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The Project Schedule Control Method Under the Influence of Uncertain Factors and Resource Constraints

Qingyue Gu, Chunjing Liu

Project Management Department, China Petroleum Engineering & Construction Corp., Beijing, China

Email address:
guqingyue@cpecc.com.cn (Qingyue Gu), 369865852@qq.com (Chunjing Liu)

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Abstract: Due to the reduce of the national investment and technology development, the market environment changes rapidly and the competition become more and more fierce, the situation require companies to improve the management level, at the same time the uncertainty and the complexity of construction projects also increase sharply, competition for scarce resources gradually intensified, all those factors leading to more and more difficult to complete the project timely, this paper adopt Delphi method to identify schedule risk, by introducing the severity index and important index as secondary indexes, through schedule risk analysis to determine the schedule risk control valve value (sensitivity index), take the sensitivity index as a valid trigger out decision basis of action, to build a comprehensive (project - activity layer) framework of project schedule risk identification, monitoring and correction organization. It can help project manager to identify the risk in advance, good for adopt some measures to control the risk and make the goal come true.

Keywords: Sczhedule Risk Analysis, The Sensitivity Index, Control Valve Value

1. Introduction

Schedule plan and schedule control is the core content of engineering project management practice and research, from the traditional earned value method, the network diagram to the critical chain schedule management method, schedule management methods have make a huge change, the method become more and more complex but the effective is not improved accordingly [1]. At the same time, a variety of project management software research and development come into our view and it is widely applied in the actual project environment (such as project, P6, etc.). However, because of the complexity of the project itself and the execution environment is uncertainty and the resources is limited, so in the actual, it is still a big challenge for project manager to delivery the project on time accord to contract and within budget in accordance with the specification. In Conclude, failed to take effective planning and control methods to cope with and compensate for execution in the process of high uncertainty and resource constraints, is an important factor for the completion of the project. so this paper try to adopt a simple and practical method to assist the project manager to reduce the risk.

government investment reduced sharply, and in order to cope with the situation, PPP mode is invented and become a new way to attract the investment, however the comprehensive operation ability is a great challenge to the enterprise. it is directly relate to the project benefits, under this circumstance time management will gradually become the main content of project management, project time limit for a project is a indictor to decide project success and the crucial factors to affect the expected gain. If the project schedule is out of control, will cause delays and penalty cost; Needs to take measures to catch up the construction period after delay, it will increase cost sharply (such as increasing staff, add equipment, improvement of raw materials, and adopting new technologies, etc.), and can lead to waste of manpower and material resources, even may affect the quality and safety of the entire project. Therefore, how to make the actual engineering conforms to the current situation through take risk aversion methods is crucial [2].

2. Schedule Risk Analysis, SRA

One of the primary features that distinguishes project management from general management is the special attention to scheduling. Unfortunately, some people think that project

management is nothing but scheduling, and this is incorrect. Scheduling is just one of the tools used to manage project and should not be considered as the primary one. Overall, schedule risk analysis is similar to job safety analysis (JSA)[3], on the basis of network chart, which can identify the risk factors of key working procedure and according to the classification by the degree of risk probability and risk impact, and valuation.

One meaning of the control is power and domination. In management, this is sometimes called the command-and-control approach, which in its worst form degenerates into the use of fear and intimidation to get things done. This method works when people have no other desirable options for employment or are not free to leave (as in the military or a prison). However, in a robust economy, very few will tolerate such management for long.

The second meaning of control—and the one I advocate for managers—is highlighted in the extracted quotation. Control is exercised by comparing where you are to where you are supposed to be so that corrective action can be taken when there is a deviation. Notice that this is an information systems or guidance definition. Further note that two things are necessary for control to exist. First, you must have a plan that tells where you are supposed to be in the first place. If you have no plan, then, you cannot possibly have control. I think we need to remind ourselves of this almost every day, because it is so easy to forget when you are constantly being assaulted by demands to do this and that and a million other things [4].

2.1. Schedule Risk Factors Identification

Schedule risk identification requires two steps: the first is determine the overall construction organization plan according to the project characteristic and construction, adopt the mode of network diagram describes the logical relationship between each working procedure; The second is to organize the project design, procurement personnel, legal personnel, construction technical staff focuses on the restrictive factors of each working procedure, to form the total risk list (see figure 1). In the schedule risk identification stage, the more detailed analysis, the more conducive to the progress of the projects of control, the accuracy of the risk factors identification is very important to control the progress reasonable [5].

Naturally, the primary reason for scheduling a project is to ensure that the deadline can be met. Most projects have a deadline imposed. Furthermore, since the critical path method helps identify which activities will determine the end date, it also helps guide how the project should be managed.

However, it is easy to get carried away from scheduling and spend all of your time updating, revising, and so on. The scheduling software in use today should be viewed as a tool, and managers should not become slaves to the tool. It is also very easy to create schedules that look good on paper but don't work in practice. The main reason is usually that resources are not available to do the work when it comes due. In fact, unless resource allocation is handled properly, schedules are next to useless. Fortunately, today's scheduling software handles resource allocation fairly well, but we leave discussion of the methods used to the software manuals. I am often told that scope and priorities change so often in a given organization that it doesn't make sense to spend time finding critical paths. There are two points worth considering here. One is that if scope is changing often in a project, not enough time is being spent doing up-front definition and planning. Scope changes most often occur because something is forgotten. Better attention to what is being done in the beginning usually reduces scope creep. Second, if priorities are changing often, management does not have its act together [6]. Generally, the organization is trying to tackle too much work for the number of resources available. We all have "wish lists" of things we want to do personally, but we have to put some of them on hold until time and/or money become available. The same is true of organizations. Experience shows that when you have individuals working on many projects, productivity suffers. One company found, as an example, that when it stopped having people work on multiple projects.

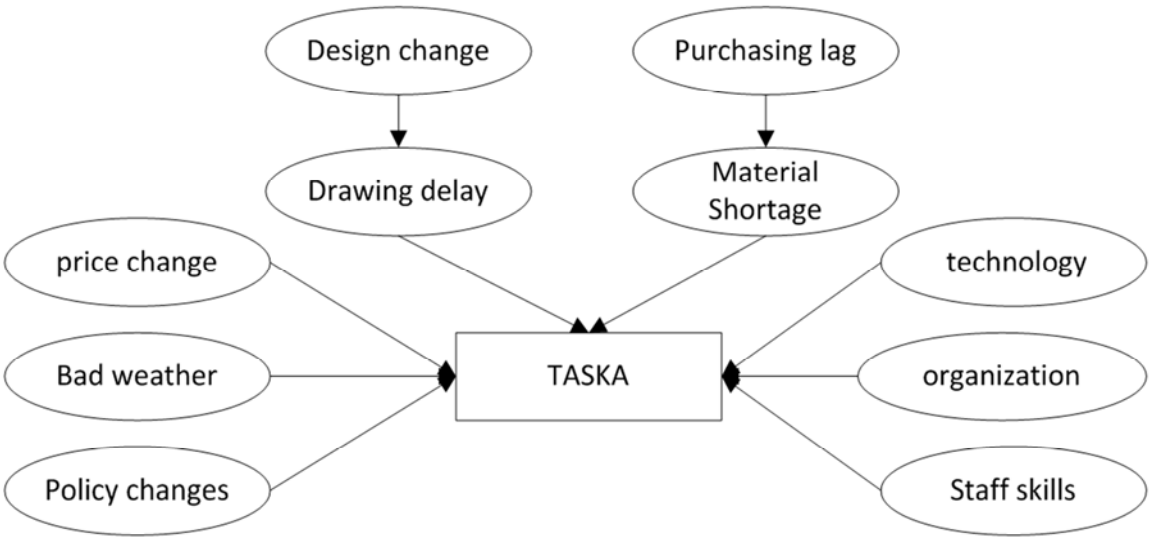

Figure 1. *Risk list.*

2.2. Risk Quantification

Each working procedure relate to different risk factors, the probability of risk factor and the influence degree is also different, according to the time limit for a project different activities should have different levels of uncertainty and importance. In the process of risk factors identification on the basis of different risk elements of quantitative risk can make the important degree and the degree of influence obvious.

In order to effectively express the risk of harm degree, introduced the important degree to represent the various risk factors on the degree of important operation, reflecting the risk factors of uncertainty impact of uncertainty on duration of operation according to the value [7].

$$\text{Severity} = \text{risk probability} * \text{affect job completion} \quad (1)$$

$$\text{Important degree} = \text{the risk severity/all the severity of a risk factor} \quad (2)$$

Due to risk quantification has certain subjectivity, so be sure to choose experienced management personnel to determine the factors through Delphi method. When determining the probability and impact of risk factors can refer to the historical data and experience for similar projects, through those skills can ensure the authenticity, validity of evaluation and improve the veracity of the evaluation of risk factors.

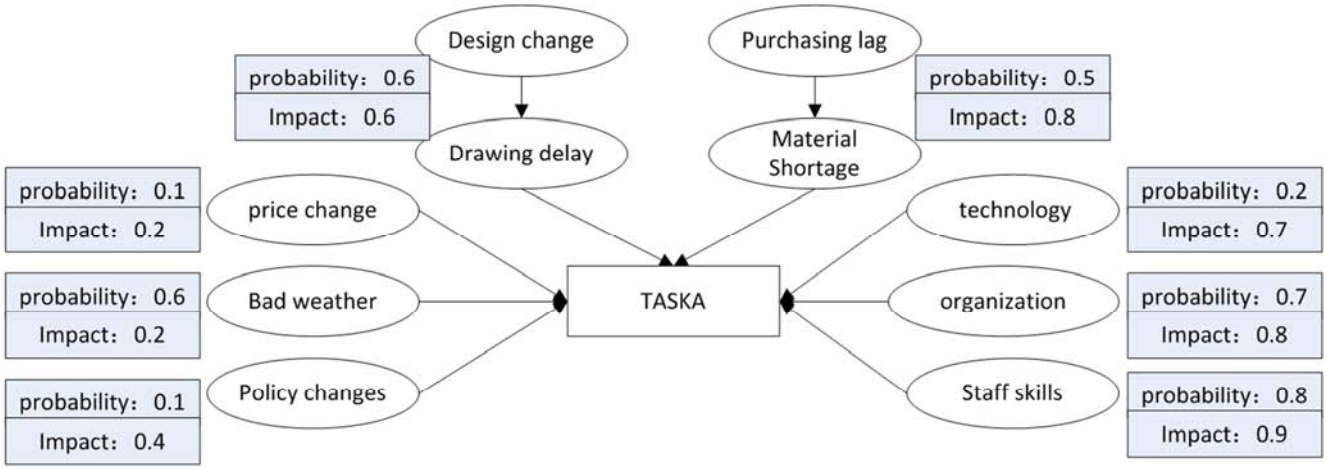

Figure 2. *Risk quantification.*

Through the formula of provided above, the severity and Important degree of to calculate the severity and important degree of each factors.

2.3. The determination of risk threshold (sensitivity index)

Comprehensive important degree and severity degree of two indicators set sensitivity threshold as a trigger action,

$$\text{Sensitivity index} = \text{important degree} + \text{severity degree} \quad (3)$$

According to the sensitivity index value set "action area" and "no action/ less area". "Action area " activity is known as the high sensitivity factors, they are high risk, are the important cause leading to the whole project schedule delay, have significant influence on project completion date; So during the project implementation should be monitored for such activities, once they happened, the corresponding control countermeasures should be taken; "No action or less area" activity because of its low degree of probability or losses [8], referred to as the low sensitivity factors, small impact on the overall project schedule, need not be monitored during project execution. In figure 3 hypothesis in 0.4 as a threshold, then the factors according to the formula (3) determine the sensitivity index, just sensitivity index is greater than the threshold, the need for action, else do not need to take action [9].

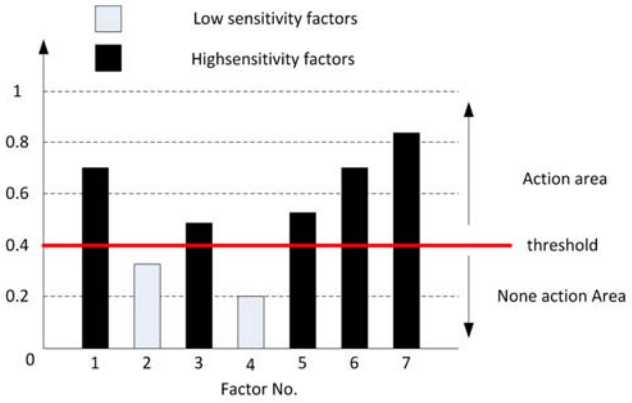

Figure 3. *Sensitivity index.*

3. The Usage of the Method in Project Practice

3.1. Project Overview

The designed pressure of Tie-Da oil line project (Anshan - dalian section) is 8.0 MPa, and it can convey 2000 x 10^4 t

Russian crude oil every year. The starting point is liaoyang pump station, the finish point of the line is Dalian oil station, the total length is 372 km, new lines adopt L450M steel tube, the diameter of the pipe is D813mm, This project through large and medium-sized rivers 23 times, crossing small river 50 times, across railway 13 times, across highway 9 times, through the provincial trunk road 17 times. six full set process in Station, including 2 new station (liaoyang pump station, wafangdian pump station), 4 transform station (Anshan transfer station, arashi transfer station, xingang oil station, dalian petrochemical station).

3.2. Schedule Risk Analysis

At the beginning of the project construction, the owner organization the experts from the supervision unit and EPC unit hold a meeting to identify the risk factor from the point of construction coordination between design, procurement, land expropriation, at last identified 22 schedule risk factors and combining the design unit capacity, supplier prestige, climate, expert experience using the Delphi method. the indicator may exist collinearity, multicollinearity in the use of statistical knowledge can effectively test the multicollinearity of the indicator.

Table 1. *Collinearity inspection results.*

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1	.875		.216	.842		
U_1	.425	.267	.315	1.338	.136	.334	2.760
U_2	-.237	.285	-.321	-1.162	.212	.351	2.766
V_1	.125	.223	.114	.534	.611	.412	2.455
V_2	.121	.245	.120	.517	.613	.343	2.978
V_3	.121	.264	.149	.874	.431	.423	2.379
W_1	.131	.253	.151	.484	.645	.454	2.499
W_2	.051	.486	.021	.048	.943	.159	6.259
W_3	-.054	.265	-.025	-.244	.841	.458	2.215

Because the VIF is less than 10, there is no multicollinearity of the indicator. According to the membership degree principle and the common linear test, the risk index is reasonable.

After the index is determined, the occurrence probability and influence degree of risk factors are evaluated by 10 experts adopt Delphi.

Table 2. *List of risk factors.*

List of risk factors	indicator	Risk probability	affective	Severity
Drawing designU_1	1) Drawing delay U_{11}	0.6	0.8	0.48
	2) Design change U_{12}	0.3	0.6	0.18
Purchase U_2	1) Purchase delay U_{21}	0.4	0.7	0.28
	2) Substandard goods U_{22}	0.3	0.7	0.21
	3) price change U_{23}	0.1	0.4	0.04
Coordination of land requisition U_3	1) policy change U_{31}	0.1	0.6	0.06
	2) villager resist U_{32}	0.2	0.6	0.12
	3) compensate too high U_{33}	0.7	0.4	0.28
Construction organization designU_4	1) The feasibility of the construction organization designU_{41}	0.3	0.7	0.21
	2) Transport path planning U_{42}	0.2	0.6	0.12
	3) the scientific Construction of planning U_{43}	0.3	0.5	0.15
Organization and management abilityU_5	1) OrganizationU_{51}	0.1	0.9	0.09
	2) Management program U_{52}	0.2	0.7	0.14
	3) Personnel responsibilities U_{53}	0.1	0.9	0.09
construction technologyU_6	1) Construction technology of matureU_{61}	0.2	0.7	0.14
	2) The stablility of Construction technology U_{62}	0.3	0.6	0.18
Staff skills and qualityU_7	1) the basic quality of employeesU_{71}	0.4	0.7	0.28
	2) Employee executionU_{72}	0.3	0.8	0.24
	3) Staff professional skillsU_{73}	0.2	0.7	0.14
External factorsU_8	1) Climatic conditionsU_{81}	0.1	0.8	0.08
	2) Terrain environmentU_{82}	0.1	0.8	0.08
	3) Policy factorsU_{83}	0.2	0.7	0.14

According to the formula: severity = risk probability * for assignments to determine the influence of the impact of each risk factor severity.

According to membership degree theory, the risk factors evaluation index as a collection, if the experts on the 10 grade index U_{11} sum to M, total score for M_0, then the membership degree of evaluation indexes, the R value equal M/M_0, the greater the risk factors in the greater the extent belongs to the

collection, namely U11 occupies an important position among the indicators (importance), through the statistical analysis of 10 experts, get the following results calculated using the formula of important degree (see table 2).

Table 2. *The important degree of quantitative table.*

Risk factor	The evaluation index	expert										important degree
U_1	U_{11}	2	1	3	5	1	2	1	4	1	2	0.42
	U_{12}	1	2	1	1	3	2	2	2	1	1	0.38
	U_{21}	1	2	2	2	2	1	2	2	1	1	0.32
U_2	U_{22}	2	1	2	5	5	4	4	5	5	4	0.42
	U_{23}	5	4	4	1	1	2	2	1	1	2	0.34
	U_{31}	1	2	2	1	1	2	2	2	1	3	0.46
U_3	U_{32}	1	2	1	2	1	1	1	2	1	2	0.34
	U_{33}	1	2	1	2	1	1	1	5	5	1	0.38
	U_{41}	2	1	1	2	2	2	1	1	1	1	0.27
U_4	U_{42}	5	4	2	1	2	2	1	3	3	4	0.42
	U_{43}	1	2	5	4	4	5	5	1	1	2	0.34
	U_{51}	2	1	1	2	2	1	1	2	1	1	0.23
U_5	U_{52}	1	2	1	1	2	1	2	2	1	1	0.32
	U_{53}	1	2	2	2	5	4	4	5	5	1	0.25
U_6	U_{61}	2	1	2	2	1	2	2	1	1	2	0.34
	U_{62}	5	4	4	5	1	2	1	1	1	4	0.82
	U_{71}	1	2	2	1	1	2	2	2	1	1	0.12
U_7	U_{72}	1	2	1	1	2	1	2	2	1	1	0.32
	U_{73}	1	2	2	2	5	4	4	5	5	4	0.42
	U_{81}	2	1	2	2	1	2	2	1	1	2	0.31
U_8	U_{82}	2	1	2	1	1	1	1	2	2	3	0.16
	U_{83}	1	1	1	2	1	1	1	1	2	2	0.13

Using the formula: sensitivity index = severity + important degrees, the sensitivity of each indicator can be obtained index.

Risk factor	The evaluation index	severity degree	important degree	Sensitivity index	Action area
U_1	U_{11}	0.48	0.42	0.9	More action
	U_{12}	0.18	0.38	0.56	Action
	U_{21}	0.28	0.32	0.6	Action
U_2	U_{22}	0.21	0.42	0.63	Action
	U_{23}	0.04	0.34	0.38	Less action
	U_{31}	0.06	0.46	0.52	Action
U_3	U_{32}	0.12	0.34	0.46	Action
	U_{33}	0.28	0.38	0.66	Action
	U_{41}	0.21	0.27	0.48	Less action
U_4	U_{42}	0.12	0.42	0.54	Action
	U_{43}	0.15	0.34	0.49	Action
	U_{51}	0.09	0.23	0.32	Less action
U_5	U_{52}	0.14	0.32	0.46	Action
	U_{53}	0.09	0.25	0.34	Less action
U_6	U_{61}	0.14	0.34	0.48	Action
	U_{62}	0.18	0.82	1	More action
	U_{71}	0.28	0.12	0.4	Action
U_7	U_{72}	0.24	0.32	0.56	Action
	U_{73}	0.14	0.42	0.56	Action
	U_{81}	0.08	0.31	0.39	Less action
U_8	U_{82}	0.08	0.16	0.24	Less action
	U_{83}	0.14	0.13	0.27	Less action

According to the analysis and calculation, and finally recognize the U11, U6 2 more action area, 7 little action area, 13 have action area, the classification can make the schedule management in actual control for somewhat, in improving the efficiency of management.

3.3. Effect Evaluation

To a great extent using this kind of schedule risk identification and assessment to eliminate the factors that affect the progress in advance, schedule control to the contractor, winning advantage is conducive to the contractor fully combined with expert experience, the climate factors such as the objective reason, reduces the possibility of occurrence of a risk, effective guarantee the project construction period, has obtained the good economic benefits. Is a kind of simple operation, high practicality schedule control method [10].

4. Conclusion

This is a kind of schedule control method based on activities, from bottom to top, can be widely collected the project management team to the project schedule risk cognition, at the same time, through the quantitative risk factors and the

threshold setting facilitate project management personnel to monitor the risk factors, it is important to monitor mechanism and management methods. Its main management purpose has two: one is to make the uncertain effect on the time limit for a project to a minimum, second is to increase the likelihood of completion or completed ahead of schedule [11]. In this paper, on the basis of network chart plan, increased the risk factors identification, quantification, and puts forward the method of dynamic monitoring to the introduction of the threshold setting of schedule risk management at the same time, can make according to the schedule management process, to a certain extent, make project managers identify schedule risk and its severity, and avoid the blindness of the project schedule management.

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