Formation of Teams of Performers of Projects at Innovative Enterprises within the Framework of the Industry 4.0 Concept

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***Abstract*— The problem of human resource management in the planning and implementation of high-tech projects in innovative enterprises is considered. This problem arises in the conditions of the fourth industrial revolution, due to the need for effective implementation of projects using breakthrough technologies, since such projects require a special level of competence of contractors. The procedures for forming an expert commission for evaluating alternative options for the composition of teams of high-tech project performers are described, as well as the process of forming a collective decision in the form of conjunctive consensus. The methodological basis of the described process of collective expert assessment is based on the following tools known in the theory of variational calculus, such as: α – truncated middle calculus, excess ratio, statistics Q, the values selective average. An illustrative example is given of evaluating alternative options for the composition of the project for creating a new model of a self-propelled passenger ramp at a typical aviation profile enterprise.**

***Keywords*—** *industry 4.0, innovative enterprise, project team, self-propelled passenger gangway, expert evaluations*

1. Introduction

The concept of the Fourth Industrial Revolution, better known as "Industry 4.0," was named in 2011 by the initiative of German businessmen, politicians and scientists led by C. Griffstaff (Siemens PLN Software), who identified it as a way of increasing the competitiveness of the German manufacturing industry through enhanced integration of "cyber-physics systems" (or CPS) into production processes [1]. CPS means the integration of machines and human work connected to the Internet, as well as the process of creating a network of machines that will not only produce products with fewer errors, but will also be able to autonomously change the production patterns as needed, while remaining highly effective. At the same time, the driving force is integrated intelligence processes and products that generate so-called large data that completely change the production landscape and create new markets. Industry 4.0 is a production that is equivalent to consumer-oriented "Internet things", in which household items, from cars to toasters, will be connected to the Internet. This concept provides that further industrial development will be linked to the implementation of three revolutionary trends until 2030, namely:

- a revolution in the design and organization of production processes (technological and organizational reengineering industry, based on the total digitalization of production processes);
- the transition to new materials (their integration into automated systems of design and production, the combination of the production of materials and the production of components);
- reasonable environments (their mass implementation is expected in the 2050's and 30's) [2], [3].

According to the forecasts of the world's leading institutions (UNIDO, OECD, World Bank) and international industrial associations and research companies (including MIT, KPMG), by 2030, the above-mentioned trends in industrial production can only be achieved through the introduction of advanced production technologies (APT) on the basis of converging technologies, which are called "breakthroughs", emphasizing their revolutionizing influence on the structure of production. The

International Journal of Supply Chain Management
IJSCM, ISSN: 2050-7399 (Online), 2051-3771 (Print)

general understanding of the APT is as follows:

1) technological substitution, leading to a qualitative improvement of existing or the creation of fundamentally new products;

2) automation of the production process, which introduces new requirements for the qualification of specialists;

3) customization of production as a flexible adaptation to the needs of the customer;

4) localization - reducing costs by saving on logistics and geographical proximity to the customer (customer);

5) economic efficiency, related either to a reduction in cost relative to mass production, or to resource savings, increased productivity, investment attractiveness and competitiveness [2], [3].

Thus, APT are associated with non-traditional methods of processing, new tools for control and management of production processes, as well as the use of new materials, automated and intelligent control and management systems for equipment, production processes and systems.

Ukraine has great potential and competitive technologies in the aerospace industry, the production of new materials with specified properties, industrial biotechnologies, mathematical modeling and regulation of chemical, biochemical and biophysical processes, and intelligent production systems. The "Industry 4.0" movement in Ukraine is an integration platform for the unification of business associations, communities and market participants in information and communication technologies, industrial control systems, engineering and machine-tool engineering, scientists and educators for the purpose of rapid modernization of the Ukrainian industry, massive and rapid implementation. New technologies 4.0 and accelerated development of Ukrainian high value added production.

Already there are enterprises that implement the main achievements of Industry 4.0. Therefore, in Ukraine, "ArcelorMittal Kryviy Rih" is an innovator who deliberately and purposefully uses trends 4.0 for the development of his company. The company's investment project for the new system of maintenance has all the features of predictive maintenance, but is based on the Internet of things, cloud technologies, communication of machines (objects) with each other and according to international standards. Another company - "Azov Controls" is a long-term partner of Rockwell Automation and the leader in Ukraine of automated control systems for the technological process of blast furnaces. Another company that effectively implements Industry 4.0 technologies is Kaeser Kompressoren. The current philosophy of technical solutions of the company is based on the priority of digital technology not only as an element of innovation, but one of the key differentiators and competitive advantages of its equipment [4]. Along with this, in modern Ukraine there are quite a few small enterprises, whose activities are connected with the use of breakthrough technologies. A number of such enterprises successfully operates in the domestic aerospace industry.

For the above-mentioned enterprises, which realize the concept of Industry 4.0 during their activities, the management of human resources is a common concern. This problem arises from the peculiarities of implementing projects using breakthrough technologies, since such projects require a special level of competence of the executors [5].

The purpose of the article is to describe the technology of formation of teams of executors on innovative enterprises on the example of the project of creation of a new self-propelled passenger gangway (SPG) on a typical small enterprise of aviation profile.

2. Materials and Methods

The creation of a new SPG model involves the introduction of innovations in the development of the system of berthing the ladder to the plane of the aircraft.

The purpose of the project is the development of a modernized design of the SPG, the production of a prototype and the conduct of field tests.

The beginning of the production order is the receipt of the technical task (TT) for the research and development work on the development of the SPG, and the completion of the submission for the issue of quality certificates and the conformity of the modernized SPG model.

The development of the typical design of the SPG is in accordance with the following guidance documents.

Results of production task:

- a set of technical documentation describing the SPG, methods and equipment for manufacturing the required number of identical staircase instances, methods for ensuring safe operation, as well as methods and equipment for technical operation that ensure reliable operation during the specified service life and technical resource;
- test specimen of SPG, which passed the established types of tests;
- a set of documentation confirming the compliance of the prototype with the requirements of the customer of the SPG, as well as the compliance of the characteristics obtained in the

tests of the prototype, the requirements of the TT and the certification basis;

- submission of a request for certification of a new SPG model.

The creation of a self-propelled passenger gangway is a rather complicated task, which requires the implementation of a large number of works carried out sequentially, and some of them in parallel. In general, the creation of a new SPG model involves the following steps: start of the project; project initiation; Preparatory stage; production; innovation stage; trial; certification of the ladder; preparation of ladder for transportation to the customer; debugging stage; completion of the project. At the same time, the preparatory stage involves the implementation of a number of tasks, among which the task of forming a team of project executors is very important.

The innovative component of this project is the development of a mooring equipment complex (MEC). Work on the MEC project is being carried out by the project team under the direction of the Chief Designer. The chief designer approves the decision in all directions of designing. The promotion of the detail of the technical product and its processing is carried out by HR- and Project-managers together with specialized production units. The essence of this process is the consistent approximation of the characteristics of the MEC to the characteristics specified in the technical task (TT).

The development of MEC is in accordance with the deductive principle "from general to specific", detailing the chosen general version of the technical product. At the level of detail is also an iterative process of analysis of possible options, their assessment and decision-making on choosing a variant at this level of detail.

The peculiarity is that the evaluation of variants of the lower level of detail of the MEC is made taking into account the further "lifting" to the previous higher level of detail, and then to the top representing the SPG as a whole.

At the stage of elaboration of the prototype, the production departments, according to their specialization, conduct research on individual characteristics of the MEC through various types of tests.

The research is carried out by working out the actual results in order to form and make decisions about the possibility of further elaboration of the existing version, or the introduction of a new version of the technical product (if the received MEC does not meet the specified characteristics).

All documentation received on each of the MEC details is stored and used when there is a "return" to the earlier variants of the complex.

After each project iteration, the evaluation of the characteristics of the MEC variant is carried out and conclusions are drawn on the relevance of the characteristics under study. If necessary, changes are made to the initial version of the assessment of changes, after which a decision is taken to make changes to the detail and the formation of a new version with the relevant documentation is taking place. Or, if all the conditions are satisfied, there is a transition to the next level of detail with a more detailed development of the option and the beginning of a new evaluation cycle.

The task is to determine, on the basis of the work of the expert commission, the only option for the team to develop a MEC for a new SPG model. This task is a sequence of subtasks:

1. Formation of the expert commission.
2. Formation of alternative variants of the team of MEC developers.
3. Formation of individual expert judgments about the benefits of this or that variant of the team.
4. Construction of a generalized ranking that reflects the collective opinion of members of the expert commission regarding the composition of the team of MEC developers.
5. To give a special one, to take a solution for hardening, to form a solution about the warehouse of the team of industrial enterprises of MEC.

The following scenario example was considered, which will detail 2 and 4 stages, as the most critical in solving this problem.

Considered stage is implemented directly by HR-manager with the participation of its immediate environment (Project-managers), while the following steps were taken:

- creation of a model of the competences of the private firm "Space" regarding their possible participation in the development of MEC, on the basis of a competent approach (methods "360 degrees", Assessment Center and Azimuth methodology);
- on the basis of the created model of competencies - formation of the personnel of the private firm "Space" employees of the group of potential participants of the MEC development project;
- determination, according to the time chart, of the employees not included in the project of modernization of the SPT-154 of the employees included in the group formed in step b);
- unclear assessment of the possibilities of interaction of potential project participants who have been selected in step c);
- formation of alternative variants of the team of MEC developers (Table 1).

The results of the implementation of the described stage are the basis for their evaluation by members of the expert commission.

Table 1. Alternate variants of the team of MEC developers

Roles in the MEC development project	**Options for the MEC Developer Team**											
	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}
	Board numbers of employees											
Project team leader (Team Leader)	023	005	023	005	003	005	023	023	003	003	023	003
Design engineer	005	003	005	023	005	003	005	003	023	023	005	005
Electronic equipment engineer	027	021	020	027	020	021	027	027	021	020	027	021
Cutting-edge workpiece	037	036	037	037	036	036	037	036	036	037	037	036
Turner	040	040	042	047	040	042	047	040	042	040	042	047
Driller	046	048	046	041	046	041	048	048	046	041	046	046
The welder	028	028	026	028	026	026	026	028	028	028	026	028
Locksmith for mechanically assembling works	031	032	030	035	031	032	030	035	031	035	032	030

The aggregation of individual preferences of the members of the expert commission is performed by combining the probabilistic masses given in Table 2 of the alternatives of the teams of developers of the mooring equipment complex selected by experts, taking into account the coefficients of competence of the experts $\Omega = \{\omega_i \mid i = \overline{1,7}\}$. Based on the fact that the value of the coefficient of conflict varies from 0.67 to 0.8, which indicates the existence of significant conflict between individual groups of certificates. Consequently, it is necessary to determine the combined masses of probability of choosing alternatives for the team of MEC developers (Table 3).

Table 2. Alternate variants of the team of MEC developers

Option for team composition	**Alternate options for the team of MEC developers**											
	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}
Combined mass of probability m_K	0,136	0,047	0,26	0,08	0,07	0,062	0,057	0,062	0,066	0,044	0,05	0,05

Subsequently, based on the values of combined masses of probability regarding the alternatives selected by experts from the composition of teams of MEC developers, the resultant ratio, which is a generalized ranking, is determined and reflects the collective opinion of the members of the expert commission.

Conflicts when evaluating members of an expert commission of the same object usually arise as a result of one of two, or both of these factors at once: the unjustified choice of detection and / or analysis of expert information (this factor generates a situation of inaccuracy of the data being obtained); insufficient consideration of information on the competence of experts (this factor generates uncertainty about the data obtained).

Based on the values obtained in Table 2 of the estimated alternative options for the teams of high-tech project, a resultant relation (generalized ranking) is constructed, reflecting the collective opinion of the expert commission:

$$\begin{aligned} &A_3 \succ A_1 \succ A_4 \succ A_5 \succ A_9 \succ A_6 \succ \\ &\succ A_8 \succ A_7 \succ A_{12} \succ A_{11} \succ A_2 \succ A_{10} \end{aligned}. \quad (1)$$

From the above results it is seen that the greatest value of the combined probability mass m_K has an alternate version of the developer team A_3.

To test expert judgment for consistency, we use the Kendell-Smith concordance coefficient.

We scan each expert's estimates for n ratings. For this assessment, the data given by a specific expert to each of the options of the project team, we denote the numbers of the natural series in such a way that the number 1 is assigned a maximum estimate, and the number n - the minimum. If all n grades are different, then the corresponding numbers in the natural series are the grades of the corresponding expert. If the ratings given by a particular expert are the same, then these estimates are assigned the same rank, which is equal to the arithmetic mean of the corresponding numbers of the integer. Table 3 lists the ranks of the analyzed variants of the team of MEC developers.

Table 3. Alternate variants of the team of MEC developers

Experts	Option for team composition											
	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}
E_1	6	5	4	9	7	3	1	2	8	9	5	4
E_2	9	5	7	8	1	6	4	2	3	5	3	6
E_3	8	9	2	6	7	3	1	4	5	8	6	8
E_4	8	3	7	4	9	6	2	1	5	7	5	9
E_5	6	5	6	2	8	3	1	4	9	5	3	6
E_6	9	7	8	5	6	4	2	3	1	5	7	4
E_7	9	2	4	6	3	6	1	8	7	4	3	5
Total rank R_i	55	36	38	40	41	31	12	24	38	43	32	42
Deviation from the average amount of ranks	19	0	2	4	5	-5	-24	-12	2	7	-4	6
Squares of deviations	361	0	4	16	25	25	576	144	4	49	16	36

Since in the testimony of experts (Table 3) there is a repetition of ranks, to determine the degree of consistency of estimates, it is necessary to calculate the value of the coefficient of Kendall-Smith plural concordation using the formula:

$$W = \frac{S}{l^2(m^3-m) - l\sum_{j=1}^{l}(t_j^3 - t_j)}, \qquad (2)$$

$$S = 12 \cdot \sum_{i=1}^{m}(R_i - \bar{R})^2,$$

where t_j – the number of the same ranks, arranged by the j-th expert.

For the case under consideration

$$W = \frac{12 \cdot 1256}{7^2(12^3-12) - 7\cdot 42} = \frac{15072}{83790} = 0{,}17. \quad (3)$$

The value of the coefficient W ≈0,2 means that the link between estimates by different experts is insignificant.

As is known (Beshelev et all., 1974), for n > 7 the value *m (n – 1)W* s subordinated to χ^2 – the distribution with the number of degrees of freedom *f = n – 1*. Where n – the number of variants of the team of developers MEC, m – the number of experts.

The significance of the coefficient of concordation *W* will be established using the Pearson criterion. Calculate the value of a formula that takes into account the repetition of ranks:

$$\chi_P^2 = S \Bigg/ \left(l \cdot m \cdot (m-1) - \frac{\sum_{j=1}^{l}(t_j^3 - t_j)}{m-1} \right), \quad (4)$$

$$\chi_p^2 = \frac{1256}{12\cdot 42 - \frac{42}{6}} = \frac{1256}{497} = 2{,}52. \quad (5)$$

Compare the calculated value χ_p^2 with table values from the distribution of Pearson, found for the accepted level of significance and the number of degrees of freedom *f = n – 1*.

At 1% level of significance ($\alpha = 0{,}01$) and number of degrees of freedom *f = 9 – 1 = 8* the table value $\chi_{кр}^2$ is 20,1.

Since $\chi_p^2 < \chi_{кр}^2$ (2,52<20,1), the coefficient of concordation can be considered insignificant.

Analyzing the results, we come to the conclusion that the full agreement between the members of the expert commission was not achieved. To obtain a final evaluation, it is necessary to solve the task of clustering expert assessments.

The solution of the problem of clustering evaluation of variants of the team of MEC developers is to analyze, on the basis of the variational calculation, an array of individual estimates of the advantage of one alternative option to another [6].

During the work of the expert commission, experts had to assess the alternatives $A_i \in K$, $i = \overline{1,12}$ formed at the previous stage, or identify the best alternatives groups $X_k = \left\{A_i \mid i = \overline{1,s}\right\}$, $s \leq 12$, $X_k \subseteq K$, and then determine the extent of their benefits within a given scale in relation to all other alternatives to the team of developers of the mooring equipment complex (to the plural K).

As a result of the expert survey, groups of alternatives $X_k \subseteq K$ from the plurality K and determination of the degree of advantage of the selected groups of alternatives were identified.

Table 4 shows the values of the coefficient of excess, asymmetry, selective mean and α-dispensed mean for choices expert assessments of alternatives to the composition teams MEC developers.

Table 4. Values of the measures of the average level of assessments reviewed by the expert commission of options for the team of MEC developers

Indicators of expert assessments	Alternate options for team composition											
	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}
Excess	2,005	1,909	1,983	2,888	3,502	2,399	4,045	2,512	3,029	1,976	2,785	3,151
Statistics Q	1,891	1,904	2,030	2,552	2,631	2,379	2,710	2,442	2,644	1,914	2,465	2,473
Selective average	39,3	50,7	55,8	43,1	45,2	51,4	76,9	62,5	51,5	50,3	54,7	47,4
α – truncated middle	37	50,8	56,2	40,4	42,8	52,3	81,9	64,1	50,1	50,5	57,2	42,8

Consider the partition scheme of the formed variation series constructed according to the numerical sample of expert estimates for $A_1 - A_{12}$ (Table 4).

The analysis of data in Table 4 has shown that the coefficient of sampling excess k and the value of statistics Q for the variants of the team A_4, A_6 and A_8 are in ranges $2{,}0 \leq k \leq 4{,}0$ and $2{,}0 \leq Q \leq 2{,}6$ respectively.

The decisive rule for A_4, A_6 and A_8 has the form

$$X \Rightarrow X_0 = \{ x_{(1)}, x_{(n)} \}. \qquad (6)$$

Level truncation $\alpha = 0\%$.

From this it follows that the row does not creep $[x_{(1)}, x_{(7)}] \in X_0$, ts values can be taken homogeneous.

Calculate the degree of consistency of expert assessments, for example, for the option composition of the team A_6. To calculate the degree of consistency of opinion of members of the commission, we use the coefficient of variation [7]:

$$V(X_{A_6}) = 0{,}3 (30\%). \qquad (7)$$

Given the fact that the value of the coefficient of variation is less than 33%, the degree of consistency of expert assessments should be considered high.

For A_1 the value of the coefficients of excess and statistics Q are in the ranges $2.0 \leq k \leq 4{,}0$, $Q < 2{,}0$; for A_2 – $k < 2{,}0$, $Q < 2{,}0$; for A_3 – $k < 2{,}0$, $2{,}0 \leq Q \leq 2{,}6$; which corresponds to the rule

$$X \Rightarrow \begin{cases} X_1 = \{ x_{(1)}, x_{([\alpha n])} \}, \\ X_0 = \{ x_{([\alpha n]+1)}, x_{(n-[\alpha n])} \}, \\ X_2 = \{ x_{(n-[\alpha n]+1)}, x_{(n)} \}. \end{cases} \qquad (8)$$

Level truncation $\alpha = 25\%$.

As a result, a row can be divided into 3 clusters:

$$X \Rightarrow \begin{cases} X_1 = \{ x_{(1)}, x_{(6)} \}, \\ X_0 = \{ x_{(7)}, x_{(19)} \}, \\ X_2 = \{ x_{(10)}, x_{(12)} \}. \end{cases} \qquad (9)$$

A subset X_0 characterizes the homogeneous component of the variation series.

Calculate the degree of consistency of expert estimates for each of the selected subsets (X_0, X_1, X_2).

To calculate the degree of consistency of expert opinions we use the coefficient of variation [8]:

- coefficient of variation for the initial set of expert assessments according to the simplified version of the team A_1 $V(X_{A_1}) = 0{,}486(48{,}6\%)$;
- for the subset X_0 the coefficient of variation $V(X_0) = 0{,}214(21{,}4\%)$;
- for the subset X_1 the coefficient of variation $V(X_1) = 0{,}126(12{,}6\%)$;
- for the subset X_2 the coefficient of variation $V(X_2) = 0{,}088(8{,}8\%)$.

Calculated values of the coefficients of variation for the selected subsets (clusters) do not exceed 33%. Consequently, we can conclude that within the clusters of opinion experts can be considered concerted.

For variants A_5 and A_9 values of the coefficients of excess and statistics Q are in the ranges $2{,}0 \le k \le 4{,}0$ and $2{,}6 < Q \le 3{,}2$, that corresponds to the rule

$$X \Rightarrow \begin{cases} X_1 = \{ x_{(1)}, x_{([\alpha n])} \}, \\ X_0 = \{ x_{([\alpha n]+1)}, x_{(n-[\alpha n])} \}, \\ X_2 = \{ x_{(n-[\alpha n]+1)}, x_{(n)} \}. \end{cases} \qquad (10)$$

Level truncation $\alpha = 18{,}75\%$.

As a result, the row will be divided into 3 clusters:

$$X \Rightarrow \begin{cases} X_1 = \{ x_{(1)}, x_{(4)} \}, \\ X_0 = \{ x_{(5)}, x_{(7)} \}, \\ X_2 = \{ x_{(8)}, x_{(12)} \}. \end{cases} \qquad (11)$$

Calculate the degree of consistency of expert estimates for each of the selected subsets (X_0, X_1, X_2) using the coefficient of variation [7]:

- coefficient of variation for the initial set of expert assessments for the team option A_9 $V(X_{A_9}) = 0{,}374(37{,}4\%)$;
- for the subset X_0 the coefficient of variation $V(X_0) = 0{,}177(17{,}7\%)$;
- for the subset X_1 the coefficient of variation $V(X_1) = 0{,}184(18{,}4\%)$;
- for the subset X_2 the coefficient of variation $V(X_2) = 0{,}116(11{,}6\%)$.

Calculated values of the coefficients of variation for the selected subsets (clusters) do not exceed 33%. Consequently, we can conclude that within the clusters of opinion experts can be considered concerted.

For a team variant A_7 the values of the coefficients of excess (k =4,0456) and statistics Q (Q = 2,7108) are in the ranges $4{,}0 < k \le 5{,}5$ and $2{,}6 < Q \le 3{,}2$, that corresponds to the rule

$$X \Rightarrow \begin{cases} X_1 = \{ x_{(1)}, x_{([\alpha_1 n])} \}, \\ X`_1 = \{ x_{(1)}, x_{([\alpha_2 n])} \}, \\ X_0 = \{ x_{([\alpha_1 n]+1)}, x_{(n-[\alpha_1 n])} \}, \\ X_2 = \{ x_{(n-[\alpha_1 n]+1)}, x_{(n)} \}, \\ X`_2 = \{ x_{(n-[\alpha_2 n]+1)}, x_{(n)} \}. \end{cases} \qquad (12)$$

Level truncation $\alpha_1 = 25\%;\ \alpha_2 = 18{,}75\%$.

$$X \Rightarrow \begin{cases} X_1 = \{ x_{(1)}, x_{(6)} \}, \\ X`_1 = \{ x_{(1)}, x_{(4)} \}, \\ X_0 = \{ x_{(5)}, x_{(7)} \}, \\ X_2 = \{ x_{(8)}, x_{(10)} \}, \\ X`_2 = \{ x_{(11)}, x_{(12)} \}. \end{cases} \qquad (13)$$

The components of the series X_1, X_2, X_1', X_2' ($X_1' \subset X_1, X_2' \subset X_2$) are characterized by groups of experts, whose assessments are to some extent different from those of the main group X_0, which characterizes a homogeneous component.

Calculate the degree of consistency of expert estimates for each of the selected subsets ($X_0, X_1, X_2, X_1', X_2'$) using the coefficient of variation [7]:

- coefficient of variation for the initial set of expert assessments of the command variant A_7 $V(X_{A_7}) = 1{,}063$ which indicates the presence of values that are very different from the average;
- for the subset X_0 the coefficient of variation $V(X_0) = 0{,}042(4{,}2\%)$;
- for the subset X_1 the coefficient of variation $V(X_1) = 0{,}373(37{,}3\%)$;
- for the subset X_2 the coefficient of variation $V(X_2) = 0{,}015(1{,}5\%)$;
- for the subset X_1' the coefficient of variation $V(X_1') = 0{,}422(42{,}2\%)$;
- for the subset X_2' the coefficient of variation $V(X_2') = 0{,}046(4{,}6\%)$;
- for the subset, which is created by difference $X_1 \setminus X_1'$, the coefficient of variation is equal to 0;
- for the subset, which is created by difference $X_2 \setminus X_2'$, the coefficient of variation is equal to 0.

The calculated values of the coefficients of variation for subsets X_0, X_2, do not exceed 33%. Consequently, we can conclude that within these clusters, the views of experts can be considered concerted. The opinions of the experts included in the subset, which are formed by difference $X_1 \setminus X_1'$ and $X_2 \setminus X_2'$ can be considered homogeneous and coordinated.

3. Results and Discussion

The analysis of the current state of the problem of managing high-tech projects at innovative enterprises in the conditions of the 4 industrial revolution and the formation of the sixth technological structure has been carried out. This analysis has shown that in order to increase the efficiency of portfolio management at enterprises of this type, it is necessary to develop special methodological means of supporting decision-making by HR- and Project-managers regarding the formation of the composition of the performers of high-tech projects taking into account a number of indicators of different nature, first of all, the competence of the personnel.

The advanced method of collective expert evaluation of alternative variants of the VTP team is described, by means of a combination of means of forming and supporting decisions of HR- and Project managers.

An illustrative example of the application of theoretical results for supporting the activities of HR- and Project-managers in forming the composition of the developers of the mooring equipment complex for the self-propelled passenger gangway SPT-154 on a typical innovation enterprise of the aviation profile is considered; the calculation based on the average made it possible to determine, with the highest value of the function of reliability, the only version of a team of twelve alternatives.

The considered technology can be used to solve a wide range of applied tasks related to the management of human resources in terms of forming an effective team of executors of high-tech projects.

The limitation in the application of the proposed methodological tools lies in their focus on the assessment of the ability of only production personnel. At the same time, the evaluation of team members of the project executives engaged in management is not considered.

4. Conclusion

The process of work of the expert commission consisting of seven experts on the selection of the team of the project team for the development of MEC from twelve alternatives is considered. It received a number of individual expert judgments about the benefits of this or that variant of the team of MEC developers. The next step was to aggregate these judgments by computing the combined probability masses based on Dempster's rule. Thus, a generic ranking was constructed, which reflects the collective opinion of members of the expert commission regarding the composition of the team of MEC developers.

Based on the above calculations, the following conclusions can be drawn:

1. The most important values of the validity function belong to the command option A_3, while the degree of trust based on experts' estimates is in the range from 0,0015 to 0,2228.
2. There is a decrease in the degree of complete ignorance, in the same manner, indicating the presence of an inverse proportional relationship between the level of trust and complete ignorance.
3. The level of conflict varies from 0,22 to 0,43, indicating that.
4. The presence of some conflict between individual groups of certificates of members of the expert commission.
5. The total value of all probability masses of the selected focal elements is greater than the probability mass referring to the basis of the analysis $(\sum_{i=1}^{p} m_j(X_i) > m_j(\mathrm{K}),\ j=\overline{1,12})$.
6. Experts' judgments can be considered non-interrelated.
7. The results of the analysis of expert estimates based on the calculation of α – truncated meanings confirmed that the most important values of the function of reliability is the composition of the MEC developers team A_3, which must be submitted to the approval of the decision maker.

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