

PRELIMINARIES OF RESEARCH, THE CHOICE OF TOPIC

The choice of topic

In everyday life, we often get into situations when we have to choose between two or more appliances the one that is the most suitable to us. This is a complex problem, since it is impossible to grade and compare the instruments along any of their parameters. The gradelist can only be stated based on the simultaneous balancing of more of their traits. The professional literature places such problems in the line of multiattributes decision problems.

The situation is similar in the case of military equipment, since these, as instruments made for a special purpose, possess many basic characteristics that need to be taken into account for the grading of the equipment and determining its usability. Along with determining its usability, choosing the most suitable one from a stack of equipment is an important question that often arises. The problem can be solved by a special measurement procedure, which measures the examined equipment against a scale with a pre-determined content of information.

The mid- and long term development plans of the Hungarian Defense Forces (HDF) especially raised the importance of comparison and selection of the most suitable items. Based on the plans the modernization of military technology will begin in 2006, which will result in the procurement of huge amounts of new equipment. In these situations the ways by which we select the most suitable from the possible equipments for the planned task will be important. The processes of multiattributes decision problems were worked out to solve such problems, and because of this in my thesis I examine the applicability of this theory in the comparison of military technology.

Based on my hypothesis, the proceeding of multiattributes decision problems that have been used in civilian life for a long time, can also be used in the comparison of military technology.

In choosing this topic, the Vehicle Development Program of the HDF played a key role. In the programs indicated, I continuously worked from January 2000 as engineering and decision theory expert. In my work, I experienced in practice what help some decision support procedures can give during the preparation and execution of decisionmaking.

In the framework of the programs, I took part in the development of the TENDER decision supporting software system, which was developed for decision supporting of the procurement procedure within the framework of the vehicle development and vehicle procurement programs. I worked out the mathematical model of comparison for military vehicles, based on engineering viewpoints, and during both programs, I led the work groups consisting of operators with whom I conducted the testing of the program and the processing of data. This in total meant the storing of 10,000 data and the calculations done with them.

The subject of research

I divided the subject of research into two groups, these are:

- the military equipment compared;
- the mathematical methods suitable for conducting a comparison.

I searched and showed those general characteristics of military equipment of which knowledge is important and have key importance in conducting of the comparison.

I examined two groups of mathematical models, these are:

- multiattributes decision problems;
- multiple statistical analysis.

The goal of research

The main goal of research was to collect employable and practical modern mathematical methods used in the process of decision, the presentation of their application, and based on the results of real time examples the stating of the conditions for their application. Within this:

- the collecting and analyzation of methods of multiattributes decision problems and choosing those methods which are applicable during the comparison of military equipment;
- the collecting of those mathematical statistics and, within those, processes of multiattributes decision problems which are applicable in the preparation of decisions and the decision making process;
- the studying of practical applications of the models, including civilian and military applications also;
- the analyzation of military equipment from a decision theory point of view, which includes the discovery of the special characteristics of the equipment that play a key role during the comparison;
- the identification of those possible situations of decision, to which the decision support of the chosen methods is applicable;
- choosing those pieces of military equipment through which I examined the application of the chosen methods and collecting their needed data;
- the presentation through real life examples of application of the chosen procedures of multiattributes decision problems and the mathematical statistics;
- the stating of boundary condition of application;
- stating the information content of the results;
- within the framework of the examining of the TENDER program, stating the effect of the usable functions on rankings.

THE RESEARCH WORK ACCOMPLISHED

The method of research and the accomplished tasks

To base my research, I studied the national and international professional literature. This included the studying of multiattributes decision problems and of the necessary fields of mathematics that are necessary for the application of this theory. The broad use of literature is shown by the 63 professional books and articles in the catalogue.

Along the studying of the theory, I continued to work for three years as an expert in the MoD Bureau of Procurement and Security Investment. Along this expert function, I analyzed a decision model used in a 1989 Hungarocamion procurement procedure, I analyzed the comparative examination of military vehicles, made by the order of the Directorate of Armor-Vehicle Technology in 1992. I continued consultations in the Research Institute of Calculations and Automatization of the Hungarian Academy of Sciences, where more decision models were worked out, and decision supporting software systems were developed in the framework of procurement procedures, for the decision supporting of conducting procurements. I studied the TASCFORM procedure, developed for the Armed Forces of the USA, intended for the numericalization of general purpose military organizations, which it determines based on the totaling of military equipment's individual military capabilities, or for a specific field multiattributes decision problems procedures developed for a field of military technology.

The usability of the collected decision models, I proved through comparing examinations conducted on military equipment. For the examinations, I collected and worked out circa 1200 data of 96 types of four military technology equipment groups. The examined equipment were artillery fire control systems, assault rifle, heavy rifles, and military purpose all terrain vehicles. In the case of the artillery fire control systems, I used the results of an already conducted research, thus my results, came to this way, can be used in practice.

The military equipment in the same category I compared using several procedures. I checked the results from the different procedures with themselves, and with the views of the professionals in this field. Based on the analyzation of the results of the comparing examinations, I stated the usability of the procedures, the precision of the procedures and the boundary condition of application.

My examinations targeted the examinations of methods that help define the values belonging to equipment with which the views necessary to the examination and weights that show the importance of these views can be stated, and the concrete comparing procedures.

Along the stating of applicable mathematic models, the compared military equipment made up the subject of my examinations. I searched and stated characteristics, features of these equipment that become needed during such examinations. I examined the equipment comparison itself, which in this special field can be understood as capability examinations of these military equipment. I also identified those possible decision situations to whose decision supporting these models can be used. I analyzed the law regulations of the comparing in the field of procurement, and the regulations these rules implement on the decision models.

My scientific achievements I stated based on the analyzation of the results of the comparison done on the chosen military equipment. These statements I grouped into five theses.

I closed the research in my dissertation with recommendations, I stated those fields and situations, in which the ways and methods I worked out can be used without further research. I stated the models that need further research before application. In conclusion, I stated the possible fields of further research in connection with the topic.

THE SUMMARY OF SCIENTIFIC ACHIEVEMENTS

New scientific achievements

1. SCIENTIFIC ACHIEVEMENT

One piece of military equipment, we can characterize and compare with another, based on the views and projections of the examination goals. In case of such and similar cases decision support in civilian life the so called multiattributes decision problems is used, because of this in my dissertation I viewed the adaptability of this theory in the comparison and capability examination of military equipment. During my work, I compare the fire control systems and military purpose vehicles using the Kesselring, KIPA, Promethee & GAIA (Geometrical Analysis for Interactive Assistance) és AHP (Analytic Hierarchy Process) methods. Based on the results of the comparing and examining analyses done on the equipment, I stated that:

- using the appropriate methods of multiattributes decision problems military equipment can be ranked, and the relative ratios of capability of the pieces of equipment examined can be determined corresponding to the objective of examination;
- by the combined application of the methods of multiattributes decision problems information can be learnt on the preciseness of results, whether the right decision making model was chosen and the connections of a general nature pertinent to the military equipment examined.

2. SCIENTIFIC ACHIEVEMENT.

It is imperative to identify the situation requiring a decision when using decision support models. In my case the most important factor of the situation is the environment of the decision, since this environment includes all the circumstances making it necessary to make a comparison. My basic point is that the environment will always have qualities that influence the process of comparison, thus it is absolutely necessary to identify them. When examining the options, I determined that TTDE can be applied in the Hungarian Defense Forces in four basic situations, which are:

Procurement: to determine the best piece of equipment during the course of public procurement or other procedures from those possible or that participate in the tender.

Development: to determine the number or quotient showing the improvement in overall capabilities of the piece of equipment during development.

Selection: to determine the most suitable type of military equipment for the mission.

Comparison: to determine the numbers showing the relative capability ratios of equipment for tactical tasks.

3. SCIENTIFIC ACHIEVEMENT.

The starting point for comparing pieces of military equipment is the system of criteria determining the areas in which these pieces of equipment are measured. These criteria are of different importance, shown by the so-called weight paired to them. To determine these weights different procedures are used, yielding results with different contents of information. In the course of my research, I examined the applicability of these procedures in determining the weights of the system of criteria used for characterize military equipment, and it was also an objective of my research to determine the conditions in which these methods are best applied. In my work I weighed the system of criteria for fire control systems and heavy rifles using the Guilford and AHP procedures. Having analyzed the results, I concluded that:

- the system of criteria for military equipment can be weighed by significantly decreasing the subjectivity of experts and decision-makers;
- in the case of the AHP procedure yielding results on the level of a grade of ratios it is recommended to keep the number of criteria to be simultaneously compared below nine, this number in te case of the Guilford procedure can reach 12.

4. SCIENTIFIC ACHIEVEMENT.

A piece of military equipment in most cases can be described by hundreds of features. A significant part of these characteristics are closely interrelated due to technical reasons. My hypothesis was that if these highly correlated characteristics could be grouped, then the great amount of data would become analyzable and it would become possible to simplify this great amount of characteristics which is usually too much for a decision making model. In discovering the technical reasons for the relations between characteristics the groups of characteristics would become describable with the help of one characteristic by group, and these could then be used as criteria. To prove my hypothesis I examined factor analysis and principal component analysis from among the procedures of multiattributes decision problems. By using these methods I divide 7 characteristics of 32 assault rifles into 3 groups, and 17 characteristics of 49 types of vehicles into 5 groups. After the analization of results, I determined that:

- using multiattributes decision problems interrelated characteristics describing equipment can be divided into groups;
- the groups of these characteristics can then be the basis of drawing up a system of criteria.

5. SCIENTIFIC ACHIEVEMENT.

Nationally and internationally several decision-support software systems are used (PROMCALC & GAIA, Expert Choice, WINGDSS) which have been developed to tackle problems of multiattributes decision problems. The TENDER program was developed to support the Vehicle Development Program of the Hungarian Defense Forces, and especially to compare military all-terrain and road utility vehicles. In my work I determined the areas which I judged necessary to develop the program so that it would become capable of decision support in comparing military equipment in general. From among these criteria in relation to the decision model, I devised a general utility function which makes it possible to use the TENDER in a wide variety of ways. The general utility function:

$$g(a) = \begin{cases} g_1(a), & \text{if } a_0 \leq a < a_1 \\ \vdots \\ g_n(a), & \text{if } a_{n-1} \leq a \leq a_n \end{cases}$$

$$a_i < a_{i+1}, \quad g_i(a) = m_i a + c_i, \quad i = 1, \dots, n, \quad m_i \in R, \quad c_i \in R,$$

$$\text{if } m_i \geq 0 \text{ then } g_{i+1}(a_i) \geq g_i(a_i) \quad i = 1, \dots, n-1,$$

$$\text{if } m_i \leq 0 \text{ then } g_{i+1}(a_i) \leq g_i(a_i) \quad i = 1, \dots, n-1.$$

RECOMMENDATIONS

I recommend the practical application of multiattributes decision problems to solve the following problems, without further research:

- to calculate the indicative numbers characterizing military equipment used in tactical roles by using AHP procedure;
- with the PROMETHEE and GAIA procedures for military organizations for supporting the decisions to select the right piece of equipment;
- in the preparation stage of public procurement with the TENDER program and/or AHP procedure.

In the case of equipment to be procured in the next five years, I recommend:

- the creation of databases which make it possible to do the tests and other tasks associated with the preparations for making a decision;
- commencing research with the aim of drawing up a system of criteria characterizing the piece of equipment in question;
- commencing research on the theoretical preparations for decision in a public procurement procedure, this includes devising methods for measurement of criteria and the listing of preliminary grades.

In connection with the TENDER program, I recommend:

- using the program in general, in the public procurement of all military equipment;
- developing the program based on the information in my dissertation.

In connection with the TASCFORM procedure, I recommend:

- commencing research which would produce a method for devising indicative numbers measuring the capabilities of a general-purpose military organization (this would be a battalion-level unit in the case of HDF), similar to TASCFORM (this would also mean testing TASCFORM for usability).

In connection with education and training, I recommend;

- differentiated teaching of multiattributes decision problems in different areas of military higher education and in training courses on management theory.