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Effectometrics of Transport Technological System

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Abstract

With the modern development of science and technology, there is a need to create new assessment approaches in regard to both the various newly developed, as well as existing technical facilities and technologies of transport systems. Many of the natural and human resources required for manufacturing and operation of technical facilities already suffer significant global limitation. Therefore, the predominant role within the technical development of the human community belongs not to facilities, but to technologies. It causes the need to develop new assessment methods in concern of the various process efficiencies, especially within transport and technological systems. At the same time, we should mention that one of the key constraints on the effective development of science and technology is a generally accepted assessment on the basis of economic concept "econometrics". It is especially true for new technical facilities and technologies. The modern development of social relations on the basis of science and technology intensive development requires the consideration of both economic and other efficiencies. For example: social, environmental, technological, and many others. Therefore, it is necessary under the modern approach to tactical and technical data, to search for identification methods in regard to the key efficiencies and assessment methods in relation to them. In our opinion, it is possible within assessment of various efficiencies on the basis of the increasingly developing multi-criteria assessment within the scientific and practical approaches. Such method allows you to find and apply new approaches and criteria in the long-term development of equipment and technologies. We determine as "effectometrics" - one of the possible approaches (methods) for the effectiveness assessment of the facilities development and technologies which can facilitate this within the existing transport processes.

Keywords: effectometrics, efficiency, multicriteriality, transport, technology, equipment, processes, indicators.

1. INTRODUCTION

The efficiency of modern manufacturing enterprise is a complex multisided concept [1, p. 36-37].

Economic efficiency plays dominant role and refers to indication of certain economic freedom, but it has unfairly overshadowed other types of efficiency. In economic studies, there is very little attention to other types of efficiency [2, p. 2].

Therefore, it is necessary to use new efficiency assessment methods.

It is especially important within the assessment of various work efficiencies, both for complex process technical systems as a whole, and for the technologies and technical facilities that constitute such systems. Such approach has a paramount importance for *transport and technological systems* (TTS).

There is a need to develop detailed methodological tools to examine the effectiveness of investment projects and solutions for the creation of new equipment, technologies and management systems [3, p.303].

There is idea to use the method of effectometrics with the participation of the decision-maker (DMR) on the basis of expert assessment and multi-criteria approach. We determine the general efficiency as conditional efficiency.

We consider the concept of effectometrics from disaggregation frame of reference, i.e., unbundling of the system in order to study its elements, and synergy, i.e., an additional effect output that occurs in each system when its elements interact.

In a market economy a necessary condition for the effective functioning of the TTS is a compromise between the interests of all participants within the production process: owners, managers, production workers, as well as manufacturers, transport and consumers. All of them have interest in the effective operation of the enterprise.

We distinguish the following types of efficiencies in accordance with the business goals [4, p. 1]:

- by the degree of business significance the types of efficiency include strategic and tactical types;

- by relation to the external environment the types of efficiency include external and internal types;

- by the content, there are: technological, economic, industrial, scientific and technical, environmental and social types;

- by social characteristics, there are company-wide, intra-company, group and individual types; type of organizational structure and management mechanism;

- by the relation to the object and subject of management, there are: functional, production and management types.

The assessment mechanism of complex technical systems currently has insufficient development and lacks formalization, so there is no good consideration of the multiplicative influence of multiple criteria on the data of various system efficiencies, their synergistic nature, as well as types development of various effects, such as social, environmental, functional, and many others.

The author and end user of all technical facilities is a person. Therefore, all new technologies refer to a human.

It is obvious that there is necessity in appropriate information and innovation resources in order to evaluate various efficiencies, especially within large process technical system. They should include a database and a knowledge base with grounds on an expert basis and organization within the form of a local computer network with modern computer technologies structure [1, p. 135-157].

At the same time, on the one hand, data on the development topology of transport and technological systems and their indicators are necessary, and, on the other hand, it refers to the relevant norms, requirements of project documentation, etc.

The presence of a significant unused potential of transport and technological systems conditions on a detailed assessment of their performance on a multi-criteria basis. It has aim to increase the TTS efficiencies in the current conditions of their development. One of the most problematic issues of the transport and technological system is the lack of revision in regard to its development directions [5].

Fig. 1, as an example, shows a graphtopological semantic scheme of the transport and technological system (TTS) for cargo transportation through a seaport.

The system reflects the possibilities and usage efficiency of various transport types, including main and industrial. At the same time, a reverse transport option is possible.

The diagram illustrates the processes and objects of the transport and technological system in the dynamics of cargo movement from the manufacturer to the consumer. Each item or process of such a system requires certain costs to ensure its operation from the total cost of goods paid by the consumer. There is distribution of the paid amount in shares to the task performers (services) according to the established criteria (weights) of efficiency, and we determine the entire paid amount as to be equal to one (100%).

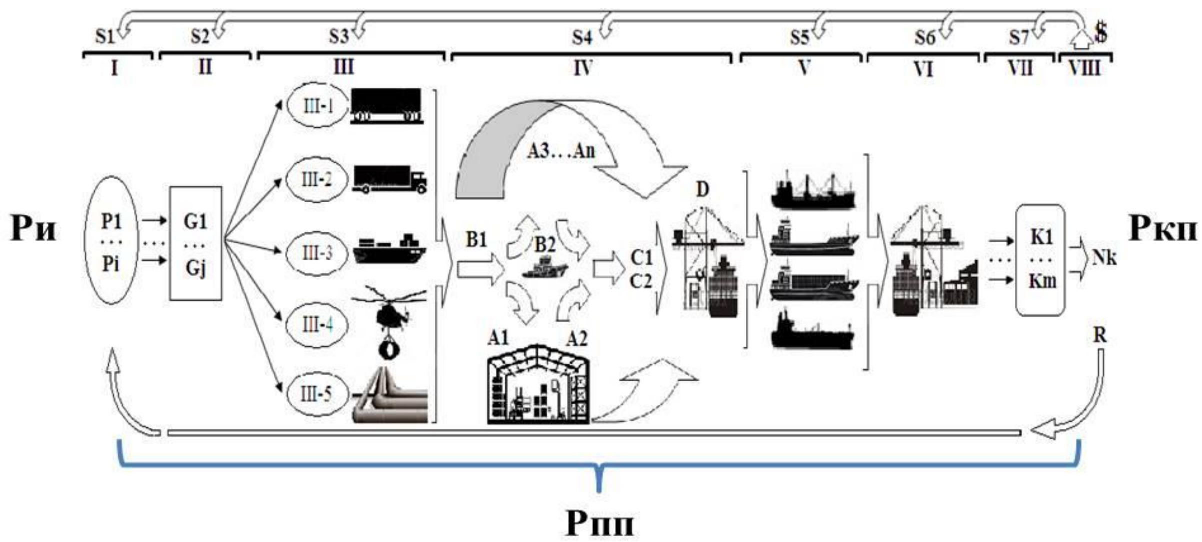

Fig. 1. Graphotopological semantic scheme of the transport and technological system of cargo transportation from the manufacturer to the consumer through the seaport

Pi (Pu) – producer; Pic (Pnn) – intermediate consumers; Pfc (Pкп) – final consumer; $ – cost (price) of cargo (goods) and services paid by the consumer; S1-S7 – payment for stages of cargo flows in the system (SMMA $ shares); I – main producer; (P1... Pi) – auxiliary producers; II – shippers (G1... Gj); III – external transport (III-1 – railway, III-2 – automobile, III-3 – water, III-4 – air, *III-5 – fixed); IV – intra-port transport and technological system of the port of unloading, storage, loading (A1-transshipment through the warehouse; A2 – transport and technological warehouse operations; A3 ... an – transshipment by direct option; B1, B2-land and water industrial transport of the port; C1, C2 – transshipment operations with cyclic and continuous devices; d – cargo operations on a ship in the port; V – maritime transportation; VI – port of discharge; VII – consignees (K1... km); VIII – consumers (NK), (potential manufacturers); R – Version of the system reversibility.*

The scheme (Fig.1) includes transport and technological processes: delivery of goods to the port from manufacturer (shippers) by external main transport, unloading and warehousing of goods within the port territory, their reloading to the intra-port transport, delivery to the waterfront, loading on ships, the process of transporting goods by sea from the manufacturer to the consumer, as well as other auxiliary transport and technological processes.

Under the current situation, each of the participants within the process-based industry, such as transport, has interest in getting as much money as possible from the total amount of investment allocated by the end user.

Therefore, all participants within the transport process have interest in maximum profits from the total investment of the end user with the financial interest alignment of other process participants.

It, of course, affects the result of the required efficiency, both for the entire process and its separate elements, and causes the need to introduce the concept of "effectometrics" to scientific society.

The effectometrics will help to comprehensively display the criteria for various efficiencies justification, management decisions, and the capacity to monitor and evaluate them within a multi-criteria basis.

In regard to studies of the patterns and features of the effectometrics development in technical systems, we should pay special attention to the interests of both goods manufacturers and service sector, especially with concern to the processes of cargo and passenger transportation.

In connection with the modern development of technology, methodological approaches change in relation to the efficiency assessment in process technical systems.

The transport and technological systems of many countries have demonstrated different dynamics of transportation load in recent years, which requires an individual approach to the various efficiencies assessment in regard to each element for each type of transport.

The competitive map of the world market [6, p. 92-93] stands as evidence, which demonstrates significant deregulation of logistics cargo flows.

The proposed method of assessment bases on the formation of the system data array on the basis the determined indicators of economic, environmental, social, functional and other types of efficiency. At the same time, there is a choice in relation to evaluation criteria for TTS efficiency indicators and the establishment of the significance (weight) of items and logistics flows that constitute the system. It is important for work assessment and the rational determination of the transport directions development and technological system under study.

The technology development has already reached such level of evolution that it is no longer effective to create new types of technology, but the studies in the field of technology pattern development is in high demand [7, 8].

We should pay special attention to the development of new technologies, to study those phenomena and processes that are new for humanity. For example, the unidentified flying objects (UFOs) use the unknown to mankind types of technologies and energies, overcome the gravity and resistance force within the modern physics framework by means of technological advantages.

Within the applied studies on the technical systems efficiency, there are two problems under settlement: the efficiency operation assessment with use of technical system and choice of rational approach (strategy) in regard to technical means (systems) in the operation.

In engineering the problem of efficiency has close connection with the problem of technical means reliability; the increasing complexity of technical systems leads to a decrease in their reliability and decrease their effectiveness [9, p. 30].

The experimental approach to the study of the efficiency in large-scale technical systems has limitations.

Thus, the problem study of TTS rationalization with a set of criteria is in the form of [10, p. 128]:

$$Max\ U\ [f_1(x), f_2(x), \dots , f_r(x)]\ with\ x \in X, \qquad (1)$$

when $f_1(x), f_2(x), \dots , f_r(x)$ – are the values of the corresponding criteria (on the solution vector x);

X – is a limited set of valid solutions;

U – General (global) preference function – value function defined on the set of criteria values.

Fig. 2 graphically depicts the main elements of the efficiency multi-criteria assessment of transport and technological systems: processes and technologies, types of efficiencies, indicators and their assessment criteria.

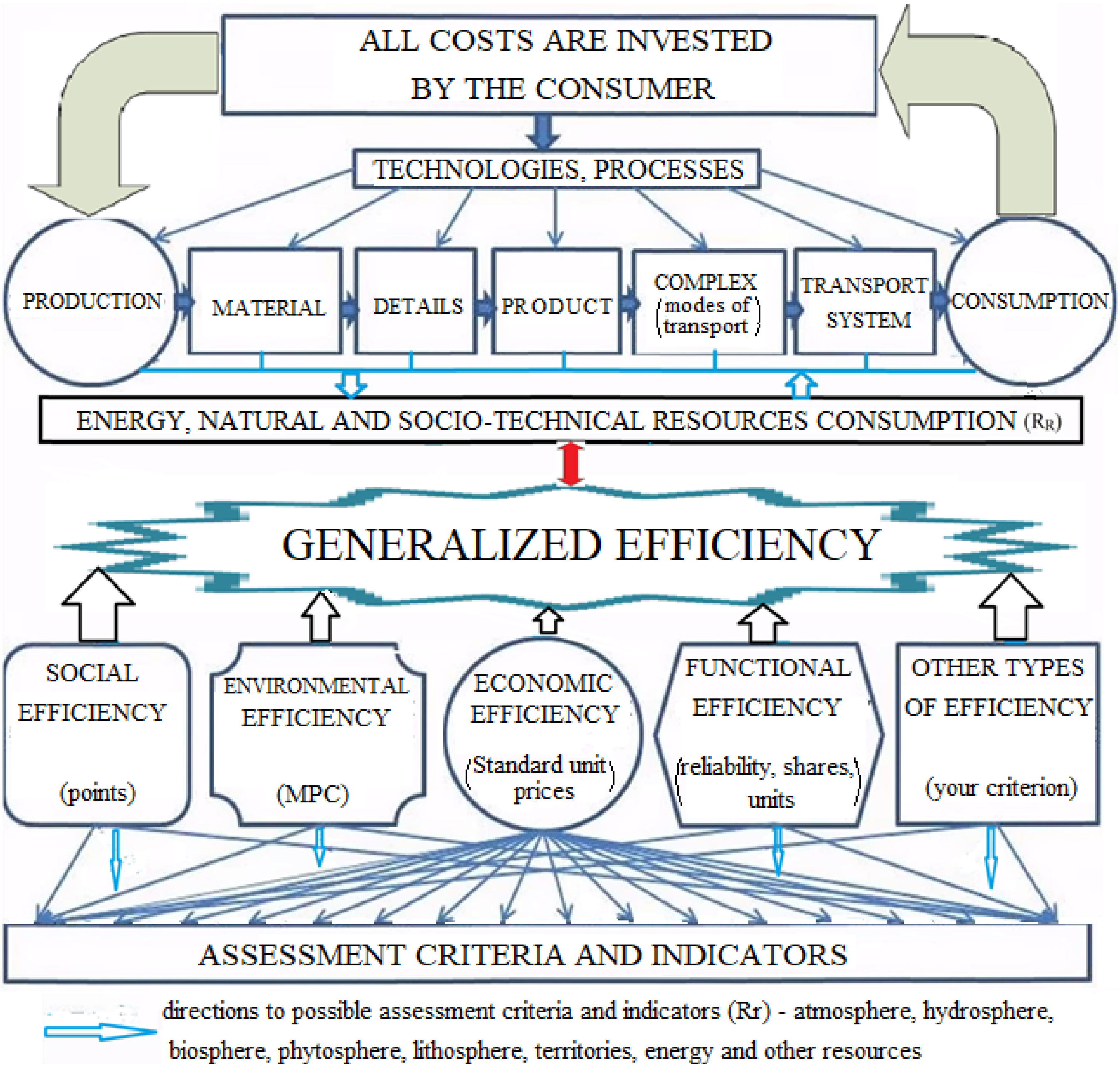

Fig. 2. The main elements of efficiency multi-criteria evaluation within diacoptics of transport and technological systems

The creation of any new kind of efficiency in relation to equipment or technology has a costly character.

The increase in system costs has two main directions: safety and performance of work and has a presentation as the sequential costs development flowchart within the system in function of the planned safety and efficiency measures of its work (Fig.3).

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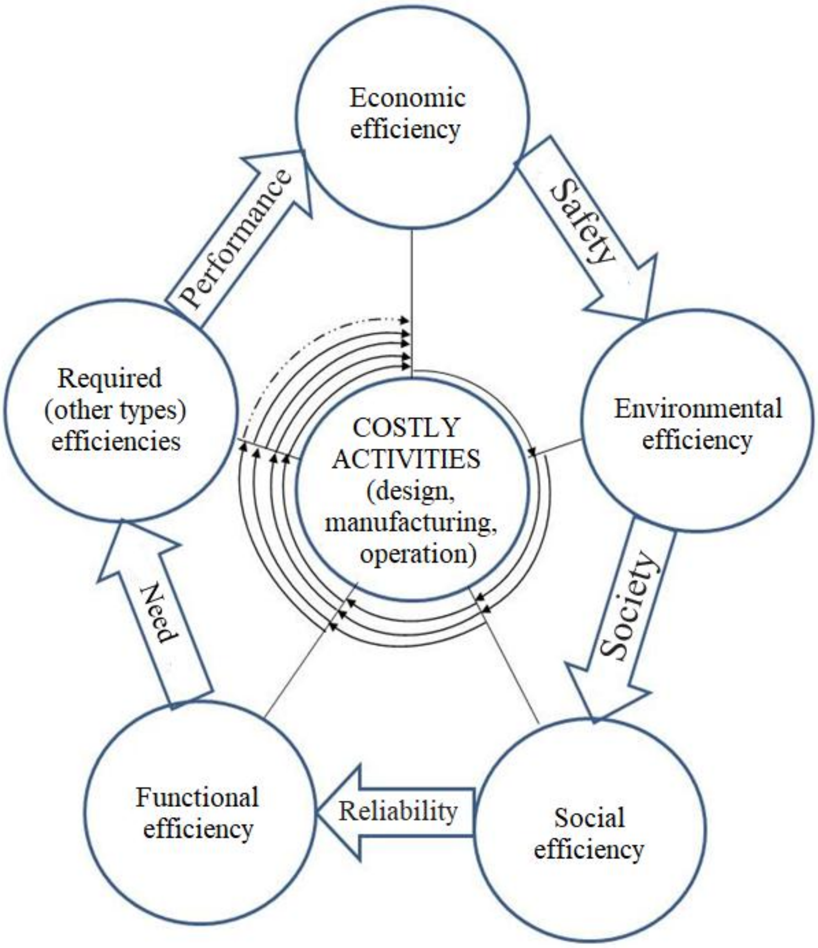

Fig. 3. The development structure of efficiencies and their corresponding costs in the transport and technological process system

2. OBJECT AND SUBJECT OF THE RESEARCH

The object of research - process-based transport and technical systems

The subject of the research is a assessment approach on a multi-criteria basis of the various efficiencies in relation to separate elements and the entire process-based transport and technological system on the example of sea port TTS.

3. THE PURPOSE AND OBJECTIVES OF THE RESEARCH

The purpose of the research is to present one of the possible assessment approaches with effectometrics in transport and technological systems on a multi-criteria basis.

To achieve this goal it is necessary to examine the following tasks:

1. Determine the necessary efficiency indicators and evaluation criteria.
2. Expertly establish the significance of each specific criterion within the overall system efficiency.
3. Construct a semantic model for effectometrics of the system.

4. RESEARCH OF THE EXISTING PROBLEM SOLUTIONS

Within the analysis of sources [4, 10, 11, 12, 13] we should note that currently, in addition to economic efficiency, there is a considerable attention to such types of efficiency as: environmental, social, scientific and technical, functional (reliability), technological, organizational, managerial, and many others.

There are appropriate developed methods for their assessment mainly on economic basis.

The well-known methods of assessment and monitoring within the efficiency issue of complex process-based systems include the efficiency assessment approach in relation to the development process of military equipment objects with respect to real data that characterizes the properties of heterogeneous items of the process-based system, as well as the system itself [14, p.2].

The method [14, p. 3-8], which also has mainly economic basis, does not consider other types of items efficiency that constitutes the system and its overall performance. It has a significant complexity within motivated decisions development in regard to the efficiency assessment of the system's facilities and technologies, which does not allow to chose their rational composition inside the system, and also complicates the priority directions identification for their design and the long-term system development as a whole and its constituent items.

In [15, p. 5-7], there is description in concern to the efficiency assessment approach of the training system process by the quantity calculation of standard knowledge unit. The drawbacks of this approach include the complex combinatorial problem in relation to fixation and variation of constraints multitude, sometimes not fully defined, and their assessments.

The approach [16] expands the systems functional capabilities on economic basis as well as artificial intelligence, seamless interaction of items with the external environment, and the development of new behavioral forms within the process-based system. The disadvantage of this approach is that there is no recognition of other efficiencies' types.

In the patent [17, p. 2], the basis of the approach as in the patent [15], mainly within descriptive, informational, adaptive and cognitive models of processes and items that have informative character and some degree of uncertainty.

A. N. Efanov and N. K. Rumyantsev [18, p. 155-156] indicate that in case of transport efficiency assessment, it is necessary to consider both economic, environmental and social aspects.

The paper [19, p. 2-5] suggests to use the approaches for efficiencies' determination within investment activities regulation in the development process of target programs, as well as in the examination of investment projects. This is also possible by: justification of investment; implementation tools of investment and innovation policies; determination of reasonable terms in effective operation of fixed assets, as well as when price justification of items and calculation of positive value for money.

The closest approach to the proposed method is [10, p. 126-141], the approach which rationalizes the processes and items of the system, as well as the system itself. At the same time, the assessment works within a certain set of heterogeneous criteria by the method of human-machine procedures, in relation to the actual system. The approach refers to the process-based space formation in concern of assessment criteria, and there is the establishment of criteria' ratio to their weight and significance. However, such approach has significant implementation difficulties and does not provide a multi-faceted assessment taking into account economic, social, environmental, functional, and other efficiencies.

5. RESEARCH METHODS

The main method of research in this work bases on synthesis - as a method of scientific research in regard to the object, which refers to the study of the object as a whole within the unity and mutual connection of its components. It helps to implement a methodological approach to structure and research the transport and technological system on the basis of processes that create a certain efficiency.

We determine such approach as "process-based synthesis". The principles of diacoptics (dismemberment as a systematic method) constitute theoretical basis of the TTS decomposition. These principles refer to system's graphotopological portrait, its decomposition into parts, equation or matrix system descriptions [20, p.53-54].

In addition, in order to solve the set tasks the research uses methods of:

- deduction – within the bibliography analysis in order to establish the main directions for problems solving to ensure the choice on a multi-criteria basis in regard to work efficiencies and implementation of process-based actions of separate items that constitute the transport and technological system and the system itself as a whole;
- system analysis - for the types formation of efficiencies and their assessment criteria;
- mathematical analysis to find solutions for necessary analytical dependencies;
- probability calculus and statistics for characteristics description of random vector assessments and the probability assessment estimation on a multi-criteria basis in relation to performance efficiencies of the objects that constitute TTS and it as a whole.

A simulation model is to determine the optimal amount of equipment [21].

The system multi-criteria analysis bases on such criteria as: cost, time, space, temperature, information, energy, labor and natural resources costs, reliability, innovation, quality, environmental pollution, legal aspect, unification, aesthetics, and others [11, p.77].

6. RESULTS

The price management of the products (services) forms on the basis of a compromise (contract) with consideration to the competence of separate expert or group of experts under the role definition as the decision maker (DM) and with concern to the value of producer and consumer, and the value of the transport component. The transport component is a value that varies within the price range of goods from 10-20%, for raw materials - up to 40% [22].

We determine the product price as a unit for further value calculations (weight) in unit shares within the scope of the efficiencies under study and their criteria.

Whereby, the total of all the value shares apart: we determine the resulting efficiency, all types of efficiency and their assessment criteria, as equal within the unit.

As an auxiliary tool for the estimation of weight (value) of efficiencies and their criteria within a unit, the DMR can use arithmetic or geometric progressions, as well as the sum of tangents values for angles up to 45 degrees (within 1) and other tools of elementary mathematics.

Table 1 contains the basic DMR range of elements for the TTS under study.

Thus, each object and process have a certain rank of importance within the performed functions, which should be under assessment and consideration by value, the need for their availability and sufficient security in the decomposed transport and technological system [11, p. 33].

After this we form the list of (rational) efficiencies and their external and internal factors with assessment criteria list and their measurement together with cross-reference to the relevant types of efficiencies (see Fig. 2).

We form the list in such a way that each of the system interacting parts components bases on assessment criteria, several in total, by two or more efficiencies, for example: economic, social, environmental, functional, or other types.

There is an assessment structure formation on a multi-criteria basis within the process-based system stages, for this purpose, they distribute by types of efficiency R_e, by grouped logistics flows R_j. The DMR sets the value (weight) of their criteria within the range in concern with the value of each.

Vertically, by efficiency and logistics flows for each horizontally located stage of the process-based system, the criterion value range as a decimal quantity has in a general form, so that for the stages of the system R_i, efficiency R_e and logistics flows R_j, they sum a unit, so, $\Sigma R_i = 1.0$; $\Sigma R_e = 1.0$; $\Sigma R_j = 1.0$ (table 1).

Table 1. Range of traffic flows and transport system elements

Logistics flows and their assessment criteria											Cargo price distribution by stages of transportation								
The numbers of transportation flows	Types of efficiency	Indicators of logistics	Logistics flows	Assessment criteria	Indicators of activities			Criteria indicator	Value of the criterion, as a decimal quantity		I	II	III	IV (A, B, C, D)	V	VI	VII	VIII	Amounts
					мин	норм	макс		Efficiencies	Logistics flows	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	
											0.700	0.013	0.011	0.116	0.008	0.137	0.013	0.002	$\Sigma R_i = 1$
1	Economic	Quantity	Material	t, pcs., m^3	5 million	12 million	17,5 million	R_{01}	0.70	0.350	R_{101}	R_{201}	R_{301}	R_{401}	R_{501}	R_{601}	R_{701}	R_{801}	$\Sigma = R_{01}$
2		Necessity	Territorial	m^2, km^2	0.76	0.78	0.78	R_{02}		0.175	R_{102}	R_{202}	R_{302}	R_{402}	R_{502}	R_{602}	R_{702}	R_{802}	$\Sigma = R_{02}$
3		Energy consumption	Energetic	Kw	18,1 million	20 million	25,9 million	R_{03}		0.087	R_{103}	R_{203}	R_{303}	R_{403}	R_{503}	R_{605}	R_{705}	R_{805}	$\Sigma = R_{03}$
4		Economic expenditures	Financial	Unit prices	109,2 million	450 million	516 million	R_{04}		0.044	R_{104}	R_{204}	R_{304}	R_{404}	R_{504}	R_{604}	R_{704}	R_{804}	$\Sigma = R_{04}$
5		Costly characteristic	Investment	Standard unit prices	106 thousand	180 thousand	218 thousand	R_{05}		0.022	R_{105}	R_{205}	R_{305}	R_{405}	R_{505}	R_{605}	R_{705}	R_{805}	$\Sigma = R_{05}$
6		Terms	Time	t / s day	2,0 thousand	4,0 thousand	6,0 thousand	R_{06}		0.022	R_{106}	R_{206}	R_{306}	R_{406}	R_{506}	R_{606}	R_{706}	R_{806}	$\Sigma = R_{06}$
7	Social	Need	Labour force	pers. / hour	3476	3600	4344	R_{07}	0.17	0.085	R_{107}	R_{207}	R_{307}	R_{407}	R_{507}	R_{607}	R_{707}	R_{807}	$\Sigma = R_{07}$
8		Established standards	Legal	Points	0.8	0.9	0.97	R_{08}		0.042	R_{108}	R_{208}	R_{308}	R_{408}	R_{508}	R_{608}	R_{708}	R_{808}	$\Sigma = R_{08}$
9		Wealth	Infrastructure	Unit C / t	0.02	0.015	0.013	R_{09}		0.021	R_{109}	R_{209}	R_{309}	R_{409}	R_{509}	R_{609}	R_{709}	R_{809}	$\Sigma = R_{09}$
10		Satisfaction	Social	points	65	80	87	R_{10}		0.011	R_{110}	R_{210}	R_{310}	R_{410}	R_{510}	R_{610}	R_{710}	R_{810}	$\Sigma = R_{10}$
11		Expediency	Customs	Hour / t	0.3	0.75	4.0	R_{11}		0.011	R_{111}	R_{211}	R_{311}	R_{411}	R_{511}	R_{611}	R_{711}	R_{811}	$\Sigma = R_{11}$
12	Functional	Number. values	Reliable	%	8 million	12 million	21,9 million	R_{12}	0.09	0.045	R_{112}	R_{212}	R_{312}	R_{412}	R_{512}	R_{612}	R_{712}	R_{812}	$\Sigma = R_{12}$
13		Novelty	Innovative	Points, %	2.0	5.0	8.0	R_{13}		0.023	R_{113}	R_{213}	R_{313}	R_{413}	R_{513}	R_{613}	R_{713}	R_{813}	$\Sigma = R_{13}$
14		Category	Qualitative	unit of calculation	250 thousand	250 thousand	281 thousand	R_{14}		0.011	R_{114}	R_{214}	R_{314}	R_{414}	R_{514}	R_{614}	R_{714}	R_{814}	$\Sigma = R_{14}$
15		Utility	Controlling	Profit indicator,%	0÷20	20	>50	R_{15}		0.006	R_{115}	R_{215}	R_{315}	R_{415}	R_{515}	R_{615}	R_{715}	R_{815}	$\Sigma = R_{15}$
16		Relevance	Informational	Unit fraction	50	75	90	R_{16}		0.003	R_{116}	R_{216}	R_{316}	R_{416}	R_{516}	R_{616}	R_{716}	R_{816}	$\Sigma = R_{16}$
17		Security	Navigational	Unit fraction	24	20	50	R_{17}		0.002	R_{117}	R_{217}	R_{317}	R_{417}	R_{517}	R_{617}	R_{717}	R_{817}	$\Sigma = R_{17}$
18	Environmental	Hazard	Environmental impact	Ambient air standard	0	>1.0	>1.0	R_{18}	0.04	0.020	R_{118}	R_{218}	R_{318}	R_{418}	R_{518}	R_{618}	R_{718}	R_{818}	$\Sigma = R_{18}$
19		Required amount	Natural resources	Service unit c / t	0.8	0.9	0.97	R_{19}		0.010	R_{119}	R_{219}	R_{319}	R_{419}	R_{519}	R_{619}	R_{719}	R_{819}	$\Sigma = R_{19}$
20		Capacity	Warehouse	m^2	5	20	23	R_{20}		0.005	R_{120}	R_{220}	R_{320}	R_{420}	R_{520}	R_{620}	R_{720}	R_{820}	$\Sigma = R_{20}$
21		Sufficiency	Others	Concr. pok	0.25	0.66	1.00	R_{21}		0.003	R_{121}	R_{221}	R_{321}	R_{421}	R_{521}	R_{621}	R_{721}	R_{821}	$\Sigma = R_{21}$
22		Fault	Meteorological	%	0.6	0.75	1.0	R_{22}		0.002	R_{122}	R_{222}	R_{322}	R_{422}	R_{522}	R_{622}	R_{722}	R_{822}	$\Sigma = R_{22}$
Amounts									$\Sigma R_e = 1$	$\Sigma R_j = 1$	$\Sigma = R_1$	$\Sigma = R_2$	$\Sigma = R_3$	$\Sigma = R_4$	$\Sigma = R_5$	$\Sigma = R_6$	$\Sigma = R_7$	$\Sigma = R_8$	

By the stages value in horizontal direction and the value of logistics flows in vertical direction, we determine the values of the logistics flow element at this stage by multiplication of the flow values and the stage value. So, for example, we will determine the value of the criterion at the IV stage of the cargo transportation process under consideration of the economic efficiency within the form of financial logistics flow, which we can define as the product of:

$$R_{403}=R_4 \cdot R_{03} \quad (2)$$

Then we provide the cost estimate for each element by the product of the criterion value with the cargo price.

We define the assessment indicators and their criteria for each performance group with reference to the indicators units of measurement.

The usage of the proposed assessment method in regard to the performance of objects and technologies within the process-based systems on a multi-criteria basis makes it possible to distribute resources and costs within the structure, make adjustments to the system under study in the direction of resource redistribution, technology changes, modernization, improvement, etc.

The producer and consumer of goods strive for the highest efficiency with maximization of their benefits and minimization of their costs [23].

One of conditions for using the proposed assessment methods for various types of efficiency (effectometrics) with the participation of DMR is to observe a certain stability of the technological process.

Whereby, there is no impact on the overall stability of the technological process by possible changes in the work of separate actors related to the distribution of economic resources and development of new efficiencies.

We consider such assessments from the synergy effect frame of reference within the disaggregation (i.e., unbundling) of technical systems. They contribute to technological progress and the discovery of new resources (for example, information and communication) that we need to effectively solve the problems under consideration.

The effectometrics allows to complement and extend such studies.

7. ANALYSIS OF RESEARCH RESULTS

The paper demonstrates the effectometrics application in order to evaluate transport systems. It will increase their development efficiency and it will allow to achieve compromise for each actor within the transport process, as well.

- improve the quality of services;
- increase the transportation volume;
- expand the list of transshipment cargo;
- conduct new researches, especially in the field of ecology, energy efficiency and resource economy;
- find investment sources for renovation of productive capacities.

The main drawbacks are that the qualitative assessment development of the technical system will require agreement with all interested parties during some time. The formation of a new effectometrics model and its implementation in transport and technological systems will require the additional financial resources, modern technologies and highly educated personnel.

The results of the study offer significant prospects for efficiencies assessment on a multi-criteria basis, as well as for their comparison.

The efficiencies qualitative assessment within the technical system will help to minimize short-term losses of enterprises, as well as realize their potential in long run.

We determine the economic assessment results of the environmental impact on the environment (Fig. 4) by partial usage of the materials under the above -mentioned method and research materials [20, p. 243-248].

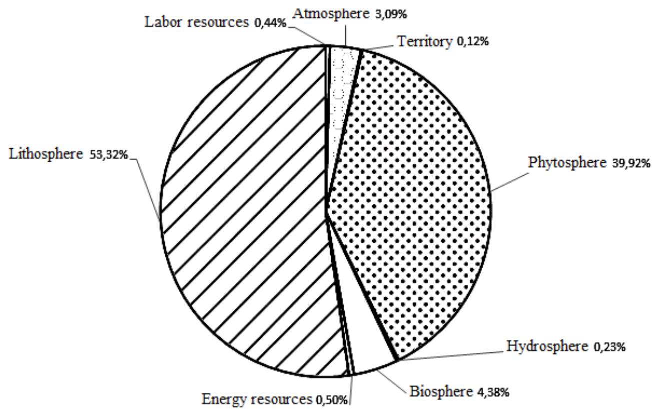

Fig. 4. The distribution circular diagram of economic assessment in regard to harmful environmental impacts of the transport and technological systems

We performed the study under the most expensive and harmful to the environment solidifying liquids that have a melting point within 85-300 degrees and change their aggregate state during transportation.

The diagram analysis (Fig. 4) shows that the most expensive are the costs within the lithosphere and phytosphere, and the least expensive are the local costs and within the hydrosphere.

8. CONCLUSIONS

1. We developed a methodology for development assessment of complex transport and technological systems (TTS), which allows to conduct appropriate studies in the field of TTS effectometrics.

2. The proposed method of efficiency assessment in regard to complex transportation systems on multi-criteria basis - is a scientific novelty that allows you to set the patterns of development for transport-technological process, with the harmonization of interests for each actor within the process-based chain "production – transportation – consumption", as well as design criteria and the required efficiency of each process and object of management system as a whole.

3. The expected technical results of the proposed effectometrics method within transport and technological systems:

- value determination of objects and technologies within the transport and technological system and their comparison with each other in case of assessment on multi-criteria basis, with consideration of the requirements for different system efficiencies;
- contingency rundown within the comparative assessment of performance indicators in existing and prospective, developing process-based systems;
- harmonization of process-based transport and technological systems with international requirements within their value under consideration of the each system actor interest;
- decrease of computation time, as well as reduction of labor intensiveness and uncertainty within the distribution of consumer investments;
- recommendations development for rational composition choice of objects and technologies within the process-based system;
- detection and research of additional features within the process-based system, which include objects and technologies, as well as promising ones, heterogeneous by their indicators and assessment criteria (sometimes contradictory);
- identification of reasonable high-priority prospective and competitive directions of development and operation of process-based systems;
- rationale of technical and economic indicators within prospective national and international programs in order to create new process-based systems, during their development and monitoring of implementation.
- 4.There is systematization of the main factors that make it necessary to revise the traditional development model of transport and technological systems in order to increase their efficiency. The key factors are:
- *resource* - plurality in funding and resources;
- *technological* – non-physical and physical ageing of the TTS infrastructure;
- *scientific and technical*- supply of highly qualified workers;
- *economic* – strategic necessity in investments;
- *environmental* – increased environmental impact of enterprises.

5. We make a conclusion that present methodology of practical problems settlement within effectometrics transportation systems requires improvement: methods and algorithms have fragmented character, there is partial tasks settlement in a separate and independent manner in relation to the manufacturer, the carrier and the consumer. Whereby, the principle of separate objects improvement without due consideration of the features within a single transport process with a balance of each actor interest is the basis for problem settlement. There should be distribution of wages and salaries among all participants of the transport and technological chain on a compromise basis.

6. It is necessary to propose algorithms and models for the synthesis of specific transport and technological systems to implement the developed methodology and start with their decomposition into elements that generate, transform and use transport flows.

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