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Diagnostics of the regional transport and logistic system's functioning (in the case of Luhansk region)

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S u m m a r y. The results of the diagnostics of the regional transport and logistics system's (RTLS) functioning are presented, the comprehensive evaluation of its functioning is calculated. Algorithm for Luhansk RTLS functioning estimation technique is developed on the basis of the normative system of diagnostics indicators.

K e y w o r d s. Transport system, diagnostics, indicators, technique, algorithm.

INTRODUCTION

Transport diagnosis is at the beginning of its formation, it represents branch of science that studies the status of the objects of diagnostics on transport, develops methods and tools for detecting defects of transport systems and their causes and systems of diagnostics using the methods and means of Cybernetics [6, 8, 12].

French scientist B. Colas [3] believes that, that making the diagnosis means to consider in dynamics phenomena symptoms, which may delay the achievement of the set goals and problem solving, endanger the planned activity. This involves developing adjustment solutions or viewing the goals and forecasts. Knowing the signs (symptoms) allows quickly and accurately to detect the nature of disorders, without making direct measurements, that is without actions that require extra time and money.

The existing framework for the diagnosis on transport one can consider to be approaches related to the evaluation and analysis of the functioning of transport and systems, in which it participates. Examples may include works [5, 14].

In the frame of transport diagnostics the following research areas can be distinguished: diagnosis in terms of energy and resource conservation, diagnosis on indicators of security and risk, diagnosis on indicators of capacity and diagnostics on territorial indicators [11].

The direction of research in the works [2, 4] is carried out on indicators of potential. This is due to the extensive use of category of potential in economics and its distribution into the transport sector. In turn, in [1, 16] attention is paid to the territorial indicators. It is caused by the natural essence of transport systems: to implement the delivery in space, as well as the dispersal and diversity of participants in the transport process and transport infrastructure.

Diagnostic approach as one of a number of scientific approaches (along with systemic,

process, etc.) is used in two aspects: general - as a realization of the concept of diagnostics in relation to the selected application object (object of investigation) and private – as implementation of methodological tools for diagnostics united by any sign, in relation to the selected application object (object of investigation) [13].

Thus, as diagnosis objects on transport we may identify: technological maintenance (transport infrastructure facilities, rolling stock, etc.), items of manufacture (goods, people), executors (drivers, dispatchers, etc.) [9].

The work [10] distinguishes the following diagnostic tools: informational – that is diagnostic information obtaining, its storage, systematization, software should be included here, technical and technological – that are various devices for receiving and processing information (devices, sensors, computer facilities, etc.), mathematical – that are diagnostic models, algorithms, of diagnosing.

Diagnostics of transport systems is a new research direction of the regional transport and logistics system (RTLS) functioning in the modern world.

According to the work [18] RTLS means a series of transportation logistics subjects, combined into logistics chains and channels and interconnected in a single process of material, informational, financial, service and other flows management, created or moved in the territory of the region for optimal and rational organization of their movement in the transport sector with minimal logistics costs and maximum useful effect for all participants in the system while respecting the necessary level of service.

In the work [23] transport system is considered as an element of a higher level – transport and logistics system, consisting, respectively, of transport and logistics systems. The authors consider interaction of these systems is an extremely complex process main purpose of which is to organize an efficient and uninterrupted movement of goods within a particular country (region).

Recent elaborations mainstream development and perfection of transport service in manufacturing sphere, distribution and production consumption abroad is logistics. 25-30% of a total national product of leading foreign countries are connected with logistical systems, such, as the USA, Japan, the Great Britain, France, Germany [20].

Luhansk region – is the transit gate of Eastern Ukraine and Luhansk, as a regional center and the city, located less than 45 km from the Russian Federation border, almost at the crossroads of the main railway and highways, in fact is the key, the use of which has been providing a positive trade balance volume between the neighboring regions. For example, in the first quarter of 2010 Rostov region's foreign trade turnover with Ukraine had increased by 55% and had reached almost $ 400 million. Due to close interaction of border areas, the share of Ukraine in foreign trade turnover of the Southern Federal District of Russia has been growing steadily and now comprises almost 30% [19, 21].

The positivity of formation and functioning of the Euroregion "Donbass" (further "Euroregion", depends a lot on condition of transformational logistic system of the incoming definite border territories – Luhansk region, Donetsk region (Ukraine) and Rostov region (the Russian Federation)) [22, 24].

Creation of a transport-logistics system in Luhansk region will ensure the effective establishment of a transport corridors network, causing the most complete use of the economic potential of the region. In addition, it can provide the opportunity to achieve increase in traffic volume and improve the competitiveness of domestic carriers, increase their share in the global market of transport services, transport potential of Luhansk region using international transport corridors [15].

Diagnostics of RTLS functioning in Luhansk region will allow: to provide reliable estimation of its current development, to lay the groundwork for hypothesizing about patterns and possible unstable state of the system, to identify the causal relationships in dysfunctions in system management, to build

an explanatory and predictive model of its operation and development, emphasizing the relevance of research.

OBJECTS AND PROBLEMS

The object of the work is diagnostics of the RTLS functioning in Luhansk region using techniques based on the creation of regulatory indicators that will allow to calculate the comprehensive evaluation of the effectiveness of its functioning in retrospect and current development, to develop an algorithm of the method based on the transport diagnostics facilities.

RESULTS OF RESEARCH

To conduct a reliable diagnosis of the overall level of RTLS efficiency it is suggested to use the regulatory system of indicators, each of which is expressed by ratio (index) of results, costs, and resources of the transport system.

A set of indicators by which standards are set, we will call the recommended regulatory indicators system (RRIS) (Fig. 1).

They are divided into primary and secondary ones. The initial parameters mean such that resulted from the direct functioning accounting of RTLS (such as turnover tkm, public highways length km, etc.). Secondary indicators – are those that are calculated (e.g. self-cost of 100 tkm, CU). RRIS is mobile for each individual case, i.e. can be added, specifically for the given region.

Structural and logical model of RTLS functioning diagnostics according to RRIS is reduced to four basic provisions (Fig. 2):

– forming a set of initial indicators that fully characterize RTLS functioning,

– calculation of the growth rates that express the most efficient mode of RTLS functioning and its ranging,

– comparison of practically ordered growth rate with the regulatory one,

– determination of integral evaluation of RTLS functioning efficiency.

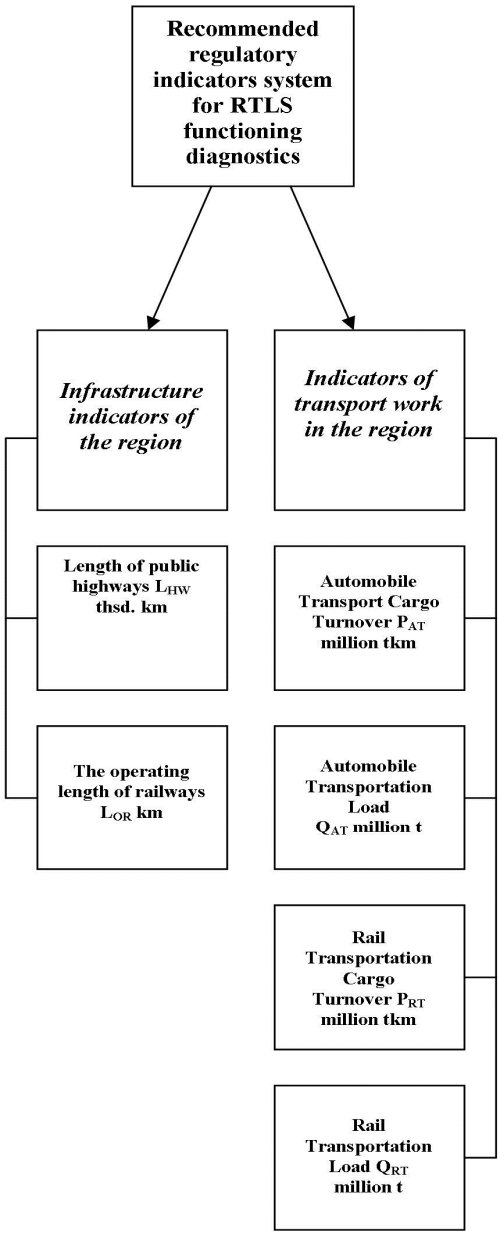


Fig. 1. The recommended regulatory diagnostics indicators system of RTLS functioning in Luhansk region

Using the method of ranking we assign the rank (priority) for each of the indicators in RRIS. The first rank (priority) is assigned to the index with the largest growth rate, the second – to the growth rate index lower, than the first index, but higher than in all the rest. When the growth rate indexes are the same, the one that is top-priority for the effective functioning of the RTLS in the region is preferred.

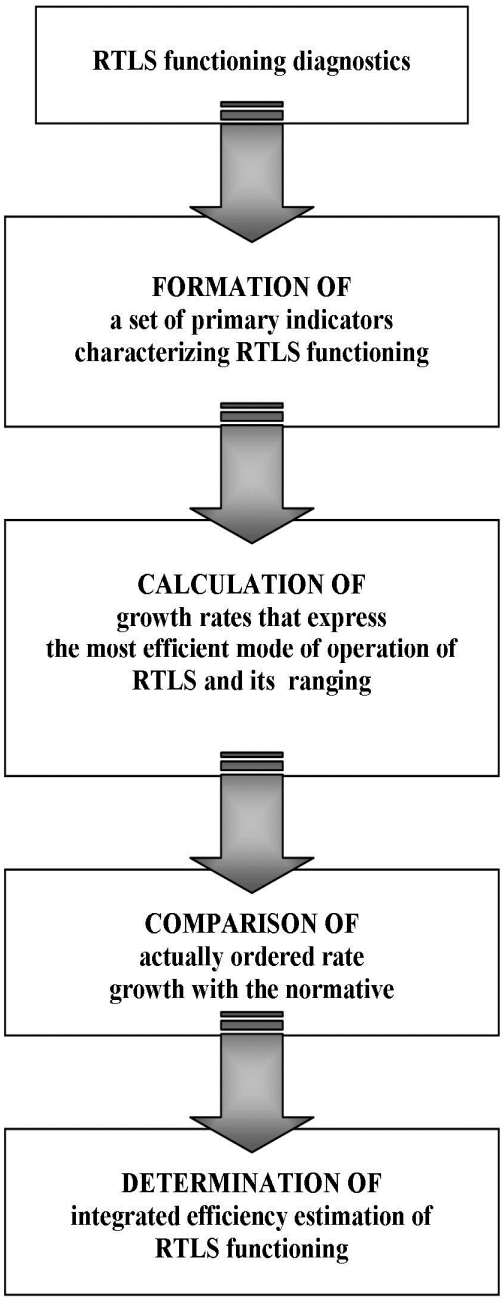


Fig. 2. The structural and logical diagnostics model of RTLS functioning in Luhansk region by the RRIS

Regulatory ranks (priorities) of the growth rates of the RTLS in Luhansk region, that are listed in Table 1, were determined on the basis of the following reasons.

Automobile transport has a list of significant advantages (has a high level of mobility and the possibility of "door to door" delivery, has a very short delivery time, regular frequency of departures, traffic time reliability), has a sectoral and regional character (is used mainly for transport destination of 200 km).

The automobile transport cargo turnover, P_{AT}, million t, determines the volume of transport work for cargo transportation, measured in tariff tkm, and is an important indicator that characterizes the RTLS functioning.

The automobile transportation load Q_{AT} million t, is the sum of the sent and received cargoes from other enterprises (units) for further transportation.

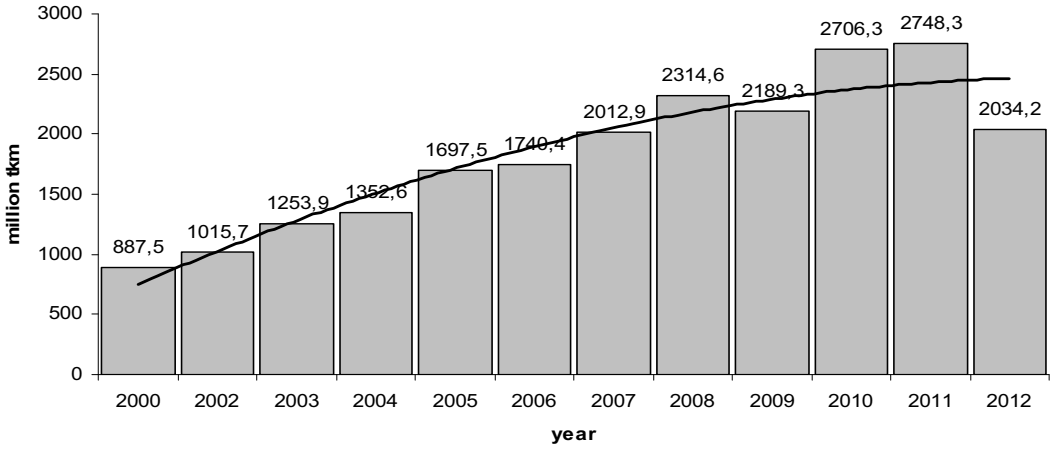
Table 1. Regulatory ranks (priorities) of Luhansk region growth rates

#	Diagnostics Indicators of THE RTLS Functioning	Regulatory ranks (priorities) of the growth rates
1	Automobile Transport Cargo Turnover P_{AT} million tkm	1
2	Automobile Transportation Load Q_{AT} million t	2
3	Length of public highways L_{HW} total thsd. km	3
4	Rail Transportation Cargo Turnover P_{RT} million tkm	4
5	Cargo transported by rail transport Q_{RT} million t	5
6	The operating length of railways L_{OR} km	6

The previous two indicators are not possible to obtain in the absence of an extensive network of routes (the length of public highways in Luhansk region is 5.9 thsd km, the density of highways in Luhansk region is 209.7 km per 1000 km^2 (in Ukraine 269 km per 1000 km^2)).

Rail transport is used mainly for transportation on big enough distance, has the property of mass transportation and relatively low cost of transportation. The operating length of railways in Luhansk region is 1092.4 km (the sixth place in Ukraine), extensive length of routes is 2,380 km.

Let us consider the dynamics of development of each of the indicators of the recommended regulatory system (Fig. 3 for automobile transport, Fig. 4 for rail transport) according to [25, 26].



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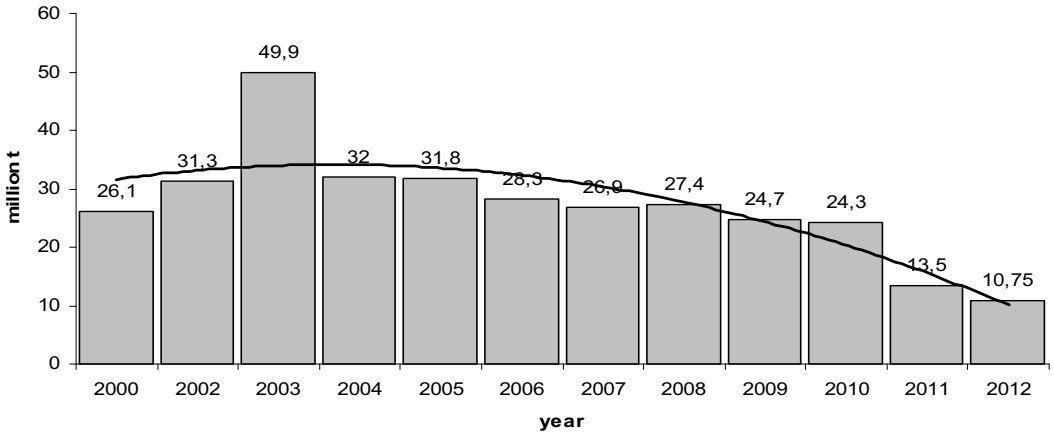

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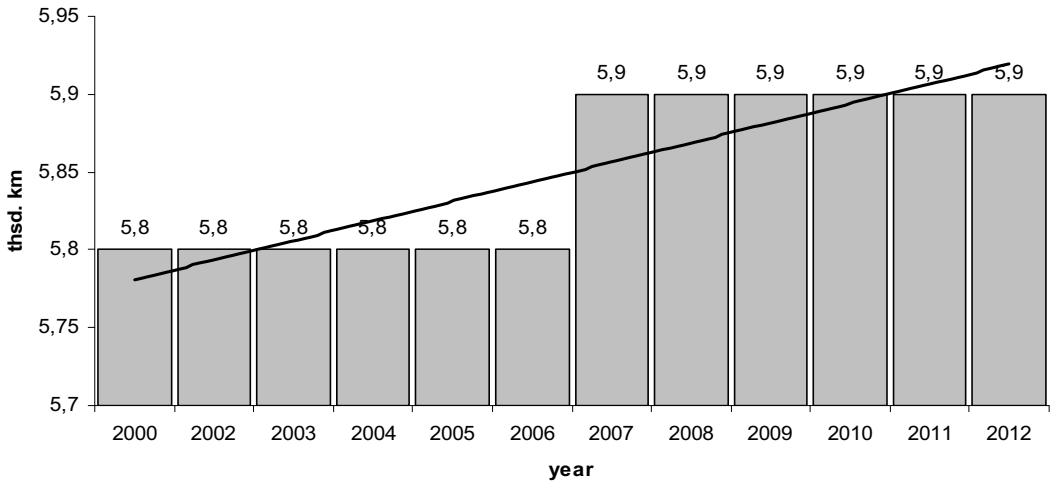

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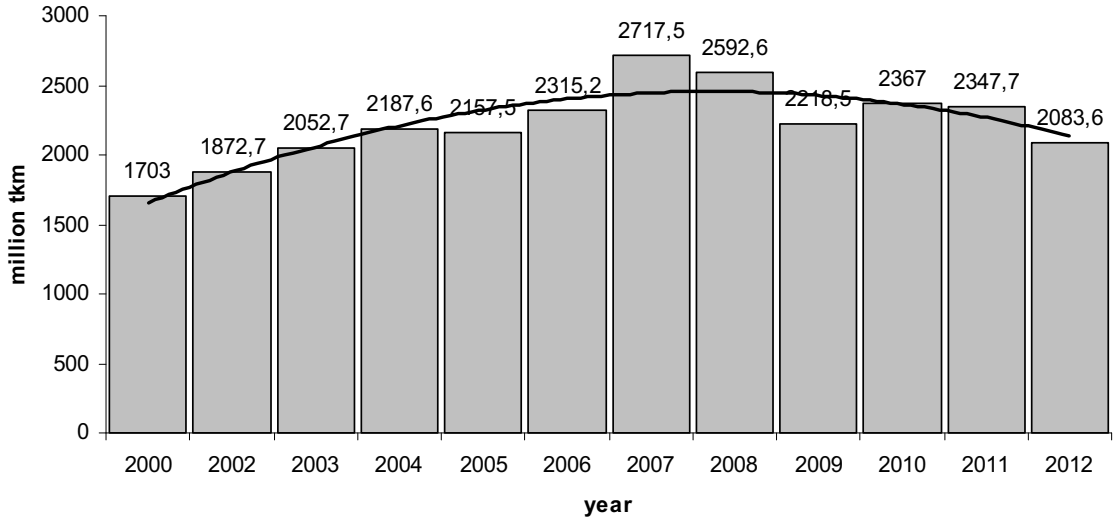
Fig. 3. Dynamics of automobile transport indicators development in Luhansk region: a – by cargo turnover million tkm, b – by transportation of cargoes million t, c – by the length of public highways thsd km



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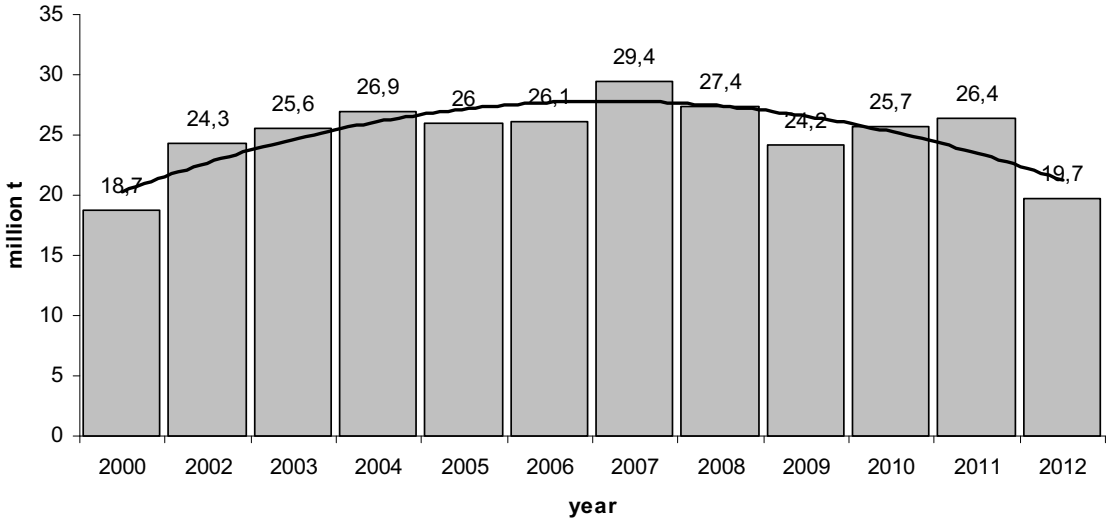

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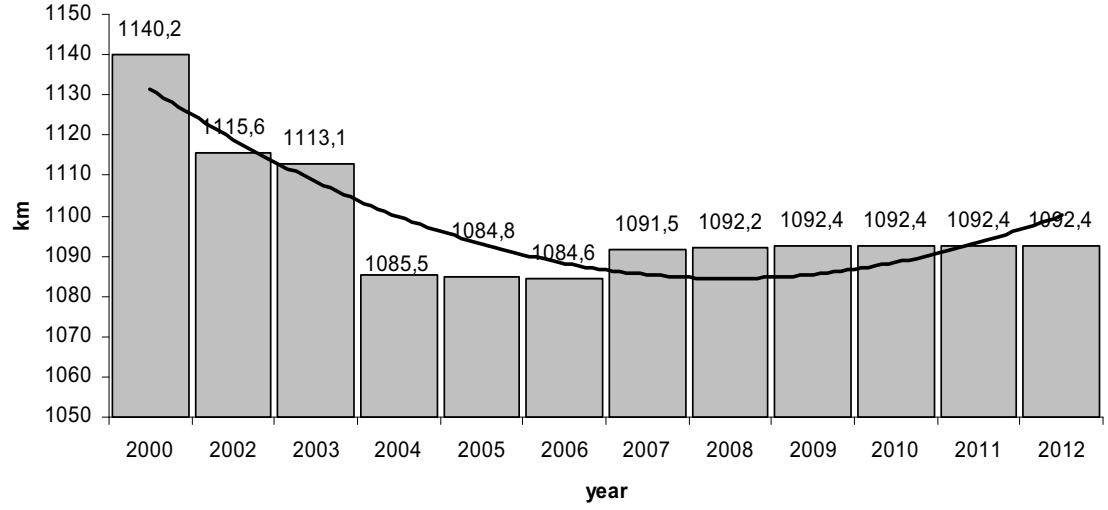

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Fig. 4. Dynamics of rail transport indicators development in Lugansk region: a – by cargo turnover million tkm, b – by transportation of cargoes million t, c – by the length of railways operating length km

The level of efficiency of RTLS should be determined on the basis of two coefficients: Kendall coefficient K_K and Spearman coefficient K_S. Complex (resulting) estimation of the RTLS functioning efficiency will be calculated by the following formula:

$$K_R = \frac{(1+K_K)+(1+K_S)}{4}. \quad (1)$$

The RTLS functioning efficiency assessment is calculated using the formula of the Kendall Rank Correlation Coefficient [7, 17, 27]:

$$K_K = 1 - \frac{4\sum_{i=1}^{n} m_i}{n(n-1)}, \quad (2)$$

where: $\sum_{i=1}^{n} m_i$ – is a number of violated regulatory ratios of *i* indicators growth rates,

n – is a number of indicators in the regulatory system.

By the results of calculations of Kendall coefficient using the formula (2) we obtain the following dynamics (Fig. 5).

The value of the numerator and denominator of the calculation formula are directly proportional to the number of violations of the requirements and therefore their total number. Value of the coefficient that is calculated changes from -1 to +1. The value of the rate +1 corresponds to RTLS functioning with the highest efficiency. If the rate is -1, there is deterioration in absolutely all efficiency indicators. Zero-rating of RTLS functioning efficiency proves that in the estimated period it has not changed compared to the previous.

To improve the accuracy of evaluation of RTLS functioning efficiency the Spearman's rank correlation coefficient is used [7, 17, 28], which is calculated by the following formula:

$$K_S = 1 - \frac{6\sum_{j=1}^{n} y_i^2}{n(n^2-1)}, \quad (3)$$

where: y_i – is the difference of *i* indicator ranks in the actual and normative ordering of the growth rate.

Spearman's rank correlation coefficient K_S shows that the integral evaluation is given not only to the number of violated regulatory ratios, but also quality content and significance of these violations are taken into account. K_S allows to reveal a more efficient regime of RTLS functioning among those that have the same value assessment K_K.

By results of calculations of Spearman's coefficient using formula (3) we obtain its following dynamics (Fig. 6).

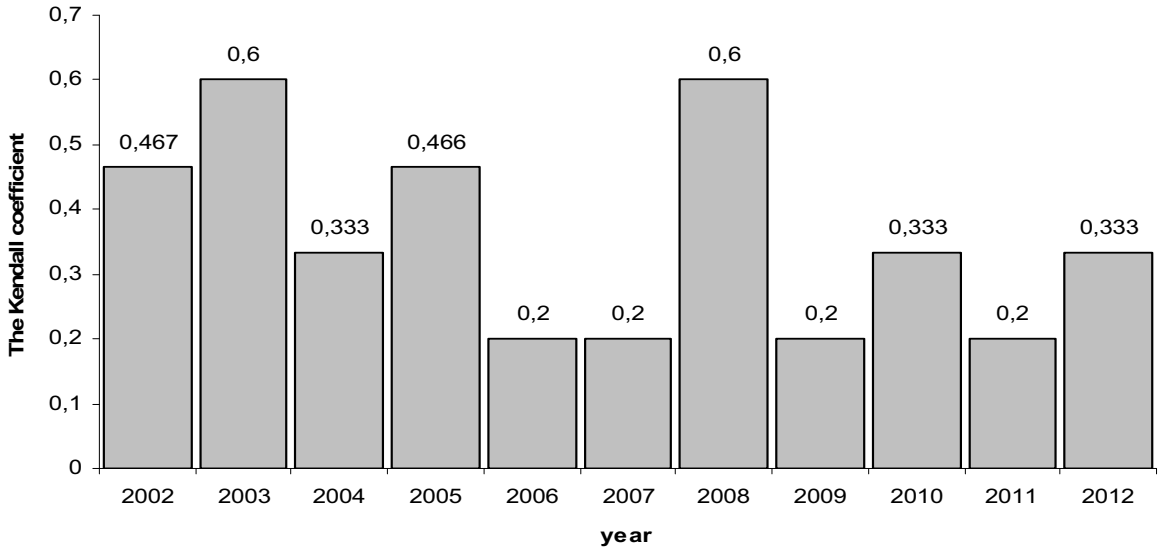

Fig. 5. Dynamics of Kendall coefficient for Luhansk region

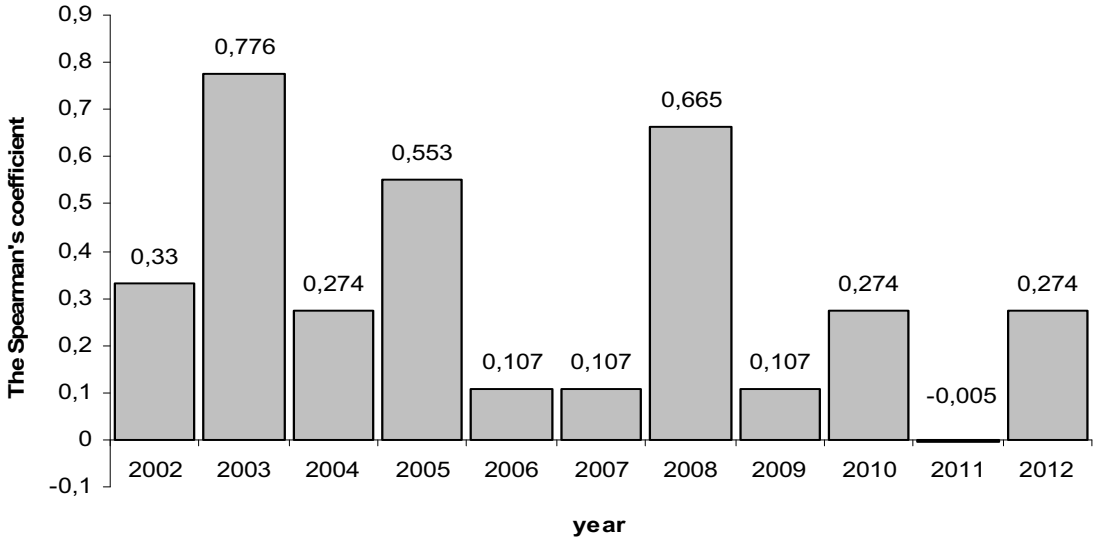

Fig. 6. Spearman's coefficient dynamics for Luhansk region

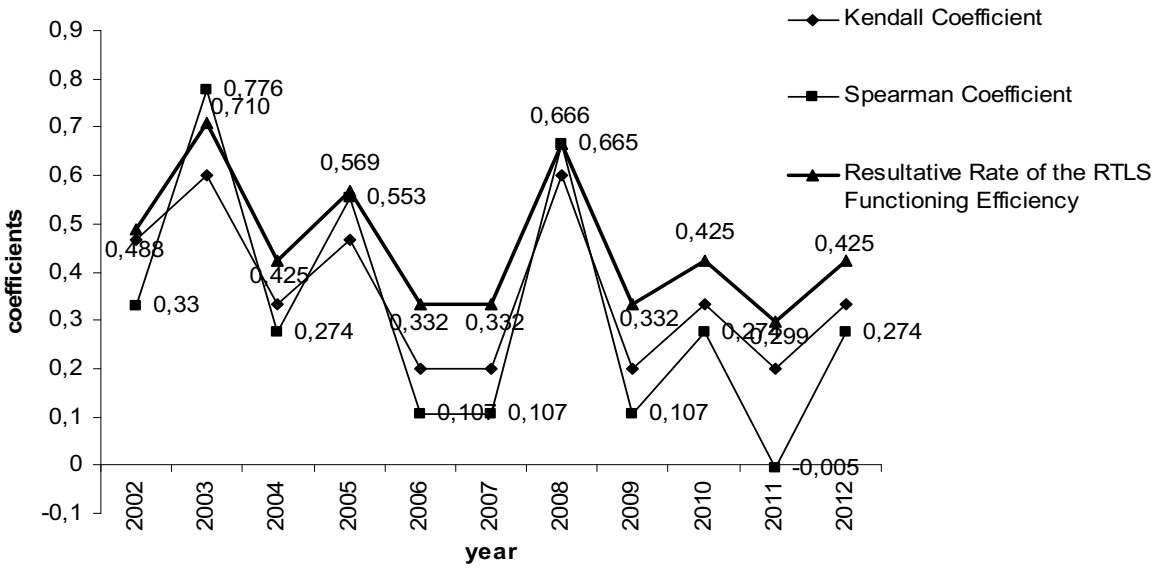

Fig. 7. Dynamics of the comprehensive assessment of RTLS functioning efficiency in Luhansk region

Comprehensive assessment of RTLS functioning efficiency calculated by formula (1) has the following dynamics (Fig. 7):

Aggregation of K_K and K_S by formula (1) changes the scale of assessments of RTLS functioning efficiency: if K_K and K_S change their values from -1 to +1, then range of values K_R is from 0 to 1. Herewith the value of $K_R = 0.5$ corresponds to the middle of the scale of assessments K_K i K_S.

Comprehensive assessment is characterized by quantitative criteria of levels of RTLS functioning efficiency (Table 2).

Table 2. Quantitative criteria of the level of RTLS functioning efficiency

Quantitative criteria	Level of RTLS functioning efficiency
up to 0.3	practically doesn't function
0.3-0.5	lightly functioning
0.5-0.7	moderately functioning
0.7-1.0	operate with the highest efficiency

The algorithm for methodology of assessing the RTLS functioning in Luhansk region is shown in Fig. 8.

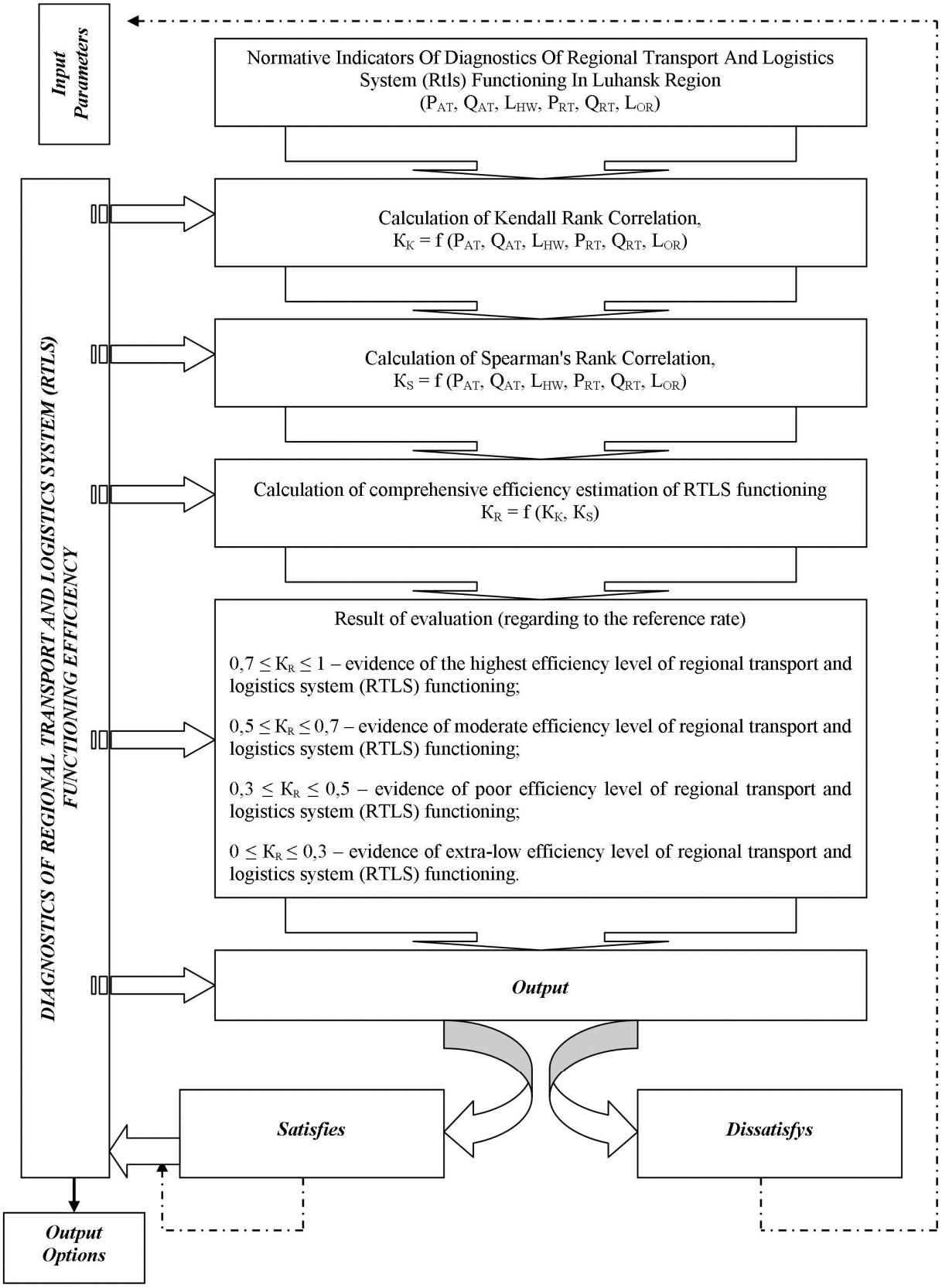

Fig. 8. Algorithm for methodology of assessing RTLS functioning in Luhansk region

CONCLUSIONS

1. Stable RTLS functioning is provided through the implementation of advanced transport diagnostic methods.

2. Diagnostics of the RTLS in Luhansk region is conducted on the bases of methodology that is based on RRIS creation, allows calculating a comprehensive assessment of the effectiveness of the system and determining its level. The calculation results revealed the following: in 2003 the RTLS in Luhansk region functioned with the highest efficiency, moderate functioning of the system was achieved in 2005, 2008, in 2002, 2004, 2006, 2007, 2009, 2010, 2011, 2012 a comprehensive assessment index indicates poor functioning of the system.

3. The sequence of actions that lead to the solution the given task is confirmed by the development of algorithm for methodology to assess the functioning of the RTLS in Luhansk region on the basis of transport diagnostics.

4. Qualitative diagnosis of RTLS functioning will allow achieving the transportations volume growth and increasing the competitiveness of domestic carriers, increasing their share in the global transport market, implementation of transport potential in Luhansk region.

5. Further research on this issue should be conducted in developing predictive model of the RTLS, which will characterize the state of technical and technological development of the region and improvement of transport diagnosis methods.

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ДИАГНОСТИКА ФУНКЦИОНИРОВАНИЯ РЕГИОНАЛЬНОЙ ТРАНСПОРТНО-ЛОГИСТИЧЕСКОЙ СИСТЕМЫ
(на примере Луганского региона)

Александр Кравченко, Евгений Медведев

А н н о т а ц и я . Представлены результаты диагностики функционирования региональной транспортно-логистической системы, рассчитана комплексная оценка ее функционирования. Разработан алгоритм методики оценки функционирования РТЛС Луганского региона на основе нормативной системы показателей диагностики.

К л ю ч е в ы е с л о в а . Транспортная система, диагностика, показатели, методика, алгоритм.