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A conceptual model of decision-making support of the volunteer team in conditions of dynamic changes

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ABSTRACT

The paper examines the problem of decision-making by a team of volunteers in transport logistics tasks under conditions of dynamic changes in the external environment. Transport logistics is a system of organizing cargo delivery to the place of need along a certain route. The task of transport logistics, during dynamic changes in the external environment, is a task of multi-criteria selection due to consideration of various criteria. Solving the problems of transport logistics requires the construction of a conceptual model of decision-making support, regarding the choice of the best route, taking into account all the factors that influence decision-making, and the choice of the decision-making method. The multi-criteria decision-making methods which are used in the transport sector are analyzed. A conceptual model of decision-making support for choosing the optimal route in the transport logistics problem is proposed. Verification of the proposed model was carried out, for which the task of choosing the best route of cargo transportation in the transport logistics problem was set and solved. When finding a solution, the multi-criteria decision-making methods were used: Analytic Hierarchy Process method, Multiplicative Analytic Hierarchy Process method, Simple Multi-Attribute Rating Technique method, improved Simple Multi-Attribute Rating Technique method. The criteria used to evaluate alternative routes for cargo transportation were identified based on volunteer surveys. In order to evaluate the alternatives according to the established criteria, volunteer experts were involved, since during dynamic changes in the conditions of cargo transportation, the involvement of professional experts is a difficult task. To establish the reliability of the evaluations of alternatives according to the criteria obtained from volunteer experts, the Kendall and Spearman correlation coefficients were calculated. Analytic Hierarchy Process method, Multiplicative Analytic Hierarchy Process method, and the improved Simple Multi-Attribute Rating Technique method are found to provide the most reliable results, but the Analytic Hierarchy Process method and Multiplicative Analytic Hierarchy Process methods are more time-consuming during data input than the improved Smart method.

Keywords: Transport logistics; decision support; multi-criteria decision-making methods; criteria; alternatives; Spearman coefficient; the Kendall coefficient

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INTRODUCTION

The volunteer movement as a form of social activity, aimed at providing non-state assistance to the segments of the population that especially need it, has existed for a long time. Until recently, the objects of volunteer assistance were mainly groups of people who suffered from natural disasters, social cataclysms, and catastrophes. Thus, the Law of Ukraine "On Volunteering" specifies the following areas of volunteering: assistance to the poor, the unemployed, those with many children the homeless, homeless persons; providing care for the sick, disabled, single, elderly and other persons who, due to their physical, material or other characteristics, need support and assistance; providing assistance to citizens who have suffered as a result of an emergency situation of a man-made or natural nature [1]. Since 2014, one of the volunteer movement directions became the military one – protection and safety of the population and the interests of the state because of military aggression of the Russian Federation against Ukraine and/or another country against Ukraine; providing assistance to the Armed Forces of Ukraine, other military formations, law enforcement agencies, state authorities during a special period, a legal regime of emergency or martial law, conducting an anti-terrorist operation, implementing measures to ensure national security and defense; providing assistance to persons/families who find themselves in difficult life circumstances due to damage caused by hostilities, a terrorist act, armed conflict, temporary occupation, armed aggression of the Russian Federation against Ukraine and/or another country against Ukraine [1]. Volunteers provide assistance to military units; collection and delivery of humanitarian aid to the population; transportation of people from dangerous zones [2], which is the task of transport logistics.

One of the main tasks of transport logistics is the search for the best (optimal) route [3], namely, the route by which the logistics object can be delivered in the shortest time, with minimal costs, and even with minimal negative impact on the logistics object as from the side of external factors, as well as from the side of a temporary factor during the delivery of objects that are included in this category. In this aspect, the task of building an optimal logistics route is multi-criteria. Multi-criteria problems under stable transportation conditions include the transport problem [4], for the solution of which various methods of multi-criteria optimization are used [4, 5], [6, 7], [8, 9], [10, 11], 12]. The solution of the transport problem is the optimal, according to some criterion, the plan of transportation of the logistic object from the point of departure to the point of need.

However, in the conditions of military operations with a dynamically changing situation, the uncertainty of the state of the external environment arises and because of this the transport logistics systems require volunteers to promptly take into account quick changes in the external environment, in particular, changes in the available resource, changes in the needs of resource recipients, possible gaps in sections of the route related to their combat overlaps, etc.

The problem of multi-criteria selection arises and it consists in finding the best alternative (route) taking into account the evaluations of alternatives according to a large number of criteria in operational conditions. But, obtaining evaluations of alternatives according to criteria in operational conditions is a difficult task, as it is practically impossible to involve professional experts.

Thus, an important and urgent task is the development of a conceptual decision support model for a team of volunteers to solve the problem of transport logistics in the conditions of dynamic changes in the external environment.

ANALYSIS OF DECISION-MAKING METHODS IN THE PROBLEM OF OPERATIONAL TRANSPORT LOGISTICS

The paper reviewed the multi-criteria decision-making methods (MSDM), which are widely used in the transport sector. Thus, from the analysis of publications for the period from 1982 to 2019 carried out by the authors in [13], it was established that the Analytic Hierarchy Process (AHP) method and its modifications, for example, the Multiplicative Analytic Hierarchy Process (MAHP), are most often used to solve problems in the transport sector. A significant number of problems were solved using the ELimination Et Choix Traduisant la Realite (ELECTRE) family of ranking methods.

In addition, MSDM methods are used to solve the problem of multi-criteria selection in logistics, namely supplier selection [14]. In this work, the problem of supplier selection of autonomous systems for trains was solved using the TOPSIS method.

In [15], the authors build a multi-criteria decision-making model for logistic processes in woodworking production, which are dynamic and represented in the form of a Petri net, the nodes of which are a log warehouse, a processing place, a sawmill, and a wood warehouse. The authors analyzed the MSDM methods, among which the authors singled out the MAUT, AHP, Fuzzy Theory, and the Smart (Simple Multi-Attribute Rating Technique) method, which is simple and often used in solving problems in construction, transport, and logistics.

New methods and models for solving multi-criteria problems are being built on the basis of multi-criteria selection methods. In [16], the authors build a model for the supply process based on the following MSDM methods: the PROMETHEE method for ranking alternatives and the AHP method for calculating criteria weights.

In [17], the authors developed an improved Smart method based on the Smart and TOPSIS methods, which allows processing of mixed data types (quantitative, qualitative, relay (“yes”/”no”)) [6, 17]. In order to reduce the subjective role of the decision-maker (DM) during the assignment of points to the criteria and when evaluating the alternatives according to the criteria, the authors suggested building a matrix of solutions according to the TOPSIS method.

The normalization of the quantitative elements of the solution matrix takes into account actions on the criteria: in the case of maximization, the formula is used:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, \quad (1)$$

in the case of minimization:

$$r_{ij} = 1 - \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, \quad (2)$$

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where x_{ij} ($i=\overline{1,n}$, $j=\overline{j,m}$) is the element of the decision matrix, r_{ij} is the element of the normalized decision matrix; n is the number of alternatives; m is the number of criteria by which alternatives are evaluated.

To transformation the qualitative evaluations of alternatives according to the criteria to quantitative values from zero to one, it is proposed to use the Harrington scale [17], which is a multi-interval discrete verbal-numerical scale. For evaluations of criteria that are relays in the improved Smart method, evaluations of expert evaluation are used [17].

Thus, the following MSDM methods were chosen for further analysis: AHP, MAHP, ELECTRE, TOPSIS, Smart and the improved Smart method.

The analysis of the selected methods was conducted from the point of view of:

– the possibility of processing mixed type of data, as evaluations of each alternative route, along which the logistics object can be transported by a team of volunteers, can be represented by mixed type data according to the appropriate criteria;

– minimal data input time (the number of pairwise comparison matrices), which reduces the time spent by volunteers when using multi-criteria decision-making methods.

The results of the analysis are presented in Table 1.

The conducted analysis showed that the TOPSIS, Smart, improved Smart method, in which only one comparison matrix is built, are the best in terms of minimum data input time (number of pairwise comparison matrices).

In Table 1 m is the number of criteria by which alternatives are evaluated.

The TOPSIS method allows processing only quantitative data. The ELECTRE method also allows you to process only quantitative data, in addition, criteria comparisons are performed when building agreement and disagreement matrices. In the AHP and MAHP methods, a matrix of pairwise comparisons is built, but these methods allow the processing of mixed type data and provide high reliability of the obtained solutions.

The aim of this work is to develop a conceptual model of decision-making support for a team of volunteers and to choose a decision-making method for the transport logistics task in conditions of dynamic changes in the external environment, which will ensure high reliability of the obtained decision.

Table 1. **Comparison of MSDM methods**

No.		Number of pairwise comparison matrices	Data type
1	AHP	$1+m$	Mixed
2	MAHP	$1+m$	Mixed
3	TOPSIS	1	Quantitative
4	ELECTRE	2	Quantitative
5	Smart	1	Mixed
6	Improved Smart method	1	Mixed

Source: **compiled by the author**

THE PURPOSE AND OBJECTIVES OF THE RESEARCH

To achieve the goal, the following tasks were formulated:

– development of decision support models for choosing the best route in the task of transport logistics for a team of volunteers;

– verification of the developed model using multi-criteria selection methods, which allow processing mixed types of data and are characterized by minimal data input time before solving the transport logistics problem.

A CONCEPTUAL MODEL OF A TEAM OF VOLUNTEERS DECISION-MAKING SUPPORT IN CONDITIONS OF DYNAMIC CHANGE

At the heart of any purposeful human activity is the problem of choice. A problem is a complex theoretical or practical situation that requires study, research, and solution [18]. In most problems, solution options must be evaluated from different points of view, taking into account physical, economic, technical and other parameters that affect the complexity of the problem solution [19]. With a large number of evaluations, it becomes difficult to take them into account, and then the DM needs help. It can be the help of experts or the use of tools.

But decision-making by a team of volunteers in the task of transport logistics during wartime, that is, in conditions of dynamic changes in the external environment, has the following peculiarities:

– most decisions are made in situations that have not been encountered before;

– the selection of decision options takes place in conditions of incomplete and uncertain information about the current situation;

– decisions, usually the most responsible, are made under strict time constraints and constantly changing information.

On the basis of the above, a conceptual model of decision-making support by the volunteer team in conditions of dynamic changes in the external environment is proposed, which relies on its own human resources and information received from experts, who are members of the volunteer team (Fig. 1).

The problem of determining the best route for the delivery of the logistics object is faced by the DM (the coordinator of the volunteer team). To find a solution to the problem, the DM solves the following tasks: determining the purpose and conditions of the operation; formation of a set of alternatives and criteria; choice and decision making. In the conditions of dynamic changes in the conditions on the routes, volunteers-observers ($VTM_{A_{i\_j}}$, $i=\overline{1,m}$, $j=\overline{1,n}$, where m is the number of routes, n is the number of sections on the i route), who are on the sections of the corresponding route join the stage of forming a set of criteria and updating them.

Each route has a different length L_i, $i=\overline{1,m}$ with the corresponding length of sections:

$$L_{ij} - \sum_{j=1}^{n} L_{ij} = L_i,\ i=\overline{1,m}.$$

Volunteer observers are volunteer experts on the state of route sections; therefore, they are the main performers of the stage of information collection and evaluation according to criteria.

The selection and decision-making of the DM is performed on the basis of all information about the state of the relevant routes.

Let's write this model in the theoretical-multiple representation [20].

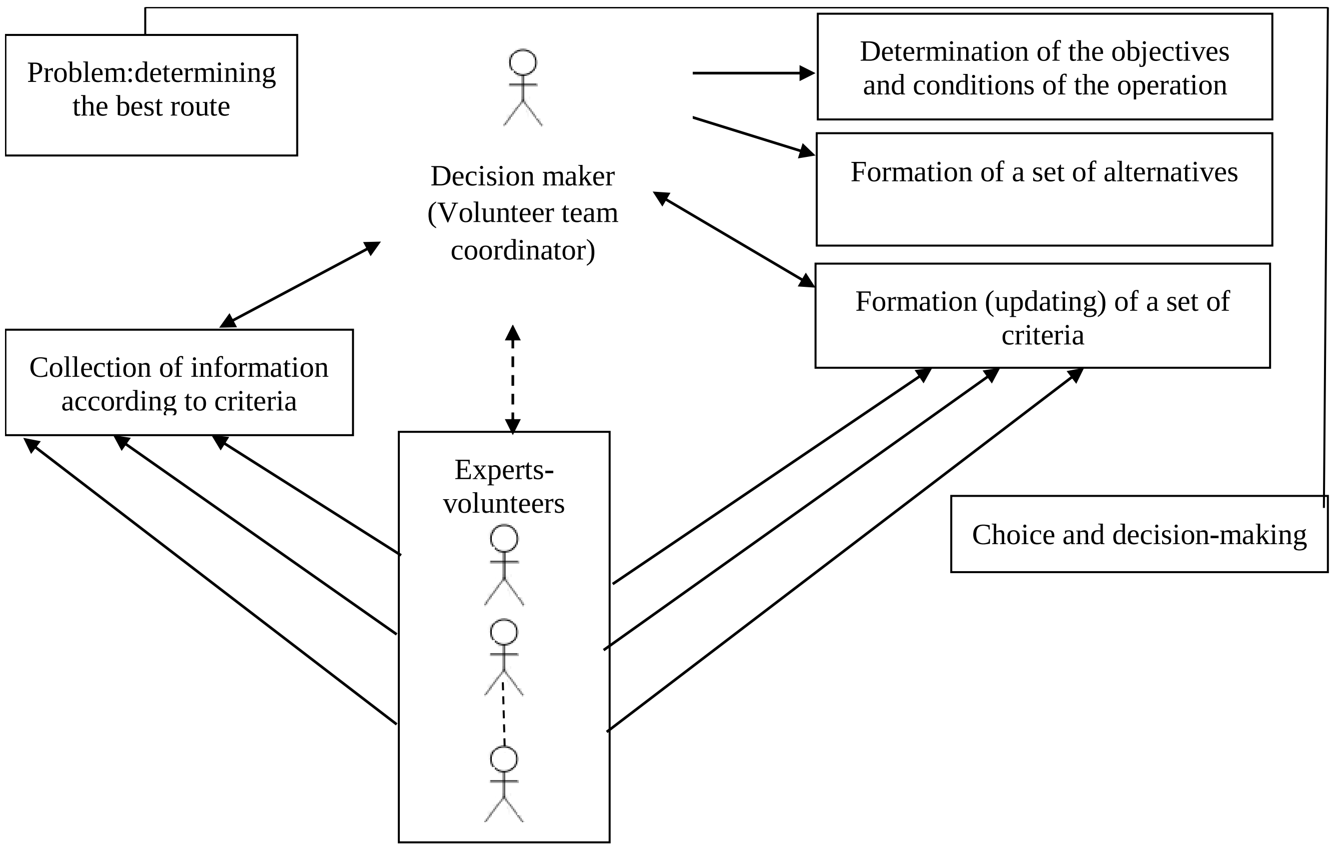

Fig. 1. **A conceptual model of a team of volunteer's decision-making support in conditions of dynamic change**
Source: **compiled by the author**

A conceptual model of decision support that takes into account information about the state of the external environment looks like:

$$\text{CMDS} = < I_1, I_2, ..., I_n, A_1, A_2, ..., A_m >, \quad (3)$$

where: $I = \{I_1, I_2, ..., I_n\}$ is the information about the state of the external environment;

$A = \{A_1, A_2, ..., A_m\}$ is the set of alternative solutions;

n is the number of states of the external environment;

m is the number of alternative solutions.

The conceptual model for choosing the best solution looks like this:

$$BS = < A, K, I, E_I, M, f >, \quad (4)$$

where $K = \{K_1, K_2, ..., K_n\}$ is the set of criteria for evaluation of alternative solutions; n is the number of criteria;

E_I IS expert assessments characterizing the external environment;

$M = \{M_1, M_2, ..., M_L\}$ is the set of multi-criteria decision-making methods; L is- the number of methods;

f is the function of comparing decision evaluations.

Taking (4) into account, we will formulate the decision-making task of the volunteer team in the conditions of dynamic changes.

Find the best alternative solution:

$$A_i \in A \ (i = \overline{1, m}),$$

taking into account expert assessments E_I alternatives according to the criteria $K_j \in K$ ($j = \overline{1, n}$) according to the conditions of the external environment I, using the method

$$M_s \in M \ (s = \overline{1, L}),$$

which is ordered according to the comparisons function f.

Expert assessments that characterize the external environment can be obtained by interviewing volunteer experts; a set of criteria for evaluating alternative solutions can be found by brainstorming.

The advantage of engaging volunteer experts is the reduction of time to obtain relevant information, the minimization of costs for development and decision-making, the ability to quickly take into account changes in the external environment during decision-making.

Experimental research

During the verification of the proposed model, the problem of transport logistics was set and solved, namely, the delivery of some resources by a team of volunteers from the point of departure to the point of delivery, taking into account the proposed conceptual model of decision support and the model [21].

From the point of departure R_0, in which the member or members of the volunteer team VTM_0 are located, to the point, including the delivery of the cargo R_E there are five alternative routes A_i, $i = \overline{1,5}$ (Fig. 2).

A member / members of the volunteer team VTM_E are present at the cargo delivery point. Each route has a different length L_i, $i = \overline{1,5}$ and split into n sections of length L_{ij} so that $\sum_{j=1}^{n} L_{ij} = L_i$, $i = \overline{1,5}$.

So, the 1st, 2nd and 4th routes are split into 3 sections, the 3rd and 5th routes are split into 4 sections. There are volunteers-observers on the relevant sections of the routes:

$$VTM_{A_{i\_j}}, i = \overline{1,5}, \ j = \overline{1,n},$$

$$\text{where } n = \begin{cases} 3, \text{ for } 1,2,4 \text{ routes} \\ 4, \text{ for } 3,5 \text{ routes} \end{cases}.$$

According to the proposed conceptual model, the work of the volunteer team is coordinated by the coordinator of the volunteer team VTM_{MAIN}, who makes a decision on choosing a route.

At the stage of forming a set of criteria, a survey of members of the volunteer team is conducted to determine the criteria by which alternative routes are evaluated when choosing the best route.

As a result of the survey, the following criteria were determined, which are represented by different types of data:

– The distance between the points of dispatch to the point of need of the resource (criterion C_1) - quantitative type of data.

– Average resource delivery time (criterion C_2) – quantitative data type.

– Road surface quality (criterion C_3) - qualitative data type.

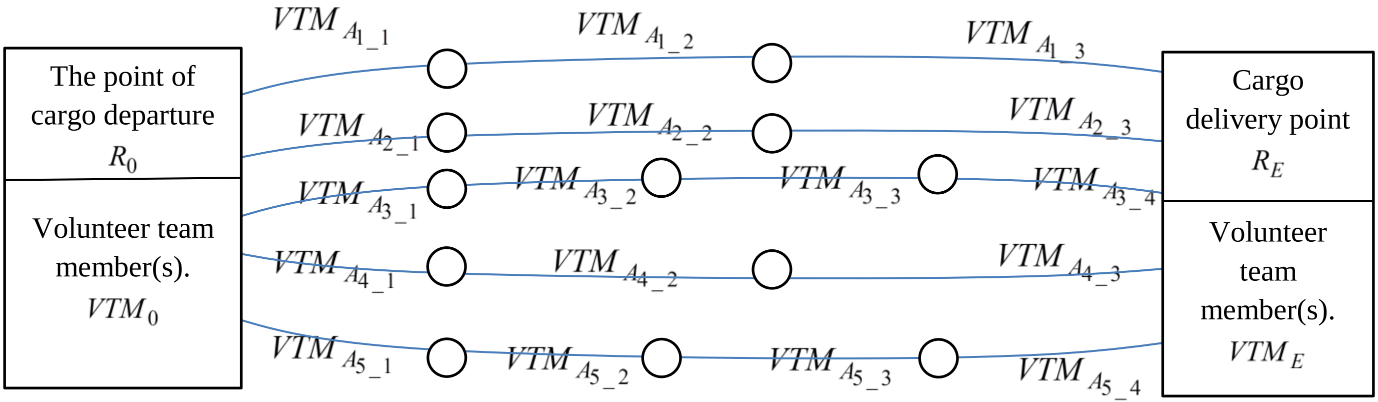

Fig. 2. **A model of decision-making by a team of volunteers regarding the selection of the optimal route for the task of transport logistics**
Source: **compiled by the author**

– The presence of danger (criterion C_4) - relay data type.

– The possibility of refueling (C_5 criterion)- relay data type.

– The possibility of transport vehicle repairing (criterion C_6) – relay data type.

Volunteer team coordinator (VTM_{MAIN}) has information about C_1 and C_2 criteria, so he provides evaluations of alternative routes according to these criteria.

Volunteer experts who are located directly on the sections of the respective routes ($VTM_{A_i\_j}$) have operational information about criteria C_3, C_4, C_5, C_6 and provide evaluations based on these criteria to the coordinator of the volunteer team.

Evaluations of criteria from volunteer experts at different sections for the respective routes are collected in Table 2.

For criterion C_4, it is proposed to calculate the level of danger as the ratio of the number of dangerous sections to the number of all sections on the route. Accordingly, we get the level of danger, which can be presented as follows:

$$\text{danger\_level} - \begin{cases} \geq 66\%, \text{high} \\ 33\% - 65\%, \text{medium} \\ \leq 32\%, \text{low} \end{cases}, \qquad (5)$$

For criterion C_5, the value "available" is selected if there is a possibility of refueling on a larger number of segments. For criterion C_6, the value “available” is also selected if there is a possibility of repairing the transport vehicle on a larger number of sections.

Volunteer team coordinator, who is at the point of resource dispatch, selects the evaluations of criteria C_3, C_4, C_5, C_6, which are obtained from volunteer experts and adds evaluations of alternative routes according to the last criteria C_1 and C_2 (calculated average time of the resource delivery at average constant speed of 90 km/h) to choose the best route. Table 3 presents the evaluations of alternative routes A_i, $i=\overline{1,5}$ according to the criteria C_j, $j=\overline{1,6}$ represented by different types of data for the considered problem.

Thus, the initial data for solving the problem of transport logistics were obtained. Further, to solve the given problem, the multi-criteria decision-making methods AHP, Smart and improved Smart methods were applied.

Table 4 presents the results of calculations using these methods, where the assessment of the best alternative according to the relevant criterion is highlighted in bold.

Based on the data presented in Table 4, we will provide the ranks of alternatives (Table 5). The alternative with the highest value of the generalized assessment of alternatives is assigned rank 1 and so on.

The following ranking of alternatives was obtained:

– $A_4 \succ A_2 \succ A_5 \succ A_1 \succ A_3$ by the AHP method;

– $A_4 \succ A_2 \succ A_5 \succ A_1 \succ A_3$ by the MAHP method;

– $A_4 \succ A_2 \succ A_1 \succ A_3 \succ A_5$ by the improved Smart method;

– $A_1 \succ A_2 \succ A_4 \succ A_5 \succ A_3$ by the Smart method.

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Table 2. **Route evaluation by volunteer experts**

Criteria	Road surface quality (C_3)	The presence of a danger (C_4)	Possibility of refueling (C_5)	Possibility of vehicle repair (C_6)
1st route				
$VTM_{A_{1\_1}}$	good	not available	not available	available
$VTM_{A_{1\_2}}$	good	available	not available	available
$VTM_{A_{1\_3}}$	good	available	not available	available
2nd route				
$VTM_{A_{2\_1}}$	good	not available	available	available
$VTM_{A_{2\_2}}$	normal	not available	available	available
$VTM_{A_{1\_3}}$	normal	available	available	available
3rd route				
$VTM_{A_{3\_1}}$	good	not available	not available	not available
$VTM_{A_{3\_2}}$	normal	not available	not available	not available
$VTM_{A_{3\_3}}$	normal	available	not available	not available
$VTM_{A_{3\_4}}$	normal	available	not available	not available
4th route				
$VTM_{A_{4\_1}}$	good	not available	available	available
$VTM_{A_{4\_2}}$	normal	not available	available	available
$VTM_{A_{4\_3}}$	normal	not available	available	available
5th route				
$VTM_{A_{5\_1}}$	good	not available	not available	not available
$VTM_{A_{5\_2}}$	good	not available	not available	not available
$VTM_{A_{5\_3}}$	good	available	not available	not available
$VTM_{A_{5\_4}}$	good	available	not available	not available

Source: **compiled by the author**

Table 3. **Estimates of alternative routes**

Alternatives	C_1 (km)	C_2 (h)	C_3	C_4	C_5	C_6
A_1	133	1.48	good	high	available	not available
A_2	132	1.47	normal	medium	not available	available
A_3	180.48	2.01	normal	medium	not available	not available
A_4	145.54	1.62	normal	low	available	available
A_5	222.15	2.47	good	medium	not available	not available

Source: **compiled by the author**

Table 4. **Results of calculations using MSDM methods**

Alternatives	AHP	MAHP	Smart	Improved Smart method
A_1	0.183	4.883	**0.652**	1.293
A_2	0.202	4.967	0.607	1.412
A_3	0.129	4.876	0.192	1.098
A_4	**0.291**	**5.377**	0.601	**1.416**
A_5	0.195	4.901	0.345	1.013

Source: **compiled by the author**

Thus, according to the AHP, MAHP and improved Smart method, the fourth route was the best one. The first route was the best according to the Smart method. We believe that the improved Smart method showed the same result as the AHP and MAHP methods, which are most often used to solve problems in the transport sector and provide the most reliable solution.

Taking into account the ranking results of the considered methods (Table 5, columns 1, 2, 3 and 4), the resulting ranking of routes was obtained (Table 5, column 6). To obtain the resulting ranking, a method was applied based on the calculation of the smallest value of the sum of the values of the ranks of the corresponding alternatives [14]. First, the sum of the corresponding rank values for each alternative A_i $(i=\overline{1,5})$ was found, which were assigned to the corresponding alternative after ranking according to the considered methods (Table 5, column 5). Next, a resulting rank of 1 was assigned to the alternative with the smallest value of the sum, and so on in ascending order (Table 5, column 6). As a result, the following resulting routes ranking was obtained:

$A_4 \succ A_2 \succ A_1 \succ A_5 \succ A_3$, that is, the 4th route turned out to be the best.

To obtain a solution, the evaluations of alternatives provided by volunteer experts, who are members of the volunteer team but are not professional experts, were taken into account. Therefore, it is necessary to establish the degree of reliability of decisions obtained on the basis of insider expert assessments based on the calculation of Kendall and Spearman rank correlation coefficients [22]. The closer the value of the Kendall and Spearman correlation coefficients is to 1, the more reliable is the assessment of criteria based on the assessments of insider experts.

The Kendall correlation coefficient is calculated using these three formulas [22]:

$$\tau_{obs} = \frac{P-Q}{\frac{N(N-1)}{2}}, \quad (6)$$

$$\tau_{obs} = 1-\frac{4Q}{N(N-1)}, \quad (7)$$

$$\tau_{obs} = \frac{4P}{N(N-1)}-1, \quad (8)$$

where P is the number of matches; Q is the number of inversions; N is the number of ranked features.

Table 5. **Alternative ranking results**

Alternatives	AHP	MAHP	Smart	Improved Smart method	Sum	The resulting rank
	1	2	3	4	5	6
A_1	4	4	**1**	3	12	3
A_2	2	2	2	2	8	2
A_3	5	5	5	4	19	5
A_4	**1**	**1**	3	**1**	**6**	**1**
A_5	3	3	4	5	15	4

Source: **compiled by the author**

The following values of Kendall's correlation coefficients were obtained when comparing the results of ranking alternatives using the AHP, MAHP, Smart method and the improved method and the resulting ranking (Table 6).

Table 6. **The value of Kendall's correlation coefficients**

Kendall's correlation coefficient	AHP	MAHP	Smart	Improved Smart method
τ_{obs}	0.8	0.8	0.4	0.8

Source: **compiled by the author**

Spearman's correlation coefficient was also calculated using the formula [21]:

$$\rho = 1 - \frac{6\sum_{i=1}^{n}(d_i^2)}{n(n^2-1)}, \qquad (9)$$

where d_i is the difference between ranks for each feature; n is the number of ranked features.

The following values of Spearman's correlation coefficients were obtained when comparing the results of ranking alternatives using the AHP, MAHP, Smart method, the improved Smart method and the resulting ranking (Table 7).

Table 7. **The value of Spearman's correlation coefficients**

Spearman's correlation coefficient	AHP	MAHP	Smart	Improved Smart method
ρ	0.9	0.9	0.6	0.9

Source: **compiled by the author**

The analysis of the obtained values of the Kendall and Spearman correlation coefficients showed that more reliable are the decisions obtained based on the evaluations of the criteria provided by volunteer experts using the AHP, MAHP and improved Smart method.

Analysis of the obtained results

As a result of the study, it was found that during the ranking of alternative routes by the AHP, MAHP and improved Smart method (Table 5), the first rank was assigned to the A_4 alternative, that is, the fourth route turned out to be the best. I.e., the solution according to the improved Smart method coincides with the solution according to the well-known AHP, MAHP methods.

Since the evaluation of the criteria during the solution of the multi-criteria problem of transport logistics in the conditions of dynamic changes in the external environment is performed by volunteer experts, the correlation coefficients of Kendall and Spearman were calculated in the work. The result of the study (Table 6 and Table 7) showed that Kendall's correlation coefficient is 0.8 when comparing the results of ranking alternatives by the AHP, MAHP and improved Smart method, and is 0.4 for the Smart method.

Spearman's correlation coefficient when comparing the results of ranking alternatives using the AHP, MAHP, and improved Smart method was 0.9, and 0.6 for the Smart method. Thus, it was found that AHP, MAHP and the improved Smart method give a more reliable evaluation of criteria based on the evaluations of volunteer experts than the Smart method.

Based on the comparison of multi-criteria selection methods (Table 1) in terms of data input time (number of pairwise comparison matrices), the AHP and MAHP methods are more time-consuming than the Smart methods and the improved Smart method.

It is recommended using of the proposed conceptual decision-making model and the improved Smart method to solve the multi-criteria problem of transport logistics in the conditions of dynamic changes in the external environment, when it is not possible to involve professional experts to evaluate the criteria.

This will make it possible to take into account operational data of various types received from volunteer experts, reduce the decision-making time of the volunteer team coordinator, and also increase the reliability of the decision.

Further research can be directed to the development of a mobile support system for receiving mobile assistance solving the transport logistics problems in operational conditions based on the proposed conceptual model of decision-making and the improved Smart method.

CONCLUSIONS

1. A conceptual model of decision-making support under conditions of dynamic changes was proposed and its verification was carried out for solving the task of choosing the best route in the task of transport logistics for a team of volunteers. The feature of this model is the possibility of involving non-professional experts – volunteer experts, located at different sections of each of the possible (alternative) routes.

2. During the verification of the proposed conceptual model with the application of multi-criteria selection methods (AHP, MAHP, Smart and the improved Smart method) for solving the problem of transport logistics, since volunteer experts are involved in evaluating the criteria, Kendall and Spearman correlation coefficients were calculated to establish a more reliable solution. It turned out that the AHP, MAHP and the improved Smart method showed a more reliable assessment of the criteria, based on which it is possible to conclude about the feasibility of their use when finding a solution to the problem of transport logistics in conditions of dynamic changes in the external environment based on the assessments of non-professional experts. But the AHP and MAHP methods require more data input time than the improved Smart method.

Thus, it is recommended to use the developed conceptual model and the improved Smart method to support the decision-making of a team of volunteers in the conditions of dynamic changes in the external environment when solving transport logistics problems and a number of other volunteer tasks.

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Концептуальна модель підтримки прийняття рішень команди волонтерів в умовах динамічних змін

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АНОТАЦІЯ

В роботі розглянуто проблема підтримки прийняття рішень команди волонтерів в задачах транспортної логістики в умовах динамічних змін зовнішнього середовища. Транспортна логістика представляє собою систему організації доставки вантажу до місця потреби за деяким маршрутом. Задача транспортної логістики, під час динамічних змін зовнішнього середовища є задачею багатокритеріального вибору внаслідок врахування різних критеріїв. Рішення задач транспортної логістики потребує побудови концептуальної моделі підтримки прийняття рішень, щодо вибору найкращого маршруту з урахуванням всіх чинників, які впливають на прийняття рішення та вибору методу прийняття рішення. Проаналізовано методи багатокритеріального вибору, які застосовуються в транспортному секторі. Запропоновано концептуальна модель підтримки прийняття рішень, щодо вибору оптимального маршруту в задачі транспортної логістики. Проведено верифікацію запропонованої моделі, для чого було поставлено та вирішено задачу вибору найкращого маршруту перевезення вантажу в задачі транспортної логістики. При знаходженні рішення було застосовано методи багатокритеріального вибору: Analytic Hierarchy Process method, Multiplicative Analytic Hierarchy Process method, Simple Multi-Attribute Rating Technique method, вдосконалений Simple Multi-Attribute Rating Technique method. Критерії, за якими оцінювалися альтернативні маршрути перевезення вантажу були виявлені на основі опитувань волонтерів. Для оцінки альтернатив за встановленими критеріями було долучено експерти-волонтери, так як під час динамічних змін умов транспортування вантажів долучення експертів-професіоналів є складною задачею. Для встановлення достовірності оцінок альтернатив за критеріями отриманих від експертів-волонтерів було розраховано коефіцієнти кореляція Кендала та Спірмена. Отримано, що методи Analytic Hierarchy Process method, Multiplicative Analytic Hierarchy Process method та вдосконалений Simple Multi-Attribute Rating Technique method надають найбільш достовірні результати, але Analytic Hierarchy Process method та Multiplicative Analytic Hierarchy Process method є більш часозатратними під час введення даних, ніж вдосконалений Simple Multi-Attribute Rating Technique method.

Ключові слова: транспортна логістика; підтримка прийняття рішень; методи багатокритеріального вибору; критерії; альтернативи; коефіцієнт Спірмена; коефіцієнт Кендалла

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