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Program Evaluation and Review Technique as the tool for time control

Метод анализа и оценки программ как механизм контроля сроков

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Ключевые слова: контроль проекта; контроль сроков; инвестиционно-строительный проект; вероятностное моделирование; метод анализа и оценки программ; сетевой график

Abstract. The free market economy comes to the life of the people and creates the new structure of the work relationships between the investors and builders. One of the most important thing of the investment and construction project is the meeting of the target date. The delays in the implementation of this project entail the material and image losses. But the building is a complex process, many factors such as delivery delays, adverse weather conditions, the correcting of low quality works, machinery and mechanisms breakdowns influence on it. During the planning stage it is unknown which of these situations may arise in the implementation process and disrupt the work schedule. That is why building projects require the strongest time control. This article presents one of the best ways to control the building process, which is named Program Evaluation and Review Technique (PERT). Although there were mentioned other variations of the time control methods, such as Graphical Evaluation and Review Technique (GERT) and method of the statistic modeling (Monte Carlo), the advantages of PERT and disadvantages of them are presented. It allows to control the expectancy of the erection and the probability of the project completion in time. This means that it allows manager to control the activity time of the project. The example of the PERT usage is represented with the comparison between the controlled project and the non-controlled project.

Аннотация. Рыночная экономика плотно вошла в нашу жизнь и создала новую структуру рабочих отношений между заказчиками и строителями. Одной из важнейших задач менеджера инвестиционно-строительного проекта является строительство объекта в установленный срок. Задержки в реализации таких проектов влекут за собой не только материальные, но и имиджевые (репутационные) потери. Однако строительство – это сложный составной процесс, на него могут повлиять многие факторы, такие как задержки поставок, неблагоприятные погодные условия, исправления некачественно выполненных работ, поломки машин и механизмов. На стадии планирования неизвестно, какая из этих ситуаций может возникнуть в процессе реализации проекта и нарушить график работ, поэтому строительные проекты требуют усиленного контроля сроков. В статье представлен один из лучших способов управления процессом строительства, который называется метод анализа и оценки программ (PERT). Также были рассмотрены и другие методы вероятностного моделирования, такие как Графический метод анализа (GERT) и метод статистических испытаний (Monte Carlo), проведен сравнительный анализ преимуществ и недостатков данных методов. Метод PERT позволяет контролировать ожидаемую продолжительность проекта, а также рассчитать вероятность его завершения в срок. Пример использования метода PERT для контроля проекта представлен сравнением проекта с контролируемым процессом строительства и полностью неконтролируемым.

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Introduction

From the beginning of the free market economy there is the natural contest between companies, which are working in the different spheres of social life. Their rivalry increases the rate of any type of the construction such as residential or commercial property. The definition “property” came as the economical term not so long ago in Russia and nowadays it is still developing because of Russia history.

The property is the one of the most profitable investment in today life. Capital providers are concerned in the fastest time erection and the nearest facility completion deadline in case of the investment efficiency rate. The speed of the erection affects the start of the pay-off period which influences on the profit from this property [1]. The erection of the building to the deadline time needs to be controlled by the developer, not only on technology process and workmanship, but also of the time control [2, 3]. The cash flow of the residential property will begin almost immediately after the company receipts of a building permit. In this moment the building works have not already started so the sense of the facilities completion deadline has not such big influence on the result profits.

The importance of the time control could not be exaggerated during the national significant building such as stadiums for the FIFA World Cup 2018. The collapse of the facility completion deadline destructs the meaning of the idea realization and falls into disrepute country on the global stage.

The project success depends on the detailed working calendar plan and control system, which should monitor the progress of the erection [4, 5]. It could be realize with the periodical acquisition of the facts, the comparison of them with the planning data, the analysis of the results and making of the management decision. The effects of them must destruct the negative factors and allow the accomplishment of the project target [6].

This article describes the using of Program Evaluation and Review Technique (PERT) method as the tools for the time control of the building and evaluation of the investment project final cost [7].

PERT was created by the Navi’s Special Project Office and connected with the Polaris-Submarine weapon System and Fleet Ballistic Missile. It was developed “to save time in achieving end-objectives” [8]. Graphical Evaluation and Review Technique (GERT) was developed in 1966 by Pritsker [9]. It is only a modification of PERT and allows following several different distribution, nevertheless it is not as spreading as PERT in case of its complexity to the computer adaptation.

Ameen developed special program which help to teach project management techniques for his students in 1987 [10]. Later, in 1991, Badiru makes another one simulator and called it STARC, which allows to determine the probability of the expiration into deadline [11, 12] “Additional authors which have studied various PERT problems via simulation include Kltngel (1966), Gray (1969), Burt (1971), Herbert (1979), Schonberger (1981), and Dodin (1984), and Kidd (1986)” [13].

This interest in the modeling allows a possible profit from PERT. Spending of the recourses, times and money is the reason of the economical losses, which could come to the stagnation of the whole region, if it touches something meaningful for this site.

The purpose of this study is to adapt the probabilistic modelling methods to control project time. The main objective is to consider the use of probabilistic models as a time-control mechanism through the PERT method.

Methods and Results

How it was mentioned earlier, there are a few methods of the project planning, which take into account the stochastic building characteristic. The best known of them are PERT, GERT and Monte Carlo method.

Program evaluation and review technique (PERT) is the method of analysis and program evaluation, which is based on the three activity time estimation. There are optimistic, pessimistic and prospective activity time estimations, which are made by experts [14].

Graphic evaluation and review technique (GERT) is a method of operation modelling. This method shows the variations of the project completion in case of special kind of the algorithms and connects with ending a few of the previous algorithms [15].

The method of the statistic modeling or Monte Carlo method is based on a large number of the non-connected realization, which is overlooked in the network model [16].

The methods do not have any practical profits for the time planning of the project, because during the building there is the divergence of the basic plan and there is no reason to use the old plan after it.

This article presents another way of the using of the probability distribution methods. This is method of the time control of the project on the example of PERT methods [17, 18]. A peculiarity of PERT is the list of all or the definite activity time probability for the counting of all project time [19, 20].

As it was said earlier, PERT uses three experts mentioned:

- Optimistic – activity couldn`t be completed faster than $t_{i\ opt}$
- Pessimistic – activity couldn`t be completed slowly than $t_{i\ pes}$
- Most likely (normal) – most likely time will take $t_{i\ norm}$

If there is three values, then it is possible to count the expected activity time t_{ie} with formula:

$$t_{ie} = \frac{t_{i\,opt} + 4t_{i\,nor} + t_{i\,pess}}{6}, \quad (1)$$

where: $t_{i\ opt}$ – the minimum value, when it is take into account that every task meet the target time or is made earlier

$t_{i\ norm}$ – the time value, when it is take into account that everything is as usual

$t_{i\ pess}$ – the maximum value, when it is take into account that every task do not meet target time (excluding of the massive catastrophe)

The degree of indeterminacy of activity time estimate may be shown by the dispersion:

$$\sigma_i^2 = \left(\frac{t_{pess} - t_{opt}}{6}\right)^2. \quad (2)$$

PERT allows to get the normal dispersion of the project time planning probability, which mode is according to the expected activity time. The standard deviation of normal distribution curve should be calculate to find the probability of completition of the project in time, which is differing from the expected. It shows the stage of the indeterminacy for the whole project:

$$\sigma_{Te} = \sqrt{\sum \sigma_i^2}. \quad (3)$$

This formula takes into account only activity dispersions, which create the critical path.

According to the probability theory, the probability of the project accomplishment is in the range from T_e-σ_{Te} to T_e+σ_{Te} [21] equals to 68.27 %, the probability of the project accomplishment is in the range from T_e-3σ_{Te} to T_e+3σ_{Te} equals to 99.73 % (Fig.1).

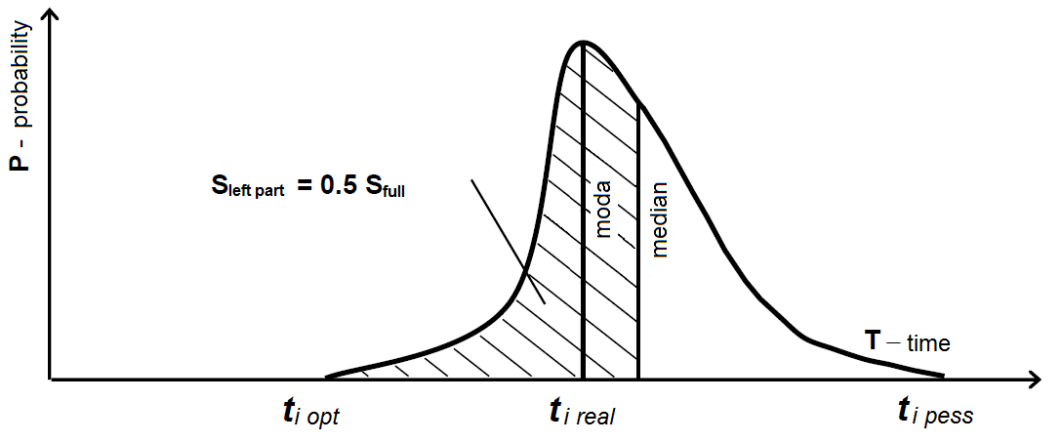

Figure 1. The frequency probability curve of the duration of each activity

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In fact, the investors and builder are interested the probability of the project completion to the deadline, for example, to contract date T_{plan}. It could be found from the formula:

$$Z = \frac{T_{plan} - T_e}{\sigma_{Te}}, \quad (4)$$

where: T_{plan} – planning time of the target date meeting;

T_e – expected activity time – the probability of the project implementation in expected time activity or faster equals to 0.5 (50 %). To count the expected activity time of the project it is necessary to define for all tasks the expected activity time t_{ie} as the target value.

In account to Z value, it is possible to find the probability of the project completion with using of the special tables, and express it in terms of per cent or unit fraction [22].

The using of PERT method gets the possibility to find the diapason of the task deadline, also it allows to make a decision about the probability of the end activity in time according to the task, which were done to the monitoring time [23].

As the example of the PERT using during the building process, we would consider the project, collateral to the activity chart (Fig.2)

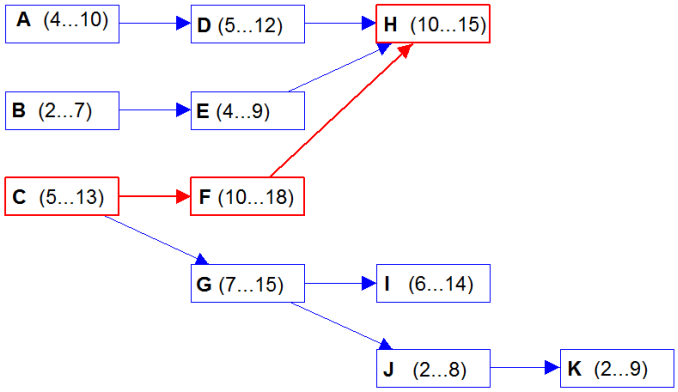

Figure 2. The activity chart

The list of the expert activity time estimations, the results of the expected activity time estimation and the full time of the task are showed in the Table 1.

Table 1. The time estimations of the tasks

Activity	Time estimates			Expected time
	Optimistic	Normal (Most likely)	Pessimistic	
A	4	6	10	6.3
B	2	4	7	4.2
C	5	8	13	8.3
D	5	8	12	8.2
E	4	6	9	6.2
F	10	13	18	13.3
G	7	11	15	11.0
H	10	12	15	12.2
I	6	9	14	9.3
J	2	3	8	3.7
K	2	5	9	5.2
Full duration of the project	25	33	46	33.8

In the beginning of the project, it easy to see that the full time of the project task is in the range of 25 to 46 days. This estimation is the main advantage of PERT method, because it allows to count probability of the project finishing to the negotiated deadline.

This probability could change in the time, so it is reasonable to compare two variants of the project. The first one shows the near-estimated time of each task, another one slows-up of the project.

Table 2. The probability of the project completion in time

	Status date	Actual value of the tasks	The estimation of the full time considering executed tasks			Expected	P %	Required time
			Opt.	Norm.	Pess.			
I variant	0	0	25.0	33.0	46.0	33.8	70	25-46
	10	4	28.0	33.0	41.0	33.5	75	18-31
	20	7	29.5	31.5	36.0	31.9	92	9.5-16
	30	11	30.0	30.0	30.0	30.0	99	0.0
II variant	0	0	25.0	33.0	46.0	33.8	70	25-46
	10	3	28.5	33.5	41.5	34.0	67	18.5-31.5
	20	6	32.5	34.5	41.5	35.3	41	12.5-21.5
	30	10	32.5	34.5	37.5	34.7	54	2.5-7.5

During the works, the project was monitored each 10 days in this example. The appraisal of the tasks and the comparing of the spending time with the mentioned estimation provide the possibility of the additional time evaluation. So there is new probability of the project finishing to negotiated deadline.

Also the trend of the activities completing must be tracked. The data base of the trends lets to trace the effects of the factors, which influence on the activity time and how much are their effects. In the future it makes a possibility to eliminate critical errors and to plan project with a glance to this trends.

The graph shows the increasing of the successful deadline of the first variant project because of the tasks, which are done in planned period. The probability curve locates nearby the targeted line. The curve of the second variant shows the fall of the probability in case of the activity delay. This mean there was not any profitable actions.

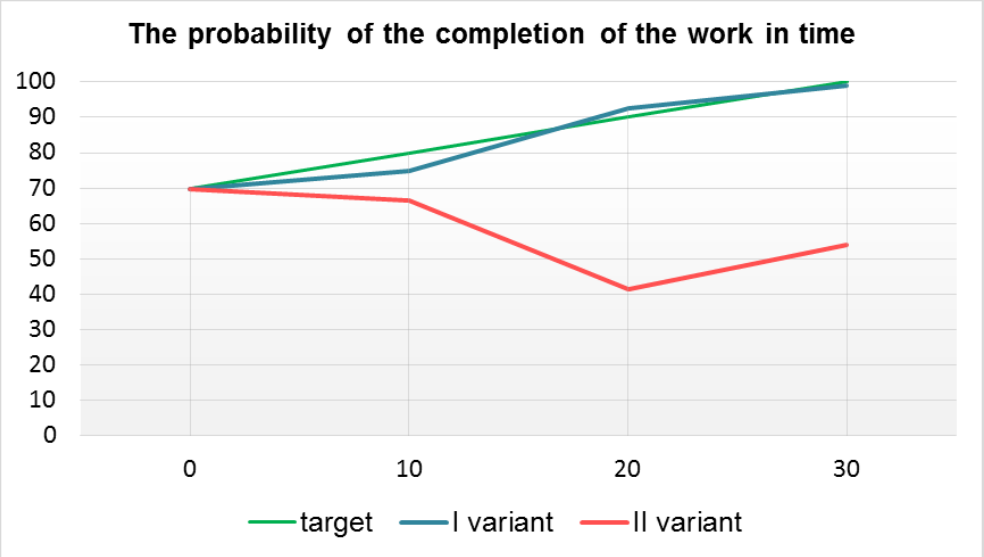

Figure 3. The probability of the completion of the project within the contract period

The project monitoring with some frequency make a possibility to find the time lag and to influence the situation. So if some actions will be done, the delay of the activity could be escaped. In contrast, the neglect of the time collapse reduces the successful deadline. This information provides the possibility of the work acceleration in case of the strict deadline or the extension of the object entry date.

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It is critical to underscore that there is no possibility to influence on the finished task, so all actions must touch on the processing or non-started activity. The reducing of the project time is supplied with the acceleration of the critical task, the amplification of the workmen, vehicles and devices, the using of the progressive methods and highly-energetic equipment. Also some tasks could be excluded from the list of the task and made after the setting to work.

The timeout of the project could be estimated to the contract date with the penalty function or the function of “the lost benefits” or the comparing of the acceleration activity cost and the vindictive damages. The developer has to evaluate his actions. Are the vindictive damages comparing with the cost of the actions? Is it cheaper to pay penalty?

But these actions touch only the commercial project, which deadline does not have the global consequences and does not devalue the idea of the project. For example, there can be the national significant buildings such as Olympic objects in Sochi or the soccer world championship stadiums.

Discussion

There was considered PERT methods using as the mechanism of the time control. The method was presented on the example of the simple project with 11 tasks, but the project with the bigger scope of the task is reasonable to control with the MS Project program. Unfortunately, the authors exclude PERT method from the last version, and now it is usable only in the old version of 2003 and 2007 years [24] or with the help of the superstructure [25] or formulas in the new version.

The additional problem associated with the subcritical path, which might change the probability of the project finishing to the deadline [26]. It is possible if the scatter of the subcritical path activity duration as well as the dispersion of them is bigger than the similar critical task evaluation of the time. There is a problem to measure the probability of the activity transformation from the non-critical to the critical task and to measure the diapason of the float time for each activity.

It is widely thought that the accuracy of the networked model computation and the program analyze depends on the numbers of the activities. More than 30 tasks on one path guarantee the high level of the accuracy; otherwise, PERT method gives only the approximated time of duration of the project.

The reason of PERT method usage should to be examined according to the costs of the building rate of the growth and the possible penalty payment. [27, 28, 29] The sanction could to be much cheaper than the costs of the accelerative erection [30].

Conclusion

The application of PERT method does not make economic sense without the time control. To finish project in time, it is necessary to count the probability of the completion of the project within the contract period not only in the beginning of the erection, but during the project realization. It is should be done in case of the unexpected circumstances that could influence on the deadline of the project. During the estimation of the situation it requests the analysis of the task, which was done before, and there is no possibility to influence on them, so all actions appertain to the future activities. The using of PERT method allows to the recounting of the possible times of the remaining task and takes into account the optimistic and pessimistic time estimation.

PERT method could be used with the Microsoft Project program; this is the advantages in case of the practical needs.

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