PROCEDURES FOR CHANGE MANAGEMENT IN THE REALIZATION PHASE OF CONSTRUCTION PROJECTS

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In later phases of the life cycle of a project, the possibility of impact on the project and the level of uncertainty decrease, while the realization of the project increases. One of the main problems in the realization phase is that the quantity of requests for changes does not diminish during the project life cycle. Therefore, approval of changes must be reduced as the project proceeds. Research was carried out on theoretical systems of change management and their practical application. The theoretical basis for the research is Dynamic Planning and Control Methodology ("DPM"). Research on its practical applicability was carried out in Croatia. The paper presents the results of the research in the form of change management procedures which integrate strategic and operational aspects of a construction project. These procedures are applicable in a dynamic project realization environment and are based on contemporary knowledge of change management. They originally arose from two issues: the need for objective decision making in approving changes and the willingness to apply new solutions and the latest knowledge in construction practice.

Keywords: building performance, change, decision analysis, dynamic planning.

INTRODUCTION

Scientists have been dealing intensively with a systematic approach to change management in construction projects in the last fifteen years. Change management arises from the need for efficient and effective control over construction projects.

The existing research on change management focuses on the identification of facts which influence the success of change processes, and studies best practice in the implementation of change management (Motawa *et al.*, 2006). Examples of this type of research include: the concept of change management in a project (Construction Industry Institute (CII), 1994), best practice in effective change management (Cox *et al.*, 1999), methods for reducing the total number of changes in construction projects (Stocks and Singh, 1999), best practice recommendations for effective change management (Construction Industry Research and Information Association (CIRIA), 2001) and advanced change management (Ibbs *et al.*, 2001).

Hester and associates dealt with the evaluation of the effect of changes on certain elements of a project. They studied the influence of changes during construction on work productivity (Hester *et al.*, 1991). Lee and associates developed models for the

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classification and quantification of losses in productivity resulting from changes in projects (Lee *et al.*, 2004).

Scientists agree that the multiplicity and complexity of requests for changes in construction projects have a significant impact on the financial flows of a project. Average costs as a consequence of requests for changes in construction projects amount to 5-10% of the total project budget (Cox *et al.*, 1999). In order to reduce the effect of negative consequences of changes in construction projects, it is necessary to find a more effective approach than statistical planning and controls (Lyneis and Cooper, 2001).

Many researchers propose the use of system dynamics in the planning of activities (Love *et al.*, 2000); (Williams *et al.*, 1995); (Rodrigues and Bowers, 1996) and finding the causes of additional work in construction projects (Love *et al.*, 1999); (Love *et al.*, 1999). In addition, system dynamics methodology can improve decision making at a strategic level.

Research to date has for the most part been based on the change identification, best practice in change management during the project life cycle and evaluation of the change effect on individual project characteristics.

Identification and recommendations are not sufficient for effective and specific change management. Actual tools for predicting the impact of potential changes and the coordination of changes throughout the entire project are very necessary.There is a lack of research on the interaction between various change effects, which can increase the impact of individual influences by many times.

In later phases of the project life cycle the possibility for impact on the project decreases. A similar downward trend can be seen for the value of uncertainty in a project (see Figure 1 below).

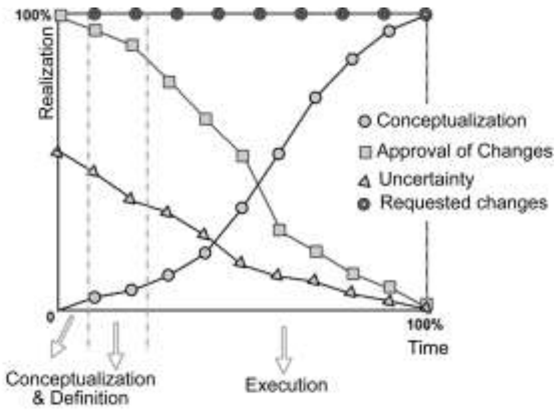

Figure 1: Project realization, changes approval and uncertainty in a project life cycle

One problem in the execution phase is the disparity between requested/potential changes in a project and changes which may be approved. Due to the nature of construction projects, requests for changes are modified with respect to the interests and variable conditions under which the construction is carried out, but they do not decrease quantitatively during the project life cycle.

The establishment of good bases for management prior to the project execution phase can contribute to better change management. It is therefore necessary during the planning phase to prescribe procedures for verification of change effects on the project plan. The proposed procedure will be described below.

If there is a systematic cycle from submission to the response to the change request, the negative consequences of change can be significantly reduced.

STRATEGIC AND OPERATIONAL MANAGEMENT

Project management can be divided into two parts which are important for change management: strategic management and operational management. Changes must be managed on the basis of integrated information from both of them. Overlooking either one of these two parts of management will lead to ineffective change management which will reflect negatively on the success of the project.

Strategic management represents the management actions for the purpose of meeting the strategic objectives of the project, which require the harmonization of execution time, costs, resources and project objectives with the strategy of the system of which the project is a part.

For the successful implementation of strategic management, the set of activities and participants in the project are not considered separately but as continuous elements in interaction.

Operational management refers to management actions in respect of the time and costs of execution and includes steps to be taken to satisfy strategic management.

One of the biggest differences between strategic and operational approaches in project management is that operational project management does not include changing the project's objectives.

Strategic and operational management have advantages and drawbacks. The strategic management application enables the project leader to make quality decisions within the overall set mode of execution and within the project constraints. However, strategic management is not able to quantify exhaustive and detailed impact on a project.

On the other hand, operational management can quantify detailed impact on a project, but has nothing with changing the objectives and global information (on available time, costs and resources). Taking appropriate decisions in operational management partially depends on the strategic level of management.

In order to effectively manage a project, synergy and simultaneous respect for strategic and operational approaches is necessary.

CHANGE MANAGEMENT IN CROATIAN CONSTRUCTION PROJECTS

Croatian construction practice has intensified change management principles and procedures during the last ten years, but still only in exceptional cases in large commercial systems and exclusively for the purpose of ensuring that planned project costs are not exceeded.

Research has been carried out of change management in Croatian construction practice, through questionnaires and interviews (Nahod, 2010). A total of 24 questionnaires were processed, from key project stakeholders (8 construction project managers, 8 construction site managers and 8 investors). The questionnaires were distributed and completed in the presence of a researcher who provided clarification where needed. The questions were structured as open and closed. The respondents were first presented with open questions (30%) and then closed questions (70%).

The interview was used as a supplement to the questionnaire and observation methods, in order to gain an opinion about experience and supplement the picture of the change effects and change management systems in practice. Interviews were held with 18 key construction project stakeholders (6 project managers, 6 construction site managers and 6 investors in 6 large construction projects in the realization phase). The projects were selected in order to show current best practice in construction project management in Croatia. Observations revealed insufficient application of the world's proven procedures which are applied in Croatia only for the purpose of formally fulfilling contract obligations. The research results provided a basis for the systematization of changes in the realization phase of construction projects in Croatia. It also revealed the level of readiness for the change management procedures implementation, which was taken into account in the procedures drafting (Nahod, 2010). The results of the research indicate that stakeholders in construction recognize the inevitability of change. It is not always possible to predict all the elements that effect construction projects, due to the level of complexity, the large number of stakeholders and the influences of technology and organization. This creates conditions for changes in the projects. Change management is not systematically applied in Croatian construction projects. According to the research conducted, 80% of respondents are satisfied with the change management in projects (which is worrying), although they recognize negative change consequences in projects. Respondents consider that in 70% of exceeding costs and deadlines in projects, the reason are changes that are approved without an objective assessment of the consequences in a project. The picture of change management in Croatia has provided a basis for measurement in which theory needs to be adapted to practice to obtain optimal results in the change management implementation in construction projects (Nahod, 2010).

A CUSTOMIZED DPM

Researchers in the world have been dealing with the integration of strategic and operational management at the project level during the last ten years. DPM was integrated with the results of research described above and customized method was derived (see Figure 2 below).

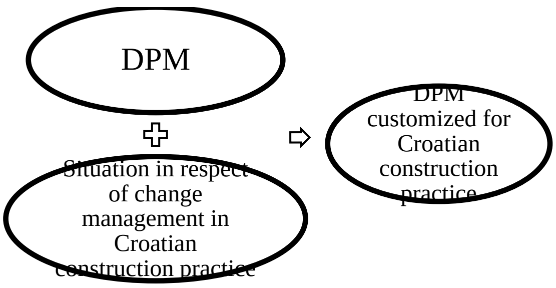

Figure 2 DPM Customized for Croatian Construction Practice

DPM (Pena-Mora and Li, 2002) integrates existing tools in one comprehensive mechanism to ensure flexible utilization with regard to the conditions variability and constraints for any specific project. The DPM framework is layered, consisting of four layers: the strategic core, the tactical layer, the operational layer and the interface layer.

Since each project is unique, the DPM requires the modelling of a change management system for each project and all relevant influences on the project. It is a demanding task of great complexity to be commonly applied in practice.

Therefore, an adaptation of the DPM that could be implemented in Croatian construction is proposed. It is derived from the existing DPM with optimal simplification in those areas where construction projects can afford to do so. In contrast to the DPM, it has two basic layers (levels) of management: strategic and operational (see Figures 3 and 4 below).

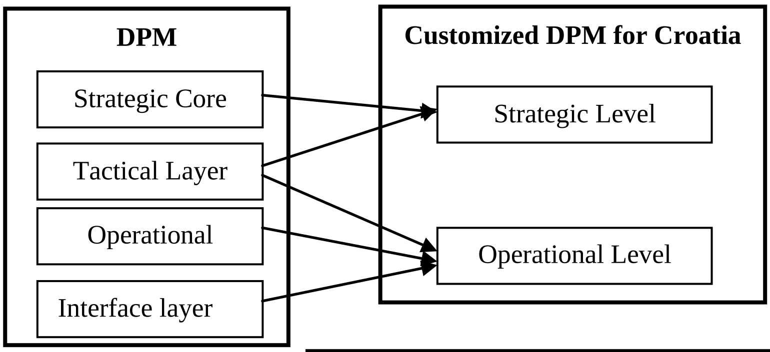

Figure 3 Customized DPM for Croatian Construction Practice

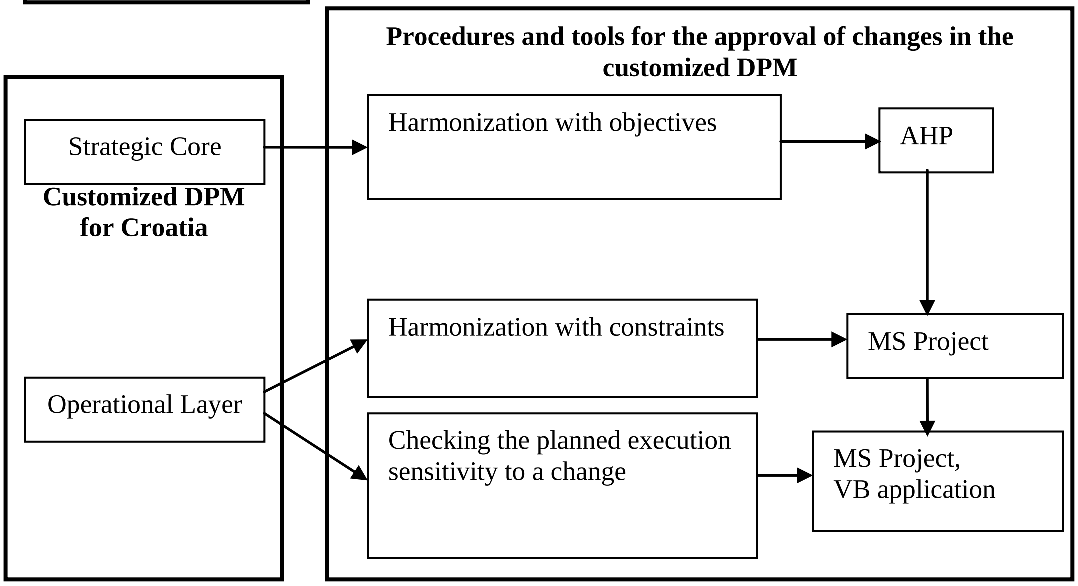

Figure 4 Procedures and tools for the customized DPM

The Strategic Core - Analytic Hierarchy Process (AHP)

Strategic management is recognized as critical for the project success. It provides guidelines for operational management and creates decisions in the initial project phases. In this way, operational decisions are adjusted to the long-term influences on the project execution. For the purposes of adapting the DPM to Croatian construction practice, a simulation of the strategic core is simplified and consists of AHP. It determines the priority of project objectives and the influence of requested change on the achievement of these objectives. A project's objectives need to be measurable, achievable and realistic. It is necessary to define 3-8 main project objectives, to determine their parameter of measurability during project execution and to determine their relative importance for the project. The project objectives have to be agreed with all relevant stakeholders on the one-off, short-term and long-term objectives of the project.

Is the change on the way to achieve the project objectives or not? The strategic Core provides an answer to this question. The objectives should be clearly defined before project execution, otherwise it is impossible to implement this part of the procedure.

The approval and rejection of change whose influence will be considered in the analysis shall represent alternatives to AHP. Software Expert Choice can be used for the AHP process facilitation.

Objectives comparison in pairs is performed for each level of the hierarchical objective structure to determine the weight of objectives importance.

Testing change approval is performed for each specific objective, assessing the extent to which the change is in line with the specific objective. Then the local weight of individual objective is calculated.

At the end of the AHP process the change has the level of compliance with project objectives (expressed in number between 0-1). The result of compliance is shown by the alternative "Approval of Change" so the local alignment is weighted with the weights of all nodes which belong, looking from the lowest level in the hierarchical model towards the highest level and then at the sum.

The operational level of change management

Operational management in the customized DPM covers the tactical, operational and interface layers of the DPM. Sine qua non is that the execution plan is approved and that it contains all necessary activities connected with adequate technological or organizational relationships.

Relationships between the activities are crucial for defining dynamics and constraints. It is therefore very important for effective planning to have detailed modelling of all activity relationships, external and internal. External relationships relate to correlations between activities, while internal relate to relationships within individual activities.

For DPM customization, network planning is relevant.

Critical Path Method (CPM) and Graphical Evaluation and Review Technique (GERT) have already been applied in construction.

CPM practical application is limited to cases where the construction is not subject to any significant limits of time or resources. In this context, an optimal plan is one that uses a hybrid approach and combines a few existing tools, taking from each its specific advantage in order to achieve maximum effectiveness of execution. The GERT method can actually manage feedback cycles in planning, but only for a static scope of work. Classic network-oriented tools are not effective in capturing cause-effect occurrence.

On the other hand, tools based on simulation were created to reveal uncertainties in construction. The most commonly used are discrete simulations which focus on operational aspects of construction projects with the aid of stochastic process waiting time. Although simulation models prove useful at the operational level, they are only partially applicable for strategic management in construction. One possible reason for poor adjustment at the strategic level is a difficult process of development and natural focus on the operational level.

In determining the advantages and drawbacks of using certain planning tools, it is important to know which project characteristics are important for project management and to take into account the complexity and uncertainty at the strategic and operational level.

Construction can be defined as a process activity that is executed at variable locations with temporarily affiliated organizations and resources in an open environment. As a result, a high degree of unpredictability is constantly present.

It is obvious that existing tools may have difficulties with the understanding of dynamic characteristics in both strategic and operational management, due to the static approach of network-oriented tools and the operational approach of simulation-oriented tools.

Since changes are dynamic, good quality change management is only possible with the aid of tools that integrate a network-oriented simulation approach, DPM and include both strategic and operational aspects of project management.

The customized DPM emerges all mentioned and is applicable in Croatian construction practice.

Change requests analysis on Project constraints

The main constraints are considered: time and cost. The proposed methodology is recommended for application in all other specific project constraints as well.

It is necessary to define the threshold of reasonableness and the feasibility threshold for each constraint. The threshold of reasonability is marginally acceptable for the project (o_{pov}), and the feasibility threshold is the project constraint that must never be exceeded (o_{izv}).

For each constraint, o_i (0< i <j) equals:

$$\left\{\begin{array}{ll} 1-\frac{o_{i,real}}{o_{i,izv}}, & ako\ je\ 0 < o_{i,real} < o_{i,pov} \\ \left(1-\frac{o_{i,real}}{o_{i,izv}}\right)\cdot\left(1-\frac{o_{i,real}-o_{i,pov}}{o_{i,izv}-o_{i,pov}}\right), & ako\ je\ o_{i,pov} < o_{i,real} < o_{i,izv} \\ 0, & ako\ je\ o_{i,real} > o_{i,izv} \\ 1, & ako\ je\ o_{i,real} \leq 0 \end{array}\right\}, \quad (1)$$

where

f_{oi} – The change approval factor for specific constraint

f_{ki} – The correction factor due to affordability constraints

$$f_{ki} = \left(1-\frac{o_{i,real}-o_{i,pov}}{o_{i,izv}-o_{i,pov}}\right), \quad (2)$$

$o_{i,real}$ – The requested change effect value on the project dimension and unit of constraint measurement

$o_{i,izv}$ – The feasibility threshold of constraint o_i on the project

$o_{i,pov}$ – The threshold of reasonability of constraint o_i on the project

$o_{i,real} \leq 0$ if the change influences the planned constraint such that its effect is even more positive that the constraint is in the initial execution plan (i.e. for the given constraint, change is positive, e.g. when a change requires the replacement of one activity with another that has a more favourable constraint value than that of the original activity).

Change Sensitivity to the Execution Plan

Change sensitivity to the execution plan is checked by testing the implementation of a change in the plan. As the project progresses, the degree of realization increases, but the possibility for influencing the project decreases (see Figure 1).

Research on changes in construction projects on the planned execution of four large construction projects in the City of Zagreb in the period from, 2004 –, 2009 led to the conclusion that for change management the crucial chain of activities is the longest chain of activities in the network plan (Nahod, 2010). Activities differ from each other in type, method of execution, engagement of resources and in all other areas, which increases the level of diversity in a project. The common diversity of these characteristics on a project leads to frequent "warming up phases", the need for coordination and organizational obstacles. Some activities may then last for a shorter period, but the appearance of changes among them creates the potential risk of additional work and error.

In order to determine the sensitivity of a requested change on the execution plan, it is necessary to determine the activities in the execution plan that will be directly influenced by the change. If the change directly affects more than one activity, the average value of sensitivity is applicable. For the purpose of calculation, an application was made in Visual Basic for MS Project which adds to each non-summary activity the value of its logical order in the network, on the basis of which it automatically calculates the sensitivity of the activity to a change.

The application adds three customized fields to each activity: $\boldsymbol{n_1}$, $\boldsymbol{n_2}$ and $\boldsymbol{n_3}$.

$\boldsymbol{n_{1,t}}$ –a number which indicates the order of observed activity in the network plan, $\boldsymbol{n_1} \in$ N

$\boldsymbol{n_{2,t}}$ –a number which indicates the sensitivity of observed activity to a change, $\boldsymbol{n_2} \in$ R, $0 < \boldsymbol{n_2} < 1$

$\boldsymbol{n_{3,t}}$ – a number which indicates the approval factor for observed activity in respect of the sensitivity of the activity in the plan,
$\boldsymbol{n_3} \in$ R, $0 < \boldsymbol{n_3} < 1$

The application works as follows:

$\boldsymbol{n_{1,t}} = 1$, (3)

(Initially for all non-summary activities)

Let t be the observed activity of the plan and t1 is the preceding activity t.

Then for each t1 (t) activity, calculate:

$$\boldsymbol{n_{1,t} = (n_{1,t1} + 1)\ if\ \begin{Bmatrix} n_{1,t1} \geq n_{1,t} \\ S_{t1} < S_t \end{Bmatrix}}, (4)$$

Where

$\boldsymbol{n_{1,t1}}$– The number which indicates the order of the preceding activity in the network plan, $\boldsymbol{n_1} \in$ N

$\boldsymbol{S_t}$ – The date of commencement of observed activities in the plan

$\boldsymbol{S_{t1}}$ – The date of commencement of the preceding activity in the plan

The procedure of increasing the value of $\boldsymbol{n_1}$ is iteratively repeated until the system has completely stabilized (until $\boldsymbol{n_1}$ is constant for each t activity). At this moment, balance is achieved, which means that the $\boldsymbol{n_1}$ variable contains the order of activities in the series of the network plan.

$n_{1,max} = \boldsymbol{max_{i=1}^{n}}(n_{1,i})$, (5)

where n is the number of activities in the plan

$n_{2,t} = n_{1,t}/n_{1,max})$, (6)

$n_{3,t} = 1 - n_{2,t} = f_{pol,t}$, (7)

$f_{pol,t}$– The change approval factor with respect to the activity sensitivity to which the change relates directly

If $\boldsymbol{t_i}$ (i=1, ..n) are all activities in the plan which are directly related to the observed change, then the following is valid:

$\mathbf{f_{pol}} = \frac{\sum_{i=1}^{n} \mathbf{f_{pol,i}}}{\mathbf{n}}$, (8)

which means that the impact of the sensitivity of the activity to change is the mean value of sensitivity for all planned activities that are directly related to the change.

TOTAL IMPACT OF CHANGE ON PLANNED EXECUTION

At the end, the approval impact of the change is integrated in respect of its compliance with the objective, the influence of all relevant constraints in the project on the potential approval of the change and the impact of sensitivity.

The final approval factor $\boldsymbol{f_{odo}}$ is:

$\boldsymbol{f_{odo}} = \frac{f_{cilj} + \sum_{i=0}^{j}[(f_{oi} \circ f_{ki}) + f_f] + f_{pol}}{j+2}$, (9)

Where

$\boldsymbol{f_{cilj}}$ –Approval change factor with respect to compliance with the project objectives

$\boldsymbol{f_{oi}}$ –Approval change factor with respect to the impact of the change on constraint

$\boldsymbol{f_{ki}}$ –Correction factor with respect to the reasonability of the constraint

$\boldsymbol{f_{f}}$ –Correction factor with respect to the flexibility of the constraints, $\boldsymbol{f_f} \leq 0.15$

$\boldsymbol{f_{pol}}$ –Approval change factor with respect to the sensitivity of activity to change

j –number of constraints in a project to be taken into account in the calculation

The value of the approval factor can be interpreted as follows:

$\boldsymbol{f_{odo}} > 0.5$ ... the change is acceptable according to the customized DPM

$\boldsymbol{f_{odo}} \leq 0.5$ ... the change is not acceptable according to the customized DPM

CONCLUSIONS

The customized DPM method is originally provided by DPM and readiness of construction industry in Croatia. It's practical and comprehensive tool for objective decision making in change approval process. The effects of changes are therefore quantified by the impact on project objectives, constraints and compliance to initial project execution plan. Proposed model could be implemented in construction projects in the phase of execution. If the change requests and approval would be recorded, the simple analysis of concerned items would give direct proof and validation of it, as it has been done on 4 mentioned projects in Croatia.

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