Expert and statistical approach to information support of decision-making at management of program projects

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Abstract[1]

In this article the approach to ranging of alternative variants of requirements formation at different stages of the project is considered. The offered approach is based on processes representation of requirements formation in the form of consecutive components. Each components is associated with the own law of performance time distribution that allows to form the numerical integral characteristic of processes in the form of Shennon entropy value.

1. Introduction

In the literature devoted to questions of quality management of software products and program projects, importance of creation an effective control system of requirements to software product is emphasized. The analysis of references [1,2] allows to argue that the mistakes allowed at requirements formation, involve serious consequences, up to a project failure. In [3] it is emphasized that weak readiness of experts in questions of identification of problems and requirements of the customers, insufficient tool support of this kind of activity is one of the main reasons for release of the software products whose properties in insufficient degree satisfy to expectations of customers and users.

In [1] it is noted that the view of development of programs complexes only as on creation of ideas and methods of management without need of a regulation of the design process and developing of program systems is still rather widespread. Growth of complexity of software products, increase of requirements to their quality, need of creation of program systems in limited terms, compels to develop effective control systems of program projects that, including, demands development of methodological, methodical, modeling, tool, information bases of operated formation of qualitative requirements.

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Management of requirements formation is necessary to consider from positions of management of difficult systems. This conclusion is caused by that management of creation of software product, in fact, is management of organizational and technical system, i.e. the accounting of a human factor has basic importance. It is possible to make the conclusion of the analysis of references that the functional architecture of a control system of requirements has three components: management of owners; management of requirements extraction; management of requirements submission to software product [4,5].

In [6,7] importance of the organization of effective system of communications between interested parties as bases of formation of a rational approach to management of difficult systems is noted. Using terminology of program engineering, it is possible to state this thesis in the following look: ensuring effective communications and information exchange between owners of software product is a necessary condition of management of requirements formation to program system. Thus, following [6] communication it is not identified with narrower concept of communication or transmission of messages. Purpose of communication consists in formation of the compromise solution accepted for all owners on the basis of an exchange of opinions and discussion of the different points of view on software product.

In this work one of tasks of information support of management of requirements formation – creation of structural and computing models of processes of requirements formation to software product at different stages of its life cycle is considered.

2. Numerical modeling of requirements formation process

It is possible to argue that time of works execution, connected with implementation of the project, is the integral characteristic of a unique combination of properties of external and internal environments of the project in which the software product is realized.

One of base principles of "good" requirements is their feasibility. Time is the indirect integral characteristic which depends on qualification of the personnel, complexity of a task, availability of technological resources, depth of understanding and other. One of base provisions of system engineering in projects management is generation of alternative variants of processes performance and their ranging by criterion of feasibility.

The offer to use time as the integral indirect characteristic of properties of the difficult system, allowing measurement, it is not new. It is enough to remember the theory of reliability of technical systems. Possibility of use of time as the integral metric characteristic of the program project is mentioned, for example, in [3,8,9].

Difficult character of the processes proceeding in external and internal environments of the project, limited possibilities of mechanisms research, forming them, allow to argue, that creation of mathematical models of the project is expedient for carrying out on the basis of the concept of «a black box». It, in turn, brings to thought about possibility of use of mathematic and statistical methods as instrument of modeling of program projects. At the same time such property of any project as uniqueness [10] is a serious methodological obstacle in a way of use of mathematic and statistical methods as instrument of modeling of program projects.

In work [11] possibility of construction difficult (in other words – unique) systems on the basis of standard elements is emphasized. From this it follows that the model of process of requirements formation can be presented in the form of system of the mathematic and statistical models corresponding to different components of a phase.

One of key problems of management of program projects is complexity of obtaining measuring data about a project course [2, 8, 9, etc.]. Owing to this fact (especially at the initial stage of the project) as a possible approach to modeling of process of requirements formation it is necessary to consider an expert and statistical approach (the term is borrowed from [12]). If to consider process of requirements formation as set of the interconnected components, the qualified expert can estimate, for example, in what time interval it is supposed to finish discussion concerning borders of software product at different ways of the organization of procedure of carrying out discussion (various procedures of carrying out discussion are described, for example, in [2,5,8,9,13, etc.]).

In [14] four standard models for estimation by experts of time of the works, presented in tab. 3, are described. To each of them the law of work performance time distribution is put in compliance. Representation of process of requirements formation in the form of consistently connected components allows to consider casual time of realization of process in a look

$$T = \sum_{i=1}^{m} \tau_i , \qquad (1)$$

where τ_i – casual time of end i component of requirements formation process. If the law of distribution of $F_i(t)$ of i process component is known, (1) it is possible to transform to a look

$$T = \sum_{i=1}^{m} (F_i^{-1}(t)) , \qquad (2)$$

where $\tau_i = F_i^{-1}(t)$ – casual time of realization of i process components.

Allocation of laws of distribution of different components of requirements formation process, and also assessment of the general time of requirements formation in the form of (1), does possible to estimate the law of requirements formation completion time distribution by means of numerical modeling. For this N times realization of casual time τ_i^j is formed. Where j – number of realization of casual process (j=1, 2, ..., N) on which values by means of (2) a sample $\{T_1, T_2, ..., T_N\}$ is formed. On the basis of a sample the assessment of the law of distribution $\hat{F}(t)$ is under construction.

Construction $\hat{F}(t)$ for different procedures of requirements coordination does possible the solution of a comparative analysis task of alternative variants of requirements formation procedures on criterion of uncertainty. As the metric characteristic of uncertainty can act, for example, Shennon entropy. The choice of such criterion is caused, first, that the quantitative assessment of uncertainty unequivocally pays off on the basis of the law of distribution of a continuous random variable. It does possible to compare objects which correspond to different laws of distribution. Secondly, that such system model as «the uncertainty cone» is widely used in the literature devoted to management of program projects.

Let's assume, there is K of alternative procedures of requirements formation (interviewing, JAD, CORE, VOID etc.). The assessment of realization time of i component (i=1, 2, ..., m) within option k variant (k=1, 2, ..., K) of requirements formations is meaningful a stochastic assessment. Compliance establishment between different estimates of the expert and types of laws of work performance time distribution (see tab. 3), allows to generate samples {T} the demanded volume of N on which estimates of laws of process completion time distribution are under construction. Estimates, in turn, allow to receive the integral characteristic of k alternative (presented in the form of an uncertainty measure) in a look

$$S_k = -\int_0^{\overset{*}{b}} \frac{d\,F^{(k)}(t)}{dt} \ln\left(\frac{d\,F^{(k)}(t)}{dt}\right)dt\,, \qquad (3)$$

here $\overset{*}{b}$ – area of actually possible values of a random variable T.

If value $\overset{*}{b}$ can't be defined for any substantial reasons, as $\overset{*}{b}$ assessment such as $\overset{*}{b}=6\sigma$ can be used, where σ is determined by known rules through $\hat{F}^{(k)}(t)$. Use of an assessment (3) creates preconditions of ranging of alternative options of requirements formation.

Let's consider an example of use of an offered approach for an assessment of requirements formation process to software product. Let's say that three experts (N=3) participate in an assessment of requirements formation and there are 4 alternative procedures of requirements formation (K=4). In tab. 4 estimates of experts for each stage of requirement formation and for each alternative are presented. Time is measured in the working days. It is necessary to receive integral characteristics of alternatives in the form of an uncertainty measure.

For each known alternative with use of the models presented in tab. 3, and also (1) laws of requirements formation process completion time distribution $F^{(k)}(t)$ were constructed. On fig. 1a as an example the models corresponding to the first alternative and calculated according to tab. 4 are given.

On fig. 1b for comparison the models received on the basis of only estimates of average time of performance of i stage are presented. Thus information about borders of an interval of possible values of a random variable is actually rejected. In known literature it is called as "the effect of ripples» [9]. Results of research of ranges borders informativeness of possible values of a continuous random variable are given in [15]. Apparently from fig. 1 «the effect of ripples» rather strongly distorts likelihood characteristics of alternative variants of requirements formation process.

Uncertainty measures values are given in tab. 1, calculated according to (3) with use of the models listed in tab. 3.

The results presented in tab. 1, form the basis for ranging of alternative variants of requirements coordination for set of the estimates given by different experts. The first stage of ranging is formation of "reference" model to which available variants of requirements formation will be compared. The best estimates given by different experts to available alternatives (in a case when the characteristic of alternative is the uncertainty measure, the best assessment corresponds to smaller value of uncertainty) will be parameters of "reference" model.

Table 1

Uncertainty measures values

		Expert			
		1	2	3	Distance from the "standard alternative"
Alternative	1	0,51	0,53	0,57	0,0001
	2	0,59	0,58	0,60	0,0105
	3	0,60	0,54	0,61	0,0107
	4	0,65	0,63	0,56	0,0296
Parameters "standard" alternative		0,51	0,53	0,56	

Formation of "reference" model allows to realize the following procedure of ranging.

Step 1. On the basis of an Euclidean metrics the integral characteristic of distance of each alternative from reference (4) is calculated.

$$W_k = \sum_{i=1}^{N} (x_i^{(k)} - x_i^{(e)})^2\,, \qquad (4)$$

where $k=\overline{1;4}$, $x_i^{(e)}$, – the reference value of i parameter formed by a rule $x_i^{(e)} = \min_k\{x_i^{(k)}\}$.

Step 2. Alternative variants are ranged in ascending order corresponding to them W_k values ($k=\overline{1;4}$). The calculated W_k values are presented in tab. 1.

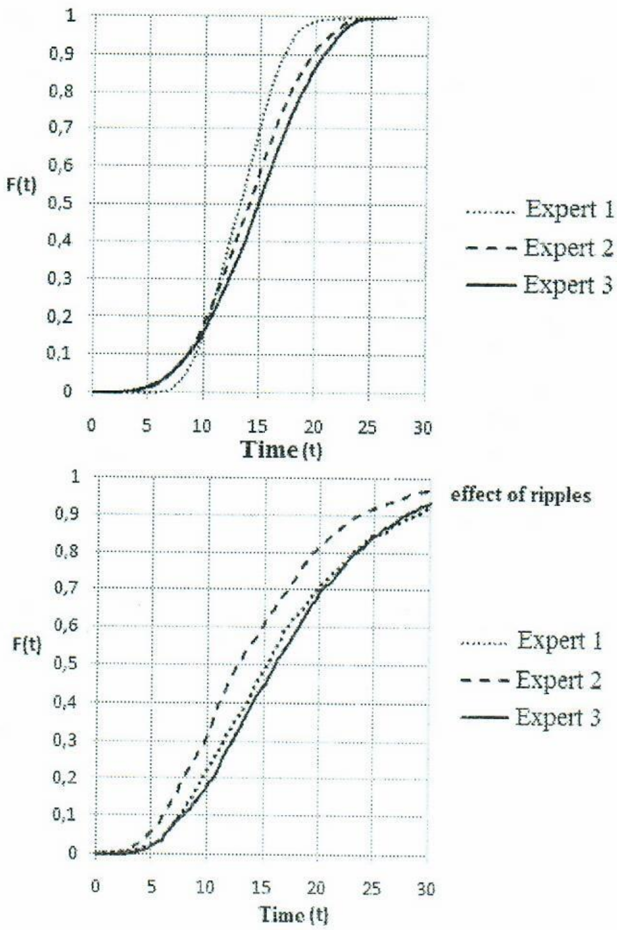
Let's notice that offered procedure of ranging is the known method called in marketing by "an internal benchmarking» [16].

Values of the similar estimates received in conditions of «effect of ripples» are given in tab. 2.

Table 2

Uncertainty measures values for «effect of ripples»

		Expert			
		1	2	3	Distance from the "standard alternative"
Alternative	1	0,62	0,68	0,67	0,0294
	2	0,60	0,62	0,68	0,0179
	3	0,57	0,55	0,62	0,0025
	4	0,64	0,60	0,57	0,0074
Parameters "standard" alternative		0,57	0,55	0,57	



a) according to table 4
б) influence of the "ripple effect"

Fig. 1. Probabilistic characteristics of the formation of an alternative implementation of the first requirements

Table 3

Expert evaluation form

Expert evaluation form	The model of the distribution of continuous random variable
There are lower and upper bounds of execution time [0,b]	The uniform distribution law f(t)=1/b
We know the expected time performance, M(t), где t□[0,∞)	Exponential law of distribution f(t)=λe-λt
We know the expected run time of M(t), as well as the lower and upper bounds of execution time [0, b], (M(t)□[0, b])	$f(t)=\exp(\mu_0+\mu_1 t)$, where the parameters μ_0, μ_1 found by solving the system of equations $\begin{cases} \int_0^b \exp(\mu_0+\mu_1 t)dt = 1, \\ \int_0^b t\exp(\mu_0+\mu_1 t)dt = M(t). \end{cases}$
We know the expected run time of M(t), as well as the lower and upper bounds of execution time [0, b], (M(t)□[0, b]), as well as the fact that the distance from M(t) to the borders of the interval probability decreases.	The triangular distribution $f(t)=\begin{cases} \frac{2t}{bM(t)} \text{ npu } 0 \le t \le M(t \\ \frac{2b}{b(b-M(t))} \text{ npu } M(t) < t \le \end{cases}$

Table 4

Evaluation expert for the k-phase is the formation of the requirements

An alternative form of requirements	Expert	Evaluation expert for the k-phase is the formation of the requirements				
		1	2	3	4	5
1	1	[0;6]	[0;4]	M(t)=5	M(t)=6	[0;2]
	2	[0;7]	[0;4]	[0;10]	[0;6]	[0;1]
	3	M(t)=4	M(t)=3, [0;4]	[0;10]	M(t)=4, [0;7]	[0;2]
2	1	[0;5]	[0;4]	M(t)=6, [0;9]	M(t)=6	[0;2]
	2	[0;5]	[0;3]	[0;9]	[0;5]	M(t)=1, [0;2]
	3	M(t)=4, [0;5]	M(t)=2, [0;3]	[0;9]	M(t)=4, [0;6]	[0;3]
3	1	[0;7]	M(t)=7, [0;10]	[0;4]	[0;6]	[0;3]
	2	[0;7]	[0;10]	M(t)=2	M(t)=4, [0;6]	M(t)=2, [0;3]
	3	M(t)=5, [0;7]	M(t)=7, [0;10]	[0;4]	M(t)=3	[0;2]
4	1	M(t)=7, [0;10]	[0;6]	[0;7]	[0;4]	[0;3]

	2	[0;1 0]	M(t) =4, [0;6]	[0;7]	M(t) =2	[0;2]
	3	M(t) =7, [0;1 0]	M(t) =3, [0;6]	M(t) =5, [0;7]	[0;4]	[0;2]

3. Visualization of key parameters of the project

The offered approach to ranging of projects on the basis of uncertainty measure creates a basis of the solution of one of tasks of an initial design stage – evident representation of key parameters of alternative variants of the project [3]. In [10] the system model of an initial stage of the project within which key measurements of the project are expected results; costs of realization; time of project implementation is described.

The approach described earlier allows to range alternative variants of the project on two indicators: «requirements (i.e. expected results) – time of project implementation». The described scheme can be used for ranging of alternative versions of the project on indicators «the requirement – costs of realization». The received results allow to visualize an arrangement of projects in the plane «requirements – costs of realization – requirements – time of project implementation», that serves as information support for making decision on a choice of variant of project implementation.

Let's assume that as a result of the comparative analysis of variants of the project on indicators «requirements – costs of realization» are received the results presented in tab. 5.

Table 5

Uncertainty measures values on indicators «requirements – costs of realization»

		Expert			
		1	2	3	Distance from the "standard alternative"
Alternative	1	0,51	0,57	0,59	0,0001
	2	0,56	0,7	0,58	0,0194
	3	0,53	0,63	0,62	0,0056
	4	0,62	0,62	0,67	0,0227
Parameters "standard" alternative		0,51	0,57	0,58	

On the basis of tab. 1 and tab. 5 the chart representing a relative positioning of alternative variants of the project on a sign «realization time – costs of realization» is constructed. On axes of the chart ranks of alternative variants of the project on different sets of signs are specified. From this chart (fig. 2) can be concluded that the first option of project implementation is preferable.

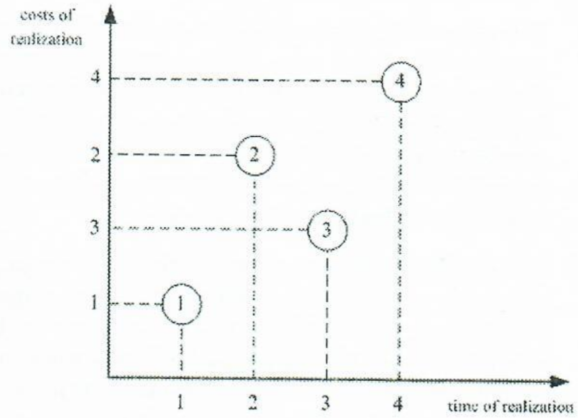


Fig. 2. Diagram of alternative design options in the space of "the time of implementation - the cost of implementation"

The offered expert and statistical approach can be used for processing and other sets of key parameters at different stages of the project, in particular at a stage of initiation of the project. In [3] referring to primary sources the extensive list of parameters which are necessary for taking into consideration at a choice of strategic decisions at an initial stage of the project is provided.

4. Program realization

The offered approach to ranging of alternative variants of requirements formation is completely formalized, in a consequence of that was developed software product «Analysis of the program project», allowing on the basis of the entered expert estimates to receive orderliness of alternatives with an uncertainty indicator. On fig. 3 the main screen form of the developed program is presented.

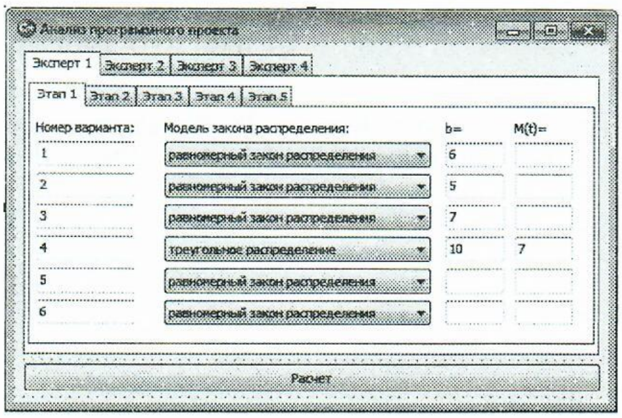


Fig. 3. Main screen form of the program "Analysis of a software project"

5. Conclusion

The following results were received:

- The offered approach should be considered only as supplementing other ways of information support of decision-making at management of program projects. In [17] it is noted that in the conditions of uncertainty any model has value if only allows to receive useful information about properties of difficult system to which class the program project belongs.

  The described approach allows to formalize ranging procedure of alternative variants of project stages performance in the conditions of uncertainty. It is rather universal and can be used by comparison of variants of realization of others, besides formation of requirements, works at early stages of the project.

- The received results allow to conclude that ignoring of range borders of possible values of a random variable which in many cases can be defined from the content of works, orientation only on average value, influences results of ranging of alternative options of requirements formation.

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References

1. Lipaev V. V. "Analysis and reduction of risks of projects of difficult software". SINTEG, 2005.
2. Michael G. Christel, Kyo C. Kang "Issues in Requirements Elicitation". Technical Report CMU/SEI – 92-TR-012 ESC-TR-92-012, September 1992.
3. Milosevic D. "A tool kit for management of projects". Ayti's company: DMK Press, 2008.
4. IEEE Recommended Practice for Software Requirements Specifications IEEE STD 830-1998, June 1998.
5. Hall E., Jackson K., Dick D. "Development and management of requirements".Telelogic, 2005.
6. Vittikh V.A. "Organization of difficult systems". Samara Russian Academy of Sciences scientific center, 2010.
7. Jing Yang, Geoffrey Qiping Shen "Exploring critical success factors for stakeholder management in construction projects". Journal of civil engineering and management, 2009; 5(4): 337-348.
8. Makkonnell S. "How many there is a program project". St. Petersburg, 2007.
9. Matsyashek L.A. "Analysis of requirements and design of systems. Development of information systems with UML use". Williams publishing house, 2002.
10. Begyyuli F. "Management of the project". The lane with English V. Petrashek. FAIR PRESS, 2002.
11. Yemelyanov A.I. "Design of systems of automation of technological processes". Energoatomizdat, 1983.
12. Ayvazyan S. A., Enyukov I. Page, Meshalkin L. D. "Applied statistics: Bases of modeling and preprocessing of data". Finance and statistics, 1983.
13. Berkun S. "Management skill IT projects". St. Petersburg, 2007.
14. Gvozdev V.E., Mukaseeva V.N., Rovneyko N.I. "Likelihood estimation of feasibility of requirements to program system". The messenger УГАТУ, in the press, 2012.
15. Guzairov M. B., Gvozdev V. E., Ilyasov B. G., etc. "Statistical researches of territorial systems: monograph". Mechanical engineering, 2008.
16. Kotler F. "Marketing management. Express course". the 2nd / the Lane with English under the editorship of Of this year Bozhuk. St. Petersburg, 2006.
17. Rosenberg G. S., Shitikov V. K., Brusilovsky N. "Ecological forecasting (functional prediktor of temporary ranks)". Tolyatti, 1994.