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Challenges in applying expert systems to the investment-construction projects designing

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He design systematology possibilities in investment and construction activity tasks maintenance with engineering decisions acceptance quality estimation based on organizational and technological designing expert systems are studied. In the research course, the using challenges the expert systems for investment-construction production organizational and technological design were considered. The assessing quality principles and possibilities engineering decisions and intellectualization of the economic analysis functions for investment-construction projects planning and management are formulated. Knowledge scientific and engineering support methods bases and data are offered

Keywords: investment-construction projects, expert systems for organizational and technological design, design systemology, general engineering, database

Проблеми застосування експертних систем при проєктуванні інвестиційно-будівельних проєктів

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Вивчено можливості застосування проєктної системології в задачах планування й управління інвестиційно-будівельною діяльністю з оцінюванням якості прийняття різних видів інженерних рішень на базі експертних систем організаційно-технологічного проєктування. Вивчення цього проблемного напряму дозволить розробляти наукові принципи, методологічні положення і практичні основи створення й використання експертних систем з метою підвищення ефективності та оцінювання якості інжинірингу в ході проєктування і управління інвестиційно-будівельними проектами. У процесі проведених досліджень розглянуто проблеми застосування експертних систем для організаційно-технологічного проєктування інвестиційно-будівельного виробництва; визначено предметні галузі знань комплексного інжинірингу щодо розроблення експертних систем для підготовки інвестиційно-будівельного виробництва та управління проєктами; сформульовано принципи і можливості оцінювання якості прийняття інженерних рішень й інтелектуалізації функцій економічного аналізу, планування та управління інвестиційно-будівельними проєктами; запропоновано методика і принципи побудови експертних систем на основі методів науково-інженерного супроводу формування баз знань і даних. Серед першочергових напрямів подальших досліджень обрано можливості розв’язання тих «стикових» завдань, які є визначальними для реалізації системи «проект – об'єкта будівництва»: розподіл обсягів інвестицій та робіт між учасниками інвестиційно-будівельної діяльності, техніко-економічне обґрунтування ефективності інвестицій й техніко-економічного обґрунтування проєкту, складання технічного завдання на проєктування об'єкта будівництва, проєктування методів і засобів будівництва, експлуатації та реновацій на етапах і стадіях життєвого циклу системи «проект – об'єкта будівництва», прийняття раціональних інтегрованих рішень з монтажу технологічної та будівельної частин проєкту, моніторинг експлуатації й реновації системи «проект – об'єкта будівництва».

Ключові слова: інвестиційно-будівельні проєкти, експертні системи організаційно-технологічного проєктування, проєктна системологія, комплексний інжиніринг баз знань і даних

Introduction

The design systematology in planning and management of the investment-construction activity (ICA) projects together with the different engineering decisions making a quality assessment based on the expert systems for the organizational and technological design (ES-OTD) are considered as one of the challenging directions. They allow developing the scientific principles, methodological provisions, and practical foundations for the expert systems creation and use in order to increase the efficiency and upgrade the quality of engineering in designing and managing the ICA projects [1, 2].

The studies have established that 50% of the research and technical development tasks, as well as over 70% of the organizational and technological preparation tasks and the ICA, projects engineering and legal support, engineering field regardless, require the heuristic procedures use, symbolic coding methods, symbolic logic. More requirements are the professional qualitative evaluation involvement of the experience, as well as the highly qualified experts knowledge in the integrated engineering services related to developing and making different types of engineering and economic decisions (Fig. 1) [2, 5].

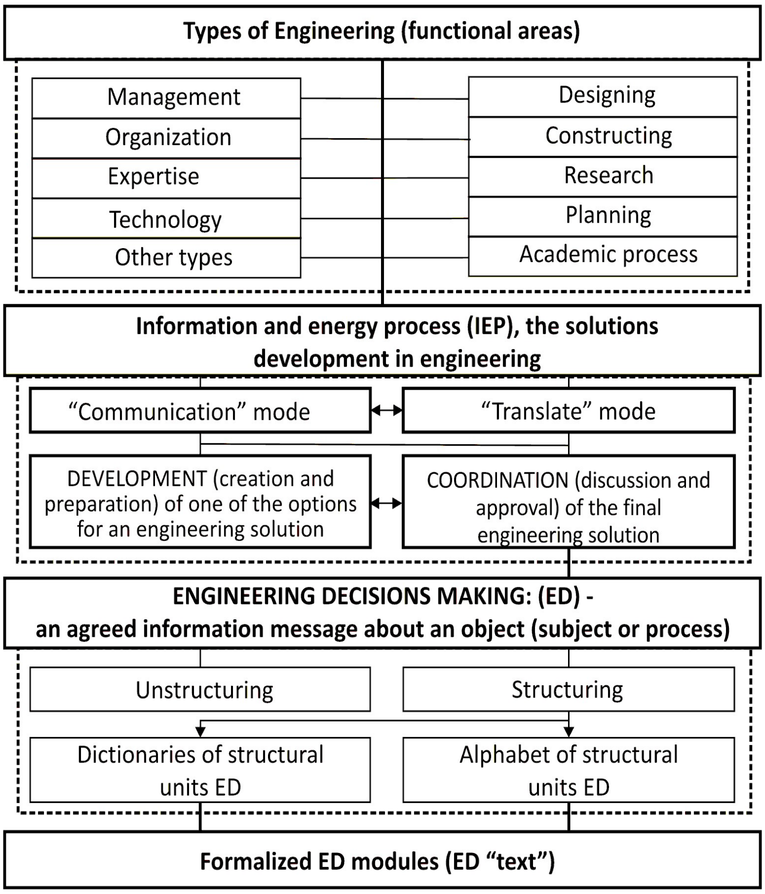

Figure 1 – Engineering decision making in the ICA project systemology

Among the main reasons for this phenomenon, it should be mentioned first of all: it is difficult to formalize the «butt» tasks nature of the investment-constructing projects (ICP) macro- and micro-designing and management; as well as unpredictability and uncertainty of many external environment factors affecting the ICA life cycle dynamics. Secondly, the existing market economy regulatory and legal framework structure is cumbersome and complex (contradictory); its many years of attempts to harmonize with EU standards. Moreover, the inadequacy of the logic mathematical and axiomatic methods and models to the real conditions and principles of the project - construction object (P-CO) general integrated engineering and management organizational forms in their full life cycle development [5, 6]. (Figure 2).

The current situation analysis allows concluding the timeliness and necessity of domestic and foreign experience generalization and systematization in terms of the developing system approaches, updating methods and tools of the expert systems that use information knowledge and procedures for solving poorly formalized general ICP engineering problems. Therefore, the expert systems (ES-OTD) formation funds utilization methodology, which is capable to accumulate, store and purposefully transform information, "derive" new knowledge from the existing, generalize and systematize the experience, self-study, and adapt to engineering changing conditions is an urgent problem, both in the design and its implementation in the ICA projects management.

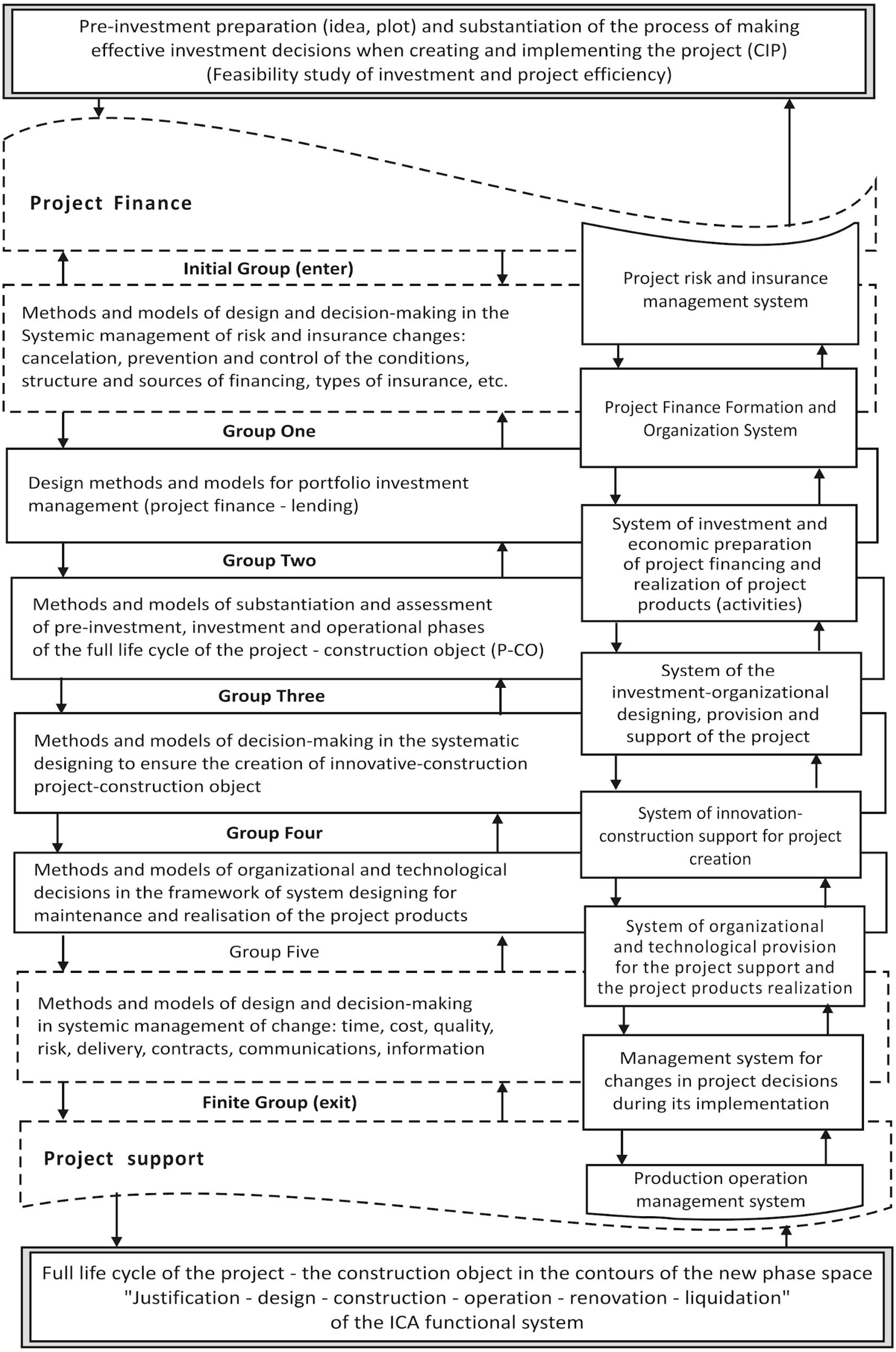

Figure 2 – Functional diagram of the "butt" ICA groups tasks (in the context of the design solidity concept, rationality and constructivism of scientific and engineering decision-making and the project behaviour control)

Review of the research sources and publications

The ICA project systematology field as well as the general engineering P-CO field is under active study on creating and improving methods and expert system-program that operates not with the algorithms, digits, and formulas but uses language logic, semantic structures, and symbols that simulate human behavior, using knowledge and inference procedures to solve poorly formalized problems. Expert system methods typically use a logic-linguistic model (fig. 3) and its interface has two main functions: to provide advice and explanations to the user and to manage the knowledge acquisition. [2, 3, 6, 5, 8].

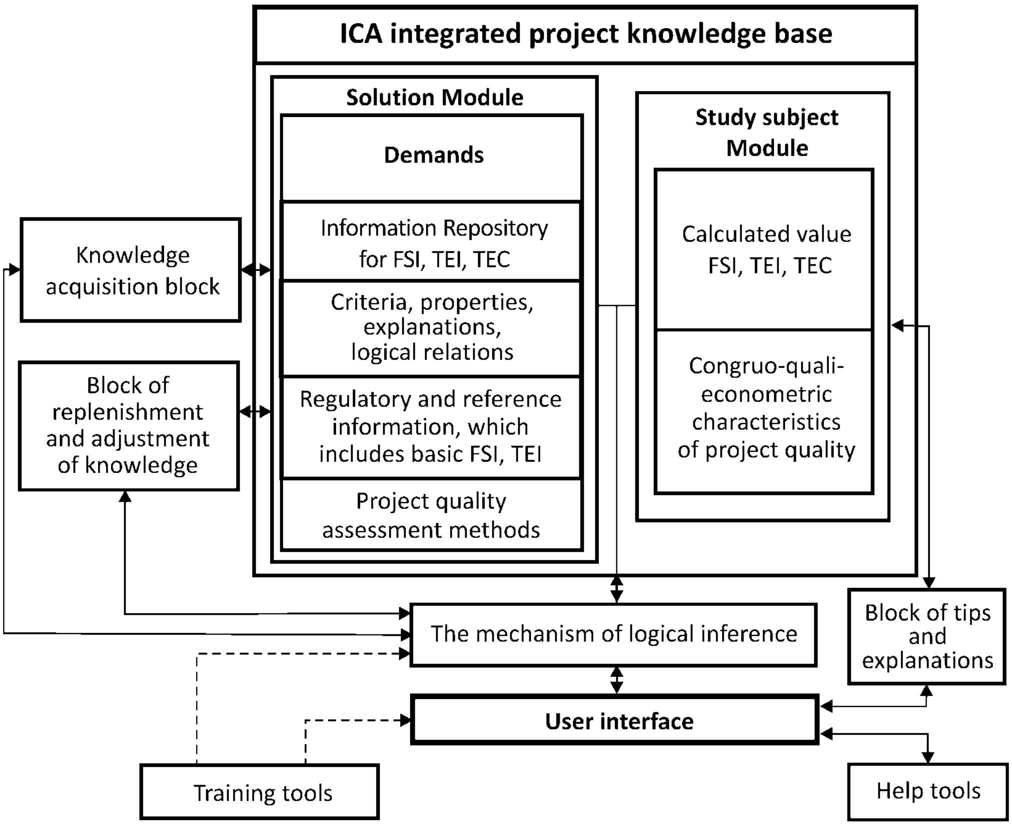

Figure 3 – The structural diagram of the ES-OTP management for quality assessment of innovative ICP integrated engineering models: feasibility study for investment (fsi); technical and economic indicators (tei); technical and economic calculations (TEC)

The paper considered the conclusions of the analytical paper of the scientific school leading specialists V. Glushkov, A. Gusakov, N. Ilyin, Yu. Bogomolov, J. Jones, E. Zavadskas and other scientists and specialists of the domestic and foreign system engineers schools for the expert systems in management and construction. It can be assumed that a unified approach has not yet been developed to a comprehensive quality assessment of the ES-OTP creation and implementation, and engineering and managerial decisions making in the project engineering support. [1, 2, 5, 7].

Definition of unsolved aspects of the problem

The purpose of such an assessment may be one of the project product management (PPM) parameters number: meeting consumer demand for the products that meet the world standards innovative level; the project viability; introduction of the technologies and equipment advanced systems to ensure the production; acceleration of the object commissioning and capacities development; compliance with all resources types the strictest economy; maintaining the ecological balance, etc.

Problem statement – to analyze the challenges using the expert systems for ICA organizational-technical designing and project management. To propose the concept, methodology, and principles to construct ES-OTD (content and structure), based on the methods of research-technical support for the creation of the knowledge database. To justify the approaches regarding the general scientific engineering tasks related to creating and making (selecting) a decision from a variety of alternative options using knowledge and databases, both aiming in increasing the design products competitiveness and quality, and performing other works that determine the composition of engineering support throughout the ICA life cycle.

Basic material and results

The informational research results have shown that scientific- technical and engineering support for P-CO in the ICA system, as a rule, is a "butt" task solution of the project systematology problems. They could occur on different steps and stages of the life cycle (designing – construction – exploitation – renovation - decommissioning and disposal) with the error minimum risk in uncertain terms that are not regulated by existing rules and standards, or due to a lack of sufficient experience or direct analogs in domestic or global practice.

At the same time, complex scientific, technical, and engineering support, as a service set, includes both consulting and technological, as well as construction engineering. That is why designing is considered as the main methodological link in providing engineering support, the results of which ultimately determine, according to the Multi-Criteria Assessment, the investments and innovations effectiveness in general (both at the macro and micro levels). This is because the implementation of technical, organizational, technological, managerial, and economic project conditions - construction object operation goes through the multi-criteria quality assessment of the comprehensive engineering design solution in the full life cycle of ICP.

That is why the methodology development for the expert systems based on the general engineering knowledge database is one of the prioritized research streams in the ICA global practice. The typical ES-OTP (Fig. 3) has the structure that consists, as a rule, of such basic components as a solver (logical-semantic inference mechanism); the database (operational memory); knowledge database; knowledge acquisition tools; explanations, and dialog interface [1, 2, 5, 6]. The expert system core should be the engineering knowledge and database, which should be accumulated in the construction process.

The basic principles and technology of building ES-OTP require the creator interaction – "knowledge engineer" and experts in and experts in the ICA project systemology subject area. The main task of the "knowledge engineer" is to choose the particular type and sort the knowledge presentation form of engineering activity and decision-making strategy (Fig. 4).

There are two main approaches to solving problems related to justification and decision-making using knowledge bases: 1) ready-made solution selection from an alternatives (options) variety embedded in the knowledge base; 2) solutions formation for individual components that are stored in the knowledge base. At the same time, three types of solution strategy options are methodologically distinguished: direct reasoning (direct inference) chain, reverse inference, and mixed-initiative.

At the same time, conceptually, the technology for the ES-OTP development should include the following main stages:

1. Identification – defining the problem and choosing the ES-OTP subject area engineering activities types.
2. Conceptualization - ES-OTP structure definition, goals, hypotheses, solution strategy, components of formation, software, and technology.
3. Formalization - defining the circle of experts, planning expertise, acquiring and presenting knowledge in a formal symbolic form.
4. Testing – the ES prototype development, program verification, logical and semantic consistency, and effectiveness of the conclusions.
5. Trial operation - checking the ES-OTP efficiency in practice.
6. Improvement - ES-OTP adjustment based on the results of trial operation and industrial (software) operation with the knowledge and data banks replenishment, which include rules, data and criterion engineering models, and various organizational and technological solutions aspects.

At the same time, the considered expert systems of the project engineering (ES-OTP) can methodologically perform certain ICP functions:

- data interpretation to determine their meaning;
- technical and organizational-economic systems state determination;
- system monitoring (including radiation and environmental safety) or continuous interpretation of the project data in real-time or in the ICP phase space;
- future development forecast based on modeling the present and the past;
- activities planning and development to achieve the set goals and its scientific and technical support;
- integrated design and construction of buildings and structures in the full life cycle (creation - operation - renovation - decommissioning and disposal);
- forensic construction and technical expertise (FCTE) when investigating the accidents' causes in buildings and structures, their parts and elements.

The ES-OTP process is the user's dialogue with the computer system, where, in response to a question posed by the software complex, the user has the opportunity to obtain expert advice or advice using the professional experts' experience, stored in the database. It is important to note that expert systems significantly reduce the complexity of the task by working with a small, subject-limited human knowledge area.

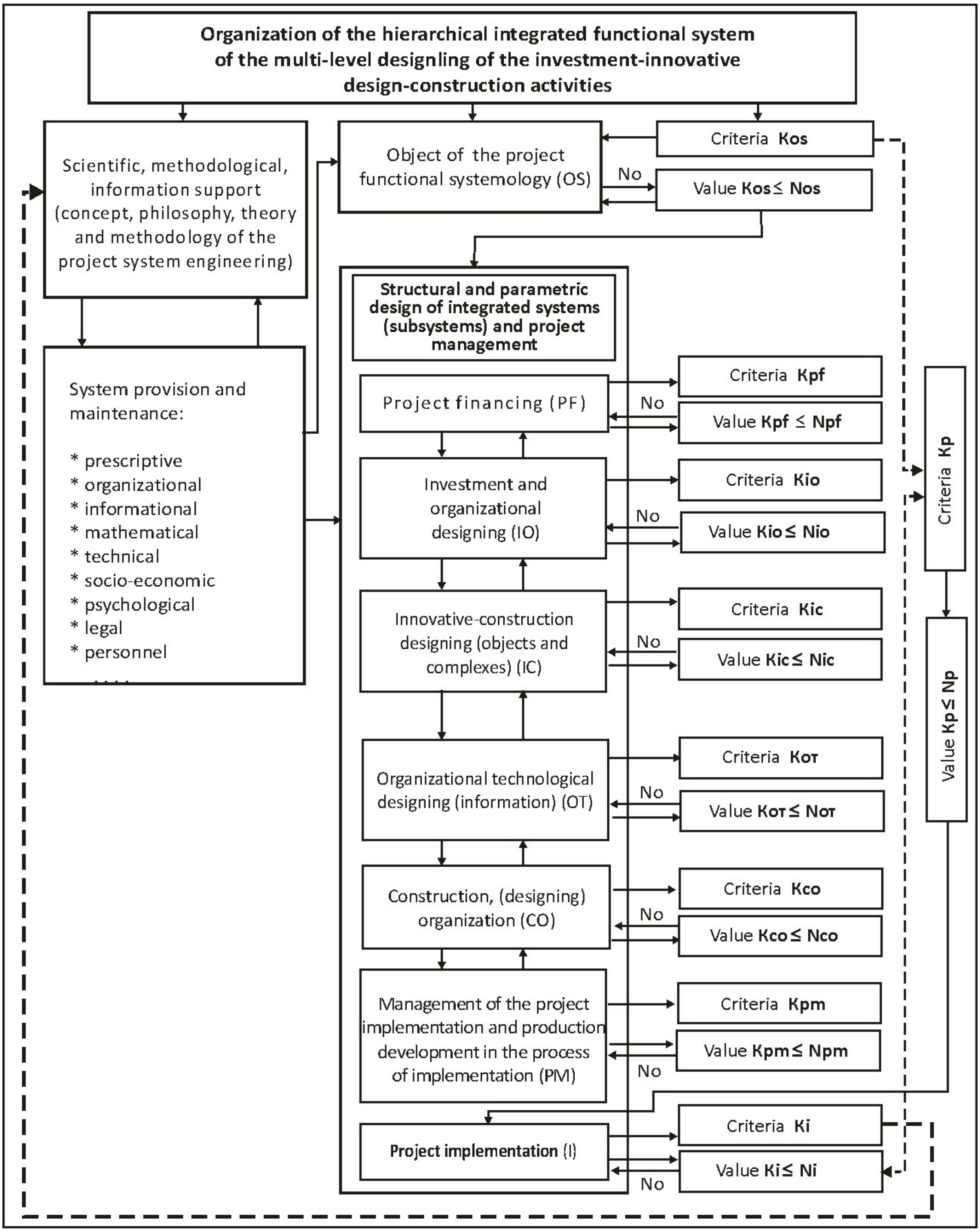

Figure 4 – An enlarged scheme of prescriptive (regulatory) criterion-expert selection of evaluation in ES-OTP:

Kos, Ki, Kp, Kpm - self subordinate criteria in accordance with the generalized assessment of the innovative-designing and investment-construction organization of the project and the design solution implementation;

Nos, Ni, Np, Npm – respectively evaluation criteria normative values;

Kpf, Kio, Kic, Kот, Kco – subsystems local criteria of the organizational and technological design system;

Npf, Nio, Nic, Nот, Nco - local evaluation of local criteria.

Conclusions

1. Due to the large number of self-operating ICA member-organizations, as well as the "butt" tasks considerable volume and complexity in the designing systemology for the formation and the necessity of integrated engineering and management decisions for the preparation and engineering investment-construction projects support are significantly increased by the project decisions making consequences.

2. Certain subject areas of knowledge in general engineering in terms of the expert systems development for the investment-construction production preparation and ICA project management require not so much of calculation procedures and computational operations as logical (meaningful) analysis, synthesis and adaptability, informal methods, qualitative assessments, and the specialists experience.

3. Among the prioritized development areas could be selected and practically implemented solutions of those "butt" tasks that are decisive for the implementation of the projects-construction object – this is the investment and work distribution between the ICA participants, the investment efficiency feasibility study, and project feasibility study in the reference terms development for the construction object design, designing methods and construction means, operation and renovation at the P-CO life cycle steps and stages, making rational integrated decisions for the technological and construction project parts installation, monitoring the P-CO operation and renovation, etc.

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