Database of Best Practices and Decision Support Web-based System for Construction Innovation

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Summary

Many construction and facilities management Web sites can be found on the Internet. The interested parties on construction and facilities management Web sites can find databases of best practices, calculators, analyzers, software, expert and decision support systems, neural networks, etc.

Technological innovation mainly through changes in the availability of information and communication technology inclusive databases of best practices, calculators, analyzers, software, neural networks, decision support and expert systems that have been provided by a variety of new services developed by the construction and facilities management sectors.

Most of all calculators, analyzers, software, decision support and expert systems, neural networks and on-line systems seek to find out how to make the most economic decisions and most of all these decisions are intended only for economic objectives. Alternatives under evaluation have to be evaluated not only from the economic position, but take into consideration qualitative, technical, technological and other characteristics as well. Based on the analysis of the existing calculators, analyzers, information, expert and decision support systems, neural networks and in order to determine most efficient versions of best practices a Decision Support Web-Based System for Construction Innovation (*IDSS*) was developed by Vilnius Gediminas Technical University.

1 Decision support systems

1.1 Decision support systems and multiple criteria analysis

Quite a number of people when purchasing a house pay attention to its price. Others concentrate on operating and maintenance costs comprising of the house’s heating and maintenance costs, the repair work, insurance, taxes and other related expenses. A third group of customers are concerned with the development rates of the surrounding area’s infrastructure (i.e. schools, hospitals, theatres, concert halls, stores and communication lines, etc.), the environment’s level of contamination and neighbors, etc. A fourth group of purchasers puts emphasis on the issues of comfort and convenience.

Most customers identify comfort and convenience with the number of rooms, their size and height, layout and planning, functional efficiency, proportional distribution of rooms, size of the kitchen, total area of the apartment, absence of hazardous substances, thermal and acoustic insulation of walls and level of the engineering equipment, etc.

However, most often purchasers try to carry out a complex evaluation of both positive and negative characteristics of the house. It should be also noted that different people when choosing between alternatives and depending on their needs and possibilities, usually use different systems of criteria and attach different values and weights to the similar criteria.

With the aim of providing customers with substantial assistance in choosing the most effective house, the decision support system (DSS) should have comprehensive historical information covering analogous buildings life cycle. This data can be both objective and subjective.

Objective data is the price of a building, its dimensions, year of construction, interest rate of the loan taken for purchasing or construction the building, the thermal and acoustic insulation of external walls, levels of contamination with hazardous substances and fluctuations of this level. Subjective data is related to the aesthetic issues of the building's exterior, the surrounding area, comfort and convenience and neighbors, etc. As a rule, people have quite different opinions on these rather subjective issues. Such opinions may change in time, which is not bad because such opinions represent people's goals and their possibilities to changes.

When analyzing possible alternatives, the customer should have the possibility to quickly receive comprehensive information (i.e. quantitative and qualitative criteria, their values and weights with the necessary explanations) that describes the project under consideration. For example, the customer should receive updated and detailed information on the substances hazardous to human health, changes on their impact in terms of time; a building's exterior finishing materials, their prices, quality, heavy-duty specification; and possible building insurance alternatives under different conditions, etc. Besides, depending on their experiences, needs and available resources, customers should be provided with the possibility to update and upgrade the criteria, their values and weights that describe the possible alternatives.

As we can see, the customer, on the basis of digital, textual, graphic, audio and video information provided by the database management system as well as the model-base management system, can generate and comprehensively analyze the possible alternatives, i.e. carry out a complex evaluation of the system of criteria, their values and weights that describe specific alternatives and help to make the necessary decisions.

The decision support system should comprise of the following four major constituent parts. These parts are: a data (database and its management system), models (model base and its management system), a user interface and a message management system.

There are several interpretations of databases (DB). The first DB is an aggregate of the interrelated and jointly stored data, i.e. information objects intended for computer processing. The concept of the second DB is wider and identifies DB with the data and a set of programs that process the same data.

Database Management Systems (DBMS) are developed for defining, creating, maintaining, controlling, managing and using databases. Special software is required for enabling the user to operate and communicate with databases. The database management system provides access to data as well as to all the control programs necessary to receive data in the form that is appropriate for an object under consideration to be analyzed without too much effort from the user who is programming.

The major functions of the Database Management System are as follows: designing of the database's structure; enlargement, collection and editing of the database; maintenance, search, sorting and other handling of data.

Some people view databases as being more or less independent systems and databanks, i.e. treating databanks as a system of information, mathematics, linguistics, organizational, software and hardware facilities.

The model-base management system performs a similar task for models in the DSS. It keeps track of all the possible models that might be run during the analysis, as well as controls for running the models. The model-base management system also links between models so that the output of one model can be input into another model.

The user interface represents all the mechanisms whereby information is input into the system and is output from the system. The system includes all the input and screens by which users can request data, models and output screens and through which users can obtain their results. The message management system allows for the use of electronic mail as another source of providing data.

DSS provides a framework through which decision-makers can obtain the necessary assistance for a decision through an easy-to-use menu or command system. Generally, a DSS will provide help in formulating alternatives, accessing data, developing models and interpreting their results, selecting options, or analyzing the impacts of a selection.

1.2 Model dimensions

The decision support system can include many models. These models can exist both inside and outside the DSS. The following three dimensions define the models: representation, time dimension and methodology.

Accordingly, the representation models can be divided further into quantitative and qualitative ones. The qualitative (i.e. expert and multiple criteria) models are based on judgments, subjective estimates, opinions and the expert's evaluations. When different experts evaluate the same qualitative characteristics of the same option, they often get different results. This can be explained by the different experiences, educational background, goals and available tools, etc. that may be used. The achieved results can be made more objective by applying expert evaluation methods.

The quantitative models (i.e. statistics and accounting) represent objective features of the options, irrespective of the expert's subjective evaluations and judgments. Objective features are represented directly by physical measurement units such as monetary units, kilograms, meters, degrees, percents and ratios, etc. Both quantitative and qualitative models have their advantages and drawbacks. The quantitative models represent their options in an objective way, but usually not thoroughly and comprehensively enough. On the contrary, the qualitative models represent reality subjectively, and more thoroughly and comprehensively. Therefore, the application of quantitative or qualitative methods usually depends on the concrete decision-making situation. Very often a complex method of application of both quantitative and qualitative methods should be applied when making a decision. For example, when analyzing the general level of a building's comfort, the best way would be to apply qualitative research methods. However, when making an assessment of the funds that will be spent during the period of the existence of a particular building (e.g. building's purchase, construction, maintenance, repair work and insurance expenses, etc.), it would be best to apply the quantitative methods.

Time dimension models are divided into static and dynamic ones. The static models support the position that feature the options, in the course of time that do not change, whereas the dynamic models take into consideration the changing nature of the options also in the course of time.

The methodology addresses how the data will be collected and processed. According (Sauter 1997), there are five general methodologies: complete numeration, algorithmic, heuristic, simulations and analytical ones.

When applying the complete numeration method we collect and evaluate information about all the feasible options. This method is highly time-consuming, costly, often impractical and is used for example when conducting a general census.

The algorithmic models are best represented by operations research methods and are applied when counting from the beginning till the end (i.e. from the moment of the initial data's entering until the gaining of the wanted results or goals). The heuristic models are applied for settling problems that cannot be solved algorithmically. All heuristic models involve searching, evaluating and finding a good solution. The heuristic models help to diminish the number of search options and aim at providing a solution and other findings. Heuristics is the most important part of the artificial intelligence and expert systems.

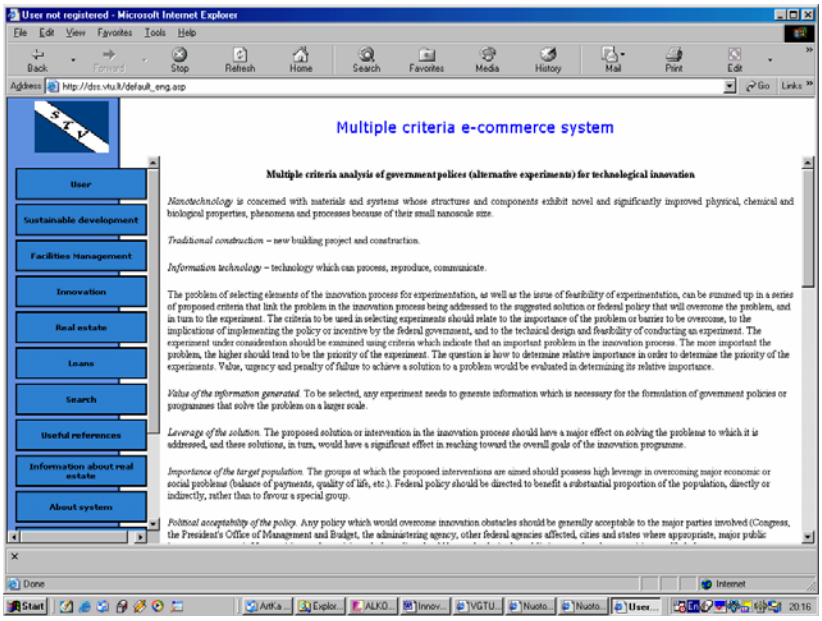
Simulation settles problems that cannot be accurately and precisely examined on the basis of a mathematical analysis. When applying these models we can create an adequate and typical situation of the options. Simulation models simplify the relationships and interdependencies of the alternatives being considered and provide information about conditions from which can be find a rational solution. Repeating the possible states of the option provides the possibility to experiment and reveals ways of improving the system's functioning. Such a method of simulation is often used when examining problems related to storage and the servicing of reserves, the demand for products, raw materials arrivals. At the beginning of the analytical modeling, a general analysis of the option is carried out. Thereafter, the option is divided into separate parts for their examination. Later we have to determine the relations and dependencies of the elements that comprise of the option. A statistical analysis serves as a perfect example of analytical modeling.

2 Web-based innovation decision support system

Based on the analysis of the existing calculators, analyzers, information, expert and decision support systems, neural networks and in order to determine most efficient versions of best practices a Web-Based Innovation Decision Support System (*IDSS*) was developed by VGTU. *IDSS* consisting of a database of best practices, database management system, model-base, model-base management system and user interface.

2.1 Database of best practice

Innovation activities involve a number of interested parties who pursue various goals and have different potentialities, educational levels and experiences. This leads to various approaches of the above parties to decision-making in this field. In order to do a full analysis of the available alternatives and to obtain an efficient compromise solution, it is often necessary to analyse economic, technical, technological, management, organisation, legal, social and other information. This information should be provided in a user-oriented way.



The presentation of information needed for decision-making in the IDSS may be in a textual form

The presentation of information needed for decision-making in the *IDSS* may be in a conceptual form (i.e. digital/numerical, textual, graphical, diagrams, graphs and drawing, etc), photographic, sound, video and quantitative forms.

The presentation of quantitative information involves criteria systems and subsystems, units of measurement, values and initial weights that fully define the provided variants. Conceptual information means a conceptual description of the alternative solutions, the criteria and ways of determining their values and the weights, etc.

In this way, the *IDSS* enables the decision-maker to receive various conceptual and quantitative information on innovation alternatives from a database of best practice and a model-base allowing him/her to analyse the above factors and to form an efficient solution.

The following parts form the *IDSS*'s database of best practice: Innovation; Construction; Facilities Management; Real Estate; Refurbishment; Sustainable Development; Loans; International Trade; Ethics.

The following tables form the *IDSS*'s database:

- Initial data tables. These contain information about the innovations (i.e. real estate, construction, finance, etc.).

- Tables assessing innovation alternatives. These contain quantitative and conceptual information about alternative innovation solutions: finance, information and internet technologies, facilities management, real estate management, etc.

The user seeking for an efficient innovation solution should provide, in the tables assessing innovation solutions, the exact information about alternatives under consideration as to the client's financial situation. It should be noted that various users making a multiple criteria analysis of the same alternatives often get diverse results. This may be due to the diversity of the overall aims and financial positions of the users. Therefore, the initial data provided by various users for calculating the innovation project differ and consequently lead to various final results.

The character of the objective's choice for the most efficient variant is largely dependent on all available information. It should also be noted that the quantitative information is objective. The actual innovation alternatives have real costs. The values of the qualitative criteria are usually rather subjective though the application of an expert's methods contributes to their objectivity.

The tables assessing innovation solutions are used as a basis for working out the matrices of decision-making. These matrices, along with the use of a model-base and models, make it possible to perform a multiple criteria analysis of alternative innovation projects, resulting in the selection of the most beneficial variants.

2.2 Model-base

The efficiency of an innovation variant is often determined by taking into account the economic, technical, technological, management, organisation, legal, social and other factors. These factors include an account of the economic, aesthetic, technical, technological, management, space, comfort, legal, social and other factors. The model-base of a decision support system should include models that enable a decision-maker to do a comprehensive analysis of the available variants and to make a proper choice. The following models of a model-base aim at performing the functions of:

- A model for the establishment of the criteria weights,
- A model for multiple criteria analysis and for setting the priorities,

- A model for the determination of a project’s utility degree,
- A model for the determination of a project’s market value.

According to the user’s needs, various models may be provided by a model management system. When a certain model (i.e. search for innovation alternatives) is used the results obtained become the initial data for some other models (i.e. a model for multiple criteria analysis and setting the priorities). The results of the latter, in turn, may be taken as the initial data for some other models (i.e. determination of utility degree of alternatives).

The management system of the model base allows a person to modify the available models, eliminate those that are no longer needed and add some new models that are linked to the existing ones.

Since the analysis of innovationis usually performed by taking into account the economic, technical, technological, management, organisation, legal, social and other factors, a model-base should include models which will enable a decision-maker to carry out a comprehensive analysis of the available variants and make a proper choice. The following multiple criteria analysis methods and models as developed by the authors (Kaklauskas 2002, Zavadskas 2002) are used by the *IDSS* in the analysis of the innovation alternatives:

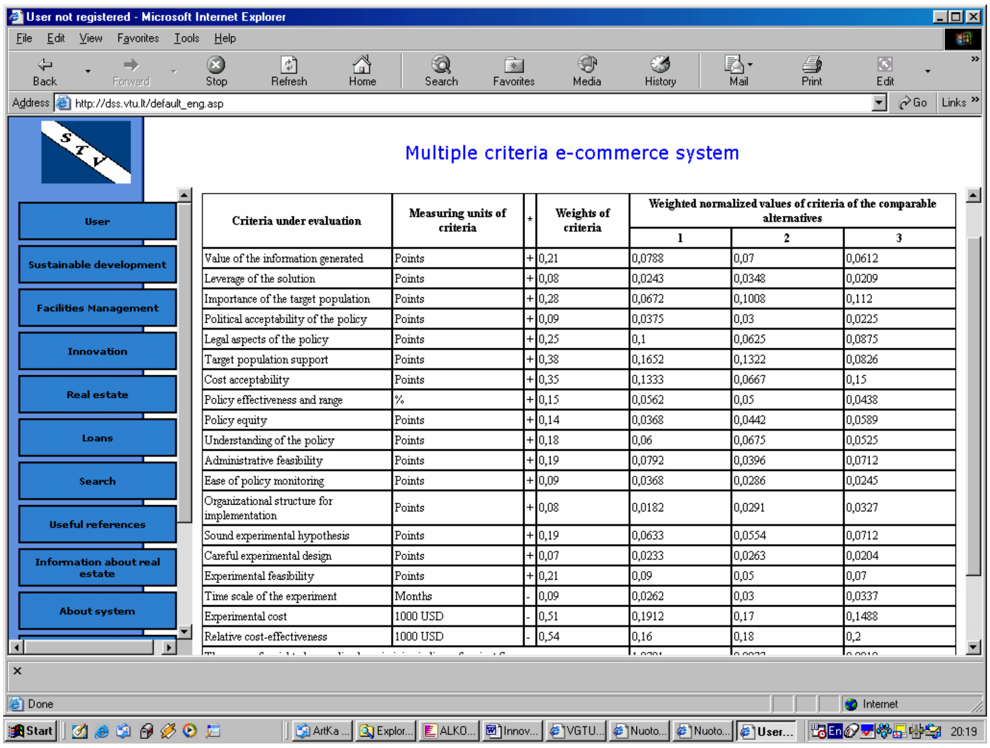
1) A new method and model of complex determination of the weight of the criteria taking into account their quantitative and qualitative characteristics was developed. This method allows one to calculate and co-ordinate the weights of the quantitative and qualitative criteria according to the above characteristics.

2) A new method and model of multiple criteria complex proportional evaluation of projects enabling the user to obtain a reduced criterion determining the complex (overall) efficiency of the project was suggested. This generalized criterion is directly proportional to the relative effect of the values and weights of the considered criteria, on the efficiency of the project.

3) In order to find what price will make a valuated project competitive on the market a method and model for determining the utility degree and market value of projects based on the complex analysis of all their benefits and drawbacks was suggested. According to this method the project’s utility degree and the market value of a project being estimated are directly proportional to the system of the criteria and adequately describe them, the values and weights of these criteria.

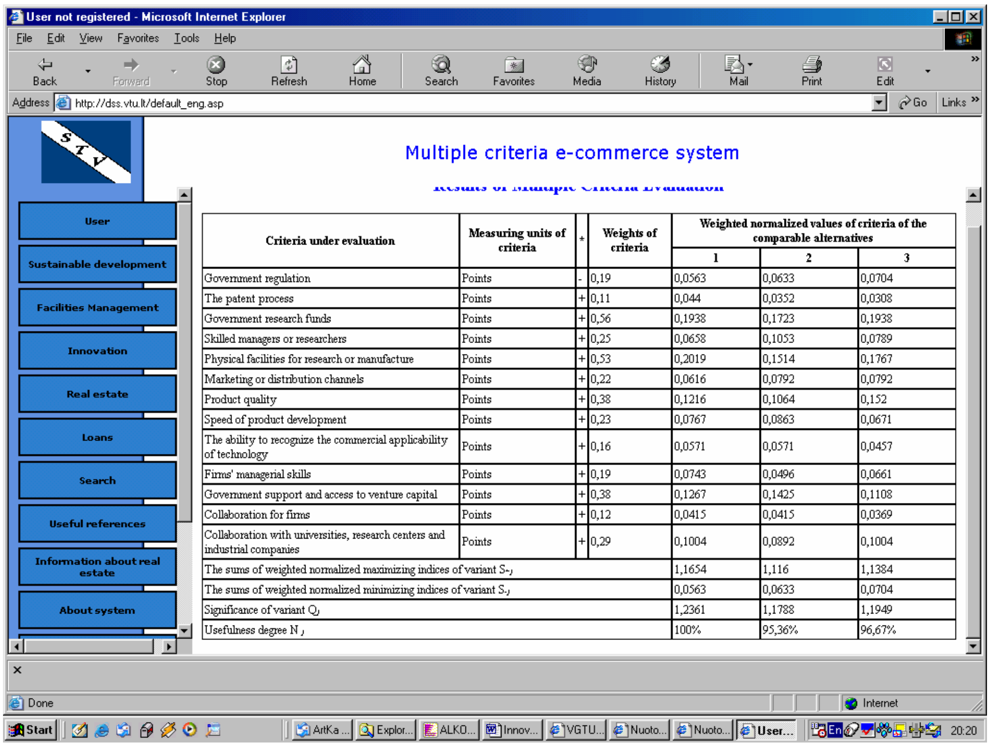
4) A new method and model of multiple criteria multi-variant design of a project’s life cycle enabling the user to make computer-aided design of up to 100,000 alternative project versions was developed. Any project’s life cycle variant obtained in this way is based on quantitative and conceptual information.

Application of Multiple Criteria Decision Support Web-Based System for Innovation (*IDSS*) allows one to determine the strengths and weaknesses of each phase and its constituent parts. Calculations were made to find out by what degree one version is better than another and the reasons disclosed why it is namely so. Landmarks are set for an increase in the efficiency of innovationversions. All this was done argumentatively, basing oneself on criteria under investigation and on their values and weights. This saved users’ time considerably by allowing them to increase both the efficiency and quality of innovation analysis.



Criteria under evaluation	Measuring units of criteria	*	Weights of criteria	Weighted normalized values of criteria of the comparable alternatives		
				1	2	3
Value of the information generated	Points	+	0,21	0,0788	0,07	0,0612
Leverage of the solution	Points	+	0,08	0,0243	0,0348	0,0209
Importance of the target population	Points	+	0,28	0,0672	0,1008	0,112
Political acceptability of the policy	Points	+	0,09	0,0375	0,03	0,0225
Legal aspects of the policy	Points	+	0,25	0,1	0,0625	0,0875
Target population support	Points	+	0,38	0,1652	0,1322	0,0826
Cost acceptability	Points	+	0,35	0,1333	0,0667	0,15
Policy effectiveness and range	%	+	0,15	0,0562	0,05	0,0438
Policy equity	Points	+	0,14	0,0368	0,0442	0,0589
Understanding of the policy	Points	+	0,18	0,06	0,0675	0,0525
Administrative feasibility	Points	+	0,19	0,0792	0,0396	0,0712
Ease of policy monitoring	Points	+	0,09	0,0368	0,0286	0,0245
Organizational structure for implementation	Points	+	0,08	0,0182	0,0291	0,0327
Sound experimental hypothesis	Points	+	0,19	0,0633	0,0554	0,0712
Careful experimental design	Points	+	0,07	0,0233	0,0263	0,0204
Experimental feasibility	Points	+	0,21	0,09	0,05	0,07
Time scale of the experiment	Months	-	0,09	0,0262	0,03	0,0337
Experimental cost	1000 USD	-	0,51	0,1912	0,17	0,1488
Relative cost-effectiveness	1000 USD	-	0,54	0,16	0,18	0,2

Multiple criteria analysis of government policies (alternative experiments) for technological innovation



Criteria under evaluation	Measuring units of criteria	*	Weights of criteria	Weighted normalized values of criteria of the comparable alternatives		
				1	2	3
Government regulation	Points	-	0,19	0,0563	0,0633	0,0704
The patent process	Points	+	0,11	0,044	0,0352	0,0308
Government research funds	Points	+	0,56	0,1938	0,1723	0,1938
Skilled managers or researchers	Points	+	0,25	0,0658	0,1053	0,0789
Physical facilities for research or manufacture	Points	+	0,53	0,2019	0,1514	0,1767
Marketing or distribution channels	Points	+	0,22	0,0616	0,0792	0,0792
Product quality	Points	+	0,38	0,1216	0,1064	0,152
Speed of product development	Points	+	0,23	0,0767	0,0863	0,0671
The ability to recognize the commercial applicability of technology	Points	+	0,16	0,0571	0,0571	0,0457
Firms' managerial skills	Points	+	0,19	0,0743	0,0496	0,0661
Government support and access to venture capital	Points	+	0,38	0,1267	0,1425	0,1108
Collaboration for firms	Points	+	0,12	0,0415	0,0415	0,0369
Collaboration with universities, research centers and industrial companies	Points	+	0,29	0,1004	0,0892	0,1004
The sums of weighted normalized maximizing indices of variant S_{+j}				1,1654	1,116	1,1384
The sums of weighted normalized minimizing indices of variant S_{-j}				0,0563	0,0633	0,0704
Significance of variant Q_j				1,2361	1,1788	1,1949
Usefulness degree N_j				100%	95,36%	96,67%

Multiple criteria analysis of the government alternatives of decreasing the barriers to innovation

Typical innovation problems solved by Decision Support Web-Based System for Innovation: Innovation; Construction; Facilities Management; Real Estate; Refurbishment; Sustainable Development; Loans; International Trade; Ethics.

3 Conclusions

The analysis of calculators, analysers, information, expert and decision support systems, neural networks that were developed by researchers from various countries assisted the authors to create of their own Decision Support Web-Based System for Innovation (*IDSS*). *IDSS* differ from others in the use of new multiple criteria analysis methods as were developed by the authors. The database of a best practices were developed providing a comprehensive assessment of alternative versions from the economic, technical, technological, management, organisational, qualitative, legislative and other perspectives. Based on the above complex databases, the developed System enables the user to analyse innovation alternatives quantitatively (i.e. a system and subsystems of criteria, units of measure, values and weights) and conceptually (i.e. the text, formula, schemes, graphs, diagrams and videotapes).

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