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EFFICIENCY INCREASE IN RESEARCH AND STUDIES WHILE APPLYING UP-TO-DATE INFORMATION TECHNOLOGIES

E. K. Zavadskas, A. Kaklauskas

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1. Introduction

The Department of Construction Technology and Management at the VGTU has achieved certain results in the fields of research and studies during the period of 1997 to 2000. Six Doctoral students (G. Ambrasas, A. Banaitis, N. Kvederytė, S. Jakučionis, V. Šarka ir V. Malienė) defended their Doctoral dissertations [1–6]. A. Kaklauskas defended a dissertation of Doctor Habilitatis under the guidance of Prof E. K. Zavadskas. Research activities took place at the Department in the following five major fields:

1. Development of a model for a complex analysis of a building life cycle [7–13];
2. Development of methods of multiple criteria analysis [14–24];
3. Development of multiple criteria decision support systems [25–37];
4. Total life analysis, modelling and forecasting construction in Lithuania [38–51];
5. Efficiency increase in of e-commerce systems applying multiple criteria decision support systems [52–56].

The study process also experienced changes. They were related to the implementation of up-to-date information technologies [32, 33, 57] in the process of studies. The following study programmes were available in the Department within the described period:

- Bachelor degree (Construction Management (specializations: Construction Technology and Management, Construction Economics) and Property Management) study programmes.
- Engineer degree (Construction Economics) study programme.
- Master degree (Construction Management (specializations: Construction Technology and Manage-

ment, Construction Economics) and Property Management) study programmes.

Since 1999 the distance (Internet) Master degree studies “Property Management” have been introduced in the Department, and Master degree studies “Construction Economics” from 2000 as well.

245 students will finish the above programmes at the Department in 2001.

Increasing efficiency of the study process is described from various perspectives in numerous publications by Prof E. K. Zavadskas [58–82].

Further the article contains a brief description of the above-mentioned achievement in research and studies within the period of 1997 to 2000.

2. A model for a complex analysis of a building life cycle

Research into a building life cycle aimed to increase its efficiency being achieved in the world may be classified in different ways:

- the investigations aimed at solving relevant problems of a particular stage of a building life cycle (ie brief, design, construction, maintenance, facilities management, demolition);
- the investigations handling a certain problem through the whole life cycle of a building;
- the investigations aimed to increase overall efficiency of a life cycle of a building;
- the investigations aimed to increase the efficiency of a life cycle of a building or its particular stage by applying recent achievements of IT and the Internet.

The research work carried out by Professors E. K. Zavadskas and A. Kaklauskas refers to the first and the third group listed above. It should be noticed

that the researchers from various countries engaged in the analysis of building life cycle and its stages did not consider the research object being analyzed by the authors of the present investigation. The latter may be described as follows: a life cycle of a building, the parties involved in its design and realization as well as micro-, meso- and macroenvironment having a particular impact on it making an integral whole. A complex analysis of the research object formulated was made with the help of new methods multiple criteria project analysis developed for this particular purpose. Today, the authors, in cooperation with the colleagues, are carrying out a research referring to the fourth group of the classification given above.

In order to design and realize a high-quality project, it is necessary to take care of its efficiency from the brief to the end of service life. The entire process must be planned and executed with consideration of goals aspired by the participating the interested parties and micro-, meso- and macrolevel environment.

In order to realize the above purposes an original model of a complex analysis of a building life cycle (see Fig 1) was developed enabling to analyze a building life cycle, the parties involved in the project as well as its micro-, meso- and macroenvironment as one complete entity.

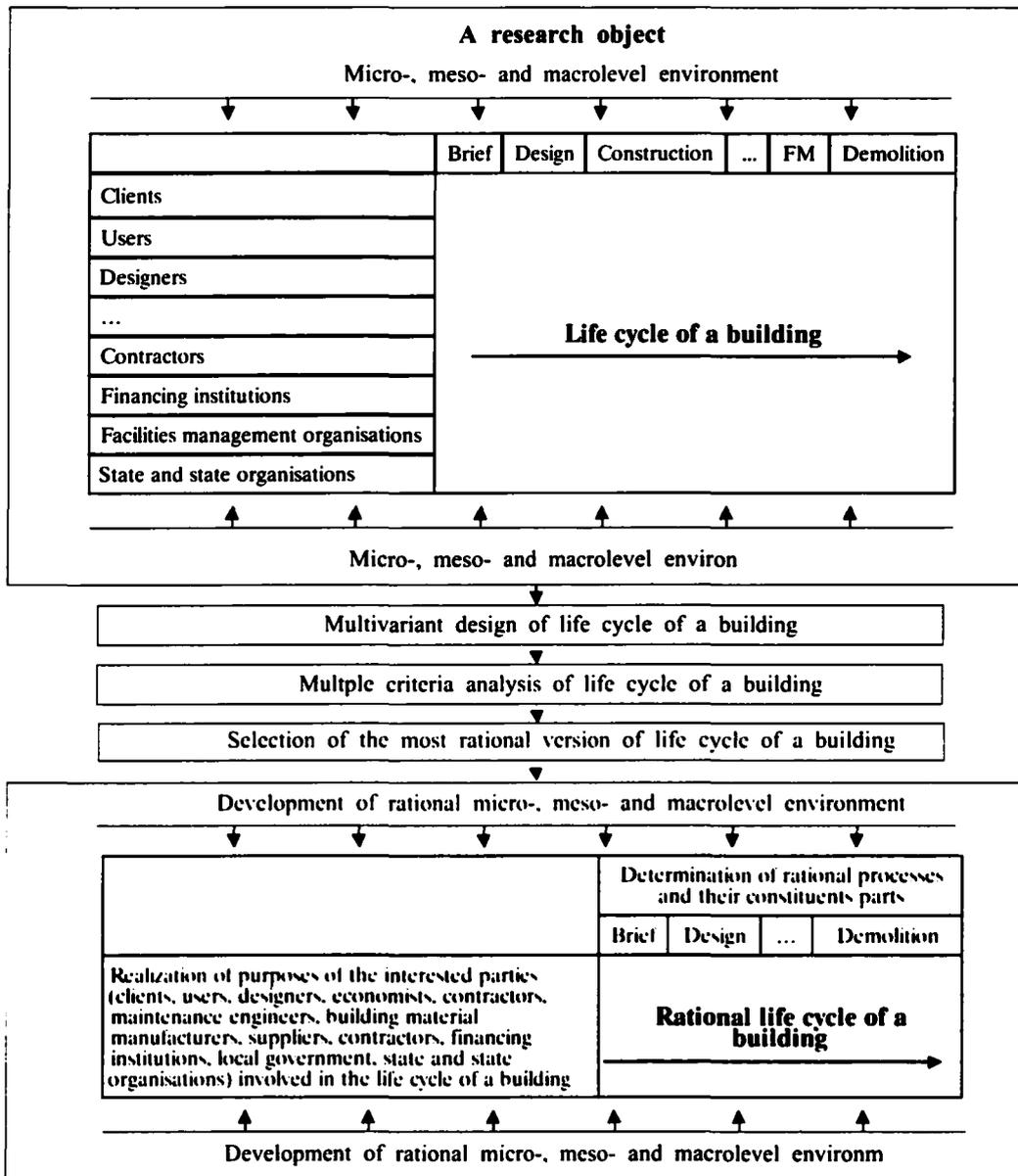


Fig 1. A model for a complex analysis of a building life cycle

A model for a complex analysis of a building life cycle was being developed step by step as follows (see Fig 1):

- A comprehensive quantitative and conceptual description of a research object;
- Multivariant design of life cycle of a building;
- Multiple criteria analysis of life cycle of a building;
- Selection of the most rational version of life cycle of a building, development of rational micro-, meso- and macrolevel environment.

A practical realization of a model for a complex analysis of a building life cycle was being developed step by step as follows (see Fig 2):

- A comprehensive quantitative and conceptual description of the life cycle of a building, its stages, the interested parties and environment;

- Development of a complex database based on quantitative and conceptual description of the research object;
- Development of new methods of multiple criteria analysis to carry out multivariant design of a building life cycle, to determine the utility degree of the alternative versions obtained and set the priorities;
- Creation of a multiple criteria decision support systems to be used in computer-aided multivariant design of a building life cycle, determining the utility degree of the alternative versions obtained and setting the priorities;
- Analysis of micro-, meso- and macrolevel environment factors influencing a building life cycle and possibilities to alter them in a desired direction.

The results obtained in the above research may be found in the authors' publications [7–13].

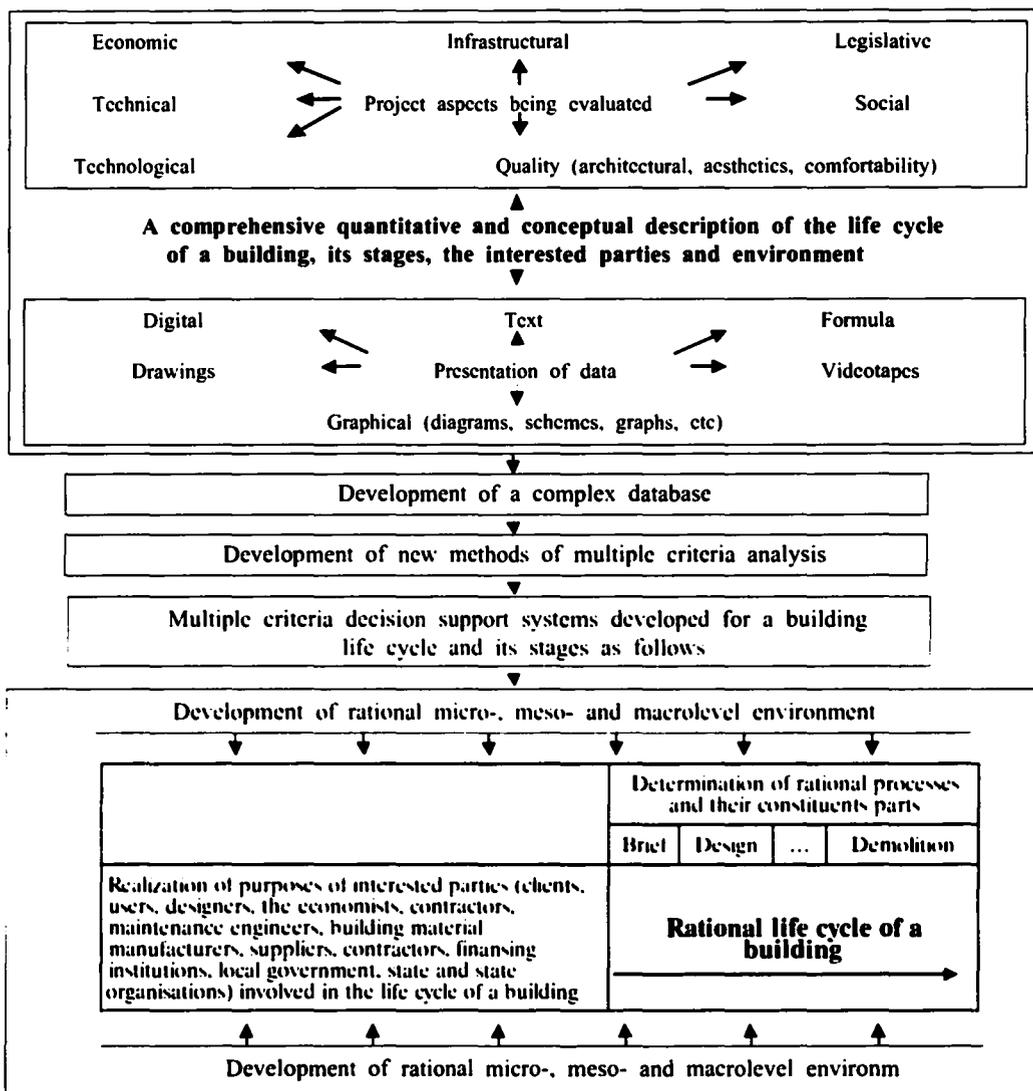


Fig 2. Practical realization of a model for a complex analysis of a building life cycle

3. Proposed methods of multiple criteria analysis

New methods for performing multiple criteria analysis of the research object chosen have been developed by the authors: a method of complex determination of the significances of the criteria taking into account their quantitative and qualitative characteristics; a method of multiple criteria complex proportional evaluation of the projects; a method for defining the utility and market value of an object; a method for multiple criteria multivariant design of a building life cycle; methods of multicriteria decision synthesis.

In order to select the best project, it is necessary, having formed the grouped decision-making matrix, to perform the multiple criteria analysis of the projects. This is done by comparing criteria numerical values and significances and analyzing the conceptual information of the investigated project. The life cycle of an investigated project can be described only on the basis of a criteria system comprising many criteria with different meanings and dimensions. Such variety of criteria makes it difficult to compare the projects directly. One of the major tasks in solving the above problem is to determine the significances of the criteria. It is most commonly done by means of expert methods.

Theoretical and practical aspects of expert methods in construction were dealt with in various research papers by D. Arditi [83], E. A. Chinyio [84], A. Gusakov [85], L. G. Evlanov [86] and others. Having determined the significances of criteria by expert methods, we learn how much one of the criteria is more significant than another one. However, having determined by these methods the significances of quantitative criteria (cost of plot and building, maintenance costs, construction time, etc), we do not find out everything we need. For instance, values of quantitative criteria in this case are not fully evaluated. A new method for complex determination of the significance of the criteria taking into account their quantitative and qualitative characteristics was developed. This method allows to calculate and coordinate the significances of the quantitative and qualitative criteria according to the above characteristics. In this case all the significances of qualitative and quantitative criteria are coordinated exactly at the same time.

V. M. Ozernoy [87] presented a number of multiple criteria decision-making methods to be used in sol-

ving discrete alternative problems: weighting methods (MacCrimon), multiattribute utility theory (Keeney and Raiffa), measurable value theory (Dyer and Sarin), analytical hierarchical method (Saaty), weighted-additive evaluation function with partial information (Kirkwood and Sarin), multiattribute method with incomplete information (Weber), pairwise comparison of alternatives with ordinal criteria (Koksalan, Karwan and Zions), simple multiattribute utility method (Einhorn and McCoch), Electre I, II and III (Roy and Vincke). Each of these methods actually represents a family of methods with similar characteristics. For example, the family of weighting methods contains at least nine different methods [87]. A. Goicoechea [88] analyzed the following multiple criteria decision-making methods: utility function assessment (Keeney), compromise programming (Zeleny), Electre (Roy, Duckstein), surrogate worth trade-off (Haines), multiobjective Simplex (Yu, Zeleny), method by Zions, Wallenius, Ariadne (Sage, White), probabilistic trade-off development, Protrade (Goicoechea, Duckstein) goal programming (Lee, Ignizio). The researchers as E. K. Zavadskas, A. Karablikovas, V. Kriukelis, H. Nakas, R. Sakalauskas, J. R. Šimkus [89], G. Geoffrey, P. Goodwin, G. Wright [90] etc also contributed to the solution of these problems. A new method of multiple criteria complex proportional evaluation of the projects enabling the user to obtain a reduced criterion determining complex (overall) efficiency of the project was suggested by the authors. This method assumes direct and proportional dependence of significance and priority of investigated versions on a system of criteria adequately describing the alternatives and on values and significances of the criteria. The system of criteria is determined and the values and initial significances of criteria are calculated by experts. All this information can be corrected by the interested parties (customer, users, etc) taking into consideration their pursued goals and existing capabilities. Hence, the assessment results of alternatives fully reflect the initial data jointly submitted by experts and the interested parties.

In order to find what price will make an object being valued competitive on the market, a method of determining the utility degree and market value of objects based on the complex analysis of all their benefits and drawbacks was suggested. According to this

method, the objects utility degree and the market value of an object being estimated are directly proportional to the system of the criteria adequately describing them and the values and significances of these criteria.

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

The results obtained in the above research may be found in the author's publications [14–24].

4. Multiple criteria decision support systems

Construction is characterised by a rather low productivity and a high fragmentation compared to other branches of industry. Much attention, efforts and time are paid by researchers, engineers and politicians of various countries to eliminate these disadvantages. Various researchers [91–99] developing expert and decision support systems are currently working on these problems at the levels of construction industry, particular organisations and projects.

According to the classification of investigations made in the field of building life cycle, aimed at increasing its efficiency, which was given in Chapter 2, expert and decision support systems used in construction may be divided into four groups.

The analysis of expert and decision support systems used in construction which were developed by researchers from various countries helped the authors to create multiple criteria decision support systems of their own. The systems developed by the authors in cooperation with their colleagues differ from others in the use of new original methods (presented in Chapter 3) and the object of investigation (presented in Chapter 2). Researchers from various countries involved in the analysis of a building life cycle and its components as well as handling the problems of their design did not touch upon the topic making a research object of the authors, ie life cycle of a building, the parties interested in the project and micro-, meso- and macroenvironment factors as an integral whole.

Decision support systems developed by the authors of the present research belong to the first, second

and third group of the classification of these systems. Multiple criteria decision support systems developed for a building life cycle and its stages as follows: multiple criteria analysis of a building life cycle and its stages, multivariant design and multiple criteria analysis of refurbishment of residential houses, multiple criteria analysis of construction projects, project total quality analysis, etc

The results obtained in the above research may be found in the author's publications [25–37].

5. Total life analysis, modelling and forecasting construction in Lithuania

The trends of construction industry development were investigated by researchers from various countries in a conceptual form. For example, according to R. C. Harvey [100, 101], past, present and future construction is closely connected with major economic indices of the state, such as total domestic product, state expenditures, consumer expenditures, fixed investment, average earnings, retail prices, disposable income, interest rate, etc To prove this idea R. C. Harvey [100, 101] presents some conceptual material. A. Akintoye [102] analyzed the relationship between cost of construction in the UK in 1974–90 and 23 economic factors (ie rate of pound and unemployment, volume of construction, total domestic product, actual interest rate, income per capita, company's taxes, number of private contractors, etc). The above analysis was made in textual, numerical and graphical forms, yielding diverse results. Researchers from Salford university [103] analyzed (in 1955–94) and predicted (since 1994) the investment in the UK construction, volume of construction, number of workers employed in this branch, as well as investigating the relationships between various factors. R. H. Barnard [104] and P. H. Hillebrandt [105] studied the relationship between the demand for construction products and the economic situation and social and economic policy of the state. G. Briscoe [106] analyzed the relationship between interest rate and state support in dwelling purchasing by the inhabitants, etc and the investment in construction. R. C. Harvey [101] studied the effect of amalgamation of building firms on the increase in construction efficiency. P.H.Hillebrandt [105] described some ways of increasing the

export of construction products, while S. Chapman and C. Grandjean [107] considered the ways of harmonizing the activities of construction specialists in the EU, publishing some guidelines in this sphere [108–110]. As it can be observed, researchers from various countries use conceptual and quantitative forms of analysis while studying the effect of certain factors on the efficiency of construction industry. However, the papers mentioned did not deal with a complex approach to construction industry taking into account economic, technical, technological, quality, infrastructural, legislative, social and other factors. The authors of the present investigation was trying to fill this gap by basing his work on all of the above factors.

The life cycle process model of efficient construction industry suggested by this research is based on presumption that the efficiency of construction industry depends on many micro-, meso- and macrolevel variables. The presence of specific macro, meso- and micro-level variable factors right away imposes objective limitations for efficient activities of construction industry. The construction industry, in presence of these objective limitations, tries to perform its functions in their bounds with utmost efficiency. For instance, organisations, depending upon certain micro-, meso- and macrolevel environment, would do their best to look for activities in such fields of construction industry as designing, production of building materials, tools and mechanisms, construction of dwelling houses, thermal refurbishment of buildings, supply, etc, and in geographic locations including the capital, various towns and districts of the country, rural districts, etc as well as working and with the interested parties the goals of which would find maximum satisfaction. Advanced organisations, basing themselves on this assertion, are trying to create for themselves rational environmental and operating conditions in order to achieve the best satisfaction of customers' needs, to win better reputation and to earn more profit. Therefore, basing oneself on main development trends of construction industry in advanced industrial countries, it is possible to issue recommendations on the increase of efficiency of transition construction industry in Lithuania. When rational variable micro-, meso- and macrolevel factors determines for Lithuania have been realized, they should create better and more favourable conditions for efficient

realization of construction industry's projects.

The research aim was to produce an analytical model of the rational construction industry in Lithuania by undertaking a complex analysis of micro-, meso- and macroenvironment factors affecting it and to give recommendations on the increase of its competitive ability. The research was performed by studying the expertise of advanced industrial economies and by adapting it for Lithuania, taking into consideration specific history, development level, needs and traditions. Simulation was undertaken to provide insight into creating an effective environment for the construction industry by choosing rational micro-, meso- and macrofactors.

The organisations of construction industry cannot correct or alter the micro-, meso- and macrolevel variables, but they can go into the essence of their effect and take them into consideration when realizing various projects. Organisations, knowing the micro-, meso- and macrolevel factors affecting the projects being realized, can organise their present and future activities more successfully.

Based on the above considerations, it is possible to propose a life cycle process model of an efficient construction industry on the basis of the performed search for a rational variable environment for Lithuania (ie seek to explore ways of harmonising the relationship between Lithuanian construction in transition and its environment). Upon completion of such a model, the interested parties by taking into consideration the existing limitations of micro-, meso- and macrolevel environment and the existing possibilities, will be able to use their resources in a more rational manner.

This research seeks to explore ways of harmonising the relationship between the transitional Lithuanian construction and its environment. The research included the following stages presented in Figure 3.

The results obtained in the above research may be found in the authors' publications [38–51, 111–113].

6. Efficiency increase in efficiency of e-commerce systems applying multiple criteria decision support systems

Many systems of electronic commerce are processing and submitting just the economic information for decisions, and applying economic models as well. However, the alternatives under consideration have to be

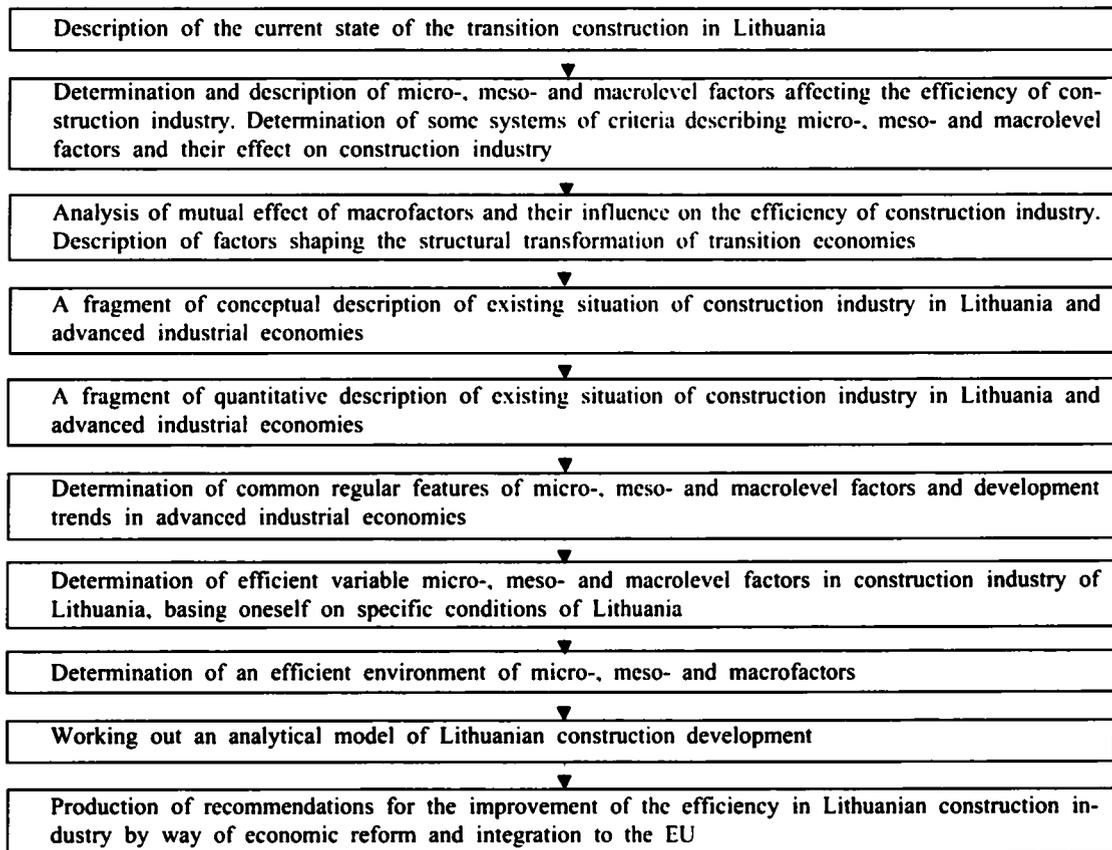


Fig 3. Main stages of working out an analytical model of Lithuanian construction development

evaluate not only in economic position, but taking into account the qualitative, technical and other characteristics, too. For example, the analysis of property is being usually performed taking into account economic, quality (architectural, aesthetic, comfortability), infrastructural, technical, legal, technological, social and other factors. Therefore, the efficiency of e-commerce may be increased applying the multiple criteria decision support systems. This chapter is intended to provide how application of multiple criteria decision support systems developed by the authors could increase the efficiency of e-commerce of construction materials and property. The suggested systems are better compared with other online systems, because the intelligent agents here are comparing a number of alternatives different parameters with each other.

This chapter also includes a short description of the interested parties that could apply suggested systems in their activities and capabilities of systems.

6.1. Efficiency increase in e-commerce construction materials systems

Many e-commerce systems are seeking to find out the most economic decisions, ie most of all they are intended only for economic objectives. However, the alternatives under evaluation have to be regarded not only in economic position, but taking into consideration the qualitative, technical and other characteristics too. For example, the analysis of alternative construction materials is being usually performed taking into account price, discounts given, thermal insulation, sound insulation, harmfulness to human health rate, aesthetic, weight, technical specifications, physical and moral longevity and other factors. Alternative solutions allow for more rational and realistic assessment of economic, technical conditions and traditions and for better satisfaction of architectural, comfort, maintenance and other customer requirements. Their application also enables to cut down project costs.

E-commerce implementation may not be followed by sales. For example, let's look at some of the early Web sites for air ticket sales. They often served only as information providers for those who shop for the lowest discount airfares. Such shoppers leave the site, without any purchase, after collecting the information. In a sense, the similar situation is in Lithuania at the moment. There are various reasons (incompletely arranged legislative base, a comparatively small part of society uses information technologies, and, in order to start e-commerce, considerable initial investments are needed, there is a lack of experience in e-commerce practical activities) predetermining that at the moment it is not useful to apply e-commerce in Lithuania, in a volume being used in the developed countries. For example, electronic procurement systems, which include top-tier features like application programming interfaces to existing legacy systems with the ability to handle different communication among multiple suppliers, can range from \$250,000 to \$2 million. With such high start-up costs expected and the current limitations of software packages, making a decision on buying versus building is critical. Therefore it is more efficient to apply search and multiple criteria analysis decision support systems in Lithuania. Following the mentioned and other ideas the authors have developed Consumer Multiple Criteria Decision Support (CMCDS) system.

The proposed CMCDS system can be valuable in the following important ways: to help customers assess their needs, to identify suitable offers to fulfil needs, to compare and evaluate offers, to match a particular offering with the customer in an attempt to get the 'best deal' for the customer, to help customers evaluate the usefulness of the product in the after-purchase evaluation stage. In general, the proposed system creates greater convenience and better choices for buyers in the purchase process.

A general purchasing decision-making model for consumers includes five principal stages: demand identification, information search, and evaluation of alternatives, purchase and delivery, and after-purchase evaluation. Efficiency of some above-mentioned stages may be increased applying the CMCDS system for e-commerce of construction materials, which is suggested by the authors. How is such a process viewed in cyberspace?

Now the developed CMCDS system allows performance of the following functions:

1. Search for construction materials. A consumer may perform a search of alternatives from catalogues of different suppliers and producers. It is possible because the forms of data submission are standardized in a specific level. Such standardization creates the conditions to use special intelligent agents performing search of the required construction materials in various catalogues, and gathering information about them. One or several regions may limit such search.

2. Finding out alternatives and making comparative tables. Consumers specify requirements and constraints and the system queries the information of a specific construction materials from a number of online vendors and returns a price-list and other characteristics that best meets their desire. The system performs the tedious, time-consuming, and repetitive tasks of searching databases, retrieving and filtering information, and delivering it back to the user. Results of search of a specific construction materials are submitted in tables, which may include direct references to a Web page of a supplier or producer. By submission such a display, the multiple criteria comparisons can become more effectively supported.

3. Alternatives evaluation stage (multiple criteria analysis of alternatives and selection of most efficient ones). While going through the purchasing decision process a customer must examine a large number of alternatives, each of which is surrounded by considerable amount of information (price, discounts given, thermal insulation, sound insulation, harmfulness rate to human health of materials, aesthetic, weight, technical specifications, physical and moral longevity, etc). Following on the gathered information the priority and utility degree (utility degree is directly proportional to the relative effect of the values and significances of the criteria considered on the efficiency of the alternative) of alternatives are being calculated. It helps consumers to decide what product best fits their requirements.

The after-purchase evaluation stage. A consumer evaluates the usefulness of the product in the after-purchase evaluation stage.

6.2. Increase of efficiency of e-commerce property systems

Property decision support (PDS) system home page (<http://193.219.145.99>) has links to other Web pages:

- Theory Web page (<http://193.219.145.99/PROJ2/TEORIJA/teorija1.htm>). It includes the theory suggested by authors following on that the models of model-base have been developed.
- User guide for work with system Web page (<http://193.219.145.99/proj2/help2.pdf>). With assistance of this guide it is quite simple to use system in practice.
- Description of system aims and capabilities Web page (<http://193.219.145.99/proj2/help1.pdf>). This Web page includes a short description of the interested parties that could apply system in their activities and capabilities of system.
- Commercial property Web page (<http://193.219.145.99/PROJ2/PARDUOT/parduot.htm>).
- Dwellings Web page (<http://193.219.145.99/PROJ2/NAMAI/namai.htm>).
- Farmer's homestead estates Web page (<http://193.219.145.99/PROJ2/SODYBOS/sodybos.htm>).

These links are presented in underline text. Seeking to explore the link, click the underline place. While further development of PDS system it is provided to expand a database (above Web pages) with other types of property.

Presentation of information in commercial property, dwellings, farmer's homestead estates and other types of property Web pages may be in conceptual (digital, textual, graphical, photographic, video) and quantitative forms. Thus, quantitative information presentation involves criteria systems and subsystems, units of measurement, values and initial significances fully defining the variants provided. Quantitative information of property is submitted in a form of grouped decision-making matrix, where the columns mean n property under valuation, and rows include quantitative infor-

mation. Conceptual information means a conceptual description of the property, the criteria and ways of determining their values and significances, etc Conceptual information is needed to make more complete and accurate valuation of the property considered. In this way, system enables the decision maker to get various conceptual and quantitative information on property from a database and a model-base allowing him to analyze the above factors and make an efficient solution.

Capabilities to use the PDS system in practice are:

- Property valuation in various aspects (ie determination of market value, value in use, investment value, etc).
- Valuation of factors affecting value of property (for example valuation of property location, property depreciation, etc).
- Determination of the highest and best use of a property.

While further development of PDS system it is provided to expand a database of property, to create possibilities to perform property assignment operations (rent, lease, donation, purchase-sale, etc) and payment, payment control, to receive information about the state of personal account of a customer (checking of availability of the required amount of money in account), to perform information exchange (announcement board, discussions forums, advertising, e-mail box, articles, other information). Since the information on offered property subject on regular changes, therefore the up-to-date information should be searched in Web pages of brokers and other interested in groups. Thus it is envisaged to submit references to Web sites of the interested parties. Moreover, it is foreseen to place information on activities of property appraisers, brokers and other interested parties, various announcements, notices, information of market situation, its changes and future prospects, information bulletins issued, other up-to-date information for users' attention.

The results obtained in the above research may be found in the authors' publications [52-56].

7. Property management postgraduate Internet studies

Unprecedented and large-scale transformations of social, economic, legal, political and other spheres are occurring in Lithuania. Lithuania is seeking a rapid in-

tegration (harmonisation) with various structures of the EU. At the same time, one of the most intensively developing sectors of Lithuanian economy is the real estate market. The property and construction industry, under the effect of these changes, feel a particular need for property management (PM) specialists, as specialists in a new field, trained according to the highest standards. In 1999, a distance learning programme (via Internet) of "Property management" leading to Master degree was introduced at the Department of Construction Technology and Management. The present programme of distance (Internet) studies is the first of such kind in Lithuania.

The programme of PM distance studies has been developed in the following phases:

- To analyse the needs of the market and learners at national level;
- Alternative curriculum designs prepared and evaluated against market needs. Rational solutions chosen;
- To determine who the learners are likely to be, what is to be learned, where the learning will take place, what equipment and tutorial support will be required;
- To develop appropriate teaching techniques, to set-up and test technical infrastructure;
- To organise the most effective means of delivering learning to satisfy the market needs;
- To develop appropriate teaching techniques;
- To test learning material;
- To revise learning materials subsequent to testing.

Some information on the studies can be found on the VGTU Internet pages (<http://www.vtu.lt/dmc01/index1.htm>).

After the programme of distance studies has been created all potential users - authorities and organisations were informed about the project and its results by the following means: advertisements in regional and national newspapers, journals; meetings with students, authorities, employees of banks, insurance companies, retail shopping groups, real estate companies, venture capitalists, and other interested parties; sending leaflets to offices of authorities, banks, insurance companies,

retail shopping groups, real estate companies, venture capitalists, and other interested parties; publication of the programme materials, use of www, articles in the journals of the professional organisations representing the property management disciplines. This dissemination brings to the attention of a wider audience the issues facing PM professionals in Lithuania.

Students admitted to the studies are being divided into two groups: students who have completed the studies of higher education in this or similar field, and students who have completed the studies of higher education not in this or similar field. The programme for the students of those groups differs at 25%. The students having completed studies of higher education in this or similar field are improving their knowledge further. The students who completed studies of higher education not in this or similar field are trying to fill gaps of unavailable knowledge. Duration of studies is 2 years: three first semesters are intended for studying, and the fourth semester is for final (graduate) thesis. Students have to take five examinations within each semester on average. Duration of a semester covers 16 weeks. The knowledge obtained by a student is being evaluated by an examination. Most of all a student must answer three or four extensive, or ten brief questions within an examination.

The individual modules (property management, economics, valuation, facilities management, real estate investment and finance, law, decision support systems, etc) which make up the distance learning programme are self-contained units of study which can be undertaken by learners at a time, place and pace which suits their needs and those of their employers. It is recognised that the adoption of distance learning can assist learners and their employers by making available specialist knowledge throughout the learner's working life. This enables the concept of lifelong learning to be catered for by the programme.

Undertaking the programme in a distance learning mode of study involves learners in various activities which may initially be unknown to them: induction programme, directed learning, independent study, computing facilities. At the start of the programme, an induction programme is organised which seeks to integrate learners into the distance learning environment and to explain to them the detailed demands. The study ma-

terial provided for each module seeks to provide learners with guidance on directed learning. After learners' induction into the programme, most of their study is undertaken by them working in their own time and place. It is essential for learners undertaking this programme on a distance learning basis, to have the right computing facilities available to them.

All programme materials are presented as printed programme notes which enhance, where appropriate, to take advantage of modern teaching techniques and delivery mechanisms. In particular, the following media are used in specific modules: electronic format the textbooks, video, computer software, computer learning systems, computer conferencing, computer networks, face-to-face contact. The choice of media is often relatively easy to make because for much of the time, local constraints, questions of accessibility and of cost virtually dictate the media through which learners will have to work. Accessibility is vitally important to any learners who have to use self-instructional materials.

The module writers utilised electronic technologies for preparing their module material. This assisted the programme team to prepare the material in a variety of suitable formats for dissemination. Once in electronic format the material can be made available in paper format, on CD, over the Internet and by file transfer (FTP). This ensures the learners to have the material available in the way which best suits their learning needs. Equipment, such as video-recorders and computers are utilised wherever possible. In addition, face-to-face contact, telephone, fax, surface mail, e-mail are used, too.

The results obtained in the above work may be found in the authors' publications [32, 33, 57].

8. Conclusions

1. An original model of a complex analysis of a building life cycle enabling the user to analyze a building life cycle and its stages, the parties involved in the project as well as its micro-, meso- and macro-environment as an integral whole is developed. A building life cycle as well as the parties involved in the project and the environment having a certain impact on it are described from various perspectives in numerous publications by the authors in quantitative (a system and subsystems of criteria, units of measure, values and significances) and conceptual (text, formula, graphical

(ie schemes, graphs, diagrams and video tapes) forms.

2. The suggested systems and subsystems of criteria relating to a building life cycle and based on economic, technical, technological, qualitative (ie comfortability, architectural, aesthetic, and the like), legislative, social and other factors are described in a number of publications.

3. A new method for a complex determination of the criteria significance taking into account their quantitative and qualitative characteristics was developed. This method allows to calculate and coordinate the significances of the quantitative and qualitative criteria according to the above characteristics.

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

5. In order to find what price will make an object being valued competitive on the market, a method of determining the utility degree and market value of objects based on the complex analysis of all their benefits and drawbacks was suggested. According to this method, the objects utility degree and the market value of an object being estimated are directly proportional to the criteria system adequately describing them and the values and significances of these criteria.

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

7. An original model for a complex analysis of a building life cycle enabling the user to analyze a building life cycle and its stages, the parties involved in the project as well as its micro- and macro- environment as an integral whole is developed.

8. Original multiple criteria decision support systems to be used in construction for a complex analysis of a building life cycle and its stages, the parties involved and micro- and macro- level environment factors were created. These systems were used for multivariant design and multiple criteria analysis of the life

cycles and their stages of one-family houses, agricultural, industrial and in-situ buildings.

9. Formalized presentation of the research shows how changes in the environment and the extent to which the goals pursued by various interested parties are satisfied cause corresponding changes in the value and utility degree of a building life cycle. With this in mind, it is possible to solve the problem of optimization concerning satisfaction of the needs at reasonable expenditures. This requires the analysis of building life cycle versions allowing to find an optimal combination of goals pursued and finances available.

10. In order to increase the efficiency of a building life cycle, a model for analyzing, modelling and predicting the development of Lithuanian construction industry was developed enabling the users to achieve better practical results in designing a more effective life cycle of buildings. Theoretical conclusions of the present work were used in scientific research carried out under PHARE programme as well as in the projects ordered by the Ministry for Construction and Urban Development.

11. Starting from 1999, the distance (Internet) post-graduate studies "Property Management" have taken place in the Department of Construction Technology and Management at the VGTU, and "Construction Economics" studies from 2000 as well.

12. Now the developed e-commerce construction materials system allows performance of the following functions: search of construction materials; finding out of alternatives and making of comparative tables; alternatives evaluation stage (multiple criteria analysis of alternatives and selection of most efficient ones); the after-purchase evaluation stage (a consumer evaluates the usefulness of the product in the after-purchase evaluation stage).

13. The main data obtained in the research were discussed at the scientific conferences and seminars held in Edinburgh, Glasgow (UK), Gavle (Sweden), Paris, Lisbon, Athens, Leipzig, Poznan, Zieliona Gura, Riga, Vilnius, Kaunas, Moscow, Minsk.

14. The theoretical results of the investigation were used in 19 research and budgeted works (1990–1999) performed both in Lithuania and abroad.

15. The data obtained in the research were used in the educational process at Vilnius Gediminas Technical University for:

- Preparing lecture courses on building economy and investment, total quality management, quantitative and qualitative methods of analysis, functional value analysis and contracts at Vilnius Gediminas Technical University for Bachelor and Master degrees as well as for engineers in Civil Engineering, Construction Management and Property Management;
- Compiling the materials for the course of lectures „Multiple criteria analysis of projects” for Doctoral students in construction;
- Developing the Internet module of lectures „Decision support systems in construction”.

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MOKSLO IR STUDIJŲ EFEKTYVUMO DIDINIMAS TAIKANT NAUJAUSIAS INFORMACIJOS TECHNOLOGIJAS

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Santrauka

Pristatomi prof. E. K. Zavadsko ir prof. A. Kaklauskos 1997-2000 m. laimėjimai moksle ir studijų procese. Šiuo laikotarpiu 6 katedros doktorantai (G. Ambrasas, A. Banaitis, N. Kvederytė, S. Jakučionis, V. Šarka ir V. Malienė [1-6]) apgynė daktaro disertacijas. Prof. E. K. Zavadsko vadovaujamas A. Kaklauskas apgynė habilituoto daktaro disertaciją. Taip pat buvo atlikta daug mokslo tiriamųjų užsakomųjų ir biudžetinių darbų tiek Lietuvoje, tiek užsienyje. Moksliniai tyrimai katedroje buvo atliekami penkiomis pagrindinėmis kryptimis:

1. Sukurtas originalus pastato gyvavimo proceso kompleksinės analizės modelis [7-13]. Šis modelis leidžia kompleksiskai analizuoti pastato gyvavimo procesą, jo sudėtinės dalis, suinteresuotas grupes ir išorinę aplinką kaip visumą.

2. Buvo sukurti nauji daugiakriterinės analizės metodai [14-24]: kompleksinis kriterijų reikšmingumo nustatymo, atsižvelgiant į jų kokybines ir kiekybines charakteristikas; projektų daugiakriterinio kompleksinio proporcingo įvertinimo; daugiakriterinis objektų naudingumo laipsnio ir rinkos vertės nustatymo; pastato gyvavimo proceso daugiakriterinio variantinio projektavimo; daugiakriterinių sprendimų sintezės metodai.

3. Sukurtos originalios daugiakriterinės sprendimų paramos sistemos [25-37] statyboje, sudarančios sąlygas kompleksiskai analizuoti pastato gyvavimo procesą, jo sudėtinės dalis, jame dalyvaujančias suinteresuotas grupes ir šį projektą veikiančią išorinę mikro-, meso- ir makrolygmens aplinką. Su šiomis sistemomis buvo atliktas vienbučių gyvenamųjų namų, žemės ūkio gamybinių, pramoninių, monolitinių gyvenamųjų bei kitų pastatų gyvavimo proceso ir jo sudėtinių dalių variantinis projektavimas, daugiakriterinis įvertinimas ir naudingumo laipsnio nustatymas.

4. Siekiant padidinti pastatų gyvavimo proceso efektyvumą, buvo sukurtas Lietuvos statybos šakos analizės, modeliavimo ir prognozės modelis [38-51], kurį įdiegus praktikoje būtų sudarytos sąlygos racionaliau įgyvendinti pastatų gyvavimo procesus. Šio darbo teoriniai rezultatai buvo pritaikyti atliekant mokslinius tyrimus pagal PHARE programą bei vykdamant Statybos ir urbanistikos ministerijos užsakymus. Taikydamos šį modelį statybos šakos organizacijos ir kitos suinteresuotos grupės, atsižvelgdamos į esamus mikro- ir makrolyg-

mens aplinkos apribojimus bei galimybes, galės racionaliau panaudoti savo išteklius.

5. Kuriamos elektroninės komercijos sistemos [52-56].

Studijų procese taip pat vyko permainos. Jos buvo susijusios su naujausių informacijos technologijų diegimu į mokymo procesą. Jau aprašomuoju laikotarpiu Statybos technologijos ir vadybos katedroje buvo nemaža studijų programų: pagrindinės studijų programos (statybos valdymas (pakraipos: statybos technologija ir vadyba; statybos ekonomika ir verslas) ir nekilnojamojo turto vadyba); specialiųjų profesinių studijų programa (statybos ekonomika ir verslas); magistrantūros studijų programos (statybos valdymas (specializacijos: statybos technologija ir vadyba; statybos ekonomika ir verslas) ir nekilnojamojo turto vertinimas ir vadyba). Nuo 1999 m. katedroje vyksta nuotolinės (internetinės) magistrantūros „Nekilnojamojo turto vertinimas ir vadyba“, o nuo 2000 „Statybos ekonomikos ir verslas“ studijos [32, 33, 57]. Numatoma, kad minėtas programas katedroje 2001 m. baigs 245 studentai. Taip pat prof. E. K. Zavadskas parašė daug straipsnių ir knygų studijų efektyvumo didinimo klausimais [58-82].

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