DESIGNING AN APPROACH TO BUILDING THE TEAMS OF HIGH TECHNOLOGICAL PROJECTS PERFORMERS AT VIRTUAL INSTRUMENT-MAKING ENTERPRISES

Описано підхід до формування команд виконавців високотехнологічних проектів на віртуальних приладобудівних підприємствах. Даний підхід спрямований на зниження в процесі реалізації майбутнього проекту невизначеності, пов'язаної із встановленням відповідності між завданнями проекту, що мають інноваційний характер, і рівнем компетентності потенційних виконавців високотехнологічних проектів. Наведено методику розрахунку ефективності застосування запропонованого підходу в процесі розробки високотехнологічних проектів

Ключові слова: високотехнологічний проект, віртуальне приладобудівне підприємство, команда виконавців проекту, оцінювання сценаріїв

Описан подход к формированию команд исполнителей высокотехнологичных проектов на виртуальных приборостроительных предприятиях. Данный подход направлен на снижение в процессе реализации будущего проекта неопределенности, связанной с установлением соответствия между задачами проекта, имеющими инновационный характер, и уровнем компетентности потенциальных исполнителей. Приведена методика расчета эффективности применения предложенного подхода в процессе разработки высокотехнологичных проектов

Ключевые слова: высокотехнологичный проект, виртуальное приборостроительное предприятие, команда исполнителей проекта, оценивание сценариев

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1. Introduction

Under conditions of post-industrial society, a steady trend is the formation and support of the functioning of virtual instrument-making enterprises (VIE) in the field of high technologies [1–3]. The indicated processes are directly linked to the task of implementation of high technological projects (HTP). In this case, of special relevance is the task of formation, on the one hand, of such teams of the HTP performers, the level of competence of whom will make it possible to ensure efficient HTP implementation, and on the other hand – rational distribution of human resources with the purpose of efficient realization of the portfolio of the projects within the framework of a virtual enterprise or an organization.

Specific character of HTP [1] predetermines the need to apply a number of special methods during the selection of contenders for inclusion in the team of the project, which are based on the principles of the competence-based approach. In recent years there has appeared a significant quantity of publications abroad and in Ukraine, devoted to the problem of increasing efficiency of the processes, providing for building the teams of the HTP performers on the basis of the competence-based approach [4–6]. In these publications, the issues of the formation of the key competences of the staff are considered, as well as possibilities of provision of a personnel reserve at high-technological enterprises. At the same time, up to now there have not been any studies performed in the direction of increasing the efficiency of the processes of provision the necessary and sufficient level of competence of the HTP performers. The solution to this problem is impossible without objectively taking into account different points of view of the specialists-experts, whose knowledge and experience have been gained in the result of long practical work in the organization and HTP implementation at virtual enterprises. The indicated circumstance determines the need to add special stages to existing procedure of building the teams of the HTP performers, at which an expert information will be collected, its analysis and the processing with the purpose of increasing the objectivity of the decisions being made about the selection of contenders for inclusion in a HTP team and the formation of the team of performers.

The relevance of the studies in this direction is determined by the existing contradiction between a steady tendency towards an increase of the number of virtual production enterprises in the countries of the post-industrial economy, and by the lack of methodological basis for the formation, development and support of the functioning of enterprises of this type.

2. Analysis of scientific literature and the problem statement

Expert evaluation is combined with many criteria and many alternatives, as well as the need to consider those noncoinciding, and sometimes even contradictory, expert judgments, which is a direct consequence of the presence of the so-called NO-factors (uncertainty, incompleteness, inaccuracy, indistinctness) [7]. Decrease in the influence of NO-factors on the objectivity of expert evaluation is explored in a number of monographs of contemporary authors in the aspect of providing efficiency in the reduction in the indicated factors. In this case it is proposed to use operations of ranking and clustering of the expert evaluations of special theories, namely fuzzy logic [8], the theory of evidences, described in the paper [9], the theory of plausible and paradoxical considerations of Dezert-Smarandache [10], and also the theory of rough sets [11]. In the course of the studies, devoted to the alternative choice of variants of the team, taking into account the portfolio of projects, a number of crucial problems of the rational selection of the teams of high-technological projects were determined [12].

A formal formulation of the problem implies a description of the following initial data [13]: a portfolio of VIE projects P_T, for the time interval $T = [t_{з}, t_k]$, representing a set of linearly regulated by the ratio "$\leq$" time intervals τ, $T = \{\tau\}, \leq: \tau \in [t_{з}, t_k]$, in this case the initial moment $t_{з}$ corresponds to the moment of the launch of the earliest of the unfinished projects by the present time, while t_k – to the deadline, determined for the portfolio of the VIE strategies:

$$P_T = \{g(\tau_i)\}, \tau_i = [t_i^{(1)}, t_i^{(2)}], i = \Omega_i, \qquad (1)$$

where $g(\tau_i)$ is the i-th program in the portfolio of the projects P_T, $t_i^{(1)}$ and $t_i^{(2)}$, and, accordingly, the moments of the start and completion of the i-th program, Ω_i is the set of the numbers of the time intervals τ_i (in accordance with the requirements of PMI [14]); the portfolio of the projects P_T includes, as the objects of smaller scale, projects P and tasks z, in this case the following conditions are carried out:

$$\forall g(\tau_i) | (g(\tau_i) \in P^T) \exists \{p^{(i)}(\tau_j)\}, i \in \Omega_i, j \in \Omega_j, \qquad (2)$$

$$\forall p^{(i)}(\tau_j) | (p^{(i)}(\tau_j) \in g(\tau_i)) \exists \{z^{(j)}(\tau_k)\},$$
$$i \in \Omega_i, j \in \Omega_j, k \in \Omega_k, \qquad (3)$$

where $p^{(i)}(\tau_j)$ are the projects, which are included in the i-th program, $z^{(j)}(\tau_k)$ are the problems in the j-th project, Ω_k is the set of the numbers of the time intervals of execution the tasks, which compose the k-th project.

Analysis of the problems of building the teams of performers of high technological projects [15] makes it possible to draw a conclusion that for today the procedure of evaluation of economic effect of the introduction of special methods

of forming the teams of performers into the practice of HTP design has not been fully tackled.

In connection with this, in this study we will assign to the HTP performers only those workers, who compose production personnel of VIE and designate it as the set $M^{(P)}$. In this case $M^{(P)}$ will be contained in $M^{(R)}$, $M^{(P)} \subset M^{(R)}$, where $M^{(R)}$ are the regular staff of VE, and $M^{(R)} \supset M^{(A)} \cup M^{(P)} \cup M^{(S)}$, $(M^{(A)} \cap M^{(P)} \cap M^{(S)} = \emptyset)$. Here $M^{(A)}$ are the administrative-management personnel of VE, $M^{(S)}$ are the supporting staff of VE.

The problem of decision making in this case is reduced to the selection of the acceptable variant of the team of the project $\tilde{g} \in G_{p^{(i)}}^f$ so that

$$(\forall \omega_l | \omega_l \in \Delta, l \in \Omega_l) \exists (\rho(\tilde{g}, \omega_l) \leq \chi(\omega_l)), \qquad (4)$$

where Ω_l is the set of the coefficients of uncertainties, represented in Δ.

3. The purpose and objectives of the study

The purpose of this article is intended to convey an approach to building an HTP team at virtual enterprises with the application of technologies of collective expert evaluation of scenarios.

To achieve the set goal, the following tasks are to be solved:

– to determine a compact set of alternative variants of teams' composition, whose participants have been soundly selected by different criteria;

– to determine the key stages of building the teams of the performers of high technological projects at a virtual instrument-making enterprise;

– by using the introduced designations, to form a team of the HTP performers;

– to design a special approach for the selection of alternative variants of an HTP team, taking into account a portfolio of the VIE projects.

4. Materials and methods of the study of the process of building the teams of performers of high technological projects at virtual instrument-making enterprises

4. 1. The studied materials and the equipment used in the experiment

The studies were conducted by using a portfolio of the projects of a typical VIE P_T, for the time interval $T = [t_{з}, t_k]$, i. e. a portfolio of the VIE strategies is formally described as:

$$P_T = \{g(\tau_i)\}, \tau_i = [t_i^{(1)}, t_i^{(2)}], i = \Omega_i. $$

4. 2. Methods of building the teams of the performers of high technological projects at virtual instrument-making enterprises

We accepted as the main indicators of the process of personnel management at building the teams of the performers of high technological projects at virtual instrument-making enterprises: $g(\tau_i)$ is the i-th program in the portfolio of projects P_T, $t_i^{(1)}$ and $t_i^{(2)}$ are, accordingly, the moments of beginning and completion of the i-th program, Ω_i is the set of numbers of the time intervals τ_i; $p^{(i)}(\tau_j)$ are the projects, which are

included in the i-th program, $z^{(j)}(\tau_k)$ are the tasks in the j-th project, Ω_k is the set of numbers of the time intervals of fulfillment of the problems, which compose the k-th project.

The evaluation of contenders for inclusion in an HTP team must be conducted on the basis of the competence–based approach by using the following methods:

– "360 degrees" – obtaining data about each of the contenders for the HTP team as a result of the employee survey, that of his/her direct leader, colleagues, subordinates, and sometimes also the customers of the assessed person;

– "Assessment Center" – data gathering, via expert survey, about the knowledge and experience of each contender for inclusion in an HTP team;

– "Azimuth" – adaptive testing of contenders with the purpose of compiling a profile of their competence.

The analysis of the contenders database and their selection into an HTP team were carried out by the methods of fuzzy logic.

5. Results of the study of the processes of selecting performers of high technological projects at virtual instrument-making enterprises

By using the introduced designations, the problem of forming a team of the HTP performers can be represented in the form of the tuple

$$S = \langle G_{p^{(i)}}^f, \Delta, \rho, \chi \rangle, \tag{5}$$

where $G_{p^{(i)}}^f$ is the set of acceptable alternatives of the composition of the performers of the project $p^{(i)}, f = \overline{1, N}$ is the number of variants, Δ is the set of uncertainties (disturbances), $\rho, \rho: G_{p^{(i)}}^f \times \Delta \to E$, (E – set of estimations) is the cost function for the formation of a team of a project, χ is the permissibility function of the existence of a team of a project, $\chi: \Delta \to E$.

To represent the process of forming the variants of the teams of HTP performers in dynamics, it is necessary to consider the projection of the set $G_{(i)}$, $G_{p^{(i)}}^f \subseteq M^{(P)}$ to the set $T = [t_3, t_k]$:

$$(G_{p^{(i)}}^f \subseteq M^{(P)}) \times T : \left\{ G_{p^{(i)}}^f \right\} \wedge (P_T(G_{p^{(i)}}^f) = \{\tau\} \subseteq T). \tag{6}$$

By the projection $P_T(G_{p^{(i)}}^f)$ here we understand the set of those elements from $T = [t_3, t_k]$, which can be surjectively displayed from $^{(P)}$ in $T = [t_3, t_k]$ [16].

In the practice of building the teams of the HTP performers, the most problematic is a decrease in the level of the uncertainty Δ during assessment (i. e., obtaining specific values E) for each contender $m_S \in M^{(P)}$, $S = \overline{1, N}$ for inclusion in the team of the project $G_{p^{(i)}}^f$. In this case E must include the totality of the indicators $E \supset E^{(PQ)} \cup E^{(TW)} \cup E^{(SI)}$, characterizing personal qualities $E^{(PQ)}$ (first of all, competence) of the contender for inclusion in the formed team of a project $\tilde{g} \in G_{p^{(i)}}^f$, his/her capability to work in a team (communicability, previous experience of such work) $E^{(TW)}$, as well as the expediency of such inclusion (it directly depends on the strategy of an organization and a number of external factors) $E^{(SI)}$. The essence of the problem is in the impossibility of analytic reflection of the functions ρ and χ, which means also the impossibility of applying numerical methods in this case.

A way out of the described situation is designing a special approach, the basis of which will form empirical and heuristic methods of information processing, gathered by the team of experts. In this case, for the assessment $E^{(PQ)}$ it is expedient to use the set of tools, which exists within the framework of the competence-based approach [17]. The estimation $E^{(TW)}$ may be obtained by the way of analysis of the alternatives of HTP teams $G_{p^{(i)}}^f$ by the methods of fuzzy logic. For the assessment $P_T(G_{p^{(i)}}^f)$, i. e., the expediency of one or another variant of a team taking into account a portfolio of the projects P_T of an organization, it is efficient to use a set of the methods of aggregation of the values of individual representatives of an expert group.

Fig. 1 in notation IDEF3 represents the process of decomposition of the procedure of forming a team of a project on the basis of the technologies of collective expert assessment.

Today the most promising methods of assessing the competences in contemporary systems are the methods of "360 degrees", Assessment Center and "Azimuth".

The "360 degrees" method [18] makes it possible to assess a company's employee on the basis of his/her behavior in real working situations and displayed business skills. The main purpose of applying this method is obtaining systematized information about the estimation of the level of the development of the competences of each contender for the inclusion in an HTP team. This method implies construction of special diagrams (Fig. 2) that illustrate the results of assessing the level of the competence of each contender. The comparison of the opinion of colleagues to the contender's self-appraisal is carried out on the basis of such diagrams.

In contrast to the "360 of degrees" method, Assessment Center implies integrated assessment of an employee by competences. However, in this case the method of Assessment Center is not self-sufficient, since it does not include constructing the model of the competences of specialists. The indicated circumstance determines the need to use special professional questionnaires.

Application of the "Azimuth" method makes it possible to reveal formal and informal ties between employees by way of compiling special "map of working interactions". This map is an egocentric diagram for each employer, by analyzing which it is possible to build ratings by the competences, to estimate personnel reserve, compatibility of employers, to determine key nodes of corporate network, to establish the problems of communications, to perform search for leaders and to carry out remote assessment of the staff.

For achieving maximum completeness and objectivity of the appraisal of contenders, the discussed approach is assumed to include integrated application of the methods of assessing the competence of contenders examined above.

The estimations of the competence level of each of the contenders for inclusion in an HTP team on the next stage of the proposed approach serve as the basis for assessing the permissibility of the work of the performers within the framework of one team. This problem is solved by the methods of fuzzy logic. In this case, the competence profiles of each contender are presented in the form of the function [19]:

$$f(\overline{b}) = \sum_{i=1}^n \omega_{ti} \cdot b_{ti}, \tag{7}$$

where n is the number of competences, necessary for the implementation of the considered HTP; b_i is the level of the i-th competence (degree of possession of the i-th competence); ω_i is the weight of the i-th competence; $t \in [1, \overline{T}]$ is the moment of assessing the contender in the time interval corresponding to the portfolio of VIE projects.
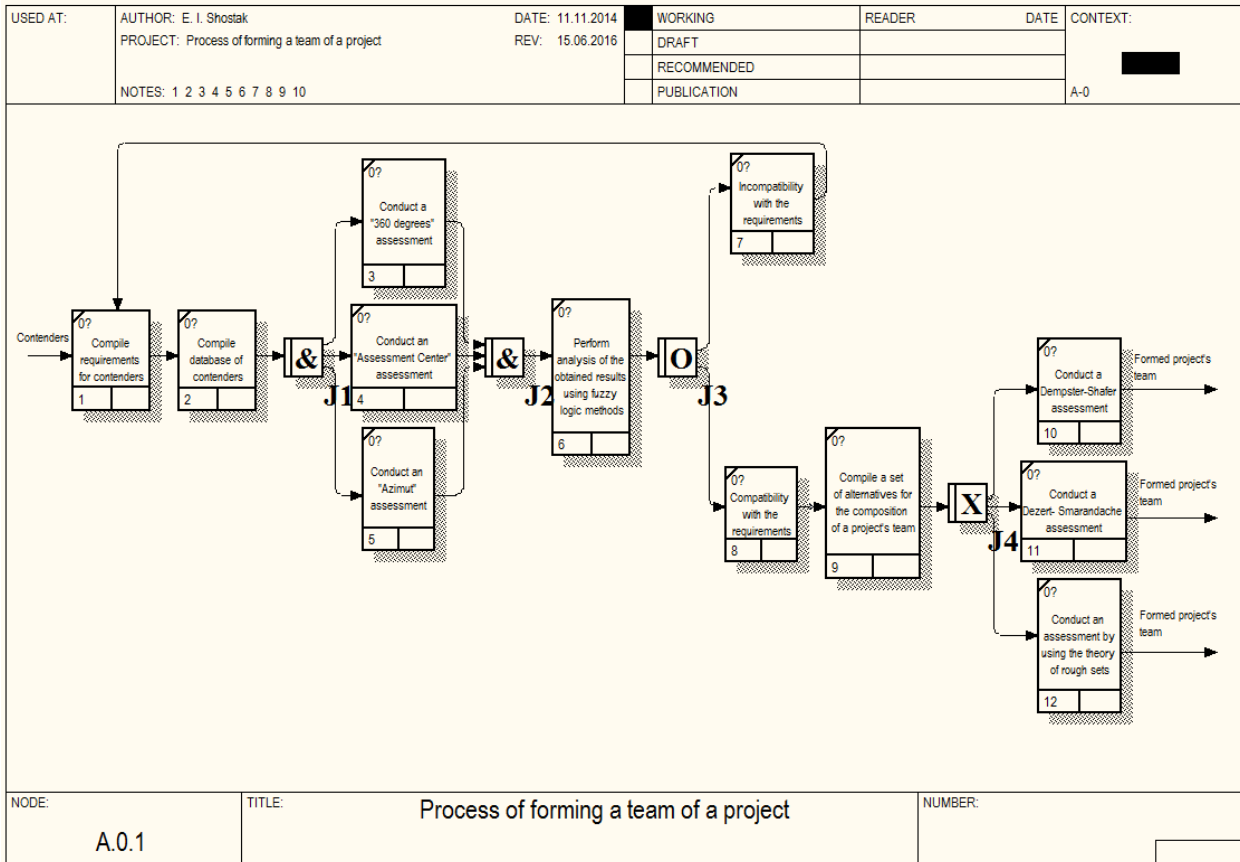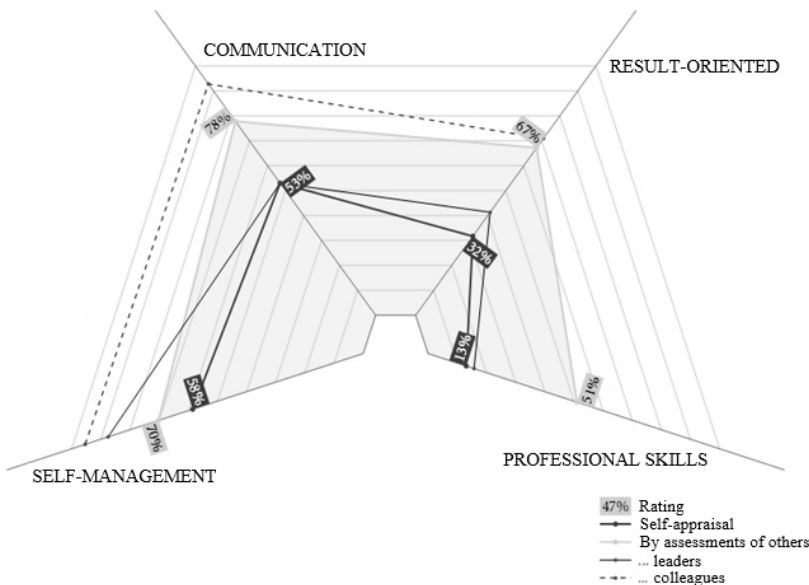
Fig. 1. Process of building a team of HTP

Fig. 2. Diagram of an employee assessment by competences

In this case the weight of the i-th competence expresses its relative significance, and it is assigned in the range from 0 to 1:

$$0 \le \sum_{i=1}^{n} \omega_{ti} \le 1, i = \overline{1, N}. \qquad (8)$$

The concept of competence and its weight, as a result of the subjectivity, inherent in the competence approach, which

is manifested in approximate nature of the conclusions of experts and linguistic nature of the estimations given by them, is blurred. The indicated circumstance predetermines the expediency of application of the theory of fuzzy sets [20] for the analysis of the results, which were obtained by using the competence-based approach to the assessment of contenders for the inclusion in an HTP team.

$$\overline{b} = b_1 \wedge b_2 \wedge b_3.$$

Let us examine the variant of realization of this stage of forming an HTP team in the form of the process, the initial data for which are the functions of competence of each contender $f(\overline{b})$, obtained in the course of the sequential application of base methods, used in the competence approach: "360 degrees" (b_1); "Assesment Center" (b_2); "Azimuth" (b_3). In this case

$$\overline{b} = b_1 \wedge b_2 \wedge b_3.$$

The values of the levels of competence $b_{ti}^{(H)}$ and $b_{ti}^{(B)}$ serve the main parameters in the analysis. At the output of the process, each contender for inclusion in an HTP team is assigned the value C (compliance with the requirements), or $\overline{C}$ (no compliance with the requirements).

Parameters of the process $\overline{b}$, $b_{ti}^{(H)}$ and $b_{ti}^{(B)}$ will be considered as linguistic variables. As is known [20], linguistic

variable is described by the set (X, T, U, G, M) where X is the name of a variable, T is the set of linguistic values X (term – a set of variables X), and each of such values is, in turn, a fuzzy variable X with the values from the universum U, containing the base variable u; G is the syntactic rule, which generates the names of each value of the variable X; M is the semantic rule, which assigns the sense M(X) in the correspondence to each value of fuzzy variable X. In this case, specific name X, generated by syntactic rule G, is called term.

A set of semantic rules M is defined as certain reflection of the set X, generated by the membership function $\mu_M(X)$, adopting the values from the interval [0,1]:

$$M = \int_{x \in X} \mu_M(X) / X, \qquad (9)$$

where $\mu_M : X \to [0,1]$ is the membership function.

Theoretical positions presented above make it possible to construct a special method of fuzzy analysis of the results of application of the competence-based approach to the assessment of the level of competence of the contenders for the inclusion in an HTP team. In the generalized form, the method includes the following steps:

1. Formation of term-sets for the input parameters $\bar{b}$, $b_{ti}^{(H)}$ and $b_{ti}^{(B)}$, and also for the output parameters C and $\bar{C}$.

2. Construction for each term, out of the formed in the previous step term-sets, the fuzzy set M with its carrier. In this case, by the carrier of the fuzzy set [20], we understand the set X′, so that

$$X' = \{x \mid \mu_M(x) > 0, x \in X'\}. \qquad (10)$$

3. Defining a set of rules of fuzzy analysis. The rules take the form of statements "IF P=Q, THEN R=Z", where P, R are the linguistic variables; Q, Z are the terms of the corresponding linguistic variables.

4. Construction, using the rules determined in step 3, of the matrices of fuzzy relations of the form

$$R^{(1)} = \int_{(x,y) \in X \times Y} \mu_{R^{(1)}}(x,y) / (x,y),$$

$$R^{(2)} = \int_{(x,z) \in X \times Z} \mu_{R^{(2)}}(x,z) / (x,z), \qquad (11)$$

$$R^{(3)} = \int_{(y,z) \in Y \times Z} \mu_{R^{(3)}}(y,z) / (y,z),$$

in this case X, Y and Z are the linguistic variables of the assessment of the level of competence of a contender for the inclusion in an HTP team, obtained by the methods of "360 degrees"; "Assessment Center" and "Azimuth", respectively.

5. Combination of matrices of fuzzy relations on the basis of the rule

$$\mu_R = \max(\mu_{R_1^{(1)}}, ..., \mu_{R_n^{(3)}}). \qquad (12)$$

6. Obtaining final conclusion about the compliance (C), or non-compliance ($\bar{C}$) of the level of competence of this contender to the requirements of HTP. Here it is appropriate to use one of the composition rules of logical conclusion, known in fuzzy mathematics, for example, the rules of Zadeh, Mamdani or Mizumoto [8].

For the considered approach we use composition rule of Zadeh in the form:

$$R(u) = A, R(u,v) = F, \qquad (13)$$

where

$$R(v) = A \circ F,$$

where ∘ is the composition sign.

In this case the membership function is defined as

$$\mu_R(v) = \max[\min(\mu_R(u), \mu_R(u,v))]. \qquad (14)$$

The next stage of the study is the expert analysis of the alternatives of an HTP team taking into account the portfolio of VIE projects.

The efficiency of the process of the collective expert assessment of the alternatives of an HTP team, formed in the previous stage, directly depends on compactness of the result presentation for approval by the person who makes the decisions (PMD) about the final composition of the HTP performers. In practice this means that the best variant is obtaining the only one composition which is the best. This case is theoretically possible; however, often it is necessary to consider several variants, in the process of analysis of which it is accepted to average the assessments of the individual experts in some way [21].

Obtaining the averaged assessment is appropriate only under the conditions of rather high coordination (proximity) of the estimates of the team of experts. The realization of collective expert evaluation leads to one of the three outcomes:

1) the proximity of estimations by individual experts makes it possible to consider the team of experts (expert board) as united group;

2) expert board is decomposed into a relatively small number of clusters, inside which the estimations are close;

3) the composition of an expert board following the result of a survey is decomposed to a large number of subgroups with a relatively small composition of each.

In the first of the cases described above, the averaging in some form of the estimations of individual experts is acceptable.

The second and the third cases imply the selection in the composition of the board of certain "types" of experts, radically different in their assessments. In these cases, it is necessary to divide the composition of an expert board into subgroups in accordance with the "type" of the experts, belonging in them, and to give the characteristic of each subgroup. The averaging of expert estimations inside each subgroup is the next stage. As a result, in order to make a decision about the best variant of an HTP composition, the person who makes decisions (PMD) will be presented in the compact and visual form with the information about the average estimations in each subgroup of experts, along with the meaningful characteristic of each of the subgroups. This approach makes it possible to consider the PMD preferences (top manager or HR-manager) while making a decision concerning one or another subgroup.

The problem of clustering of an expert board on the formal level can be represented as follows:

$$E = \{e_1, e_2, ..., e_i, ..., e_n\} \Rightarrow$$

$$\Rightarrow \{E_1\}, \{E_2\}, ..., \{E_j\}, ..., \{E_m\},$$

$$E \supset E_1 \cup E_2 \cup ... \cup E_j \cup ... \cup E_m, \tag{15}$$

$$E_1 \cap E_2 \cap ... \cap E_j \cap ... \cap E_m = \emptyset,$$

where $e_i, i = \overline{1, n}$ are the values of expert estimations of the alternatives of composition of HTP, n is the total number of estimations; $\{E_j\} = \{e_1, ..., e_k\}$ – is the j-th cluster, containing elements $\{e_1, ..., e_k\}$; $n \geq k \geq 2$ is the number of elements in the j-th cluster; $j = \overline{1, m}$ is the number of clusters.

Estimation of the median is the traditional method to solve the described problem [22]. In this case, the initial set of expert estimations $E = \{e_1, e_2, ..., e_i, ..., e_n\}$ is represented in one of the two forms of the variation row:

$$e_{(1)} \geq e_{(2)} \geq ... \geq e_{(i)} \geq ... \geq e_{(n)}$$

or

$$e_{(1)} \leq e_{(2)} \leq ... \leq e_{(i)} \leq ... \leq e_{(n)}.$$

Estimation of the median is carried out by the rule:

$$e_{med}(n) = \begin{cases} e_{(n+1/2)}, & \text{if } n \text{ is odd}; \\ e_{(n/2)} + e_{(n+1/2)} / 2, & \text{if } n - \text{an even}. \end{cases} \tag{16}$$

The problem lies in the fact that the estimation of median "intercepts" the estimations that stand out from the total row; however, the same feature ensures the robustness of assessment, determining its stability relative to the estimations, given by experts – "dissidents".

Based on the above-indicated circumstance, in practice more efficient proves to be the ranking of expert estimations.

Formally, the problem of ranking expert estimations can be represented in the following form.

Let there be n of the alternatives $S_i, i = \overline{1, n}$. Then the sequence can be formed:

$$\{S_1, S_2, ..., S_i, ..., S_n\} \Rightarrow$$

$$\Rightarrow \{S_1 \succ S_2 \succ ... \succ S_i \succ ... \succ S_n\} \vee$$

$$\vee \{S_1 \succ S_2 \sim S_3 \succ ... \succ S_i \sim S_{i+1} \succ ... \succ S_n\}. \tag{17}$$

In the given record, the signs «$\succ$» and «$\prec$», and also «$\sim$» indicate preference and equivalence, respectively;

$$\{S_1 \succ S_2 \succ ... \succ S_i \succ ... \succ S_n\}$$

is the strict, and

$$\{S_1 \succ S_2 \sim S_3 \succ ... \succ S_i \sim S_{i+1} \succ ... \succ S_n\}$$

is the flexible ranking.

In this case, the presence in the sequence of the sign «$\sim$» testifies to the existence of clusters.

At present a large number of methods of ranking and selection of the best alternatives are designed and used in practice [7, 21–23]. The most popular, under multicriteriality conditions, is the method of the analysis of hierarchies [24], however, the underlying procedure of pair by pair

comparison of alternatives generates a number of organic deficiencies, which directly influence the efficiency of the method of expert evaluation [25].

An increase in the efficiency of the process of assessing alternatives, in particular, in the problem of a rational selection of the team of the HTP performers, should be expected from the application of such methods of decrease in the level of uncertainty in the process of forming the solutions for PMD as the theory of evidence by Dempster-Shafer, the theory of plausible and paradoxical considerations of Dezert -Smarandache, and also as the theory of rough sets.

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6. Discussion of the results of the study, by the analysis of features, of the calculation of efficiency of the introduction of an approach to forming a team of the performers of high technological project

For determining the accuracy (efficiency) of the final estimation of the variants of an HTP composition, one can apply an approach, based on the calculation of the so-called "truncated average", i. e., the indicator, characterizing the quality of structuring and subsequent aggregation of the estimations, put by members of a expert board. The paper [22] proposed the assessment, which the authors called the standard error of the truncated average.

$$e_{T(\alpha)} = \sqrt{\frac{SS(\alpha)}{(n - 2g)(n - 2g - 1)}}, \tag{18}$$

where n is the volume of the assessed data sample; value g is determined by the relationship g=[αn]; [αn] is the largest integer among the values of the sample; $SS(\alpha)$ is the sum of the squared deviations [22]:

$$SS(\alpha) = (g+1)(x_{(g+1)} - T(\alpha))^2 +$$

$$+ \sum_{i=g+2}^{n-g-1} (x_{(i)} - T(\alpha))^2 + (g+1)(x_{(n-g)} - T(\alpha))^2. \tag{19}$$

The standard error of the truncated average in the case $T(\alpha = 0.5) = \text{med}$, when as the stable analog of selective medium, selective median is accepted [21] it takes the form:

$$e_{med} = 1.25 \frac{\sigma}{\sqrt{n}}, \tag{20}$$

where σ is the mean-square deviation, which is calculated by the formula

$$\sigma = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (x_i - T(0))^2}. \tag{21}$$

The standard error of the truncated average in the case asymmetrical truncation is calculated by the value

$$e_{T(\alpha_L, \alpha_U)} = \sqrt{\frac{SS(\alpha_L, \alpha_U)}{(n - g_1 - g_2)(n - g_1 - g_2 - 1)}}. \tag{22}$$

Accordingly, the sum of the squared deviations takes the form [26]:

$$SS(\alpha_L, \alpha_U) = (g_1 + 1)(x_{(g_1+1)} -$$
$$-T(\alpha))^2 + \sum_{i=g_1+2}^{n-g_2-1} (x_{(i)} - T(\alpha))^2 +$$
$$+(g_2 + 1)(x_{(n-g_2)} - T(\alpha))^2 -$$
$$-\frac{\{(g_1)(x_{(g_1+1)} - T(\alpha)) + (g_2)(x_{(n-g_2)} - T(\alpha))\}^2}{n}, \qquad (23)$$

where $g_1 = [\alpha_L n]$, $g_2 = [\alpha_U n]$.

A special feature of the considered approach to the calculation of the efficiency of the work of an expert board to form the composition of an HTP team lies in the fact that the standard error of the truncated average, measured in the same units as mean-square deviation, depends on the volume of the evaluated data sample (the greater the sample size, the less is the standard error). Thus, the smaller value of standard error, the more efficient and accurate the obtained estimation of the truncated average is, which means the quality of collective expert evaluation.

Further studies of the processes of planning and realization of high technological projects at virtual enterprises are intended to conduct in the direction of the design of analytical models of the support of life cycle of HTP [26], as well as the application of the means of artificial intelligence for forming information medium of the realization of high technological projects at virtual enterprises [27].

7. Conclusions

1. The meaningful formulation is attached of the problem of creation of the set of alternatives of the composition of the teams of HTP performers, whose participants are soundly selected on the criteria: competence; communicability; effectiveness; creativity and others. With this in mind, the limitations are taken into account for the overloading of each participant during implementation of the portfolio of projects over the time period, which corresponds to the portfolio of VIE strategies.

2. The process of building the teams of the HTP performers at virtual instrument-making enterprises is presented in the form of an ordered set of the required stages of the selection of contenders, which makes it possible to create methods and tools of support of decision making by a top manager and by an HR-manager at VIE.

3. The formal description of the process of the selection of contenders for inclusion in an HTP composition was designed, which, unlike known, makes it possible to decrease the level of uncertainty (NO-factors) in the aspects of incompleteness, carelessness, inaccuracy. This possibility is ensured by that the proposed description includes ordered sequence of the methods to decrease the level of uncertainty. Thus, for the estimation of the level of competence of contenders we applied a combination of the mutually complementing methods («360 degrees», "Assessment Center", "Azimuth") to reduce the inaccuracy; for overcoming blurred initial information during the assessment of the permissibility of the inclusion of contenders to the composition of a project's team, a special model was synthesized; the incompleteness of data is compensated by the combined application of the methods of the theory of evidence and the theory of plausible and paradoxical considerations.

4. Special approach to building the team of the HTP performers at virtual instrument-making enterprise is described, which makes it possible to carry out substantiated selection of contenders for an HTP team by different criteria. The application of this approach in practice will ensure both economic and social effect, which will ensure competitive advantages to VIE in the market for high technological production. The multistage correction of the results of collective expert evaluation with the aim of reaching consensus is the special feature of this approach providing for such advantages.

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