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Comprehensive Risk Assessment Model in Agile Construction Environment

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***Abstract*—**The article focuses on a developed comprehensive model to be used in an agile environment for the risk assessment and selection based on multi-attribute methods. The model is based on a multi-attribute evaluation of risk in construction, and the determination of their optimality criterion values are calculated using complex Multiple Criteria Decision-Making methods. The model may be further applied to risk assessment in an agile construction environment. The attributes of risk in a construction project are selected by applying the risk assessment condition to the construction sector, and the construction process efficiency in the construction industry accounts for the agile environment. The paper presents the comprehensive risk assessment model in an agile construction environment. It provides a background and a description of the proposed model and the developed analysis of the comprehensive risk assessment model in an agile construction environment with the criteria.

***Keywords*—**Assessment, environment, agile, model, risk.

I. Introduction

THE efficiency of a construction process is often associated with successful risk management [1]. The risk assessment is based on a multi-stage concept [2]. Project risks are conditioned by an environment; therefore, they need to be considered aiming for better results in terms of the scope, schedule, cost, and quality of the construction project. The framework combines risk-management and performance-based building approaches. The framework of risk assessment processes deals with the prediction of future impacts (nature, frequency, etc.) of the proposed activities [3]. The aim is to manage the decision-making process in terms of the significance, magnitude and character of impacts, the acceptability of risk and proposals of mitigation measures. The European Union has encouraged its member states to apply risk assessment in EIA, particularly to extreme events but very little specific guidance is available on how to apply risk assessment or risk analysis in EIA [3]. The origins and development of EIA and the relationship between EIA, risk assessment, technology assessment and social impact assessment were proposed. It shows EIA and risk assessment both contributing to environmental risk management. It considers the assessment and the decision and includes communication, implementation and monitoring of the selected option [4]-[8].

According to the important role of project risk management, different approaches by the professional project management associations and many government agencies have been developed to accurately model the risks imposed by a typical project. In the USA, the Project Management Institute (PMI) provided a risk management program to systematically manage the risks of projects [3]. In the UK, the Association for Project Management developed the Project Risk Analysis and Management (PRAM) guide to scientifically monitor the risks of projects [9]. Standards Association of Australia introduced a risk management guideline for risk analysis [10]. International Electrotechnical Commission (IEC) provided a general introduction to project risk management, its sub-processes, and influencing factors [11]. The Office of Government Commerce (OGC) developed a route map for risk management [12]. The developed approach helps managers to identify, assess, and control risks. The integrated risk management framework is an effective framework for making informed decisions [13]. However, often approaches offer few insights into how the process of risk management works in practice. Therefore, the new developed model must be presented as a new approach, which is more adapted to the country conditions and aimed at comprehensive environment and typical construction project conditions. This guideline provides practical information on conducting an effective risk management process. This process comprises five main parts, including risk determination, risk identification, risk evaluation, risk planning, and risk monitoring. Nevertheless, the risk evaluation is the core part of the risk management process. Considering the key importance of the risk evaluation, many models have been developed to effectively formulate the potential risks imposed by projects.

Models and frameworks used for managing construction projects are typically inspired in business “cultures” that prevail within industrial contexts. The conceptual backgrounds of quality, performance, and risk environments are explored to ascertain whether these “cultures” can complement each other. Such a framework envisages the fulfilment of requirements specified by end-users (society and individuals) and other interested parties related to the building product, as well as the agile interaction between and within the building, manufacturing, property, and capital and insurance markets, at both international, national and enterprises levels [14].

II. Assessment Processes in an Agile Environment

Risk assessment in an agile environment involves a systematic and comprehensive methodology for quantifying the probability of the occurrence of a particular adverse event and the magnitude of the associated consequence of its outcome [15], [16]. The risk assessment in an agile

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environment is faced with different types of uncertainties including aleatory and epistemic uncertainty that can be accounted by probability theory and possibility theory, game and fuzzy set theory, respectively. The former type of uncertainty is often referred to as objective or stochastic whereas the latter is often referred to as subjective or state-of-knowledge. Risk assessment model within agile environmental impact is required for the construction and presented in Fig. 1.

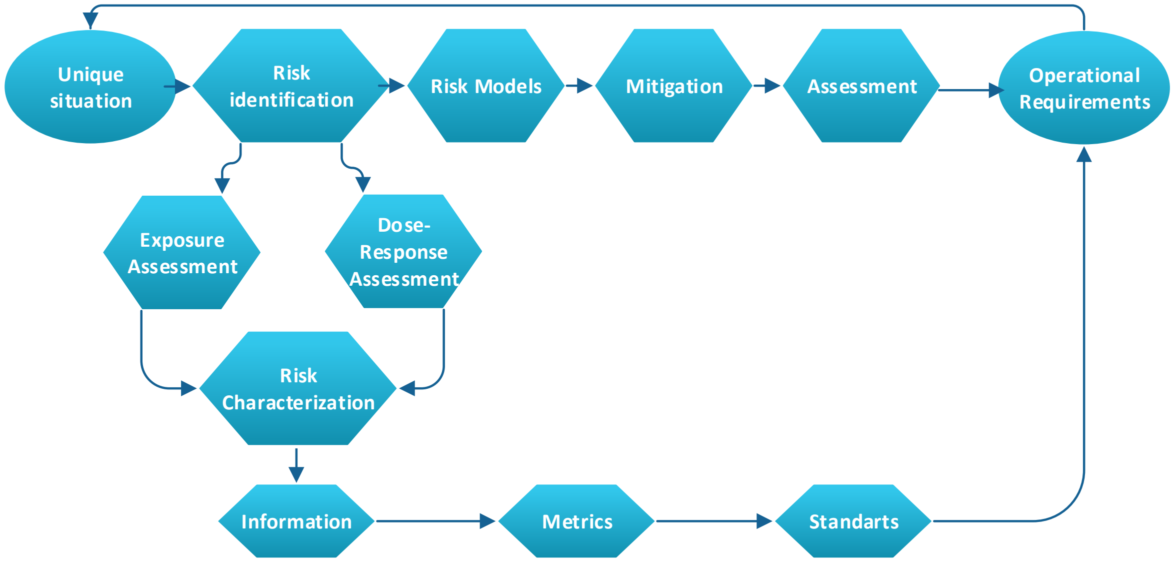

Fig. 1 Framework of risk assessment processes in an agile environment

Risk management approaches begin with a preliminary phase of risk identification intended to detect and classify potential risk items. Risk identification is studying a situation to realise what could go wrong in the project development at any given point in time during the project [17]. There are some risk identification tools such as Checklist, Influence Diagrams, Cause and Effect Diagrams, Failure Mode and Effect Analysis, Hazard and Operability Study, Fault Trees and Event Tree [18]. To identify risks in construction projects, various structures have been developed by researchers. Construction risks can be categorised in several ways based on the source of risk, the impact of a risk or by project phase [19], including generally main comprehensive risks fields as an example: local investment environment risks, technical risks, organisation management risks, social responsibility risks, economic risks.

III. Comprehensive Risk Assessment Model and Methods in Construction

The assessment of complicated problems concerns initial data with numerous values or big data; therefore, the values must correspond to the content of the problem, i.e. risk assessment. The typical risk assessment models and problem-solving methods can be divided into common, hybrid, combine, multi-stage, qualitative, quantitative and comprehensive methods [20-23]. The analysed problem type, specifics, measurement date, etc. must be included and a relevant problem-solving risk assessment model must be selected [24-29].

The game theory and possible methods are presented in the review [30]. The first analyses of the impact of normalisation methods on results of calculations were made by Peldschus and Börner in the 1980s [31]. The analyses of the impact of normalisation methods were presented by Peldschus in 1986 [32]. The background of the game theory supported the development of the calculation software LEVI-3 [33], which allows analysing different types of normalisation methods [32, 34-38]. LEVI-4 software enables the analysis of the influence of normalisation methods on calculation results [39, 40]. Turskis *et al.* [41] presented a new version of LEVI-4, which facilitated the use of new logarithmic techniques in the context of some aspects of two-sided game problems. Comprehensive risk assessment model in an agile construction environment by applying game theory and LEVI program are presented in Fig. 2. It should also be noted that LEVI 4 allows a user to apply various methods based on needs, helping the decision-maker (user) perform the integrated analysis of alternatives.

LEVI 3.0 was a result of the cooperation between VGTU and HTKW [42]. All calculations were made using LEVI 4 [43]. LEVI 4 was modified for evaluating various processes in economics, engineering and management. This software allows finding a solution under the conditions of risk and uncertainty and to compare the results by applying different methods.

The following are the main steps of comprehensive risk assessment model in an agile construction environment:

- Establish the system evaluation criteria that relate environment, conditions, inspection, transparency adaptation and communication fields capabilities to risk assessment goals;
- Identify the object for risk assessment;
- Identify the object profile and scope;
- Identify the risk characterisation measure;

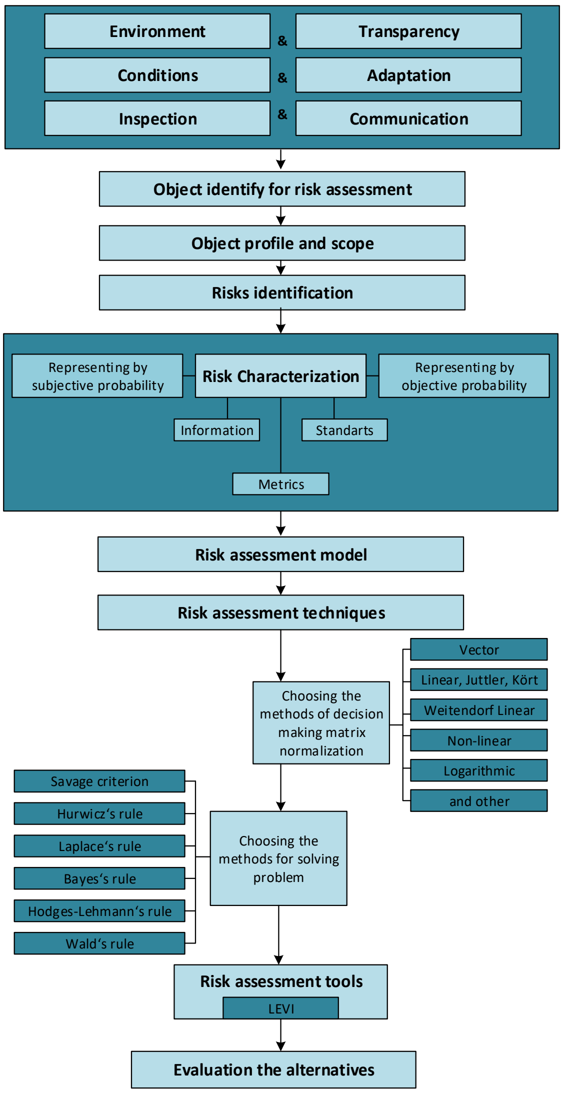

Fig. 2 Comprehensive risk assessment model in an agile construction environment

- Create the risk assessment model;
- Select the risk assessment techniques: for the weights, normalisation the decision-making matrix and problem-solving;
- Select the risk assessment tools;
- Evaluate the alternatives;
- Check the calculation results;
- If the final solution is not accepted, gather new information and go into the next iteration of multiple criteria optimisation.

The comprehensive risk assessment model in an agile construction environment can be shown using the help of a solution support system. It must present the information from the initial data, considering feasible alternatives of assessment object conditions, environment, inspection, transparency, adaptation and communication, specify the criteria appraisal information and selected alternatives, appraise them with quantitative or qualitative characteristics, and determine the optimisation direction of the attributes.

IV. Risk Assessment Model: A Practical Example of a Construction Project

This research mainly considered the use and application of game theory for comprehensive risk assessment model in an agile construction environment. The model of comprehensive risk assessment in construction was described using eighteen discrete values. Construction projects were selected as a numerical example of the riskiest activity in the construction sector. The subject of the investigation is the assessment of a construction project. Each member was described using eighteen attributes.

The attributes of the member selection were as follow: x_1 — conditions issues, x_2 — problem-solving skills in the project, x_3 — interpersonal skills of project members, x_4 — creativity of the project team, x_5 — adaptability of the project team, x_6 — collaborative skills of the project team, x_7 — safety issues in the construction site, x_8 — inspection issues, x_9 — the quality of construction works, x_{10} — transparency issues, x_{11} — technical skills, x_{12} — ICT skills, x_{13} — estimating/scheduling skills, x_{14} — communication, x_{15} — marketing, x_{16} — financial management, x_{17} — enterprise and project management relations, x_{18} — environmental awareness. The optimisation direction of the selected attributes x_{1}-$_{12}$ and x_{15}-$_{18}$ are the optimal maximum, and the attributes x_{13}-$_{14}$ are the minimum. Attributes measure of the assessment of members is presented in points. LEVI 3.0 game theory software for decision-making problems was used for the comprehensive risk assessment model in an agile construction environment.

V. Calculation Results

LEVI software can be used for as a rational method to solve a comprehensive risk assessment of a construction project. The calculation results are presented in the Fig. 3. For the problem solving the game theory, Laplace rule was used. The calculation results presented the following priority line: 1 — Construction project 3 (0.566); 2 — Construction project 4 (0.560); 3 — Construction project 2 (0.495); 2 — Construction project 2 (0.491).

VI. Conclusions

Decision making, such as risk assessment results in construction projects, contractor, etc., is very important in the construction sector. In real life, multi-criteria modelling of multi-alternative assessment problems with some criteria values, which deal with the future, must be calculated considering an agile environment.

Multi-criteria alternative assessment can be made with the help of game theory (LEVI 4) according to normalisation methods and calculation methods. The presented model and solution results have both a practical and scientific interest. The proposed model and methodology can be applied to the rational solution of a risk assessment method.

This model is applied to select alternatives for construction projects risk assessment in an agile environment. The calculation results showed that the second project is the riskiest.

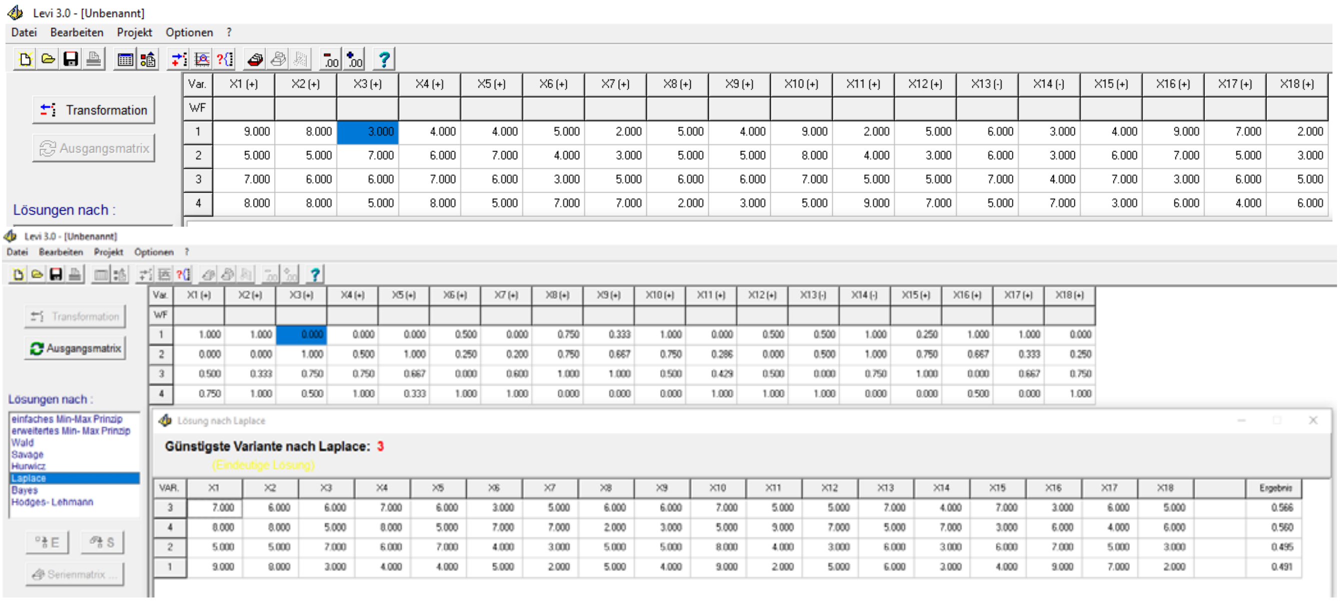

Fig. 3 Initial date and calculation results of comprehensive risk assessment model in an agile construction environment

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