16. INSTRUMENTAL APPARATUS OF METHODOLOGY OF PROJECT MANAGEMENT UNDER THE CONDITIONS OF LINGUISTIC UNCERTAINTY OF PROJECT INFORMATION

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A project management methodology is proposed under the linguistic uncertainty of project information. It is proposed to use the concept of soft computing as an instrumental apparatus, namely, the perceptual computation apparatus and interval fuzzy sets of the second type. Based on the proposed methodology, a model for the formation of a managerial decision has been developed.

Key words: *project management, uncertainty, soft computing, interval fuzzy set of the second type, perceptual computing*

Introduction

Project management is carried out in conditions of uncertainty due to the uniqueness, disposability and temporary nature of projects. These features of projects lead to the impossibility of accumulating experience and statistics on a specific project in the traditional sense of these terms. Therefore, the uncertainty of project information that arises already at the first stage of the project life cycle appears at each subsequent stage of its implementation for any type of project. Accumulation of uncertainty in the project management process violates the balance between cost indicators, deadlines and quality of the final product and in many cases leads to the inability to complete the project within the framework of the planned indicators. It follows that the ability to manage the uncertainty of project information in project management is a basic requirement for the project manager.

Analysis of existing publications on uncertainties in project management showed that in the field of project management there is no unambiguous interpretation of this concept. This also applies to the uncertainty of design information. Despite this, in [1], uncertainty is used as the main criterion for project complexity, and its appearance is associated with the presence of problems, misunderstanding, and confusion in the process of solving design problems. In some works, the uncertainty in project management is directly or indirectly associated with unknown events or conditions in the future [2, 3]. In practice “uncertainty” is often identified with the concept of “risk” (for example, in [4]), despite a sufficient number of works in which the authors describe in detail their vision of the difference between these concepts in project management [5-8]. The basis for this erroneous use of terms is work in

which risk is clearly associated with uncertainty. For example, in the latest edition of PMBOK [3], the concept of risk is described through uncertainty: “Risk is an uncertain event or condition, the occurrence of which negatively or positively affects the objectives of the project”, but there is no definition of “uncertain event” and “uncertain condition”. From the foregoing, it can be concluded that managing of uncertainty is an important process in project management. However, at present there is no understanding of the sources, types of uncertainty and, as a consequence, the general methodology of uncertainty management in project management.

Linguistic uncertainty in project management

Uncertainty when making decisions by project managers is caused by uncertainty about the sufficiency of knowledge of a problem or situation [2], that is, the lack or excess of information. At the same time, the process and the methods used in making decisions depend on the subjective understanding by the manager of the source and the type of uncertainty that he encounters. Existing uncertainty publications provide various classifications of types of uncertainty. For example, in [8] there are five types of uncertainty associated with measurement, process, model, estimation and implementation; in [10] there are two types of uncertainty associated with the fuzziness of information and the ambiguity of information.

In this paper, to determine the main source and type of uncertainty, an analysis is made of the methods that are used in project management. For analysis, the recognized PMBoK 6ed was chosen as the base document. The authors of this work have analyzed all the tools and methods offered in PMBoK for managing 49 processes from 10 areas of knowledge. In total, 6 groups of tools and methods are allocated in PMBoK, as well as 60 tools and methods that are not divided into groups.

Table 1 shows the ten most recommended tools and methods that together cover all areas of expertise in project management. The names of the fields of knowledge, tools and methods in table 1 are given according to PMBoK.

Table 1 shows that the most popular method is the method of expert assessments. In PMBoK, it is recommended to use it in 35 processes out of 49, which is about 72%. It should also be noted that expert evaluations are present implicitly in other tools and methods, for example, in data analysis, meetings, data collection, etc. Therefore, the share of expert evaluations in project management significantly exceeds 72%. The popularity of the expert assessment method in project management is primarily due to the fact that the inputs and outputs of most

project management processes cannot be described quantitatively and quantitative relationships cannot be established between them.

Table 1 - The most recommended PMBoK project management tools and techniques

Instruments and methods	Project Management Knowledge Area * / Number of processes										Total
	K1/7	K2/6	K3/6	K4/4	K5/3	K6/6	K7/3	K8/7	K9/3	K10/4	
Expert review	7	4	3	4	1	2	2	6	3	3	**35**
Data analysis	3	4	4	4	3	2	0	6	3	3	**32**
Meetings	6	1	3	1	2	3	3	4	1	4	**28**
Interpersonal skills and teamwork	3	2	0	0	0	4	3	5	1	2	**20**
Data collection	2	1	0	0	3	0	0	4	1	2	**13**
Making decisions	2	3	1	1	2	1	0	1	0	2	**13**
Project management information system	1	0	3	2	0	3	2	1	0	0	**12**
Data display	0	1	0	0	3	1	2	1	0	3	**11**
Communication technologies	0	0	0	0	0	1	2	0	0	0	**3**
Parametric assessment	0	0	1	1	0	1	0	0	0	0	**3**
Total (by field of knowledge)	**24**	**16**	**15**	**13**	**14**	**18**	**14**	**28**	**9**	**19**	**170**

*- decoding of areas of knowledge:
K1-project integration management; K2-project content management;
K3-project schedule management; K4-project cost management;
K5-project quality management; K6-project resource management;
K7-project communications management; K8-project risk management;
K9-project procurement management; K10-project stakeholder management.

When using the method of expert assessments, the project manager is faced with problems obtaining data on the status of the project and their subsequent processing. The main sources of the problem of obtaining data should include: the difficulty of collecting expert estimates; the propensity of experts to conformism; subjectivity of the opinion of an individual expert; establishing the degree of consistency of expert assessments; comparisons of divergent opinions of experts.

When processing the received data, which are provided in a linguistic form, the project manager is faced with the uncertainty of this data, which arises due to the lack of an unambiguous interpretation among the experts of the parameters used and their assessment scales, as well as the dictionary used to evaluate the parameters. In addition, the parameters used are descriptive, projects evolve over time (which leads to a change in its structure and functions), and the components of the project are active in nature with not always predictable behavior.

From the foregoing, it follows that in project management there is a significant linguistic uncertainty of expert data. Given the indirect presence of the method of expert assessments in the collection and analysis of data, meetings, the manifestation of interpersonal skills and working with a team, a ranked list of areas of knowledge by level of uncertainty will be as follows: K8, K1, K10, K6, K2, K3, K7, K5, K4, K9. It should be noted that more than 50% of the peer review method is applied in four areas of knowledge, such as risk management, project integration, stakeholders and project resources. This method is least in demand in project procurement management.

In due time "..the need for humanization of science gave rise to the idea of soft mathematics, which increasingly began to ask for a paradigm" [11]. In our opinion, such a need is already ripe in the science of project, program and portfolio management. This is confirmed by the above context analysis of PMBoK.

The structure of the instrumental apparatus of the methodology of linguistic uncertainty in project management

The presence of linguistic uncertainty in all knowledge areas of project management, which makes urgent the development of new project management methodology, application of which should significantly enhance the efficiency and effectiveness of project managers in terms of linguistic uncertainty. To achieve this only possible with a systemic-holistic approach to the development and presentation of this methodology, working title is "Methodology LN". The instrumental apparatus such methodology is proposed to construct, using concept of soft computing. This approach is consistent with the process of project management methodology [12], which is currently the position with the forms of organization of scientific knowledge [13], has acquired the status of prospects as a forerunner of a new paradigm in project management [14]. In addition, it is consistent with the concept UICS-methodology, holistic thinking of the modern scientist-practice [15].

As the first instrumental component of the methodology LN will use the technique of interval fuzzy sets of the second type. This is substantiated by the following judgments.

Management model based on fuzzy logic is a set of linguistic variables with linguistic values that express the qualitative expert assessment, and fuzzy knowledge base of logical statements "IF-THEN". The classic approach to description of linguistic values involves the use of fuzzy sets of the first type (T1 FS). Since T1 FS do not allow to fully take into account the uncertainty of the expert evaluations due to the fact that the words for different experts mean different [16], the logical is the use of fuzzy sets of second type (T2 FS). Such sets provide an additional degree of freedom when working with the uncertainty due to the fact that the membership functions of T2 FS are ' fuzzy.

In order to avoid an ambiguous interpretation of the understanding of T2 FS type, we consider the main terms and their interpretation, which today is the most used in the theory of fuzzy sets and systems of the second type.

T2 FS $\tilde{A}$ imagine in the form

$$\tilde{A} = \{ ((x,u), \mu_{\tilde{A}}(x,u)) | \forall x \in X, \forall u \in J_x \subseteq [0,1] \},$$

where X – primary universal set on which is defined $\tilde{A}$,

u – secondary universal set on which is defined $\tilde{A}$,

J_x – primary relationship function,

$\mu_{\tilde{A}}(x,u)$ – secondary relationship function $\tilde{A}$, $0 \leq \mu_{\tilde{A}}(x,u) \leq 1$.

Graphic illustration of membership function T2 FS $\tilde{A}$ is shown at Fig. 1.

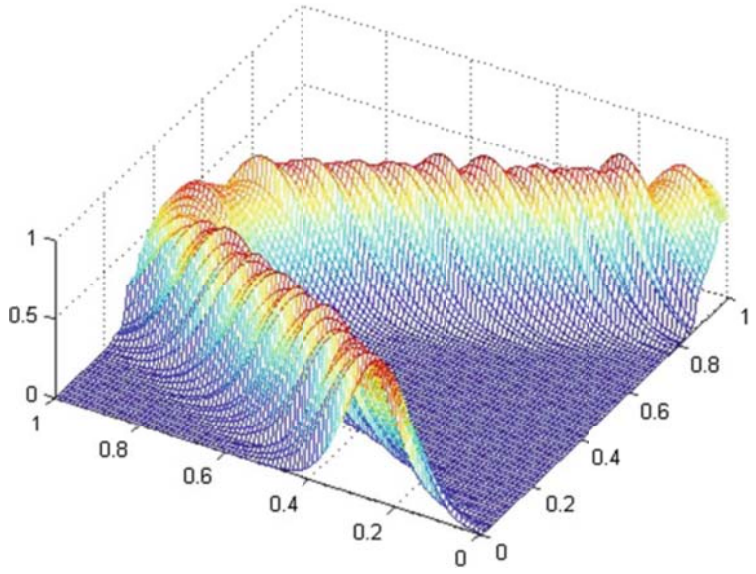

Fig. 1. Graphical 3-D representation of the membership function T2 FS Source: [16].

Due to the high computational complexity of T2 FSs, the interval T2 FS (IT2 FS) - T2 FS, for which all secondary estimates $\mu_{\tilde{A}}(x,u)$ are equal to 1 (this allows us not to consider the third dimension in IT2 FS), is currently more widely used. The combination of all the primary membership functions of IT2 FS $\tilde{A}$ is called the imprint of uncertainty. (FOU) $\tilde{A}$.

$$FOU(\tilde{A}) = \bigcup_{x \in X} J_x = \{(x,u): u \in J_x \subseteq [0,1]\},$$

$$J_x = \left[\underline{\mu}_{\tilde{A}}(x) \ , \ \bar{\mu}_{\tilde{A}}(x) \right],$$

where $\underline{\mu}_{\tilde{A}}(x)$ – value of lower membership function, $LMF(\tilde{A})$;

$\bar{\mu}_{\tilde{A}}(x)$ – value of upper membership function, $UMF(\tilde{A})$.

Graphic illustration IT2 FS $\tilde{A}$ is shown at Fig. 2.

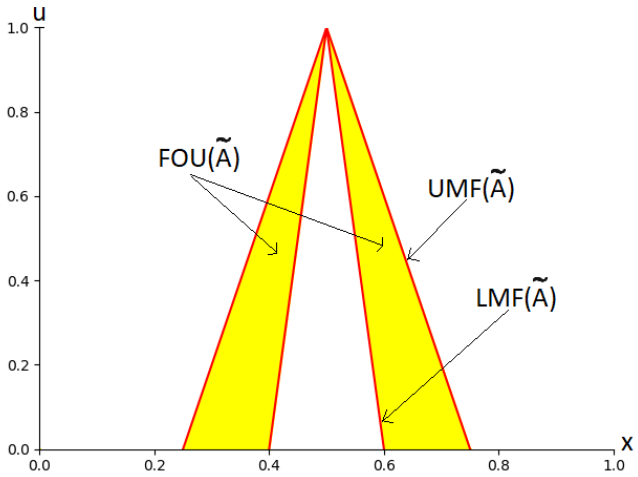

Fig. 2. Graphical representation GT2 FS

Source: [16] with revision by the authors.

As the second component of the instrumental apparatus of the LN methodology, we will use the methodology of perceptual calculations proposed by L.A. Zadeh, and further developed by J.M. Mendel. She proved herself well when applied to the processing of subjective opinions of experts on a specific parameter of the problem being solved. This methodology is based on a linguistic dictionary, the words from which are used both to activate the perceptual computer (Per-C) and to form the resulting recommendation. We consciously abandon the terminology that is not yet used in project management (Per-C), so as not to distort its original interpretation. Per-C consists of three blocks (Fig. 3):

- encoder - converts the words of experts into IT2 FSs;
- word handler - performs processing of words presented in the form of IT2FSs;
- decoder - displays the result of perceptual calculations in the form of recommendations (subjective judgment) with relevant supporting data.

According to J.M. Mendel, at least interval fuzzy sets of the second type (IT2 FS) should be used for word modeling.

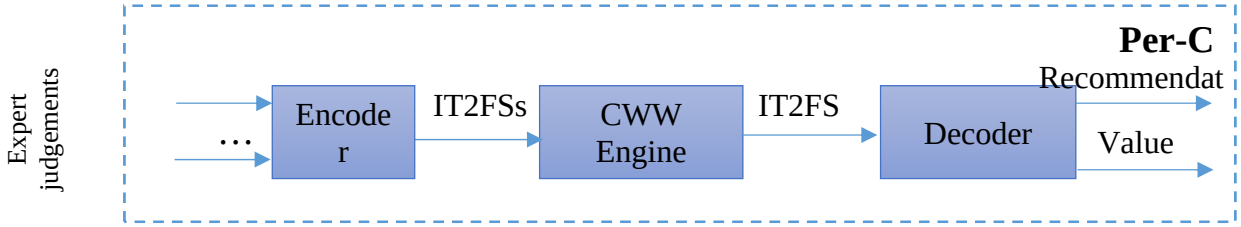

Fig. 3. Perceptual computer architecture

Source: [16] with revision by the authors.

As the third component of the instrumental apparatus of the FL methodology, we will use the interval fuzzy system of the second type (IT2 FS). It is applicable for the formation of management decisions. IT2 FS consists of five blocks (Fig. 4): fuzzifier block, rules base, fuzzy inference, type-reducer block, defuzzifier block.

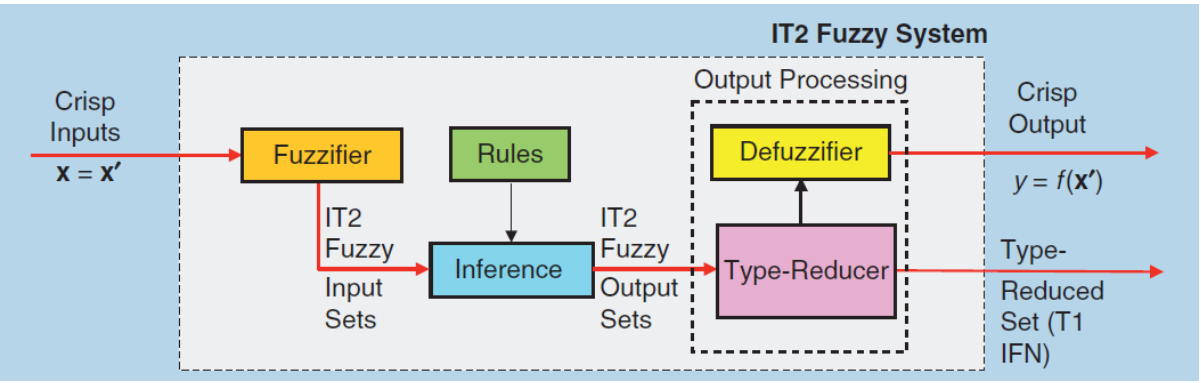

Fig. 4. Architecture of IT2 FS Source: [17].

In accordance with the theory of verbal computing and IT2 FSs, the model of formation of a managerial decision will have the following form:

$$y = F(LI, LO, R, IN),$$

$$y = \langle \tilde{Y}, T, s \rangle,$$

$$LI = \langle li_n \rangle, n = \overline{1, N},$$

$$R = \langle r_m \rangle, \ m = \overline{1, M},$$

$$IN = \langle in_n \rangle,$$

where y – evidence-based recommendation,

$\tilde{Y}, T, s$ – recommendation presented as IT2 FS, words and numbers respectively,

F – fuzzy inference operation (Mamdani algorithm),

LI – a set of input linguistic variables of the second type that describe the parameters of the project management task being solved,

N – number of input linguistic variables,

LO – the resulting linguistic variable of the second type, which describes the recommendations for solving the project management problem,

R – a set of fuzzy rules on the basis of which a recommendation is formed,

M – number of fuzzy rules,

IN – set of expert opinions,

$$in_n = F^*(V, W_n),\ in_n \in IN,$$
$$V = \langle v_j \rangle,\ j = \overline{1,J},$$
$$v_j = \langle T_j, \tilde{Y}_j \rangle\ ,$$
$$W_n = \langle w_k^n \rangle,\ w_k^n \in V,\ k = \overline{1,K},$$

where F^* – verbal operator,

V – vocabulary,

v_j – granular term,

T_j – word,

J – number of granular terms in a dictionary,

$\tilde{Y}_j$ – IT2 FS, which describes the word,

W_n – a set of expert verbal evaluations,

w_k^n – expert review,

K – the number of experts who take part in the survey.

The proposed toolkit of the FL methodology is an integral part of the project management information system (ISPM). To integrate the tools of the FL methodology with ISPM, the approaches proposed in [18, 19].

Conclusions

The conducted studies allow us to draw the following conclusions:

1. Project information in project management is uncertain. The PMBoK contextual analysis showed that uncertainty is manifested in all areas of project management knowledge, while the most uncertain are the areas of risk management, project integration, stakeholders and the content of the project, the least uncertain is project procurement management. Also,

as a result of PMBoK analysis, it was found that the main type of design information uncertainty is linguistic.

2. Taking into account the requirements for the organization of the project manager, it is necessary to develop a new methodology for project management in the context of linguistic uncertainty of project information.

3. The concept of soft computing is proposed to be used as a tool of the new methodology. At this stage, two instrumental components are identified: the apparatus of interval fuzzy sets and systems of the second type and the apparatus of perceptual calculations. The perceptive "computer" allows to manage expert estimates at decision-making by the project Manager, and interval fuzzy sets and systems of the second type – to consider linguistic uncertainty of these expert estimates.

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