselves and they closely intertwine in separate regions and terminals according to the industrial activities and dislocation of transport services’ users. The totality of regional modal transport systems forms independent regional general transport systems of horizontal type, however, every region is made from separate transport nodes, e.g. industrial centre, town, a developed agrarian region. The totality of such transport nodes and transport relations between these nodes is so much connected, that they make specific local logistic transport systems, the destination elements of which are the users of transport services.

Second important aspect of classification of transport complex systems is time management. Considering the specifics of these systems it is possible to distinguish three main aspects of the management according to the time, which differ each from other qualitatively and essentially: 1) operative (dispatcher) management of these systems; 2) economic management during the financial year; 3) long-term development management. According to the world practice of the management of objectives the latter may be divided into a) management for 4−5 years term; b) management for 10−15 years term; c) forecasting of the development for a long term (20−25 years).

Thus, it is purposeful to group transport complex systems according to three indices: technological, territorial, identifying real systems, as the objects of management and according to the time aspect, i.e. according to the specifics of management objectives.

Classification of transport complex systems is also important according to their external and internal relations. The most complicated thing is the determination of transport external relations with the whole national economy. From the territorial aspect, these relations are hierarchical and they exist on the national level, as well as on the modal and local systems’ levels; quite differently these relations reveal themselves in the different time aspects. External economical relations of transport are defined in the following way: supply of transport by the means of transportation, fuels, materials, work power, infrastructure, yearly financing of activities and prices of transport services, as well as amounts of related
monetary accumulations in transport enterprises. Most often a certain part of these external relations limits the development of transport complex systems.

It is difficult to estimate the impact of transport external relations because of the fact that optimisation and estimation of their influence may be carried out only by complex optimisation of the general transport system and its functional elements (different transport modes). However, in the present situation such an objective can not be solved even in a diminished size because of many reasons. External relations of transport enterprises with the national economy are determined by approximate methods and vary in freely selected diapasons. A certain probability occurs that through the selection of qualitative meanings of these external relations, a risk occurs to encounter considerable errors, arising due to the optimisation of the development of transport complex systems.

5. Characteristics of transport complex systems

Principal characteristics of the transport complex systems, as those of other complex systems forming national economy proportions and technical progress of the development, are dual. From philosophical point of view it has to be stated that there exist objective laws of society, its productive forces and development of industrial relations. However, transport is a specific sector, ensuring national economy facilities and shaping the development of national economy. We may state that national economy and main complex transport systems are developing according to certain objective laws. Looking from these positions, the development of transport complex systems should be considered as one-sided, influenced by objective society and by the laws of the development of its productive forces. Revealing of such objective tendencies of the development of transport complex systems is an important task for science, directly connected with the theory of their management. However, such a one-sided development trend of complex transport systems is essentially effected by objective and subjective accidental events.

Thus the duality of the nature of the transport complex systems is expressed. They mostly are influenced by accidental events, as well as by certain decisions of planning and designing in the field of transport, undertaken because of erroneous information on the development trends of transport complex systems.

Determination of the specific characteristics of complex transport systems has two aims: 1) to define the totality of supplementary specific characteristics of these systems, allowing to single out objectively in the general management theory of complex systems the independent methods and scientific trend of the management of transport complex systems; 2) to define such specific characteristics of transport complex systems that are mostly important for the management or that are first to be investigated.

Complex structural relations of transport complex systems characterise the functioning of separate internal relations making these systems, as well as indicate their interaction with external systems. It is important that expediently directed management of development system may cause the changes of its structural characteristics in the most effective direction. Precise research of existing system’s structural characteristics and formation of hierarchic structure of effective (perspective) management system constitute an important task of their management theory and methods. For this relation it is necessary to separate two different formulations of the task: 1) research of already practically existing structural characteristics by dividing them into separate sub-systems, by creating rational management and describing by most precise mathematical models the processes going on in the system, as an operational management task of the system; 2) creation of a well-grounded perspective hierarchical structure of managed and managing systems and their comparison for these aims with the different variants of structures, as the most general objective of long-term system development management.

6. Certain scientific and methodical objectives of transport systems

In the research of theoretical systems in transport it is reasonable to attribute precise co-ordination of functioning of separate elements in the general hierarchy of management of complex transport systems, as well as of their social-economic functioning conditions peculiar to that period. Social-economic conditions may be defined as a totality of factors deciding upon the sectorial and productive structure of economics, upon the job and life conditions of inhabitants, upon the technical and economic opportunities of the source of raw materials, upon the supply of productive work resources, upon the public requirements for the quality of environment and comfort, etc.
Social-economic conditions undergo changes together with the development of public productive forces and scientific as well as technical progress. This development also strongly predetermines main characteristics of transport systems as well. It has to be underlined, that complex intermodal transport problems are not estimated aprioritatively, they are efficiently solved on the basis of fundamental systematic research. In our opinion there is neglected another important part of theoretical systematic transport research, related to the definition of principal functioning and development aims and to the co-ordination of general transport system and its components. Together with the changes in the social-economic conditions of the national economy development certain aims of functioning of transport systems may be also subject to changes.

The problem of co-ordination of the principal aims of transport development and functioning is not yet sufficiently analysed in various periods of time. Numerous ways of solving methodical and practical transport problems are related to the latter. As a methodical task here may be presented the selection of the aim functions by making various economic-mathematical models, and as a practical task it may be, for example, the selection of optimal unital freight capacity of separate transport means. In solving this problem not always uniform optimal strategic decisions are made concerning the development of transport means’ fleet.

No less important is the system of various principal aims, as well as the problem of co-ordination of their components in different periods of time. A collection of various elements and relations may be analysed as a system only in that case, when separate aims of their functioning are co-ordinated so that they create totality and community. Regrettfully, this clear statement is not always valuated, for example, in the practice of economic management of transport, when separate structural management organs are not following co-ordinated goals in their practical activities.

To the methodical research of transport systems belong the following investigations for improvement:
- for research methods and means of transport complex systems;
- for optimisation of criteria of transport system functioning and development in various hierarchic levels;
- for decision making methods of transport system functioning by different time intervals;
- for the methods of selection of optimal parameters of separate elements of transport complex systems.

Research directed towards the improvement of methods and means of investigation of transport complex systems is developing intensely at present in the West European countries and the countries of CIS. The result of the research – created a practically applicable great arsenal of management objectives for separate transport systems. Often suggested mathematical models do not meet their main purpose – the means for investigation of transport system and decision making in management. Regardless of a great number and variety of proposed models, they are of different character because they are designated for solving of separate local problems. At present, it becomes more and more clear that it is necessary to create mathematical model systems reflecting the management process of hierarchically formed general transport complex systems. Furthermore, the majority of mathematical models are very formalised, they insufficiently estimate physical and technological peculiarities of the modelled systems, as well as the active role of the man in the process of functioning of these systems. Majority of the proposed models allows the definition of only relatively optimal state of investigated system, but not the optimal process of its development and functioning.

Contemporary transport economy has a complex hierarchic structure, numerous internal and external interrelations. Seeking the scientific foundation of the management of transport systems it is necessary to create and use research methods adequate to the real nature of the transport economy. To our mind, mathematical methods of transport complex systems should be able to estimate the main relations existing in complex dynamic systems; as well as the behaviour of the modelled system in dynamics; to reflect its non-linear characteristics and partially – the indeterminate character of numerous parameters and influences.

Together with the hierarchy of functioning of aims and objectives of transport systems there has to exist the hierarchy of optimisation criteria – the system of interconnected different criteria of optimisation, that guarantees the attainment of global criterion of general transport system. The issues of the hierarchy and forms of transport systems’ management optimisation are not yet sufficiently investigated.

It is evident that it is necessary to create a system consisting of interconnected optimisation criteria. The system should reflect the objectives of optimal management in hierarchically formed
complex transport systems. Perhaps among them there will be multiple criterial systems corresponding a complicated nature of complex transport systems. It is important that all of them should be not subjective, that they should base on socially necessary work expenses. Their account form (direct and secondary) finally should be determined by the possibilities and convenience of accountancy. Whereas, the optimisation criteria used in the transport systems’ functioning and operational management stages should also be co-ordinated and interconnected. Lately, a certain gap between these criteria is noticeable. Difference is also noticeable between the theoretical research of transport complex systems and the solutions of specific practical problems, in their process of functioning. Serious research should also be carried out on functional issues guaranteeing realisation of solutions attained by optimisation calculations.

7. Methods of systematic analysis in research of transport systems

The field of transport research encompasses investigation of very complicated and dynamic relations. Complexity of the research arises from the need to analyse a great amount of interrelated connections in the transport system itself or in its sub-system, as well as of those between the transport system and social-economic environment. On the one hand, the demand for transport is determined by the lay out of economic and social objects in a certain space. On the other hand, the existence (or not existence) of transport services and transport costs influences the development of national economics.

Research of transport system may be carried out in two ways:

a) by the method of „consecutive approximations“, when after starting from several main principles, afterwards additional, more specific factors are gradually involved into the analysis;

b) by the method of empirical research, when after starting from solution of single transport problem, afterwards by the way of connections we pass to more general analysis (the principle „from below up to the essence“).

Practically both these methods supplement each other, and do not compete between themselves. In the case of the research of specific situations it is very important not to miss from sight and from the general context the instruments of the general transport analysis and to use them properly. Thus the specialised analysis has to enrich the general analysis, and the general analysis has to produce the accounting point itself, as well as to present the very direction for carrying out of specific work.

In general sense the aim of transport research is to analyse the functioning of transport system, the changes occurring in it and to prepare scientifically grounded instruments (technological among them as well), which would enable the correction of the system itself, so that it would correspond with the changing situation.

Complex researches of the transport system are very urgent for Lithuania, because our country, after reestablishment of Independence, undergoes essential reorganisation of the whole economy. During a short period of time Lithuania had to form its general national policy, as well as to prepare reconstruction and development programmes for different transport modes. In the course of preparation of these programmes it was not always possible to base on the results of scientific research simply because of the reason that certain new problems occurred in our way (for example, to form the Lithuanian transport policy under the conditions of integration into the European transport services market). Some other new problems only now have been started to solve in the international dimension as well (for example, restructurisation of railways, development of multimodal transport technologies). That is why it is very important to inactivate the national scientific research in these directions and to involve Lithuanian scientists into the international co-operation in the field of transport research.

Lithuanian transport system at present consists of several transport modes. Further we will analyse more specifically the road, railway and water transport modes. And even more specifically – their freight transportation. Freight transportation by air will be not analysed only because of the reason that this type of transportation makes 0.8% of the general amount of freight turnover. Besides, transportation by road, railway and water transport under Lithuanian conditions may be connected by the common multimodal technologic schemes.

Further, for simplicity sake, we shall call our research object the freight transport system.

The aim of development and improvement of freight transport system is – to create a general national freight transport system, guaranteeing demands for „qualitative“ national transport service in this field.

One of the main directions of solution of this objective is the planning of specific transport modes and the technological management in their common interaction.

In the research of freight transport system it is considered that:
1) transport system is a complex developing object, which may be investigated only by the methods of systematic analysis;
2) management of the system – it is formation process of effective functioning (in the respect of a determined criterion) of the system. Main objective of transport system and management of freight flows is the formation of its characteristics, which guarantees necessary quality of servicing freight flows with the least expenses.

Since there is no universal transport system and freight flows functioning criterion, certain difficulties arise in selection of system’s parameters occurring during its functioning. Usually the occurring parameters should present the transport system’s operation characteristics, determining the quality of transport system’s functioning and freight flows servicing. In the course of selection of transport systems and, specifically, the management methods of rational development of national freight transportation and the principal technological schemes, we shall use the operation research theory and other mathematical methods.

Let us presume that for investigation of national freight transport system we have:
U = \{U_i, i = 1, N\} – a set of methods for solving national freight transport system development issues;
S = \{S_j, i = 1, N\} – a set of expenditure corresponding to the set U;
δ = \{δ_i, i = 1, N\} – a set of objectiveness indicators by employing the methods of the set U for the research and development of the national freight transport system;
R = \{R_j, j = 1, M\} – maximum quantities of sources that may be involved by the country for the development of freight transport system.

The objective of management of national freight transport system should be formulated as follows:
from the set \(U = \{U_i, i = 1, N\}\) to find a sub-set \(\Delta u \in U\), characterised by sub-sets \(\Delta \sigma \in \delta\) and \(\Delta s \in S\), by minimising the functional:

\[ C = f_1(\Delta U, \Delta \delta), \]  \hspace{1cm} (1)

regarding the limitation:

\[ R \geq f_2(\Delta u, \Delta s). \]  \hspace{1cm} (2)

For selection of the objectives of national freight transport system development and the methods of solution of these objectives it is necessary to make the purpose function (1), to define the set of development management objectives and the set of their solution methods \(U_0\), constantly analysing the functioning of national freight transport system and freight flows. In the aspect of theory of systems the national freight transport system is also a complex system with all characteristic features of such systems, and this determines the application of systematic analysis and operation research methods in the investigation of national freight transport system.

The structure of national freight transport system consists of a set of system elements and of their relations. This system has the following principle characteristics:
- freight flows (demands for transportation, their spatial distribution and that according to the time);
- transport network and the fleet of units of different transport modes;
- traffic plans of the units of different transport modes (their distribution in the transport network, traffic timetables).

In the course of research of the transport system's functioning problems, of the development programme preparation, of the decision-making – the below scheme of systematic analysis has been followed:
- elucidation of a problem, formulation and structurisation;
- investigation of the specifics of the subject, investigation of its internal and external relations in the aspects of time, space, structure, etc;
- formulation of the purposes of the problem solution, definition of criteria, their hierarchic relations, possibility to group and estimate qualitatively;
- definition of alternative ways and main limitations for achievement of aims.
- collection of initial, assessment of truthfulness and completeness of information, possibility to supplement information and to enhance precision.
1. **Estimation the peculiarities of complexity of transport system.** General transport system and its sub-systems are made of a great number of interrelated elements, and the number of the types of these elements is also big enough. The interaction of different transport modes, disregarding their interests and aims, determines the occurrence of systemic effects. Systemic effect will be called the effect, which can not be singled out from characteristics of separate transport means, but can be defined only through their interaction. In the analysis of transport complex system the assessment of systemic effects is very important because of the fact that on the basis of orientation to the local benefits of separate transport means – disadvantageous for the whole general system decisions are made. Therefore, there is necessary a certain mechanism for harmonisation of interests, the harmonisation of its parameters should guarantee the usefulness for all the actors of the transport system. With existence of such effects it is obvious that the effect of the whole system does not correspond with a sum of its separate elements. In this case a so-called complex systems’ integrity effect is directly revealed. An example of such effect may be the concentration and specialisation of transport process.

2. **Estimation of the hierarchic structure of national transport system.** Versatility and systemic co-ordination aspects of hierarchic structures’ peculiarities have to be born in mind. The requirements of hierarchic co-ordination do not present just an equivalent conformity of transport system’s indices on various hierarchic levels (those of time, space, etc.). On the contrary, it is considered that on various hierarchic levels, the aggregation extent of the system’s main characteristics would be different. These are indices used in planning and development of transport system, in designing and assessment of the efficient means of transport system. Some characteristics may coincide on certain hierarchic levels. For example: on all levels used indices of freight and passenger turnover, of transport amounts, etc.

3. **Estimation of peculiarities of transport system elements as well as of formalisation and management in all hierarchic levels of transport system elements.** It is very important to take into account the fact that in the transport system the man participates as a provider, a consumer and a management object of transport services, that is why not all the processes of the transport system may be subject to formalisation.

4. **Analysis of the after-effects of the decisions made.** The after-effects of decisions should be analysed not only in the technological mechanism of interacting transport means, but also in the fields of transport services’ consumers, ecology, policy, etc. It is necessary to control that the decisions made in transport system would allow the functioning indices of other economic sectors to stay within the permissible limits and would not diverge from their state.

5. **The estimation of transport system may be carried out in two aspects:** 1) as that of a relatively separate complex dynamic system, which is developing according to the laws peculiar to such systems, and 2) as an inseparable part of Lithuanian economy, an infrastructure sub-system facilitating it, preconditioning by its functioning and development the growth of other economic sectors.

6. **Employment of advanced computer opportunities.** Modern computers enable a sufficiently efficient organisation of the dialogue between an expert and modelling, calculation of numerous variants with changes of initial information, solution making according to expert’s conclusions or making corrections. At the same time the expert’s participation in the dialogue (as of a subjective actor) does not diminish the significance of involved economic-mathematical models. Besides, a qualified expert may define efficient directions of changing the parameters and structures of complex transport system, the control of expediency of changes, finding weak points and formulation of substantiated suggestions for their rational elimination. Thus may be achieved the synthesis of „subjective“ and „objective“ expert’s knowledge and intuition, his „art of engineering“ and formal methods of analysis.

Methods of systemic analysis give an opportunity to define the strategy and technical policy of transport system development in this sector of economy, to select trends of more effective transport
technologies, to define the main parameters and characteristics of transport development: the rates of growth of transport capacity, the level of transport system reserve, etc.

8. Conclusion

- For the estimation of the work of transport system, the estimation of transport process has to be done. The essential feature of the transportation process is its duality. The duality is included in the cycle of the transportation process: 1) the turnover of transport means; 2) the freight delivery time. In the first case the transport process undergoes estimation from the positions of a transport enterprise – a more efficient use of transport possibilities, operational work. In the second case the transport process is estimated from the positions of freight owner, and here first of all it is focused on the commercial operation, economic and juridical problems. The dual nature of the transport process requires versatility of its estimation. Here we have to do with two different time categories, having their own peculiar organisational, technological, operational and economic problems. However, these peculiarities are inseparable from each other and they are closely interrelated.

- Transport management and substantiated national transport system development, based on the principles of complex systems management theory, may reveal numerous qualitatively new ideas, which would essentially enable the enhancement of transport efficiency and realisation of big, still unused, its economic and technological progress reserves. The objective of complex transport systems management may be formulated as a planned and sustainable development – from the long-term forecasting to the operative management inclusively.

- In our opinion, the theory of transport complex systems management includes four main and interrelated research trends:
  - classification of transport complex systems determining their composition, external and internal relations, management objectives and structure, external and internal management objectives in various time aspects;
  - research of common and different features of various transport modes;
  - methodological foundation by accumulation of necessary and trustworthy information, including statistical, for management of transport systems, creation of means for transfer, processing and using of this information;
  - scientific foundation of creation of transport complex systems management means and methods; creation of generalised effective management methods for such systems, where it is necessary to co-ordinate optimally various management means and methods or in other territorial and time aspects. The complex of the research should serve the basis for essential improvement of transport operation, designing, planning and forecasting.

- For the comparison of different national transport systems, assessment of Lithuanian transport system, specification of the weak points of the transport system, the definition of necessary for transport development investment priorities, etc., it is necessary to characterise the state of the transport system by using the adequately formed totality of indices. It has to be based by the principles of systemic analysis, whereas the indices have to estimate the role of transport and its specific character.

- In the nearest future there should be created possible assessment methods of transport system’s internal (development and application levels) and external (the levels of balance and supply) characteristics.

References


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