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The Model of the Innovative Project as the Multivariable Control Object

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***Abstract*—The formation of a balanced system of parameters (budget; duration of implementation; customers and developers' satisfaction with the results of the project the course of the project) is a critical factor in the successful implementation of the project. Development of the formal models, which described the direct and cross-linking relationship between the input (budget, implementation time) and output (customer and developer satisfaction) parameters of the project creates the conditions for increasing the validity of decisions related to the project organization. The feature of empirical models constructing is the need to share actual (historical) data about budgets and the previously implemented projects duration, and subjective estimates (determined by experience) of consumers and developers. The paper considers the approach for the construction of parametric regression models based on the joint use of measured data and expert estimates. The additive or multiplicative form of interaction of direct and cross-linking relationship is substantiated, this depend on which target group (consumers or developers) are assigned the outputs of a multivariable object.**

Keywords—innovative project, measured data, expert estimates, multivariable control object, target group, membership function, linguistic scale

I. Introduction

Errors in solving of organizational problems associated with the creation of complex subject-centric systems are the sources of latent defects, the result of which can be the threat to the life people, natural environment, material and financial losses. For this reason, one of the main tasks of the pre-project stage is to make the reasonable conclusion about the possibility and expediency of reusing previously well-established organizational, design and technological decisions. The complexity of solving this problem is due to the following:

- On the one hand, many latent defects have been identified and fixed in known decisions, which increases reliability of forecasts of the presentation timing and quality of the expected results. In addition, the staff of the development organization is trained in the technologies of designing and constructing objects, tools that support these technologies.
- On the other hand, due to the unique properties of any project [1], previously manifested latent defects may manifest itself in a new condition.

The unreasonable trust of developers to the approaches, which previously well-proven, is difficult to establish the true causes of incidents and, as a consequence, negative effects to the basic characteristics of the project (budget, deadlines, satisfaction of users and developers) [2, 3]. In addition, each project is oriented to reach the results under predetermined conditions. Violation of restrictions on the environment of use is not guaranteed the reliable functioning of products obtained as a result of projects implementation as part of a different structure.

The development of a formal model for implementation of components of an innovative project on the basis of existing decision and information creates the basis for estimation of possibility and feasibility of focusing on known approaches, models and methods.

The paper discusses the approach to constructing a static empirical model of the project as a multiply connected control object that establishes a relationship between the main characteristics of the project based on measured data and expert estimates.

II. . Significant Features of the Innovative Project as a Modeling Object

The scientific idea of the development is to present the organization's experience in projects implementation of a certain direction in the form of an empirical mathematical model. Salient features of the project, defining the approaches to the construction of the model are:

1) The essential parameters of the project, according to the system model "project triangle" are: budget, duration of implementation, customer satisfaction with the properties of the project results, satisfaction of performers with the project terms.

2) The provision that the consumer properties of the final product are determined by the organization and progress of the project. The basis for this is, firstly, the well-known statements that the behavior of a system is determined by its

device [4]. Secondly, the well-known statement that the causes of unwanted events and phenomena are primarily errors in the organization of complex system management, and only secondarily the errors of operators [5].

In this paper, it is postulated that the objective quality characteristics of the management at different stages of the project life cycle are, firstly, customer satisfaction with the implementation results of the stage, secondly, the satisfaction of performers with the conditions in which they worked [6].

3) Assumption of comparability and homogeneity of historical data (in a statistical sense) on the main parameters of the projects and products obtained during its implementation. The basis for this assumption is, firstly, that the organization-developers specializes in the implementation of projects in a specific subject area. Secondly, the fact that inside the organization there is employee's specialization to solve the problems of a certain thematic focus. Thirdly, the fact that key aspects of employee's activity is regulated by standards and formally approved guidelines.

4) The project is considered as a static multivariable control object, the input parameters of which are the budget and the project duration, output parameters - the satisfaction of users and performers.

According to these assumptions the project could be associated with the model presented in Figure 1.

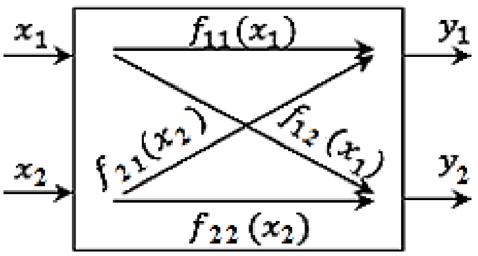

Fig. 1. Innovative project model as a multivariable control object

On the figure 1 $f_{ij}(\cdot)(i,j=\overline{1;2})$ is marked the functional dependencies, characterizing the direct and cross-link connections between input x_1 and x_2 and output y_1 and y_2 parameters. As x_1, x_2 are the budget and the duration of the project, respectively.

III. Quantification of Expert Estimates

Innovative projects belong to the class of subject-centric systems [5, 7]. This means that characteristics and behavior are largely determined by subjective decisions made by developers and users. Subjectivity in evaluation of project parameters is a distinctive feature of project management tasks. Subjective estimates include, among other things, user satisfaction with the consumer properties of the product, as well as the progress of the project by its implementers. Because of this, in construction of formal mathematical models of the project as a multivariable control object, there is a need to convert the subjective estimates of users/developers to the form of quantitative estimates.

The content of the proposed approach will be discussed using the example of forming quantitative estimates of user satisfaction.

Assume that the satisfaction of subjects can vary in the range $y \in [0;1]$. It is considered that the satisfaction is lower than the value is closer to the lower limit of the interval. And vice versa, the higher, than closer to the upper boundary of interval. Zero corresponds to the absolute dissatisfaction; one corresponds to the absolute satisfaction.

Suppose, a pre-defined linguistic scale is known in terms of which users, belonging to the same *m-th* target group evaluate theirs satisfaction with the consumer properties of the product. Suppose for definiteness that this scale is as follows: {low; average; high}. It is postulated that the ratings given by users reflect theirs true independent opinions about the properties of the product and are not affected by, for example, membership to any alliance [8].

Each *l-th* value of the linguistic scale is associated with the membership function μ_l defined on the interval $\mu_l \in [0;1]$. The position of the maximum of membership of the linguistic scale *l-th* value is determined as its reference value r_l on the y axis. The qualitative form of the membership function of the linguistic scale is shown on Figure 2.

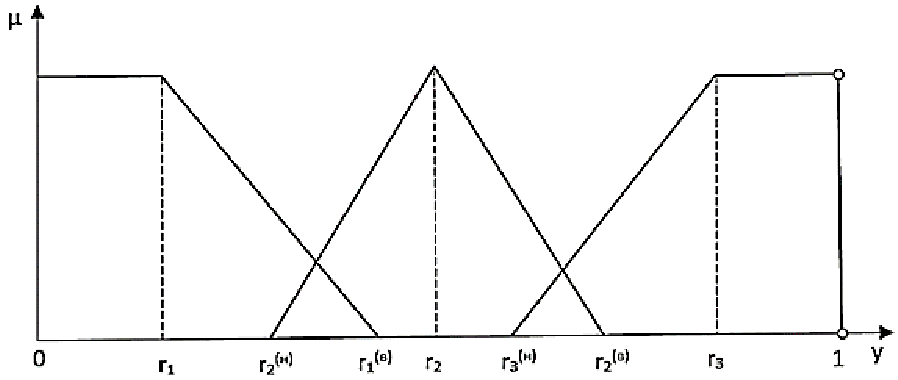

Fig. 2. The qualitative form of the membership function of the linguistic scale

$\{r_l^{(н)}, r_l^{(в)}\}$ – the lower and upper boundaries in which the *l-th* membership function is defined on the y axis.

Graphic models similar to Figure 2 are given in [9].

In terms of the linguistic scale, users express theirs satisfaction with the consumer properties of the product. In addition, each *k-th* user characterizes their confidence in the given estimate, expressed by the number $\mu_k \in [0,1]$. As a result, users belonging to the same target group are assigned the estimate of the consumer properties of the product:

$$E^{(m)} = \frac{\sum_{k=1}^{Nm} \mu_k^{(l)} * r_l^{(k)}}{\sum_{k=1}^{Nm} \mu_k^{(l)}} \quad (1)$$

where N_m - number of users belonging to the *m-th* target group;

$r_l^{(k)}$ – reference value corresponding to the *l-th* value of the linguistic scale defined by the *k-th* user;

$\mu_k^{(l)}$ – the degree of confidence of the *k-th* user in the given estimate.

As a cumulative estimate of satisfaction, in accordance with the recommendations given in [9], is selected the reference value r_l, which is closest to $E^{(m)}$. The degree of confidence in the resulting estimate is defined as $\mu_m(E^{(m)})$.

The main uncertainties that complicate practical use (1) are:

1) approaches for choosing the values of r_l;

2) approaches for choosing the form of the membership function μ_l. In literature, for example, in [10], a large number of membership functions of various shapes are described, however, clear practical recommendations on its application are not defined;

3) approaches for defining boundaries $\left\{r_l^{(\text{н})}, r_l^{(\text{в})}\right\}$ (fig.2).

To resolve the identified uncertainties, it is proposed to use the following.

The basis for determining r_l is to take into account the share of users belonging to the *m-th* target group and choosing the *l-th* value of the linguistic scale.

In this approach, the r_1 value is:

$$n_1^{(m)}/N_m \quad (2)$$

where $n_1^{(m)}$- the number of users of the *m-th* target group, who chose the value of the linguistic scale "low".

As r_2 value is:

$$r_2 = \frac{n_1^{(m)}}{N_m} + \frac{n_2^{(m)}}{2N_m} \quad (3)$$

where $n_2^{(m)}$ - the number of users of the *m-th* target group, who chose the value of the linguistic scale “average”.

As r_3 value is determined by the ratio:

$$r_3 = \frac{n_1^{(m)}}{N_m} + \frac{n_2^{(m)}}{N_m} \quad (4)$$

The value of r_2 defined by ratio (3) represents the average of the sub-interval between the values r_1 and r_3.

Regarding the uncertainties associated with the choice of the of the membership function form, and the lower and upper boundaries $\left\{r_l^{(\text{н})}, r_l^{(\text{в})}\right\}$, the following should be noted. If the r_1 value corresponds to the maximum value of the linguistic scale “low”, then to the left of r_1 the degree of satisfaction cannot increase, i.e. μ_1 at $y\in[0;r_1]$ takes the value “1”. To the right of point r_1, the expert’s confidence in the selected estimates falls.

Due to the fact that there is no information about the speed decreasing of the value μ_1 as it moves to the right from r_1, according to the principle of entropy maximization [11-13], it is advisable to consider this rate constant.

Due to the lack of information that imposes restrictions on the definition area of μ_1, it is advisable to take the entire interval $y\in[r_1;1]$ as such area .

Based on this considerations μ_1 takes the form shown in Figure 3. By analogy, the membership functions for the selected linguistic scale have the form shown in Figure 4.

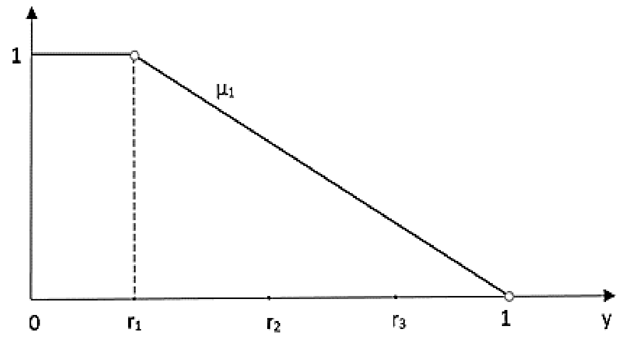

Fig. 3. Type of membership function μ_1

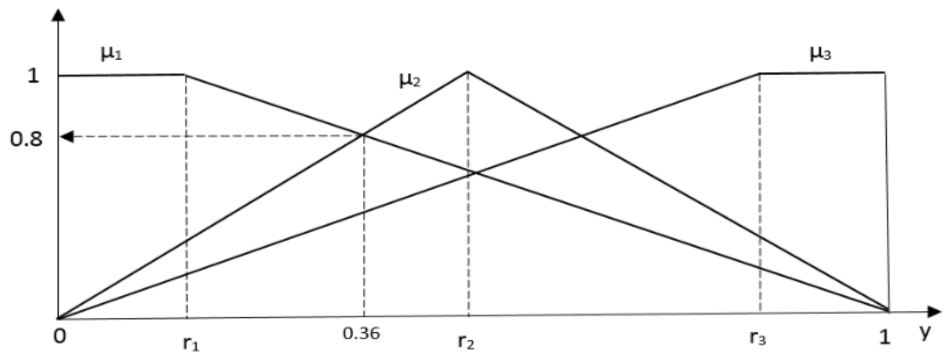

Fig. 4. The final form of the membership function of the linguistic scale

Consider an example of using the proposed approach for the quantification of expert estimates.

Suppose that as a result of interviews of ten users belonging to the same target group obtained the following estimates of product consumer properties and the degree of confidence in the given estimates:

1) {low , 0.8};
2) {average, 0.95};
3) {average, 0.7};
4) {high, 0.4};
5) {average, 0.8};
6) {low , 0.7};
7) {average, 0.8};
8) {average, 0.6};
9) {high, 0.7};
10) {high, 0.9}.

Accordance to the ratio (1), the value of E will be:

$$E^{(m)} = \frac{0{,}2(0{,}8+0{,}7)+0{,}45(0{,}95+0{,}7+0{,}8+0{,}8+0{,}6)+0{,}3(0{,}4+0{,}7+0{,}9)}{0{,}8+0{,}7+0{,}95+0{,}7+0{,}8+0{,}85+0{,}6+0{,}4+0{,}7+0{,}9} = 0{,}358$$

The closest reference value to $E^{(m)}$ is r_2=0,45. The value $E^{(m)}$ corresponds to the value μ_m (0.36) = 0.8.

The integral characteristic of satisfaction with the product properties of all target user groups according to the described approach may be the following indicator:

$$E_{\Sigma} = \frac{\sum_{m=1}^{M} E^{(m)} * \mu_m}{\sum_{l=1}^{M} \mu_m}, \quad (5)$$

where $E^{(m)}$ - characteristic of the satisfaction degree of the *m-th* target user group;

μ_m - confidence degree in the given estimate.

A similar approach can be used to study the satisfaction degree with the project progress by the various professional development groups and the project team as a whole.

It should be noted that the proposed approach to the quantification of expert estimates is largely formalized, which allows it to be implemented as a functional component in decision support systems.

IV. Conclusion

The proposed approach makes it possible to estimate the users expected satisfaction with the project results, and performers expected satisfaction with the project progress, depending on the budget and restrictions on project duration, focusing on previously used approaches to project management and product implementation technologies in the organization.

The main results of the research are:

- The significant features of the innovative project as a modeling object are identified.
- The innovative project model as a static multivariable control object, the input parameters of which are the budget and the project duration, output parameters - the satisfaction of customers and performers is proposed.
- The approach to the quantification of expert estimates is proposed. Suggested approach can be used to study the satisfaction degree with the project progress by the various professional development groups and the project team as a whole.
- The proposed approach to the quantification of expert estimates is largely formalized, which allows it to be implemented as a functional component in decision support systems.

This, in turn, creates the preconditions to reduce the number of errors in decisions related with the construction of the project management system on the stage of project initiation. The importance of the problem of reducing the number of wrong decisions in construction of management control system of a complex object is emphasized in [14-21].

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