ARCHIVES OF TRANSPORT
Volume 45, Issue 1, 2018

ISSN (print): *0866-9546*
e-ISSN (online): *2300-8830*
DOI: *10.5604/01.3001.0012.0945*

DECISION MAKING SCENARIOS IN MILITARY TRANSPORT PROCESSES

Radosław MILEWSKI[1], Tomasz SMAL[2]

[1, 2] *The general Tadeusz Kosciuszko Military Academy of Land Forces, Faculty of Management, Wroclaw, Poland*

Contact:
1) radoslaw.milewski@awl.edu.pl, 2) tomasz.smal@awl.edu.pl

Abstract:

The dynamics of change in the contemporary world affect all areas including cross-border material flows. On the one hand, globalization has disseminated thought models and patterns of behavior based on decision patterns, thus bringing logistics to the "templates" of efficient logistics. On the other hand, has imposed and forced the need for continuous changes in the optimization of decision-making processes that are adequate to increasingly complex challenges. The main purpose of this article is to introduce the reader to decision making scenarios taken in military transport processes with particular emphasis to logistics and transport costs. This article is an attempt as well at evaluating decision scenarios in transport processes, determined mainly by the cost criterion. The whole of the considerations relates to the security of transports carried out for the purpose of military operations, that is to say, military security, understood as a safe and reliable implementation of a military operation, which must be preceded by the movement of troops into theater operations. The publication uses the experience of "lessons learned", resulting from the actions of Polish military contingents abroad. The conducted studies and analyzes show that it is possible to model transport taking into consideration the cost of specific cargo mass to areas of peacekeeping operations using services provided by carriers operating on the transport market. This kind of approach will lead in the future to changes in the logistics system without the need to spend a great deal on the purchase or hire of transport resources needed to carry out the transport function at the strategic level. As it was proved, logistics processes that take place in an international system require interpersonal cooperation and consequently appropriate relations and a high level of coordination, which change should be determined by the extent of responsibility.

Key words:
transport system, logistics cost, decision making process

To cite this article:

MILEWSKI, R., SMAL, T., 2018. Decision making scenarios in military transport processes. Archives of Transport, 45(1), 65-81. DOI: https://doi.org/10.5604/01.3001.0012.0945

1. Introduction

The dynamics of change in the contemporary world affect all areas of life. These changes are occurring in many areas directly or indirectly related to cross-border material flows and, on the other hand, has imposed and forced the need for continuous changes in the optimization of decision-making processes that are adequate to increasingly complex challenges (Jacyna-Gołda, 2015).

Decision making process, decision-making games or game theory, all contains in theory and practice of decision situations as a specific arrangement of tools (guidelines) for rationalizing and optimizing the expected effect. In many cases (crisis operations, military operations, training, educational etc.) the decision-making games are being used in order to focus on assist decision-making process at each stage of a prepared decision (Jacyna -Gołda, 2015). The instrument to do so might be, among others, computer simulation systems, which are effective tools designed to support the decision in modern training centers, military command and staff, public administration as well as many other. Properly constructed, programmed and correctly used decision models are an expression of intellectual dominance over a potential opponent (Semin and others, 2016).

The main purpose of this article is to introduce the reader to decision making scenarios taken in military transport processes with particular emphasis to logistics and transport costs.

2. Identification and optimization of logistics costs

Logistics, as core function of an organization is tasked to optimize the system of goods and information flow not only within the subject but also throughout the supply chain (in macro terms also in networks). All processes connected with goods-information flows, which are: planning, implementation and monitoring, are in interest of logistics. Any tasks accomplished within whole logistics system as well as each of its subsystems generate costs, which are called logistic costs.

Including the cost of operation of logistics system allows to view the complexity of its forming in the whole chain of delivery as well as in single link of the delivery chain. Costs of logistics in an enterprise indirectly contribute to the assessment of the effectiveness of modern logistics management methods, understood as the management of all related activities of the flow of materials, goods and services from the source of supply to the user (consumer) to improve the operation of the system as a whole. In other words, the idea of logistics management is planning, integrating, coordinating and control in the logistics field so that the recipient would be supplied in an optimal, cost effective way. Often, however, the separation of logistics costs from other costs is extremely difficult due to the excessive level of coherence of processes that are "entangled" in the administrative and organizational procedures (this hinders the clarity of the logistics costs of the organization). The reason can also be too complex structure of logistics costs.

The Accounting Bill defines cost as probable reduce economic benefits of reliably defined value during the reporting period. In the form of a decrease in the value of assets or an increase in the value of liabilities and provisions that will lead to a decrease in equity or an increase in its deficit other than the withdrawal of funds by shareholders or owners. Many authors point to different sources and types of costs, which are manifested mainly in defining concepts, interpreting the essence, scope, structure, and valuing of particular elements of logistics costs.

Lack of full agreement in defining the essence and scope relates especially to costs of logistics, logistics management, logistics, logistics transformation, flows and costs of goods and information circulation, freight flows, supply chain. This is primarily due to omitting the differences between the two. The cost is also called the value-added consumption of the company's asset resources borne to achieve a particular effect (product, service, etc.). The concept of costs can be extended to the so-called costs of lost profits, which represent a hypothetical amount of alternative opportunities for action to be taken into account in the assessment and the choice of action. They may be: lost (unrealized revenue), unrealized (possible) result (profit) as well as cost difference.

Optimization is one of the activities of system analysis directed at the arrangement of variables (analysis area), whose task is to obtain the most advantageous results under certain (fixed) structure and parameters of the system under consideration (Lopez, Monzon, 2010). There are many classifications of analyzes, for example due to the number of variables and parameters (optimization range) can be distinguished: one-dimensional analysis (one-parameter analysis) and multifaceted analysis (taking into account several process parameters). In addition, a multi-faceted analysis is distinguished (With a large number of variables) and multivariate analysis (with the so-called conflict aspect) (Milewski and Smal, 2015).

The systematic approach and recognition of logistics cost structure is critical for decision-making across the logistics system. The detailed definition of the level and structure of costs and expenditures on the implementation of logistic functions and processes leads to a correct logistical efficiency calculation and the methods of its improvement. Systemic analysis of inputs and costs for carrying out a number of logistic tasks (functions) provides the opportunity to achieve not only higher profits but also the so-called synergistic effects or conjugated effects as a result of the interaction of individual companies, phases of activities and processes in the sphere of logistics.

3. System analysis in decision making process

The issue of decision-making lies in the broader context of the systemic analysis, which are methods and methods of description and analysis and synthesis of systems with high saturation variables. The system term itself, though directly linked to the general theory of systems, has not always been clearly distinguished[1]. Nicholas of Kuza introduced the concept of *"coincidentia oppositorum*", which deals with the opposite between the parts of the whole that form a higher order unity (Kurt, 1973).

According to the view that the system is a generic model, it can be stated that the use of analog models or structures is a method commonly used in science, also in cognitive processes (Bertalanffy, 1976). In Mesarovič's approach, based on axioms, general systems are treated and understood as any relation on a group of abstract sets having input and output parameter (Mesarovič, 2017). The system can be determined as internally coordinated (due to a specific function and showing a specific structure) collection of elements.

When approaching the problem of functioning of a particular logistic system, it should be stated that an approach will be characterized by an analytic-synthetic dichotomy, where the analysis will be closer to the process taking place within the system, and the holistic synthesis of the whole problem and macroscopic connections (both upper- and super-systemic). Analyzed and researched subsystem will not only characterize existing real objects but logical relationships and associations. In the definition of the system it is very important to give its function, because the set of elements itself is not yet a system, but an intra-system link already does. System elements are interrelated, their relationships and functions are precisely defined.

In the present context, the directive (deductive) statement states that multi-faceted turbulence contributes to increased decision uncertainty, while at the same time necessitating the optimization of decision-making processes in the area of effectiveness based on the probability within theory of games. More details on the base of case study were described in the article (Janasz and Smal, 2013).

4. Systematic approach to logistic and transport costs

The key importance for decision processes across the logistics system has the systematic approach and recognition of the cost structure. Searching for and analyzing corporate logistics costs is a consequence of an analysis of the overall functioning of an organization (Majka, 2014). The scale of the problem is illustrated in the Figure 1, which shows the costs and transportation time of a 20 Foot container from Mombasa to Nairobi (Kenya).

In the systemic current, in line with Bertalanffy's or Klir's concept, systemic analysis distinguishes such stages as: identification, shaping the system and probable implementation of changes (modifications). One of the identification phases is the classification of subsystems and their processes and the hierarchical structuring together with the separation of components and system interactions (correlation). Systemic approach to organization determines the systemic recognition of costs occurring in individual subsystems. After identifying (naming) subsystems it is possible to analyze the physical consumption of their components and the monetary expression of expenditures on their functioning, which is extremely important from the point of view of business activity and the possibility of making accounting entries, records or statistical presentations. The detailed definition of the level and structure of costs

[1] Initially subordinated to the hierarchical order introduced by the Christian mystic Dionysius Aeropagit.

and expenditures on the implementation of logistic functions and processes leads to a proper assessment of the effectiveness of logistics and the ways in which it might be improved.
The systemic analysis of the inputs and costs incurred for carrying out a number of logistic tasks (functions) makes it possible to achieve not only economic benefits, but also the so-called synergistic effects or conjugated effects as a result of the interaction of individual entities, phases of activities and processes in the sphere of logistics. From a systemic point of view, it is important to optimize the organization's activities. One can therefore try to measure system efficiency with cost. Additionally, attempts to optimize business activities by reducing costs in individual functional divisions often end up with a different result from the intended one. Each of the logistics cost components presented is similarly sensitive to changes in other components. Cost reduction in one logistic subsystem can cause cost increases in another logistics subsystem. Finding the lowest cost carrier often leads to an increase in storage costs, which can result in an increase in total (global) cost. There is a conflict of cost objectives (cost dichotomy problem). Therefore, while optimizing the logistics system of the organization, the attention should be also paid to logistics costs by looking at it through the prism of the system and general costs.
Logistics costs are systemic costs, resulting from functional logistic subsystems. Logistics costs include also costs direct related with system costs. These are service level costs (e.g. costs of lost orders, costs of complaints) and costs of batches of goods (e.g. parts of costs of procurement, costs of change). According to Blaik, the cost of logistics in an enterprise is the sum of the costs associated with the individual logistical functions performed. This represents the Blaik's mathematical formula:

$$LC = FMC + PSC + SC + TC + SFC + \\ + PPC + IFC + SC + IC \tag{1}$$

where: LC – logistic costs, FMC – flow management cost, PSC – logistics planning and directing the program and production structure cost, SC – storage cost, TC – transport costs, SFC – supply forming cost, PPC – product preparation cost, IFC – information flow cost, PPC – product preparation cost, SC – service cost, IC - incapacity cost.

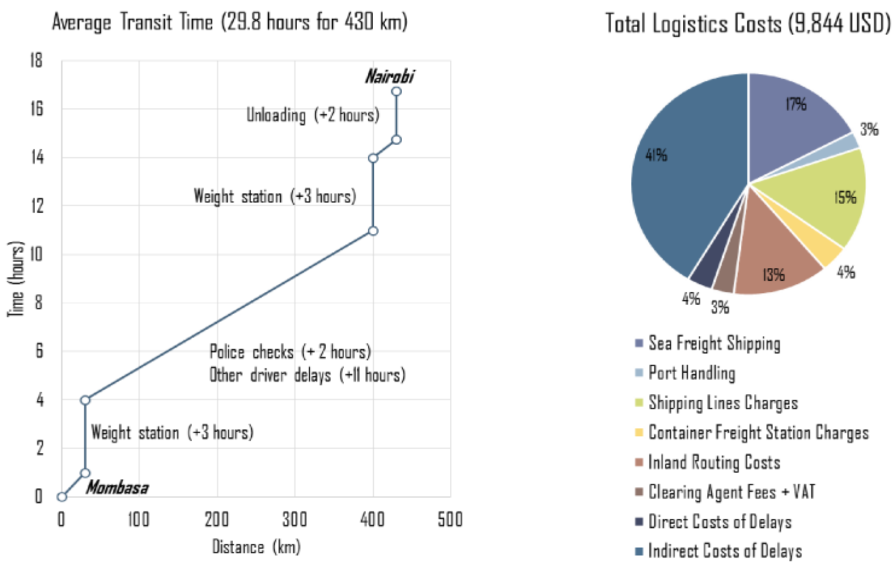

Fig. 1. Logistics Costs and Average Transit Time of a 20 Foot Container, Mombasa – Nairobi (CPCS Transcom, 2010)

Duck, Krause and Schulte make a simplified cost breakdown in logistics by distinguishing three types of logistics costs (Duck, Krause and Shulte, 2001): material costs - supplies, material costs, and costs of all departments within the material management.
From the point of view of this basic analysis (proposed by the authors) the division is: the costs of the type resulting from the transport function, the costs of auxiliary processes and the cost of losses (*vis maior*).
The largest share of the logistics cost structure (especially in the analyzed case) is the generally recognized transport costs. There are many transport cost divisions, and the most popular is the Twarog split: global transport costs (GTC), internal transport costs (ITC), external transport costs (EXT) and transport handling costs (THC).
The main factors that have a significant impact on the transport costs can be the transport sector, the mode of transport, the quality of the road, the distance to be traveled, the type of cargo, the size of the lot. Transportation costs include the involvement of all resources necessary to carry out transport tasks within and outside the enterprise. This involves engaging in the preparation and readiness to carry out transport tasks, i.e. investments in infrastructure and support systems for transport, transport planning and execution, use of external transport and auxiliary services.
The specific categories of transport costs result from the need to include:

- Preparation of means of transport and readiness for transport, (hanged contracts, costs of preparedness);
- Check of vehicle performance, installation of specialized equipment (maintenance costs in maintaining ready to use state), etc.;
- Feeder costs (cost of drive to lading destination);
- Stopovers - waiting for loading or unloading (waiting costs);
- Loading and unloading operations (transport costs of auxiliary processes);
- Empty return to the starting point of the route (the cost of the empty semi-pendulum);
- Enforced stoppages resulting from transport regulations (extraordinary costs and costs arising from *vis maior*).

In practice, the actual impact is: the number of orders (needs of customers in the cargo *pull* system), the number of deliveries (in logistic NATO networks it is a multiplication of charters) or the number of admissions (handling costs).
Transport costs can be expressed as follows:

$$\begin{aligned} TC = DVC + DWC + MFEC + OC + \\ +IC + RMC + LC + OTBC + OTC \end{aligned} \quad (2)$$

where: TC – transport cost, DVC - depreciation of vehicles and building of vehicle buy cost, DWC - work of drivers (pilots) and transport service with overheads cost, MFEC - materials, fuels and energy consumption associated with the use of cars cost, OC – office cost, IC – insurance cost, RMC - repairs and maintenance of means of transport cost, LC – lease cost, OTBC – other omitted costs of so called transport base, OTC – outsourced transport costs.

Transportation costs do not consist solely of fuel costs, driver's compensation (pilots, service) and depreciation of transport. These also include:

- The cost of adapting the means of transport for the carriage of cargo with special transport requirements, e.g. the installation of refrigerators on vehicles, the cost of renting / buying a trailer for transporting propellants, adapting the encapsulated space;
- Repair costs of means of transport;
- Costs of periodic reviews;
- Costs related to tolls for motorways, bridges, tunnels, airport charges, diplomatic consents, administrative fees;
- Costs of natural defects in loads that may result from long routes or during accidents or road accidents;
- The costs of unplanned stops due to random events (forced landing), difficult or even impossible to predict.

In addition, the record of internal and external cost must be kept. The unit of calculation can be a kilometer, a vehicle kilometers traveled or an hour.

5. Problem situation and decision problem

The decision-making situation (problem situation) is the starting point for the decision. Thus, the source of the decision-making process is the perceived decision-making situation and the decision-making background that has arisen on it. The decision situation refers to the functioning of an organization or any part thereof at a given moment or time (Flakiewicz, Wawrzyniak, 1978).

The problematic situation (decision situation) is a situation that includes the elements of difficulty, uncertainty, ambiguity, insufficiency of information, conflict, needs and aspirations, necessity of selection etc. (Bolesta-Kukułka, 2003). The emergence of a problematic situation that prompts to do something about it is reflected in the formulation of the problem to be solved (Tyszka, Zaleśkiewicz, 2001). Decision-making situation is a conscious lack of knowledge, which can be expressed in the form of a question or set of questions for which answers are sought, because it is unknown and one wants to know what one wants or need, whether for purely cognitive or practical reasons. Where a difficulty or barrier is encountered, if the way of overcoming it is known to us, there is no problem. The emergence of a problem situation raises the need to formulate question / questions about the reasons for its occurrence and the possibility of overcoming it. A problematic (decision-making) situation transformed into a question or a set of questions becomes a problem, the solution of which is to find the right answer and take actions aimed at overcoming the difficulties (Bolesta-Kukułka, 2003).

The decision problem can be defined as the deviation between the desired state (what should be) and the actual state (what is in reality). This deviation should be related to two cases: the deviation that actually occurred (exists), and the deviation that is expected to occur (in the future). In the first case, when the deviation is judged to be favorable, it should be maintained or sought to be simulated, but when it is judged to be unfavorable, it should be eliminated or at least minimized. In the second case where a positive deviation is expected, it is desirable to create conditions conducive to its production, and when a negative deviation is expected, try to prevent (block) its occurrence (Flakiewicz, Wawrzyniak, 1978).

Making a decision means settling a decision-making problem. The basis for the decision is a collection of information characterizing the decision problem. Therefore, in order to solve the problem, it is necessary to recognize and evaluate the decision problem. In order to properly formulate a decision problem, it is necessary to consider it from different angles. The factors that make it possible to characterize the problem include, among others: object, degree of structuration, extent, degree of complexity, place of occurrence, frequency of occurrence, and importance to the efficiency of a given system.

The manager (executive, leader) who chooses the solution is called the decision maker, and the decision maker is the entity that chooses the alternative (a solution to a specific problem) and assumes responsibility for the choice. If we assume that the decision maker bears the consequences of his choices, there are "material and moral incentives" that cause him to become interested in accepting that alternative that is consistent with his goals. Otherwise, this decision could be accidental (Kozielecki, 1977).

6. Turbulent factors in a decision-making process

The method of rolling horizon planning is one way of coping with uncertainty in decision-making processes. The essence is based on periodic planning in the planning horizon, assuming that pre-prepared plans can be changed as a result of unexpected changes (Hanczar, 2013, p. 74).Turbulent factors include those that affect material flow control in the new economic, political or climate-sensitive areas, as well as the dangers of migration from external and internal armed conflicts. In such a situation, it is assumed that the development of an action plan for several future periods will be backed up by the optimum decision for the closest period, so that even though decisions are taken within the planning horizon, the plan itself is only implemented for the immediate period. In subsequent periods the values of the planning parameters are updated and the plan is re-developed for the entire horizon. It is additionally extended by the parameters determining the permissible values of their changes in the sequentially devised plans (Figure 2)

The added value of such a solution is to limit the potential for changes in subsequent changes to a suitably balanced resource load, which has one drawback of reducing flexibility. The rolling planning was explicitly formulated by Baker (Baker, 1977, p. 19-27) and preceded by observations in the area of production planning in the finite horizon of planning developed by Holt and Modigliani (Holt, and others, 1960). Use of the above in decision-making processes in the areas of displacement (i.e. mainly transport and material) for military solutions seems reasonable. First, forecasts for the distant future as a rule, they seem to be unreliable and therefore their

usefulness is limited. Second, the practical side of the development of supply plans is based on limited information on the future.
To sum up the essence in such activities play all kinds of simulations in efficiency areas, based on the optimization of logistics processes, which is primarily related to the aim of minimizing total costs in the implementation of the goals.

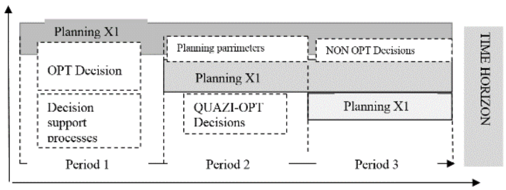

Fig. 2. Decision processes in rolling horizon planning

In the decision-making process, there is a problem of rationality (sense) of its taking. It is considered that rationality in the point of view of decision-making is based on the choice of a variant whose implementation leads to the intended goal, and the decision transformed into action is in line with reality and with the laws governing it and the conditions of action (Figure 3). Such a process encounters a number of barriers, including information, resource, personnel, competence, social, organizational, bureaucratic and competitive barriers (Zak, and others, 2012).

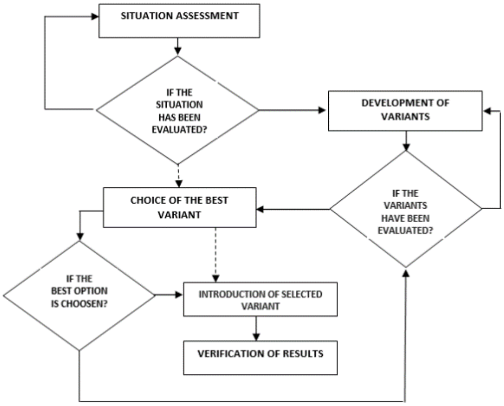

Fig. 3. Simplified algorithm of decision-making

In the decision-making process, there is often a problem of difficulty resulting from exceptional circumstances (new variables - variables). Perhaps the best decision in this situation is to delay the selection (not always possible). There is even a saying in an Anglo-Saxon culture: *take a counsel from your pillow.*

7. Decision in the process of military transport in uncertain conditions

Making decisions under uncertainty of some factors is characterized by the fact that actions that one need to be selected from may lead to different (unforeseen) consequences and the decision maker does not know what will happen. Uncertainty is related to the occurrence of so-called states of things (states of nature) that cannot be predicted and which are independent of the decision maker (Foltin and others, 2015). Weather conditions (temperature, precipitation, natural disasters, etc.), economic changes, technological breakthroughs or new types of fashion can be counted among the things that are unpredictable (Izdebski, 2014). A special class of states of nature are the strategies of competition. Taking into account the state of affairs in decision theory, decision making under uncertainty refers to (Grzesik, Karaś, 2014, p. 89):
– playing with nature;
– play with a competitor (here not analyzed).
The analyzes carried out at the University of Louvain (Figure 4) show a drastic increase in natural factors, which, as a consequence of these considerations, may mean an increase in the involvement of humanitarian aid providers in disasters. It is advisable to approach this type of research with caution, especially if it covers a period of about a hundred years and it not entirely known how effective measuring tools were then and what criteria defined the concept of natural disaster.
However, this does not change the fact that such "conditions of nature" are in the group of turbulent factors, which are the criteria for decisions. Developed (based on such and other criteria) decisions are preceded by tedious scenario analysis (for specific variants). Also, economic (including cost) factors are part of "decision constraints", and decision-making based on such criteria can be characterized by "playing with nature".

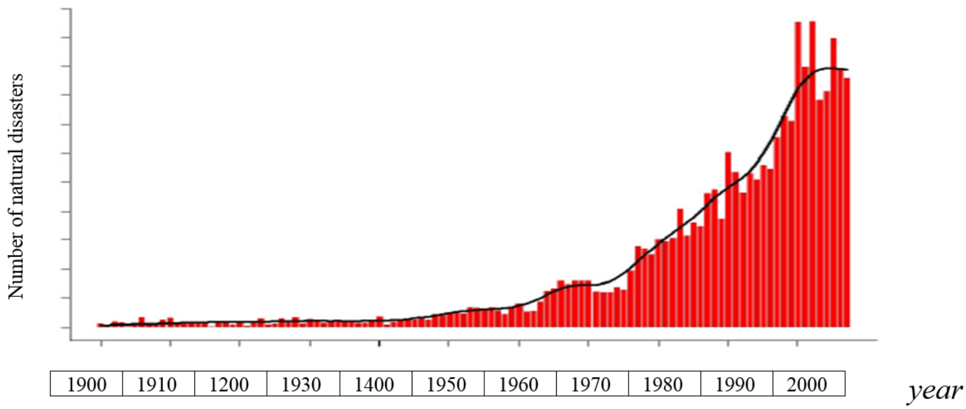

Fig. 4. Number of natural disasters noted in years 1900-2007 (Universite Catholique de Louvain)

Within the above games, the decision maker chooses between the adopted strategies of action (options). In the case of a decision on nature, the basic premise is that the state of nature that will occur will be independent of the manager's choice of strategy (option). In the case of nature games, the decision maker draws up a matrix for specific "pairs of own strategies" and "states of nature" (Bolesta-Kukuła, 2003, p. 224).

To decision-making under uncertainty applies decisive rules based on Wald"s -pessimism, Hurwicz's optimism, Savage's least proficiency, or the criterion of "lack of sufficient reason" (called Laplace's rule)

According to the Wald's criterion, the decision maker should behave as if nature was always malicious, so the decision maker should be pessimistic. This means that the decision maker should assume that regardless of which strategy he chooses, he will always experience the state that will bring him the worst result. According to this criterion, it is necessary to determine the minimum benefits for each strategy and choose the strategy for which the minimum benefit is greatest. Therefore, the decision maker chooses "the best advantage from the worst ", so either maximizing minimum profits or minimizing maximum costs (Tyszka, 2010, p. 332-339).

According to the Hurwicz criterion, the decision maker behaves like an optimist, meaning he is guided by the belief that no matter which strategy he chooses, he will always show the most favorable condition that will bring him the best possible result. According to this criterion the decision maker should choose the best decision from the best (or maximizing the maximum profit or minimizing the minimum cost). The decision maker does not have to be the extreme optimist, but can determine his or her individual optimism for the situation, and then maximize the weighted sum of the two components: the smallest and greatest utility.

According to the Savage criterion, the decision maker analyzing decision problems is driven not by the category of profit (or loss) but by the "category of grief" (disappointment, dissatisfaction). The decision maker draws attention to how he feels when the decision is made and the result is achieved. To this end, the decision maker determines for each strategy of action and state the possible loss that is the difference between the highest payout obtainable at the state of affairs and the result obtained in that state at the chosen strategy of action. This size is referred to as loss for lost profit. This results in a matrix of lost benefits that Savage proposes to apply the Wald's criterion.

According to the Laplace criterion, based on the principle of insufficient reason, if the decision maker does not know the probability of distribution on a set of states of affairs, he should assume that they are equally probable. This principle is based on the assumption made by Bayes that if we have no reason to believe that there is a difference between the probabilities of different states, then we can assume that each with mutually exclusive states it may occur with the same probability. With this assumption, the criterion of maximizing the expected value or utility can be used as the selection criterion.

Using real historical data (Table 4), a cost sample can be attempted for specific scenarios. Transport scenarios were considered, grouped according to the category of initiative (two of them are international and one is based on own resources). Based on analysis (according to specific theories) it was stated that using the Pessimism criterion (Wald's criterion), we should choose the S3 strategy, setting a low cost (Table 1).

Table 1. Scenario matrix (for the Wald criterion)

Program / initiative	Strategy of action	Cost structure (million USD)		
		Base cost	**Situation improvement**	**Situation deterioration**
S1 SALIS[2]	High cost	7,5	**6,2**	**8,9**
S2 SAC[3]	Medium cost	3,36	**2,1**	**5,5**
S3 Own resources	Low cost	1,08	**0,8**	**3,1**

Source: own elaboration based on data from Transportation and Movement Command – Coordination Centre of Movement on the Theatre

Within existing initiatives. This decision is due to the designation of the worst strategy for each strategy and the choice of the strategy that sets the best of the worst in the discussed example, $ 3.1 million. With historical data however, ex post analyzes show that such a criterion does not take into account the technical characteristics of the goods being transported and therefore does not determine the necessity to adapt the means of transport complying with the cargo hold criteria.
Using the criterion of optimism (Hurwicz criterion), assuming total optimism, S_1 strategy should be chosen as a low cost (Table 2) within existing initiatives. This decision is based on the designation of the best strategy for each strategy and the choice of the strategy that determines the best result (decision of extreme optimism), in the example discussed 0.8 million USD.
The results of the analyzes indicate that (as in the first case for the Wald's' criterion), the best scenario appears to be the S3 scenario based on the use of own resources.

A similar result is obtained assuming that the decision maker is not an extreme optimist, which is preceded by the necessity of determining the optimism factor - **Iopt**[4].

Table 2. Scenario matrix (for the Hurwicz criterion)

Program / initiative	Strategy of action	Cost structure (million USD)		
		Base cost	**Situation improvement**	**Situation deterioration**
S1 SALIS	High cost	7,5	**6,2**	**8,9**
S2 SAC	Medium cost	3,36	**2,1**	**5,5**
S3 Own resources	Low cost	1,08	**0,8**	**3,1**

Source: own elaboration based on data from Transportation and Movement Command – Coordination Centre of Movement on the Theatre

The optimism coefficient is determined by the "lottery" between the highest and the lowest cost. Based on this factor, the probability of the lowest cost is determined, at which the decision-maker is willing to "participate in the lottery". This probability is the coefficient of optimism of the decision maker. In the analyzed example the coefficient of optimism was defined as 0.4. After analysis, choose strategy S3.

Table 3. Calculation of expected benefits

Strategy of action	Expected benefits with optimistic coefficient – **Iopt**
S1	(6,2 x 0,4) + (8,9 x 0,6) = 2,48 = 5,34 = 7,82
S2	(2,1 x 0,4) + (5,5 x 0,6) = 0,84 + 3,3 = 4,14
S3	**(0,8 x 0,4) + (3,1 x 0,6) = 0,32 + 1,86 = 2,18**

Source: own elaboration based on data from Transportation and Movement Command – Coordination Centre of Movement on the Theatre

Using the Laplace criterion, the probability (0.33) of the occurrence of the state of nature (cost level) of the analyzed initiatives was the same. Using the assumed probability value, the expected values for the

[2] SALIS - Strategic Airlift Interim Solution.
[3] SAC - Strategic Air Lift Capability.
[4] Iopt – Coefficient of optimism (symbol given by the author for calculation purposes).

individual strategies were calculated, which is the mathematical calculation of Laplace's matrix:

OW (S1) = 7,5 x 0,33 + 6,2 x 0,33 + 8,9 x 0,33 = 7,46

OW (S2) = 3,36 x 0,33 + 2,1 x 0,33 + 5,5 x 0,33 = 3,61

OW (S3) = 1,08 x 033 + 0,8 x 0,33 + 3,1 x 0,33 = **1,64**

According to the principle of maximizing the expected value (here the minimization of costs as a decision optimization), choose strategy S3, which gives the lowest value - the expected value.

It is clear from the analysis above that some of the scientific criteria for profit / loss analysis treat "literally" the cost of making a decision for a particular scenario and do not take into account the other system criteria (technical parameters, availability of resources, other variables generating costs). Decision-making, as the analysis suggests, is a complex process that should take into account all possible (including uncertain) factors. The case study based on the analysis of the case study indicates a completely different choice of scenario variant, taking into account also the external criteria.

8. Decision making process determined by the cost criterion

8.1. General description

Utilizing our own (national) air transport capabilities, assuming maintenance of existing organizational arrangements for acquisition and to maintain international air transport agreements, an attempt can be made to estimate the number of potentially available means of transport and to distribute the assumed gross mass for each means within existing programs and initiatives (Table 4).

From the results presented in the table, it is necessary to use 325 tons of cargo available in national and foreign resources in these quantities (or repetitive flights) and to use available international agreements in the form of programs and transitional initiatives. The total (mass) mass of ΣTm consists of the mass of the arms and equipment carried ΣMilE (Military Equipment) and the means of combat (ammunition, explosives) and material (food, clothing, fuel) ΣMOWaM (Material Resources).

Table 4. Components of the decision model by cost criterion (variant I)

Logistics criteria – 3250 tones gross					
Available programs / initiatives	Unit capacity	Target mass (t)	Number of flights	Availability of means of transport	Cost (million USD)
Own resources	17,5(12)[5]	650	50+10(54)	C-130 + CASA 295	1,08
SALIS	120(80)	2000	17(25)	An-124-100	7,50
SAC	76,7(50)	600	8(12)	C-17	3,36
TOTAL		**3250**	**91**		**12,66**

Assuming 3250 tons of transport in the assumed model, it is possible to make the initial mass differentiation on the military equipment in the quantity resulting from the structures (52 pieces) and the unit mass of the IFV Rosomak (= 25 t). There are medical vehicles (MEV) with a mass close to KTO mass in the structure of transported equipment.

If summed up:

1) Σ Tm (t) = Σ MilE + Σ MOWaM;
2) Σ MilE (t) = 52 (IFV Rosomak + MEV) * 25 t(avg. mass) = 1300 tons;
3) Σ MOWaM0 (t) = Σ Cargo (according to supply categories.) = 1950 tons.

Therefore:

4) Σ Tm (t) = [52 (IFV Rosomak + MEV) * 25 t(avg. mass)] + [Σ Cargo (according to supply categories)] = 3250 tons.

As a result of own research and analysis, a concept based on changed assumptions has been worked out to develop a cost model. In variant II, the type of measures was changed, excluding AN-124 and other weight distribution (Table 5).

As a result of the preliminary analyzes, the transport cost of change in mass was reduced by about 20%, which indicates that the transport management model, taking into account the wider use of charter (according to the outsourcing concept), reduces transport costs to mission areas.

Another suggestion is to not use the set number of hours for SALIS units. The analysis (Figure 5) shows that the utilization rate oscillates around 71%. The idea behind the program is that it is possible to resell the time to another sender, however, it is not specified what if there is no willing operator.

[5] In parentheses, the actual average weight of the carried load (based on own tests).

Table 5. Components of the decision-making model according to the cost criterion for the development of the air shipment (Option II)

Logistics criteria – 3250 tones gross							
Available programs / initia-tives			Unit capacity	Target mass (t)	Number of flights	Availability of means of transport	Cost (million USD)
Own resources			17,5(12)[6]	650	50+10(54)	C-130 + CASA 295	1,08
CHARTER[7]			90(60)	1300	15(22)	IŁ-76	4,40
AIR BRIDGE	ACSA[8]	USA	76,7(50)	600	8(12)	C-17	3,36
SAC		PAPA[9]	76,7(50)	700	10(14)		3,92
TOTAL				**3250**			**10,48**

Source: own elaboration

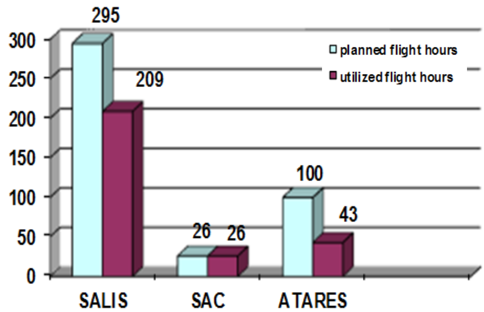

Fig. 5. Number of hours (planned and utilized) in 2010 for air transport, taking into account the breakdown into individual programs (initiatives)

Further analysis shows that the costs in the next audited year (2010) decreased slightly by only 3.43 million PLN, which indicates that there was no response to the cost analyzes prepared in 2009. The effectiveness of further use of the SALIS program in the stabilized "Afghan model" " can be qualified for typical areas of logistics waste. This situation shows that cost analysis is performed with too much delay that does not allow to react, or worse yet, may lead to a situation of neglecting even the estimated results of the previous year's survey (Figure 6).

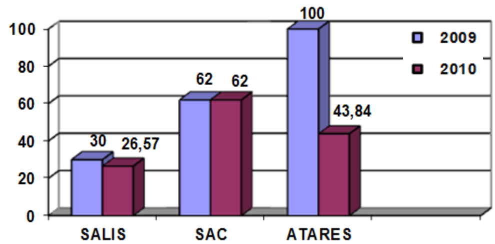

Fig. 6. The cost (in millions PLN) of using air transport programs in 2009-2010[10]

Based on analyzes of source materials and interviews with specialists, the assumptions of the railway-road option have not been established. However, by analyzing the railway infrastructure in transit countries, the development of the railway connection through Ukraine, Kazakhstan (where the main means of transport is the railway, which carries 79% of cargo and 56% of passengers), Uzbekistan[11] and Tajikistan is a matter of time assuming the target of connecting Europe with China by land. It is worth mentioning that in October 2004, an agreement was signed between the American Weidlinger Associates and the Uzautoil concern on the joint construction of the railway line 80 km from Termez to Mazar-i-Sharif (Afghanistan). The cost of the project is 210 mln USD about the rationalization of

[6] In parentheses, the actual average weight of the carried load (based on own tests) is given.
[7] The cost of one flight hour estimated at 20 thousand. USD according to Panalpina company data.
[8] Aquisition & Cross Servicing Agreement.
[9] PAPA - Military base (Hungary).
[10] For ATARES, the cost is a replaceable parameter (calculated in flight hours).
[11] As part of the construction of new rail links, Uzbekistan participates in the construction of the route connecting Andijan, Osh (Kyrgyzstan), Irkutsk and Kashgar (China). This route will run farther from Bukhara through Turkmenistan to Tehran and Karachi, enabling it to reach the Indian Ocean. The connection across several countries would make it much easier to carry loads (Naruniec, Borko and Gębski, 2005).

transport processes before full technical and organizational integration of the intermodal transport network and the establishment of a Logistics Coordination Center (LCC) at the transnational level.

8.2. Simulation variant no. 1

Considering the transport system that moves the national military components to distant operational regions (2008-2013), based on the SALIS and AMSCC programs, it is possible to try to analyze alternatives based on competitors competing against those offering transport services at costs below so far offered. Based on such analyzes it is possible to build conceptual models, taking into account the multivariate nature of the offers and the cost criterion.

Considering the diversification of suppliers, Table 6 shows the sample transport costs of the selected assortment to the area of operation. As shown in Table 7, the frequency of services offered allows for adjusting the time of shipments and does not determine the need for fast consolidation of cargo (as is the case with service-based services on SALIS).

Table 6. Sample inventory assortment with transport cost (Afghanistan)

No.	Type (quantity)	Mass	No. of packages	Type of carrier	Bar code
1.	Stock X	370 kg	2	Euro palette	/UN 1170/
2.	Stock Y	390 kg	6	Euro palette	/UN 1203/
3.	Stock Z	20 kg	1	Cardboard packaging	/UN 1950/
4.	Stock W	25 kg	1	Cardboard packaging	/UN 1263/
Total		805 kg	10		
Total cost of transport (in Euro: 3,483)[12]/ Total transport time: 8-12 days					

Source: based on data from Panalpina Military Defence

Figure 7 shows a one-way displacement model with the use of loading ports (APoE) in Europe (Luxemburg), which are also an intermediate consolidation base. The port of landing (APoD) in Bagram is at the same time a cargo distribution center at the theater of operations and is the outlet of the theater (O1, O2, ..., On). The scheme includes the possibility of consolidating cargo in the territory of the country where it is delivered by means of transports: road and rail (operational[13]).

Table 7. Multimodal solution for Panalpina (Afghanistan)

Route	Means of transport	Carrier	Occurrence
Opole - Luxemburg	Road	Panalpina truck service	Every Tuesday and Saturday
Luxemburg - Dubai	Air	Panalpina Atlas flight service B-747	Every Monday, Wednesday And Friday
Dubai - Sharjah	Road	Panalpina truck service	Every Tuesday and Saturday
Sharjah - Bagram	Air	Panalpina flight service IL-76	Every Monday, Wednesday And Friday

Source: based on data from Panalpina Military Defence

The weak link of the whole is the need for Dubai-Sharjah transshipment and road transport. This is an additional link in the transport chain, which omission is impossible (due to distance). Therefore, it is necessary to designate (as a forward-looking target solution) a site that will optimize the multimodal transport situation on a macro scale by location. An important role is seen in the logistics coordination problem, taking into account network planning methods.

8.3. Simulation variant no. 2

Variant 2 shows the possibilities of multimodal transport using two intermediate points (point system infrastructure) in Europe. Figure 8 graphically shows the displacement for Option 2 on the route: Opole - Frankfurt - Amsterdam - Sharjah - Bagram. Estimated total transport time is 7-10 days and total cost of cargo (resulting from cost analysis) - 4,146,30 Euro (Table 8).

[12] Net costs / export outside the EU - VAT = 0, i.e. to Afghanistan net price = gross price; On the route Opole - Bagram adopted the standard carrier / non-cargo insurance /

[13] Operational transport, understood as any rail transport, the gross weight of which is greater than 800 tons or that carried out within the ITT (individual timetables).

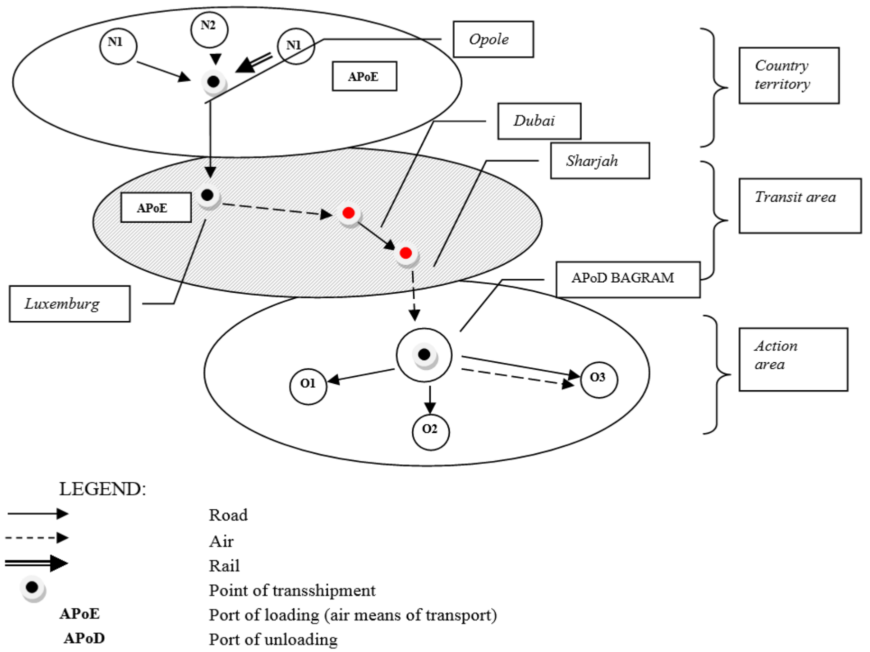

Fig. 7. One-way model of material transport (variant)

Table 8. Multimodal solution for Panalpina (Afghanistan) in variant II

Route	Means of transport	Carrier	Occurrence
Opole - Frankfurt	Road	Panalpina truck service	Every Tuesday and Saturday
Frankfurt - Amsterdam	Road	Martinair Holland truck service	Everyday
Amsterdam - Sharjah	Air	Martinair flight service	Everyday
Sharjah - Bagram	Air	Panalpina flight service IL-76	Every Monday, Wednesday and Friday

Source: based on data from Panalpina Military Defence

8.4. Simulation variant no. 3

In the third variant, a transport model was defined for the amount of material resources, where real points were introduced on the transport route that was compatible with and supported by the carrier. The route was defined as follows: Opole - Frankfurt - Dubai - Sharjah - Bagram (Figure 9). The total transport time was estimated at 7-10 days and the transport cost at 4,209.20 euros. From the carrier's data, it appears that it is possible to transport the UN1170[14] material on a passenger plane on the Frankfurt-Dubai route, provided it is repackaged to a 60-liter barrels, in which case the cost of transport would be reduced to € 3,998.80 (Table 9).

Table 9. Multimodal solution for Panalpina (Afghanistan) in variant III

Route	Means of transport	Carrier	Occurrence
Opole - Frankfurt	Road	Panalpina truck service	Every Tuesday and Saturday
Frankfurt - Dubai	Air	Emirates flight service	Everyday
Dubai - Sharjah	Road	Emirates truck service	Everyday
Sharjah - Bagram	Air	Panalpina flight service IL-76	Every Monday, Wednesday and Friday

Source: based on Panalpina Military Defence

[14] UN 1170 – Shipping name of dangerous substance (here: RID/ADR 3, ADR 1 code – ethanol)

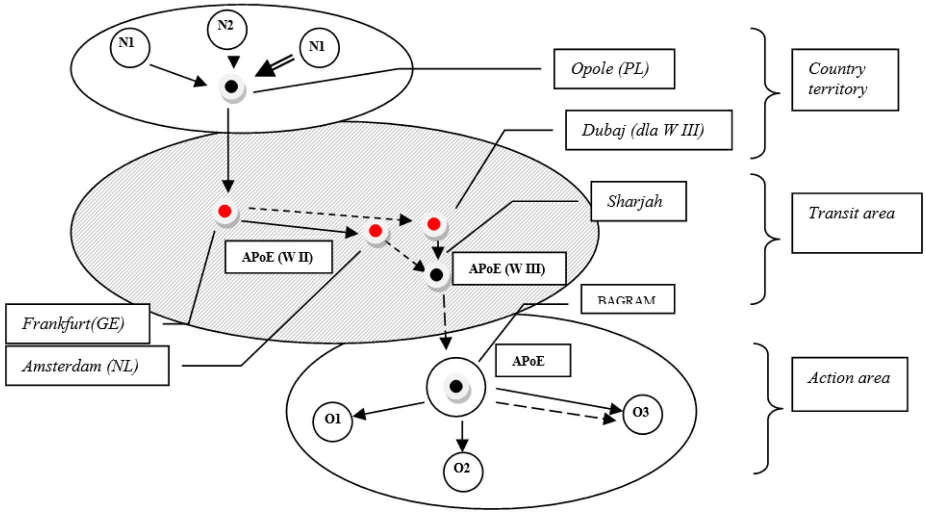

Fig. 8. One-way transport of materials (variants II and III)

8.5. Simulation variant no. 4

In option 4, a transport model for material resources was prepared for the Polish Ministry of National Defense, which introduced a variable in the form of the possibility of consolidating the loads of another payer. On this basis, it was tested how the carrier estimated the total cost of transport. Spatial assumptions remained unchanged (i.e. necessity to overcome the section of Opole - Bagram). For such formulated assumptions, the carrier attempted to develop a concept of displacement taking into account the needs of another sender (Armed Forces of the Czech Republic).

After the consolidation of the load (weight doubled to about 1620 kg) the cost of transport decreased to 19,880 Euro (Figure 9), and the time was estimated at 3-5 days (according to the carrier's statement - Table 10).

The graphical representation of transport in line with the assumptions of variant 4 is presented in Figure 10. Transit coordination at transnational level plays a vital role in this type of transport. There is therefore a need for changes in the level of reorganization of competency levels (transferring them higher within the institutional dimension) throughout NATO, which will lead to the integration of logistic operators in pan-European terms.

At a later stage of research and analysis, it is possible to carry transport to destinations (taking into account flight safety)[15]. However, the application of such a variant will only be possible under certain international coordination criteria (NATO, NATO-EU, NATO-EU, UN).

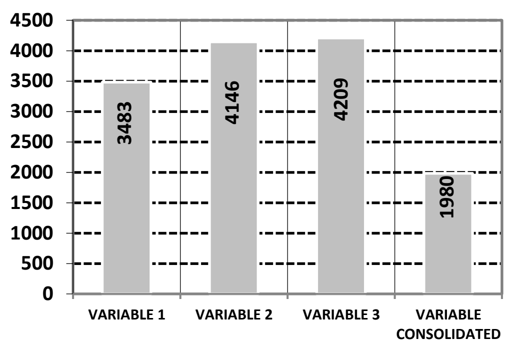

Fig. 9. Transport costs (4 variants) for x cargo weight (in Euro)

Source: based on data from Panalpina Military Defence

[15] According to the Express Delivery Cargo project (presented by Panalpina), it will be possible to carry the transport to the base in Ghazni (O3 point in the diagram).

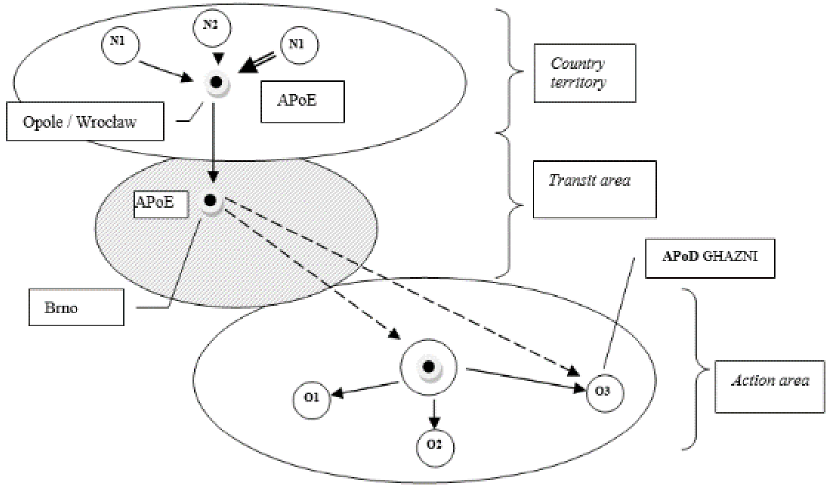

Fig. 10. One-way model of material transport (for variant IV)
Source: own elaboration

Table 10. Multimodal solution for Panalpina (Afghanistan) in variant IV

Route	Means of transport	Carrier	Occurrence	Remarks
Opole - Brno	Road	Panalpina truck service	Every Tuesday and Saturday	Consolidated cargo
Brno - Bagram	Air	Panalpina flight service IL-76	Every Monday, Wednesday and Friday	

Source: based on Panalpina Military Defence

This approach in the future will lead to changes in the logistics system without the need to spend a great deal on the purchase or hire of transport resources needed to carry out the transport function at the strategic level. Logistics processes that take place in an international system require interpersonal cooperation and consequently appropriate relations and a high level of coordination (Figure 11), which change should be determined by the extent of responsibility. Decision making scenarios in military transport processes are conducted should include turbulent factors, for example the method on rolling horizon planning is one way of coping with uncertainty in decision making processes. The essence in such activity play different kinds of simulations in efficiency and security areas, based on processes optimization. The excellent example of such approach based on computer simulation is IT system called ADAMS that is used in NATO armies to plan and organize of military transport processes (Janasz, Smal, 2013, p. 107-112). Furthermore, more and more proposals are generated in regards to decision-making, including risk analysis (Foltin and others, 2015).

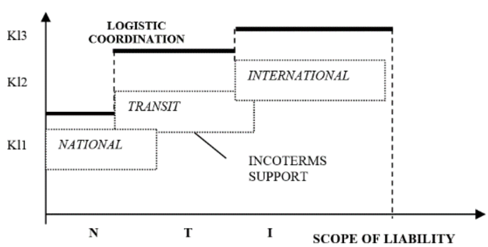

Fig. 11. Change the level of logistics coordination depending on the scope of responsibility

9. Conclusions

The presented above studies and analyzes allow us to conclude that:

1. It is possible to model transport taking into consideration the cost of specific cargo mass to areas of peacekeeping operations (UN mission, NATO, EU) using services provided by carriers operating on the transport market. For the purposes of calculating, a small mass of goods was assumed (i.e.

about 1 ton of cargo, and treated as a basic module), which does not exclude the transport of multiples of such module or any other combinations.

2. In cost modeling, it is important to carry out cost simulations each time for a specific mass of cargo, military equipment (MilE) and material resources (MOWaM) from the group of hazardous materials while maintaining an adequate level of logistical coordination carried out internationally by the NATO defense sector entities.
3. Key role in decision processes, with many multicriterial variables (e.g., technical and economic group) are Decision Support Systems, a derivative of advanced logistics and transport information systems.
4. Any action in international arrangements requiring a high level of cooperation and coordination necessitates the application of advanced storyboarding, or scenarios based on different variants, depending on the influence of turbulent factors on compact systems.
5. With the simultaneous support of such activities, there is a likelihood that the "good practices" of international co-operation are likely to be maintained, and consequently, the reduction of military spending and the reduction of the costs of peacekeeping operations outside the European continent, where the main driver of the cost of operation is strategic transport.

It is worth to mentioned that prior to taking decision all key information must be collected which describe the decision problem. The decision problem has to be recognized and evaluated as well as considered from different angles. As it was mentioned before, the factors that make it possible to characterize the problem include, among others: object, degree of structuration, extent, degree of complexity, place of occurrence, frequency of occurrence, and importance to the efficiency of a given system.

One of a method that can be used to take decision is multicriterial analysis which can be algorithm and transform into Decision Making System understood as IT tools supporting decision maker. However, making decision under uncertainty conditions, different approaches can be considered. One of the most popular possibility is decisive rules based on Wald's pessimism and Hurwicz's optimism as well as Savage's least proficiency, or criterion of "lack of sufficient reason" (called Laplace's rule).

References

[1] BAKER, K., 1977. An experimental study of rolling schedules in production planning. *Decision Sciences*, 8(1), 19-27.

[2] BERTALANFFY, L., 1976. Historia rozwoju i status ogólnej teorii systemów. In: Klir G. J. (Edit.), *Ogólna teoria systemów.* Warszawa: *WNT* Publishing House, 27-49.

[3] BOLESTA-KUKUŁKA, K., 2003. *Decyzje menedżerskie.* Warszawa: PWE Publishing House.

[4] CPCS Transcom. 2010: Analytical Comparative Transport Costs Study Along the Northern Corridor Region. [online cit.: 2017-06-01]. Available from: https://people.hofstra.edu/geotrans/eng/ch7en/conc7en/costs_ Mombasa_ Nairobi.html.

[5] DUCK, O., KRAUSE, H., SCHULTE, C., 2001: *Gospodarka materiałowa. Praktyczny poradnik*. Warszawa: Alfa - Weka Publishing House Ltd.

[6] FLAKIEWICZ, W., WAWRZYNIAK, B., 1978. *Zasady i metody podejmowania decyzji kierowniczych*. Warszawa: PWE Publishing House.

[7] FOLTIN, P., GONTARCZYK, M., ŚWIDERSKI, A., ZELKOWSKI, J., 2015. Evaluation model of the companies operating within logistic network. *Archives of Transport*, 36(4), 21-33.

[8] HANCZAR, P., 2013. *Modele decyzyjne w koordynacji strumieni podaży produktów w łańcuchu dostaw*. Wrocław: Economic University of Wrocław Publishing House.

[9] HOLT, C., MODIGLIANI, F., MUTH, J., SIMON, H., 1960. *Planning Production, Inventories, and Work Force.* Prentice-Hall.

[10] IZDEBSKI, M., 2014. The use of heuristic algorithms to optimize the transport issues on the example of municipal services companies, *Archives of Transport*, 29(1), 27-36.

[11] JACYNA-GOŁDA, I., 2015. Decision-making model for supporting supply chain efficiency evaluation. *Archives of Transport*, *33*(1), 17-31.

[12] JANASZ, D., SMAL, T., 2013. Modelling of polish military contingent redeployment from ISAF operation in Afghanistan. *Logistics and Transport*, 20(4), 107-112.

[13] KOZIELECKI, J. 1977: *Psychologiczna teoria decyzji*. Warszawa: PWE Publishing House.

[14] KURT, F. 1973. Die Metaphysik des Einen bei Nikolaus von Kues. Problemgeschichtliche Stellung und systematische Bedeutung. Leiden: Brill.
[15] LOPEZ, E., MONZON, A. 2010. Integration of Sustainability Issues in Strategic Transportation Planning: A Multi-criteria Model for the Assessment of Transport Infrastructure Plans. *Computer-aided Civil and Infrastructure Engineering*, 25(6), 440-451.
[16] MAJKA, A. 2014. Multi-objective optimization applied for planning of regional European airline. *Archives of Transport*, 29(1), 37-46.
[17] MESAROVIČ, M. 2017. Cybernetics of Global Change: Human Dimension and Managing of Complexity [online cit.: 2017-02-07]. Available from: Source: http://unesdoc.unesco.org.
[18] MILEWSKI, R., SMAL, T., 2015. The use of Multidimensional Comparative Analysis in the Choice of Means of Transport for the Army. Proc. 25th ESREL 2015 on Safety and Reliability of Complex Engineered Systems. Editors: PODOFILLINI L., SUDRET B., STOJADINOVIC B., ZICO E., KROGER W.. CRC Press/Balkema. ISBN: 978-1-138-02879-1 (Hbk+CD-ROM), ISBN: 978-1-315-64841-5 (eBook PDF), p. 17 and CD.
[19] NARUNIEC, A., BORKO, H., GĘBSKI, P. 2005. *Uzbekistan-Guide for entrepreneurs*. Warsaw: PARP Publishing House,.
[20] SEMIN, V.G., GRIGOREVA, S.V., DMITRIEVA, T.V., ILUINA, E.A. 2016. A Process Model of Risk Management in the System of Management of Strategic Sustainability of Cargo Motor Transport Enterprises. Proc. 2016 IEEE Conference on Quality Management, Transport and Information Security, Information Technologies (IT&MQ&IS). Nalchik, RUSSIA.
[21] TYSZKA, T. 2010. *Decisions. The prospect of psychological and economic*. Warszawa: Scholar Publishing House, 332- 339.
[22] TYSZKA, T., ZALEŚKIEWICZ, T. 2001. *Racjonalność decyzji: pewność i ryzyko*. Warszawa: PWE Publishing House.
[23] Universite Catholique de Louvain – Brussels – Belgium [online cit.: 2016-04-10]. Available from: www.emdat.net.
[24] ZAK, L., VALIS, D., GLOS, J., WALEK, A., 2012. Comparison of statistical and fuzzy approaches used on field data. *Mendel Journal series*, 2012(1), 46-51.