The Model for the Description of the Dynamic Behaviour of the Project Processing

Dalibor Vytlacil

1 Czech Technical University in Prague, Faculty of Civil Engineering, Department of Engineering Informatics, Thákurova 7, Prague, 166 29, Czech Republic

vytlacil@fsv.cvut.cz

Abstract. The paper deals with the problem of many projects – the difference between designed activities processing and real project implementation. The reason is the rework of many activities that is omitted in the project proposal. The consequences are the project delay and the budget overrun. The reason for the described problems is the low quality of same processed activities and the changes in project goals. This research work is focused on the development of the dynamic model that describes the project processing. The model is based on the system dynamics methodology. The main stocks are the amount of the activities expressed as the number of man-days. The changes in the stocks are influenced by the flows. The main flow is processing rate and reworking rate that influence the project dynamics. The auxiliary subsystem deals with human resources. The number of workers has the relationship to all flows of the system. The model can be used for the simulation of the dynamic behaviour of the complex projects. The outputs from the designed model are compared with model that is based on standard approach. It means the project model includes only unprocessed activities and processed activities with one processing flow. This model does not include rework activities. The results of the simulations present the difference in time according to the quality rate and the change rate. It can help to understand the key reasons for the project delay and consequently for the budget overrun.

1. Introduction

The production output in the construction industry is the finished project, usually structure designed for different purposes. The life cycle of the project includes several phases. After the definition phase the design phase starts. Part of this work is scheduling. This activity includes CPM or PERT method for a calculating the deadline of the project. This date together with milestones are aggregated into master schedule.

During the implementation phase we encounter many problems that cause time delay and budget overrun. The cost escalation can be in the infrastructure projects about 25 – 50 % and for nuclear power plant this figure is even 200 %. These problems start with time delay that causes using more resources then we expected in the master plan.

Another reason for above described problems is the rework of same finished activities because of the low quality. Another feature of long-time projects is the change of the output parameters. It leads to reworking the realized work too.
2. Model description
The research work was focused on the development of the dynamic model that will include problems during project implementation. The outputs from this model will be compared with standard approach.

The model is based on the system dynamics methodology, see [1] for the description of the project dynamics and [2] for the system dynamics. The main elements are the stocks as key model parameters and the flows that change the stock values. Other elements are convertors for the calculation of auxiliary parameters. The changes in the stocks are calculated by the equation 1, [3].

\[
Stock(t) = \int_{t_0}^{t} [flow(s) - Oflow(s)]ds + Stock(t_0)
\]

The model that reflects the investigated issues is depicted in figure 1. The common approach is described by means of figure 2. Unprocessed activities \( T \) is the stock of the activities that have to be done during the implementation of the project. Finished activities are in Processed activities \( T \) element. The model element processing \( T \) interconnects both stocks and depends on number of the resources and the productivity. The dynamic model includes quality rate element. This convertor divides the output from Processed activities element into two flows – reworking flow when finished activities have to be done once more due to low quality and continuing which is connected with Quality processed activities element. Another important convertor is change rate element. The element reflects the changes in the project that will evoke another activity rework.

**Figure 1.** Dynamic model for the described problem.

**Figure 2.** Standard model for the project implementation.
3. Simulations
The aim of the simulations is the comparison of the results from the standard model and the model with the rework process and the changes in the project goals (case 1). The model includes 10000 man-days of work. The project activities will be performed by 20 workers. The values that distinguish these two cases are in table 1. The simulation time is one year. The considered resource in the project is only manpower and the load diagram is constant.

In figures, it is possible to observe the dynamic changes of the stock values and the flow values. The standard model includes only Unprocessed activities and Processed activities values, see figure 3. Figure 4 presents the time changes in all stock elements. Figure 5 does not contain Finished activities values because the model does not include this element (case 2).

| Table 1. Input parameter values. |
|----------------------------------|
|                                | Case 1 | Case 2 |
| Base quality rate [%]           | 95     | 95     |
| Change rate [%]                 | 5      | 0      |
| Number of workers [-]           | 20     | 20     |

4. Results and discussions
The resultant values for the classical approach present the linear dependency for both observed parameters. The project duration is 3 months. No discrepancies are considered in this case and therefore it is possible to speak about theoretical behaviour.

The changes of the stock values for the developed model are depicted in figure 4 (case 1). The completion day is delayed by 180 days. It is significantly more compare to the standard model. This result is similar to the completion time in case 2 when the changes during the implementation were not considered. The figure is 165 days. In real projects, the differences are not so considerable because in case of possible project delay more resources are used. This solution solves the problem with the project length but at the same time will cause the budget overrun.

![Figure 3](#)
Figure 4. The changes in stock elements with considering the quality rate and the change rate (case 1).

Figure 5. The changes in stock elements with considering the quality rate only (case 2).

Figure 6. The flows for the model with considering the quality rate and the change rate (case 1).
5. Conclusions
The dynamic model for the description of project real behaviour has been developed. The model includes two factors that cause time delay - the rework of activities due to low quality and project parameters changes.

The results demonstrate the influence of the quality factor in projects. The quality depends not only on human resources but also on the quality of project management. The second factor – output parameters changes illustrates the importance of accurate setting all project parameters and the contract preparation. It means, no to neglect the initial phase of the project life cycle.

Evidently, there are more reasons for the delay. For example the changes in the resources. In presented cases, the amount of resources was constant. It is possible to add sub-model where the number of workers can be changed by means of the flows calculated according to hire and leave rates. Next model improvement will be focused also on project costs to reflect the relationship cost-time.

Acknowledgment(s)
This research has been supported by the Grant Agency of the Czech Technical University in Prague, grant no. SGS20/103/0HK1/2T/11.

References
[1] R. J. Madachy, *Software process dynamics*, Wiley Inter Science, New Jersey, pp., 2008.
[2] J. D. Sterman, *Business Dynamics: Systems thinking and modelling for a complex world*, Irwin/McGraw-Hill, Boston, pp., 2000.
[3] J Morecroft, *Strategic modelling and business dynamics*, Wiley, Chichester, 2008.