MULTIPLE CRITERIA DECISION SUPPORT SYSTEM MODEL FOR CONSTRUCTION WORKS TECHNOLOGICAL CARDS DESIGNING

Zenonas Turskis¹, Gintautas Ambrasas¹, Darius Kalibatas¹, Arunas Barvidas¹

Vilnius Gediminas Technical University, Department of Construction Technology and Management,
Sauletekio av. 11, LT-2040 Vilnius, Lithuania
E-mail: zenonas.turskis@st.vtu.lt

Abstract. This article deals with multiple criteria decision support system model for designing construction technological cards. The main process and model of system creation there are discussed. Application of multiple criteria decision making methods for assessing alternatives allows decision makers to choose if not optimal then rational variants. There is pointed out problem of knowledge and data bases organizing. Organized knowledge and data bases form a very important part of this model that allows to decision maker to use the knowledge of experts. Attempts were made to divide the designing process of technological cards to the steps that allow solving very important and complicated multi-stage and multi-attribute problem.

Keywords: multiple criteria, decision making, construction works, technological card, artificial intelligence

1. Introduction

Decision support systems (DSS) are a subset of computer-based information systems. Mora et al (Mora et al, 2003[1]) writes, that Scott-Morton developed in 1971 a pioneer DSS for marketing and production planning. Together with Gorry he gave the first definition for a decision support system in 1971.

Decision making is, in effect, synonymous with management. Various definitions of decision support systems have been suggested [2, 3, 4, 5] a DSS can be described as a computer-based interactive human–computer decision-making system that: supports decision makers rather than replaces them; utilizes data and models; solves problems with varying degrees of structure: (a) non-structured (unstructured or ill-structured) [3]; (b) semi-structured [4]; (c) semi-structured and unstructured [5] and finally focuses on effectiveness rather than efficiency in decision processes (facilitating decision processes). They are designed to interactively support all phases of a user's decision making process.

Decision support systems can be designed and developed using different approaches and methods. Various information systems have evolved to support the decision making process. There are decision support systems, executive information systems, artificially intelligent systems, and integrated combinations of these systems.

Decision making process includes four phases and steps of the decision-making process [6]:

1) Intelligence: observe reality; gain problem/opportunity understanding; acquire needed information.
2) Design: develop decision criteria; develop decision alternatives; identify restrictions; go to 1.
3) Choice: logically evaluate the decision alternatives; develop recommended actions that meet the decision criteria; go to 2.
4) Implementation: Ponder the decision analyses and evaluations; Weight the consequences and recommendations; Gain confidence in the decision; Design an implementation plan; Secure needed resources; Put implementation plan into action; Go to 1

The major individual systems and their primary and direct support are summarized in Table 1.

Humphreys and Bekerley's [7] decrypted five representation levels of the problem handling process:

1) Representations are mainly cultural and psychological; managers are more or less aware of what a problem involves, but its expression is mostly beyond language
2) The representations become explicit and the problem can be broken down into a number of sub problems, some of which can be formalised without being able to formalise processes in greater details.
3) Decision makers are able to define the structure of the problems they must solve. They are able to put forward models that can be used for the investigation of the alternatives they will pursue.
4) The decision makers will perform sensitivity analysis with the models they have defined in the previous stage so as to determine which input values are the most suitable.
5) Managers decide upon the most suitable values and the representation of the problem they must solve is stable and fully operational.

<table>
<thead>
<tr>
<th>Table 1. Individual and integrated decision making support systems</th>
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<tbody>
<tr>
<td><strong>System Type</strong></td>
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<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Decision Support System (DSS)</td>
</tr>
<tr>
<td>Executive Information System (EIS) and Geographic Information Systems (GIS)</td>
</tr>
<tr>
<td>Knowledge-Based System (KBS)</td>
</tr>
<tr>
<td>Machine Learning System (MLS)</td>
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<tr>
<td>Creativity Enhancing System (CES)</td>
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<tr>
<td>Integrated</td>
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<tr>
<td>Intelligent Decision Support System (IDSS)</td>
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<tr>
<td>Executive Support System (ESS)</td>
</tr>
<tr>
<td>Whole-Brained Decision Support System (WDSS) and Group Decision Support System (GDSS)</td>
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<tr>
<td>Management Support System (MSS)</td>
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</tbody>
</table>

In the course of designing construction projects an architect, structural or mechanical engineer, technologist encounter many problems, the whole of which could be characterized as follows: under strict conditions of a time limit to develop a competitive, high quality product, without doubt possessing aesthetic value, i.e. a design of a building or any other structure, which would be able to ensure the selection of rational and efficient design solutions by implementing the concept of architectural form and space, to evaluate real cost of labour-time and resources as accurately as possible, to avoid mistakes and inaccuracies, to warrant rapid pace of the construction process and fluent execution [8].

An interactive session of optimisation will typically be based on a number of stages: a) The user calls the decision support application, b) The data are acquired either from a database or from a series of answers provided by the user, and the processing of the data begins and c) Presentation of results.

There are three main types of architectures commonly used for DMSS (see Table 2, [1]).

<table>
<thead>
<tr>
<th>Table 2. Strengths and weaknesses of existing DMSS architectures</th>
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<tbody>
<tr>
<td><strong>System Type</strong></td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Network of agents</td>
</tr>
<tr>
<td>Centralised architecture</td>
</tr>
<tr>
<td>Hierarchical architecture</td>
</tr>
</tbody>
</table>

Hwang and Yoon [9], Goicoechea [10], Zavadskas [11,12], Zavadskas et al [13 – 22], Larichev et al [23], Handl [24], Karablikovas and Ustinovichius [25], Sarka et al [26], Zavadskas and Antucheviciene [27], Elhorgt [28], Figueira et al [29], Zavadskas and Vilutiene [30] and others presented a number of multiple criteria decision making methods to be used in solving discrete alternative problems and applied to solve civil engineering, technology problems and etc. Kalay [31], Zavadskas et al [18], Zavadskas et al. [32, 17, 19, 33, 34], Kaklauskas et al [35, 36] developed some decision making systems for civil engineering needs. Using the method of multiple variant designing suggested by the Zavadskas and Kaklauskas [32] and Zavadskas et al [14, 15] alternatives may be obtained. These versions are checked for their capacity to meet various requirements. Those which cannot satisfy the demands raised are excluded from further consideration. By using a decision-making matrix obtained and with the help of a multiple criteria evaluation method, the efficient variants are determined and ranked according to their priorities. In our specific case, the decision-making subsystem is equipped with programmed formulas, suggested by the authors, for the following purposes [15, 16]:

1) Alternative project designing;
2) Determination of significance of criteria;
3) Multiple criteria analysis and utility degree determination of projects;
4) Giving out recommendations.

2. Decision making support system development process

In general we follow the methodology for expert system development (see figure 3) [1].

Figure 1 gives a generalized architecture of a decision support system. A decision support system has been proposed to support rational alternative strategy. Decision support system has three major inputs. There is a data base, knowledge base, and model base. The data base contains the data directly relevant to the decision problem, including the values for the
uncontrollable events, decision alternatives, and decision criteria. The knowledge base holds problem knowledge, such as formulas for converting available data into the problem's parameters, guidance for selecting decision alternatives and problem relationships, or advice in interpreting possible outcomes. The model base is a repository for the formal (tabular, graphic, conceptual, or mathematical) models of the decision problem and the methodology for developing results (simulations and solutions) from the formal models.

Decision makers utilize computer technology (hardware and software) to process the inputs into problem-relevant outputs. The decision support system can use problem ideas, concepts, and knowledge drawn from the knowledge base to assist users in performing these processing tasks. Processing will involve:

1) Organizing problem parameters—accessing the data base, extracting the decision data, and organizing the information in the form needed by the solution model and methodology;

2) Structuring the decision problem—accessing the model base, retrieving the appropriate decision model, and operating (attaching organized parameters to) the decision model;

3) simulating policies and events—using the operating decision model to perform the computations needed to simulate outcomes from user-specified alternatives and then identifying the alternative (or alternatives) that best meets the decision criterion (or criteria) among those tested; and

4) Finding the best problem solution—accessing the model base, retrieving the appropriate solution method, and using the retrieved method to systematically determine the alternative (or alternatives), among all possible alternatives, that best meets the decision criterion (or criteria). Processing will generate status reports, forecasts, recommendations, and explanations.

The structural development process is given in figure 2.

Today's decision support system provides the user with a wide variety of interface modes: menu based interaction mode, command language style, questions and answers, form interaction, natural language processing based dialogue, and graphical user interface.

The functions of the user interface (dialogue generation and management) sub-system are to: a) allow the user to create, update, delete database files and decision models via database management systems and model-based management systems; b) provide a variety of input and output formats. The formats include multi-dimensional colour graphics, tables and multiple windows in a screen and finally c) provide different styles of dialogues (such as graphical user interfaces, menus, direct command languages, form interaction, natural language interaction, and questions and answers).

As shown in Figure 1, a DSS consists of two major sub-systems – human decision makers and computer systems. The function of a human decision maker as a component of DMSS is not to enter data to build a database, but to exercise judgment or intuition throughout the entire decision-making process.

To develop the knowledge base, we first developed a conceptual model from a variety of knowledge sources. Simplified illustration of an extended knowledge base for technological card designing is given in figure 3.

The knowledge creation process can be described as the knowledge creation cycle, which is comprised of the personal and collective cycles. The activities in these steps are outlined in Figure 4.

![Fig 1. Conceptual Decision Support System](image)
Fig 2. Structured development process [1]

Fig 3. Simplified illustration of an extended knowledge base for technological card designing

Fig 4. Activities in four steps of the LFM-SDM knowledge cycle [1]

Fig 5. Conceptual model to identify quality improvement opportunities at the operational level
<table>
<thead>
<tr>
<th>Stage of drawing up of a technological card of building process</th>
<th>Initial data are required.</th>
<th>Databases are required and features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of building object</td>
<td>Base of working drawings of the building project.</td>
<td>Base of working drawings of the building project</td>
</tr>
<tr>
<td>Component of project</td>
<td>A database of components of the project.</td>
<td>A database of components of the project.</td>
</tr>
<tr>
<td>Name of works</td>
<td>Base of working drawings of the project.</td>
<td>Base of working drawings of the project.</td>
</tr>
<tr>
<td>Order of building process works and sequence</td>
<td>A database of components of the project.</td>
<td>A database of components of the project.</td>
</tr>
<tr>
<td>Volumes of works</td>
<td>Base of working drawings of the project.</td>
<td>Base of working drawings of the project.</td>
</tr>
<tr>
<td>Calculation of material resources for civil work, the schedule of delivery of building materials on a constructing site</td>
<td>Base of working drawings of the project.</td>
<td>Base of working drawings of the project.</td>
</tr>
<tr>
<td>Selection of the mechanisms for works and scheduling of their work</td>
<td>Base of working drawings of the project.</td>
<td>Base of working drawings of the project.</td>
</tr>
<tr>
<td>Selection of the complete set of tools and complex of auxiliary means for manufacture of works</td>
<td>Typical schemes of civil work. Typical specifications. Base of working drawings of the project. The detailed description of building process. Budget calculations. Technical specifications. The calendar (network) schedule of works Database of building mechanisms. The analysis of opportunities of an effective use of available building mechanisms. A techno-economic substantiation of new mechanism purchase or their rent.</td>
<td>Database of typical schemes of work. Database of construction budget calculation norms. Database of construction budget calculation norms. It is coordinated with the schedule of manufacture of works. Schedules of delivery of materials on a building site are defined. Schedules of manufacture of works if necessary are changed.</td>
</tr>
</tbody>
</table>
Afterwards, the selected sets in a dialogue mode, at direct presence of the decision making person, adapt for a concrete technological card. Thus it is necessary to consider requirements of the project on the organization of civil work and features of the project working drawings.

Conclusions

Multiple criteria analysis of the building construction cycle allows evaluating how economic, technical, qualitative (architectural, aesthetic, comfort ability), technological, social, legislative, infrastructural, technical and other decisions are in conformity with needs and opportunities of clients, designers, contractors, users, and other participants of this process. These needs are expressed through the systems, values of quantitative and qualitative criteria; importance of criteria is being evaluated through their significances.

A major goal of decision support systems research is to develop guidelines for designing and implementing systems that can support decision making. Decision support systems can be designed and developed using different approaches and methods. Decision support systems are a subset of computer-based information systems.

The DMSS-delivered virtual expertise can reduce the need for large support staffs and corresponding organizational structures. The organization can become flatter and more project-oriented. In this setting, the decision maker can participate more directly in the DMSS design, development, implementation, and management. Such changes will not occur without displacements of old technologies and job activities, radical changes organizations, and considerable costs. As the reported applications indicate, however, the resulting benefits are likely to far outweigh the costs.

The importance of effective decision making can never be overemphasized. Decision making is synonymous with management.

The function of a human decision maker as a component of DMSS is not to enter data to build a database, but to exercise judgment or intuition throughout the entire decision-making process.

References