Why and how to evaluate the task threatness

Brožová Helena[1], Šubrt Tomáš[2], Rydval Jan[3], Pavlíčková Petra[4]

Czech University of Life Sciences Prague, Fac. of Economics and Management,
Dept. of Systems Engineering, Kamýcká 129, 165 21 Praha 6 – Suchdol, CZ
[1]brozova@pef.czu.cz, [2]subrt@pef.czu.cz, [3]rydval@pef.czu.cz, [4]pavlickovap@pef.czu.cz,

Keywords: Project management, project success, task impact, criticalness, failureness, threatness.

1. Introduction

Nowadays, the overwhelming majority of projects fail or end up with more or less problems. It concerns over half of all large complex industrial projects (Aschman, 2018, Betz, 2018). The main factors of the projects fail are budget overspending, schedule slipping, a lot of project changes gradually requested by customers, and/or severe and continuing operational problems holding for at least one year (Aschman, 2018).

Generally only methods and process of risk analysis are in the focus of many authors which suggest new, more exact approaches to this analysis (Williams, 2017, APM, 2008). Almost no authors mention the need to analyse the project in terms of the implementation of individual tasks, of their time parameters, costs and work. Commonly, methods for creating a project schedule (based on critical path) or determining the budget and resource requirements are only used but they are not aimed at predicting and preparing for potential threats of individual task. The criticality of project tasks is often defined from a time perspective only, using stochastic approaches (Bowers, 1996, Cruz et al, 1999), fuzzy sets methods (Chen, Huang, 2007, Yakhchali, 2012) or using the findings of a network analysis (Chanas, Zielinski 2003). Gong and Rowings (1995) mention that ignoring the impact of non-critical tasks, which may easily become critical, is the most frequent criticism of project duration analysis methods. Another point of view on tasks criticalness is given by the structure of relations in the project. Bowers (1996) or Williams (1992) deal with a stochastic analysis of a project network where the criticality of tasks in the project is derived from the relation between task duration and the whole project, and on the basis of a number of resources used for a task and the whole project. Another approach to analysis of the project performance is based on multiple attribute evaluation (Koelmans, 2004, de Oliveira Moraes, Laurindo, 2013).

For these reasons we introduce the task threatness matrix, our proposed tool for analysis of the criticalness and failureness potential of the project tasks. The main advantage of this tool is its similarity to project risk matrix and relatively easily obtainable data.

2. Task criticalness, failureness and threatness concept

The concept of threatness of project task combines two views – task criticalness and failureness.

The task criticalness potential (Brozova et al. 2014, 2016) is suggested to provide the overall evaluation of the task criticalness using quantitative crisp evaluation without soft knowledge about character of the tasks (Figure 1). The task criticalness potential is based on the multiple attribute decision making method using five indicators of the criticalness which are based on objective values from project schedule and are transformed using linear utility function and fuzzified using fuzzy linguistic scale:

- Duration – longer task duration means higher value of time criticalness indicator,
- Slack – shorter task slack means higher value of slack criticalness indicator,
- Cost - higher task cost means higher value of cost criticalness indicator,
- Work - higher task work means higher value of work criticalness indicator, and
- Topology - higher probability the activity will lie on critical pass related to the project topology means higher value of topological criticalness indicator.

The task failureness potential (Brozova et al. 2016, 2019) is based on the expert estimation of the possibility of task fails from different even soft aspects considering the role of human factor which are expressed using fuzzy linguistic scale (Figure 1). The task failureness indicators are primarily derived from the project triangle criteria respecting three key parameters (and can describe also other parameters of project tasks):

- Duration – higher possibility of task duration extension means higher value of time failureness indicator,
- Cost – higher possibility of task cost increasing means higher value of cost failureness indicator,
- Quality – higher possibility of task quality deterioration means higher value of quality failureness indicator.

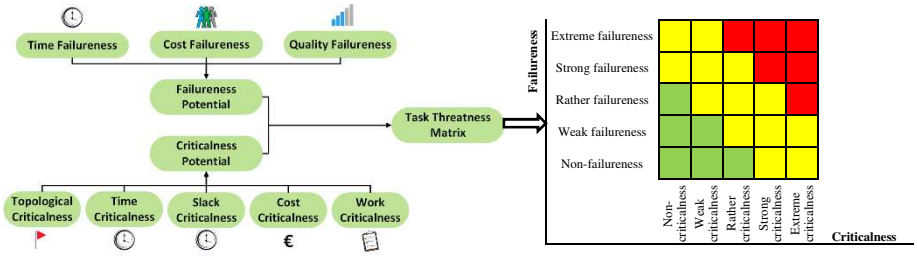

Figure 1. Factors of task threatness and task threatness matrix

The task threatness is obtain using the fuzzy linguistic evaluation of the task criticalness and failureness potentials as two-dimensional evaluation of task. The fuzzy values of criticalness and failureness potential are used for placing of the tasks into cells of task threatness matrix (Figure 1) which is inspired by Winterlink's matrix.

3. Approaches to tasks evaluation

The evaluation of all indicators can be crisp values (numbers) or fuzzy values (actually a fuzzy linguistic value). The first one is used for objective evaluation and the second one has its advantage for subjective evaluation of failureness factors and for division of tasks into five groups.

The crisp evaluation of criticalness factors is based on the objective parameters obtained from the project schedule. Each task criticalness indicator transforms the task parameter so that the best value of this parameter corresponds to the value 0 meaning the lowest criticalness and the worst parameter value corresponds to the value 1 showing the higher criticalness. Then the values of criticalness indicators are fuzzified using the six step non-uniform fuzzy scale (Table 1). The fuzzy value of each criticalness indicator is received as weighted sum of all values of linguistic variable where the weights are the membership function values of criticalness indicator. The criticalness potential of the task is then calculated as the weighted sum of individual fuzzy evaluation of indicators. The weights of all indicators are set by the experts' evaluation.

Table 1. Fuzzy linguistic terms describing intensity of task criticalness and failureness indicators

Linguistic terms		Fuzzy number
Not at all critical	Not at all failing	(0; 0; 0; 0.1)
Usually not critical	Usually not failing	(0; 0.1; 0.2; 0.3)
Rather not critical	Rather not failing	(0.2; 0.3; 0.4; 0.6)
Rather critical	Rather failing	(0.4; 0.6; 0.7; 0.8)
Usually critical	Usually failing	(0.7; 0.8; 0.9; 1)
Always critical	Always failing	(0.9; 0.1; 1; 1)

The final linguistic term expressing the classification of the task criticalness potential is received using suitable method of linguistic approximation into five step non-uniform fuzzy scale (Table 2).

The fuzzy evaluation of the task failureness is based on the expert evaluation of indicators using the six step non-uniform fuzzy scale (Table 1). The failureness potential is calculated as sum of the failureness indicators and using linguistic approximation is again mapped into five step non-uniform fuzzy scale (Table 2).

Table 2. Fuzzy linguistic terms describing the task criticalness and failureness potential

Linguistic terms		Fuzzy number
Non-criticalness	Non-failureness	(0; 0; 0.05; 0.15)
Weak criticalness	Weak failureness	(0.05; 0.15; 0.25; 0.35)
Rather criticalness	Rather failureness	(0.25; 0.35; 0.5; 0.6)
Strong criticalness	Strong failureness	(0.5; 0.6; 0.75; 0.85)
Extreme criticalness	Extreme failureness	(0.75; 0.85; 1; 1)

4. Example

The tasks threatness matrix creation is described on the following small-scale project with 7 tasks (Table 3, Figure 2). The critical path of this project consists of the tasks B, C. D, and G.

Table 3. Project example – data from project schedule

Task	Top.	Dur.	Slack	Work	Cost
A	0.5	2	9	4	5
B	0.5	3	0	3	5
C	0.25	8	0	12	15
D	0.75	4	0	8	22
E	0.25	6	6	6	18
F	0.375	1	2	5	6
G	0.625	3	0	6	4

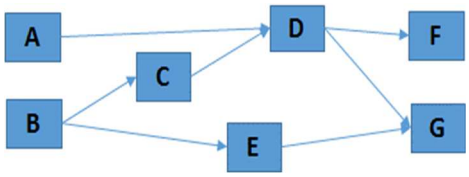

Figure 2. Project example – AON network

The Table 4 shows the initial quantitative values of criticalness factors, which are then transformed into fuzzy criticalness indicators and aggregated into the criticalness potential. The Table 5 shows the experts' evaluation of failureness indicators and their aggregation into the failureness potential.

Table 4. Project example – Task criticalness potential

Task	Criticalness factors					Criticalness potential				Linguistic approximation
	Top.	Dur.	Slack	Work	Cost					
A	0.5	0.143	0	0.111	0.056	0.057	0.141	0.215	0.324	Weak criticalness
B	0.5	0.286	1	0	0.056	0.209	0.275	0.326	0.437	Rather criticalness
C	0	1	1	1	0.611	0.586	0.696	0.725	0.772	Strong criticalness
D	1	0.429	1	0.556	1	0.665	0.785	0.824	0.883	Strong criticalness
E	0	0.714	0.333	0.333	0.778	0.327	0.428	0.51	0.645	Rather criticalness
F	0.25	0	0.778	0.222	0.111	0.111	0.197	0.281	0.396	Weak criticalness
G	0.75	0.286	1	0.333	0	0.294	0.375	0.433	0.557	Rather criticalness
Weights	0.189	0.164	0.129	0.230	0.288					

Table 5. Project example – Task failureness potential

Task	Failureness factors			Failureness potential				Linguistic approximation
	Times	Quality	Costs					
A	Not at all fail.	Rather fail.	Usually fail.	0.367	0.467	0.533	0.633	Rather failureness
B	Rather fail.	Always fail.	Always fail.	0.733	0.867	0.9	0.933	Extremely failureness
C	Not at all fail.	Rather fail.	Usually not fail.	0.133	0.233	0.3	0.4	Weakly failureness
D	Rather not fail.	Rather fail.	Rather not fail.	0.267	0.4	0.5	0.667	Rather failureness
E	Rather not fail.	Usually not fail.	Usually not fail.	0.067	0.167	0.267	0.4	Weakly failureness
F	Always fail.	Usually not fail.	Not at all fail.	0.3	0.367	0.4	0.467	Rather failureness
G	Not at all fail.	Always fail.	Rather not fail.	0.367	0.433	0.467	0.567	Rather failureness

The tasks are now placed into the task threatness matrix (Figure 3). In the red area there is the highly threatening task C requiring great attention. This task is shown as the critical task by MPM method also. In the yellow area there are all other tasks of the project. These tasks have to be controlled to ensure the successful completion of the project regardless of their criticality or non-criticality. The tasks in green area should not significantly influence the project. In this project, there is no task, so in this project all task needs more or less attention, control and care.

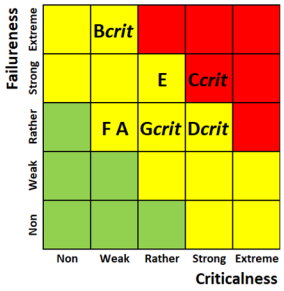

Figure 3. Project example – Task threatness matrix

5. Conclusion

The proposed task threatness matrix was presented to a number of project managers who evaluated it as an interesting, usable and useful tool to support project management. This approach is useful for tasks evaluation with respect to the project schedule, the project management triangle and possibly for other parameters of project tasks failureness or criticalness which have an impact on the project success. In the large projects, the failureness can be evaluated only for selected tasks and remaining tasks can only be arranged according to the criticalness potential in the additional row bellow the task threatness matrix. Important advantage of suggested threatness matrix is that it allows fuzzy assessments of the impact of individual tasks on project completion.

6. Acknowledgements

The research is supported by the Operational Programme Prague – Growth Pole of the Czech Republic - Implementation proof-of-concept activities CULS to promote technology transfer and knowledge into practice, No: CZ.07.1.02/0.0/0.0/17_049/0000815 - KZ10.

References

APM - Association for Project Management, 2008, "Prioritising project risks". Princess Risborough, UK: Association for Project Management.

Aschman, A., 2018, "Why Capital Project Systems Succeed or Fail", IPA, https://www.ipaglobal.com/news/article/why-capital-project-systems-succeed-or-fail-2/.

Betz, J., 2019, "27+ Impressive Project Management Statistics in 2019", https://learn.g2.com/project-management-statistics.

Bowers, J., 1996, "Identifying Critical Activities in Stochastic Resource Constrained Networks", Omega - International Journal of Management Science, Vol. 24, pp. 37–46.

Brožová, H., Bartoška, J. and Šubrt, T., 2014, "Fuzzy Approach to Risk Appetite in Project Management", In Proceedings of the 32st International conference on Mathematical Methods in Economics, pp. 61-66, Olomouc, Czech Republic.

Brožová, H., Bartoška, J., Šubrt, T. and Rydval, J., 2016, "Task Criticalness Potential: A Multiple Criteria Approach to Project Management", Kybernetika, Vol. 52, pp. 558-574.

Brožová, H., Šubrt, T. Rydval, J. and Pavlíčková, P., 2019, "Task Threatness Matrix in the Project Management", In Proceedings of the 32st International conference on Mathematical Methods in Economics, pp. 234-239, České Budějovice, Czech Republic.

Brožová, H., Šubrt, T. Rydval, J. and Pavlíčková, P., 2019, "Fuzzy Threatness Matrices in Project Management", In Proceedings of the 15thInternational Symposium on Operational Research in Slovenia, pp. 581-586. Bled, Slovenia.

Chanas, S., Zielinski, P., 2003, "On the hardness of evaluating criticality of activities in a planar network with duration intervals". Operation Research Letters, Vol. 31, pp. 53–59.

Chen, C. T. and Huang, S. F., 2007, "Applying fuzzy method for measuring criticality in project network", Information Sciences, Vol. 177, pp. 2448–2458.

Cruz, S., García, J. and Herrerías, R., 1999, "Stochastic models alternative to the classical PERT for the treatment of the risk: mesokurtic and of constant variance". Central European Journal of Operations Research, Vol. 7, pp. 159–175.

Gong, D. and Rowings, J. E., 1995, "Calculation of safe float use in risk-analysis-oriented network scheduling", International Journal of Project Management, Vol. 13, pp. 187–194.

Koelmans, R.G., 2004, "Project success and performance evaluation", In: International Platinum Conference 'Platinum Adding Value', pp. 229-236.

de Oliveira Moraes, R., Barbin Laurindo, F.J., 2013, "Performance Evaluation of IT Projects - The Shenhar and Dvir Model", J. Technol. Manag. Innov. Vol. 8, Special Issue ALTEC, pp. 15-24.

Yakhchali, S. H., 2012, "A path enumeration approach for the analysis of critical activities in fuzzy networks", Information Sciences, Vol. 204, pp. 23–35.

Williams, T., 2017, "The Nature of Risk in Complex Projects", Project Management Journal, Vol. 48, pp. 55–66.

Williams, T. M., 1992, "Criticality in stochastic networks", Journal of Operational Research Society, Vol. 43, pp. 353–357.