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Reliability-risk project expert matrix for handling maintenance projects

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Abstract

The total project time / duration time (TPT), total project cost (TPC), and total project human resources (TPR) of a project are identified in the planning phase. Matrix representation is a clear and simple way to plan and schedule projects and their processes. The Design Structure Matrix (DSM) and the Stochastic Network Planning Method (SNPM) are applied to the sequencing of tasks. The parameters of the SNPM can be altered; moreover, it takes into consideration the weight of task connections, thus, it has a wider range of applications. As an extension of SNPM, the Project Expert Matrix (PEM) contains all the information about the probability of occurrence, price, time, and resource demand of each task as well next to all the possible task connections.

The enumeration of repeating (cyclic) processes is an important aspect that has to be taken into consideration next to the risk and reliability values. A repeated execution of a cyclic process can have a high impact on some of the demands of a successful outcome of the project such as time, cost and resources. The given bounds on TPT, TPC, and TPR are considered during planning.

Keywords: Matrix-based project planning method; reliability-risk project expert matrix; maintenance projects.

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1. Introduction

We use different type of devices, machines, equipments during our work. The machinery might break down or require upgrading so maintenance is part of our life. We have to pay attention as these machines have to be able to serve us in the future. We fulfill series of activities and are carried out by the equipments in behalf of their operational capacity and proper use. We also carry out series of technical and non-technical (administrative) activities; therefore the equipment will be able to fulfill its prescribed function. Our time is limited, the companies' budget is finite and there are less and less specialists at our service. But it is necessary to do our work despite these circumstances. As a result, we would neither under-maintenance, nor over-maintenance. This requires a very accurate and useful planning procedure.

On the area of the maintenance, it is a very hard to create a suitable, fulfilling project plan. Is there a

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suitable methodology? Can we use input data of the equipments reliability or risk values? It would be necessary in the planning procedure to lay an emphasis on the repetitive activities (circles). These activities jeopardize accomplishing the project inside a deadline.

The planning methodology, which was tested already in practice on maintenance projects, responds our already arisen question. We take into account in the design of a maintenance project plan, the reliability or risk information of the equipments, and we don't forget about the time limit, budget and human resources. This is another specialty of the planning procedure.

2. Background of the Study

Maintenance is complex, since it is not only has to satisfy the support of business operations, but also play an important role in the efficiency of the production and service processes. In the preservation and development of such organization the maintenance has a very important part (Rausand, 1998; Szabó & Dancsesz, 2009; Horváth, 2006). Each person uses tools or equipments during their work. They may break down and get damaged. The repair-process of working tools needs to be provided, so they could serve our further goals (Gaál & Kovács, 2002; Gaál, 2007; Garbatov & Soares, 2001; Selvik & Aven, 2010).

It is important to note, that one must not concentrate only on the incurred maintenance costs. It should be recognized, that a good maintenance is not equal to cheap maintenance. Each of the spent Euros will bear interest on the higher availability of production side and reliable processes. If the equipment has been properly set and operated it will have longer life than before (Garbatov & Soare, 2001; Selvi & Aven, 2010; Kövesi, 1991; Péczely & Pék, 2003; Gaál, 2003; Péczely, 2009; Eisinger & Rakowsky, 2001).

After successful data collection and analysis we are still having the following problems. We have to solve the problem, how to use the previous analysis results during our maintenance planning. In the course of the project-oriented maintenance activity, the planning method will have a more and more important part, as the selection of the project participants, management and motivation, detailed project design and monitoring etc. We can conclude, that in case of maintenance projects, the system oriented approach is necessary (Szabó & Dancsesz, 2009; Horváth, 2006).

The series of the planned maintenance activities can we considered as a special maintenance project. However, the traditional project planning techniques left many of the problems unanswered that may arise during the maintenance. The first problem will be the handling of the circuits. It is a common problem, during the maintenance of a technological process that we need to return several times to the maintenance of a unit. What are these equipments units? How can we plan such reoccurrence? (Szabó, 2005; Szabó & Gaál, 2006; Szabó et al., 2007.)

Another problem which arises in the maintenance planning phase is in which order we should execute the maintenance of the units. The deterministic logic design techniques do not give a correct answer of that, because the improvement of technological equipments process is unchangeable. Here the individual steps cannot be replaced, but what equipment will we repair first and second time, can be already a priority order. In the following we are presenting a matrix-based project planning method, which can handle these problems.

3. Methods

This chapter introduces how the reliability-risk project expert matrix works.

3.1 The reliability-risk centered project expert matrix

We can describe into the diagonal of the reliability-risk center project expert matrix (r^2 PEM) the reliability values on the units (see Figure 1). These were obtained from previous diagnostic, analytical measurements. The higher the expected failure of a unit is, the greater the probability, they need to be maintained and serviced in the next period. If the reliability of a maintenance unit is p , $1-p$ is the failure indication (Khan & Haddara, 2003; Kiss & Kosztyán, 2009a; Kiss & Kosztyán, 2009b). The lower the value of failure is, the higher the probability that we do not the maintenance of the units the following maintenance period. The matrix' diagonal contain not only the reliability/ risk values of the equipments. We can give more information, e.g. maintenance cost or maintenance time too (see Figure 1).

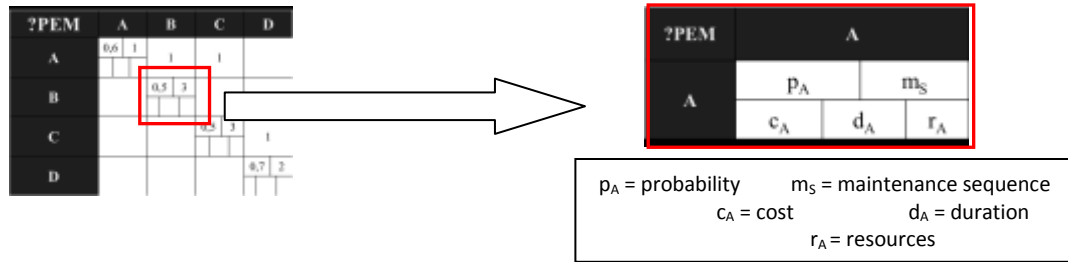


Figure 1. The indication of the data concerning the equipment units on a place

Our aim is to reach the maximum reliability of the system so it is necessary to develop a maintenance project variant, with which we are going to reach it. The worked out planning method gives a huge help in this. Before the selection of activities we give the confidence level, above which any sub-system or equipment will take part in the maintenance plan. Besides of this it is given, what the minimum level will be, which over we will into consideration the generated maintenance project plan.

3.2 The problem of handling the circles during the planning

On the maintenance are the circular processes need to checked, because these processes can modify our total project time (TPT) and also the total project cost (TPC). A conditional project total time can be calculated/ determined when we take in consideration the probabilities of the circles, so that the limits imposed by the management will be met. We can determine the maximum project time, or the maximum project cost, and also we can give the allowed number of the circle activities.

Table 1. Possible relations between task A and task B

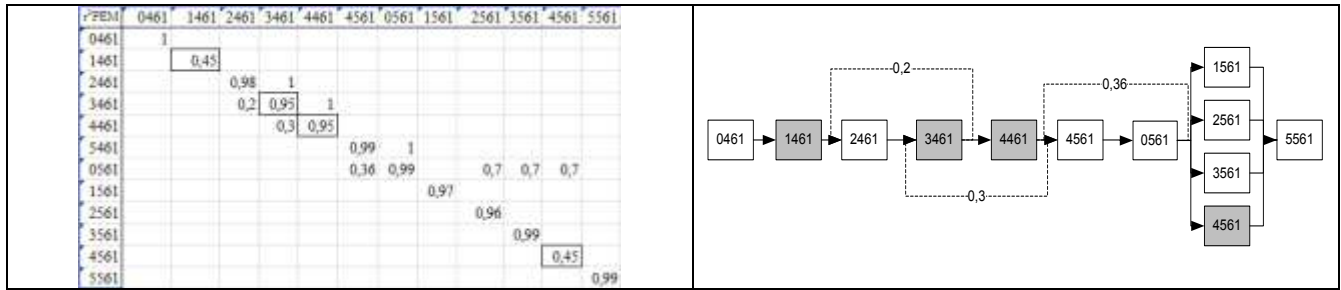
Sequential completion			Parallel completion			Iterative completion		
$(r)^2PEM$	A	B	$(r)^2PEM$	A	B	$(r)^2PEM$	A	B
			A			A		
B			B			B	X	
TPT = $d_A + d_B$			TPT = $\max(d_A, d_B)$			$TPT = \frac{\max(d_A, d_B)}{1 - p_{(AB)}}$ $TPC = \frac{c_A + c_B}{1 - p_{(AB)}}$ $E(d'_A) = \frac{d_A}{1 - p_{(AB)}}$ $E(d'_B) = \frac{d_B}{1 - p_{(AB)}}$		
TPC = $c_A + c_B$			TPC = $c_A + c_B$			$E(c'_A) = \frac{c_A}{1 - p_{(AB)}}$ $E(c'_B) = \frac{c_B}{1 - p_{(AB)}}$		

Depending on the time performance of maintenance, not only the cost, but also the reliability and risk of the equipment change. That needs to be considered in the calculations. But let's have a look at the planning method a real business example tested.

4. Results

The analytical work, the criticality assessment and the diagnostics can help to prevent 90% of the unexpected failures. With these we can save a lot of money for the company. We can reduce energy consumption, maintenance costs, but the most money could be saved by avoiding the loss of the production machines. We would like to introduce the benefits of the planning method with help of a business example. The companies' equipments arrangements are illustrated in the Table 2 below.

Table 2. The test equipment manufacturer of arrangement - complete with equipment maintenance can be scheduled with intensity



The reliability of the production line also demonstrated that the intervene is necessary, because the number of the non-production time, the refuse products, the offsets have increased so much, that the sustainability of production is at stake. The units during the production line have got an interdependent relationship, so if one of them breaks down the whole line shut down. In this case the reported 16.2% reliability is not random.

For finishing the maintenance of the production line 34 working days and 12,76 hours are available, but we got also 254.000 EUR material benefits. In addition, after the maintenance, the production line need to have a rate of reliability growth, not to prevent the sale or elimination. Our goal was with using the method, create a project plan, which is not use out the given 34 working days 12,76 hours, 254.000 EUR, and the reliability of the production line rise above 70-75%.

If the reliability of the equipment units is about 96% or more, then the implementation of maintenance is not warranted. That is why we put more emphasis on the maintenance of 1641, 3461, 4461 and 4561 equipment units. Our aim is that the reliability values will increase after the maintenance works.

Table 3. The maintenance data for equipment units

	min c(cost) (€)	max c (cost)(€)	avg. c (cost)(€)	min t (time) (day)	max t (day)	avg. t (day)
1461	45 000,00	50 000,00	47 500,00	2	10	6
3461	11 050,00	12 640,00	11 845,00	2	14	8
4461	75 370,00	79 250,00	77 310,00	2	14	8
4561	62 500,00	64 900,00	63 700,00	11	13	12
	193 920,00	206 790,00	200 355,00	17	51	34

If we calculate with the average cost and time, we can say, that we have got enough available resources to end in time and cost the maintenance of each component. If we calculate with the maximum values, we won't have extra costs, however we should expect with delay.

Please take a look at Table 4! If you have a closer look you can realize a circle between the unit 3416 and the unit 4461. Previously, this would have mean a serious problem, but with help the matrix planning method by counting the GERT expand it is no longer possible in the future.

Table 4. The units are to be maintained on the device and the circle marked

(r)r²PEM	1461	3461	4461	4561
1461	0,45			
3461		0,95	1	
4461		0,3	0,95	
4561				0,45

If we check our financial budget, we can say that we have enough cost and time to maintain all of our units. It is definable, that inside the given costs, how many times I may return from the unit 3461 to the unit 4461, or vice versa. If we examine the options separately, the results were the following:

$$TPT = \max \left\{ [E(d'_{3461}) + E(d'_{4461})]; d_{1461} d_{4561} \right\} = \max \left\{ \frac{d_{3461} + d_{4461}}{1 - p_{(3461,4461)}}; d_{1461} d_{4561} \right\} = \max \left\{ \frac{8+8}{1-0,3}; 6; 12 \right\} = \max \{ 22,86; 6; 12 \} = 22,86 \text{ nap} \quad (1)$$

$$TPC' = (E(c'_{3461}) + E(c'_{4461})) + c_{1461} + c_{4561} = \frac{c_{3461} + c_{4461}}{1 - P(34614461)} + c_{1461} + c_{4561} = \left(\frac{11.845 + 77.310}{1 - 0,3} \right) + 47.500 + 63.700 = 238.56429 \text{ EUR} \quad (2)$$

We took into account the unrealized circle during the planning. We calculated the TPT and also the TPC, and it should be noted, that the 254.400 EUR will be unutilized and also the given business days and hours too. We can also schedule the maintenance of other production lines from the remaining time and remaining money.

We solved the planning problems based on our method, within the cost and time frame, which were raised of the company. However, there is one criteria remains unclear. In the case when we maintain both units (3461, 4461) just once time, would not sufficient for the 70-75% reliability level, just for the level of 54,42%. However if we return to the units 3461 and 4461 three times (this allow is also the limits), we can realize not only 70-75% but the 80,83% too.

Table 5. The selected units after three circles maintenance

r ² PEM	0461	1461	2461	3461	4461	4561	0561	1561	2561	3561	4561	5561
0461	1											
1461		0,975										
2461			0,98	1								
3461			0,2	0,98	1							
4461				0,3	0,98							
4561						0,99	1					
0561						0,36	0,99		0,7	0,7	0,7	
1561								0,97				
2561									0,96			
3561										0,99		
4561											0,975	
5561												0,99

Conclusions

It is all important, not reach a reliability improvement only on the level of equipments, but on a system level too. Although the technological order of the maintenance operations are generally bound in case of the correction from equipment, but the correction/maintenance work of each equipment can be performed in a different order, even can be broken. It is also possible to return from the aim of control or the continuation of the work onto the given unit again.

If the maintenance budget, the human resource and the time limit are given, we can make a project plan with the help of the introduced/presented method. Based on this new planning method the most necessary corrections could be planned and also scheduled. During the planning phase we take into consideration the measured data and analysis result too. We schedule the maintenance of those units within the given budget, which plays for the companies' system-level reliability growth an important role.

The proposed planning method helps the companies to deal with maintenance on his row, with he is needed, and let the planned, expected reliability level be attained on the production lines. With the help of the method the companies can avoid the under-maintenance and also the over-maintenance too. They can easily implemented during their planning and implementation work, the challenge of "not exceeding" the time limit and also the financial budget.

Future works

It is very important and essential, that the given method receive a software support. Physical limits arose in the course of the research one and during our supporting work. We can do an accomplishment planning with a regular software, but for a more detailed planning a more technical software is required. It is the basis on the principle 'Time is money' and knowing what the industry needs, the plans need to be on

table in a few days. Another additional challenge is, to concretizing the human factor, as uncertainty factor and the integration of this into the planning procedures.

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