

Integrated System of Deadlines and Costs Earned Value Management Methodology

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ABSTRACT AND KEYWORDS

The civil construction industry faces a very competitive scenario nowadays and it is crucial to improve the efficiency of the current working methods in order to achieve with success the main demands that have been becoming increasingly higher in the past few years. The existent methods are already able to plan the future activities during the execution stage of the project, based on the amount of data collected before the beginning of its execution. However, they are not totally prepared to face the new demands of the current practices and they still present weaknesses in what concerns monitoring the project.

The model that will be presented in this paper is based on the integration of time and costs in the Masterplan and the application of the Earned Value Management technique as the main support to create a bigger and more reliable amount of data to be used by the project manager as a basis to the decisions taken during the project execution.

The ability to collect, process and to provide all the data that emerges during the execution of the project and that wasn't available during its planning stage is crucial to achieve better results and to take decisions that can lead the project to the right way. The inclusion of this new amount of data in the Masterplan of the project and the possibility to take decisions based in quantitative and strong pointers that effectively represents the real state of the project along its execution are the main goals to be achieved with the model proposed in this paper.

This study was conducted with the support of the *Soares da Costa* Company in order to implement a group of innovations that can be progressively integrated with the already existent methods without demanding drastic ruptures or requiring a big increase in the amount of investment for data acquiring. It is expected that the proposed model can be applied to any company or project in general. In order to achieve that goal and assure a smooth change, the development of the model was based in three different case studies currently in execution and one of them was posteriorly used to validate it.

The application of the model to the case study allowed the analysis of the new data input of this model and to take some conclusions from this case in particular.

Keywords: Project, Project Management, Earned Value Management, Life Cycle of the Project, Work Breakdown Structure and Baseline.

1. INTRODUCTION

The attention given by the society to the Project Management subject has been gaining increasingly more importance nowadays. Particularly in the world of civil engineering, the establishment of costs and deadlines for the projects is crucial for the success of projects. However, equally important is to monitor and assure that it develops according to what was previously established.

The changes in the current practices in the past few years and the increasing demand to guarantee that the project develops according to what was previously established, especially in what concerns time and cost, justifies the emerging of new methods to support project management. It is expected that those methods are capable of measuring in a quantitative way the evolution of the project and to serve as a base to the corrective measures applied to reorganise it, according to the new additional data not previously available.

The model proposed in this paper follows the study of the main techniques already existent and their development throughout the years and, at the same time, try to present a solution to the expectations mentioned above. In this way, this model is especially directed to the monitoring stage of medium sized projects in the civil engineering context in Portugal and not so much their planning stage. Moreover, its range of application targets specially projects with a large percentage of subcontractors involved in their execution, although not in an exclusive way.

Summarizing, the proposed model integrates time and costs of a project and proceeds to the analysis of both factors together, through its execution stage. It is a management system that is based in the utilization of the software *MS Office Project* and the application of the Earned Value Management methodology which is able to provide quantitative pointers about the state of the project.

One of the premises in the development of this model was that it should be easily implemented and applied in whatever company in the civil industry, without implying a radical change in the common practices and according to the data collecting processes already used. Considering this, three cases that are currently under development were studied and the general practices at the *Soares da Costa* Company were analysed. This study also helped to improve the proposed model by testing different possibilities and to identify the main needs of the practices that are used nowadays.

The work presented in this paper is organised in the following way:

- **1 Introduction:** includes a description about the main goals and reasons that were the basis of this work
- **2 State of Knowledge:** bibliographic research and related analysis, including the main methods developed through the years and a group of good management practices.
- **3 Case Studies:** brief description of the current methods already implemented in the company and especially the analysis of three cases currently in execution
- **4 Proposed System:** description of the management system of time and cost using *MS Office Project* and especially for the monitoring stage of Projects
- **5 Validation of the Proposed System:** application of the proposed model to one of the case studies, in order to validate its main innovations and to analyse the results obtained, when compared with the current methodology
- **6 Conclusions:** evaluation of the work performed, including the analysis of the final results when compared with the goals initially defined, the contribution of the study for the field in question, the research limitations and the identification of possible works in the future.

Research methodology

The study required to fulfil the needs of the present paper was conducted with the cooperation of *Soares da Costa* and lasted for approximately 8 months. During that period, the monitoring of a case study was closely followed as a complement of the bibliographic

research, demanded to learn the basic concepts and the essential bases necessary to develop a paper of this nature.

This paper can be divided in four main phases:

- Bibliographic research and presentation of the most important methods developed along the years, including a critical analysis about its evolution
- Gathering information, by conducting interviews and studying different cases, about the current main practices and demands which are supposed to be the foundations for developing a new model
- Development of the model, based on the data collected and integrating the set of innovations proposed, avoiding abrupt changes in the current processes.
- Validating the proposed model with the data of one of the case studied which had already been used during its development

2. BACKGROUND THEORY

State of Knowledge

The study of Project Management, according to the concept as it is nowadays understood, just appeared in the second half of the XX century, developing from different social sources and using various techniques or software support.

Frederick Taylor and Henry Gantt are considered the main pioneers of the scientific approach to this area of knowledge. The most famous techniques used nowadays are based on the main tools developed by these two authors, as for example the Gantt chart in 1910. They have given a big contribution for the increasing notoriety of this area, becoming a subject that needed further study and research. The emerging of bigger and more complex projects consequently increased the necessity and the demand of more support methods. However, it was only with the emergence and standardisation of the first computers that these techniques really boomed and could start facing the ever demanding organisational structures.

In the middle of the XX century appeared a new algorithm that is used as a support for scheduling the project's activities. It is called Critical Path Method and rapidly became the most used method, followed by Project Evaluation Review Technique, another method based in CPM, but that consider a probabilistic duration for the activities, thus providing a wider and more realistic projection of what may potentially happen, unlike the first one that considers deterministic durations.

The foundation of the Project Management Institute in 1969 and the release of the PMBOK guide, its biggest publication, were very important to unify the already existent guidelines for Project Management.

Main Methodologies

Throughout the years many methodologies have tried to achieve a more realistic approach and to find the best Time-Cost combination for the Project in general, including all the activities.

The first models aimed to achieve a better approximation to reality and to coordinate all the activities by trying to find the best correlation between the different aspects and therefore also trying to achieve the best final combination, in what concerns the time/cost trade-off.

The methods that were developed till nowadays can be grouped in three different categories: accurate, approximated and methods that overcome the basic time-cost relation. The first type of methods was more precise but also required more powerful

computers to run and so approximated methods based on approximations of the reality started to be developed. This new method could still get good results but required much less computational effort than the one inputted in the methods from the previous category. Besides these two types of categories, there are also some methods that overcome the basic time-cost trade-off and contemplate more inputs in order to improve the capacity to represent reality.

Nowadays, it is already possible to get great results using these methodologies and take advantage of the increasing capacity of the new computers. However, the ever-changing working conditions, demands and common practices, require a continual study of this subject so that the search for better results may proceed.

Factors of Success

The study of Project Management, especially when applied to civil construction in particular, has been the target of several studies in recent years, revealing the increasing awareness of society in general and especially the main stakeholders of its importance to achieve the goals of the Projects successfully.

It is essential to take into consideration that there are at least four main variables at stake, which are directly related: time, cost, quality and risk. The aim is to reach the best correlation between these four aspects according to what the Owner of the Project has set as the main goals, instead of trying to maximize each one of them individually to its full potential.

The main stakeholders of a project, particularly in the civil engineering and construction field are the project manager, the owner, the contractor, the project designer and the inspection.

The project manager is always a figure of central importance in every project, acting as the connector element between all the intervenients mentioned above. His role is to coordinate the different areas of the project during his lifecycle, managing conflicts, as well as assuring the functionality of the elements as a whole, in order to reach the final goal, which is achieving the realization of the project according with the goals that were initially defined, even if during some periods the different entities may present different priorities. To summarize, the project manager should present the following abilities: the ability to plan, knowledge of construction work, knowledge of commercial management, ability to communicate inside as well as outside the team, the ability to manage the team and the ability to coordinate.

A project can be decomposed into different stages: conception, planning, implementation, monitoring and closing processes. It's important to have in consideration that one should adopt a specific posture according to their particular demands and in order to complete it successfully.

Planning, Implementation and Monitoring the Project

This paper refers to the stages of planning, implementation and monitoring of the project, paying special attention to the last one, as the result of the study of the state of knowledge previously done and according to the main demands that the civil industry has to face nowadays.

Monitoring a project requires mainly the supervision of its scope, cost and schedule, giving that the ability to detect deviations according to what was initially established is definitely a crucial stage. In this way, the use of auxiliary tools or methods able to measure the project

progress in an objective manner, provides quality information that sustains the decision making, so that some measures can be taken beforehand to correct and redirect the project.

The establishment of baselines is the easiest way to analyze and register changes to the project. Nonetheless, the decisions taken during advanced stages must be thought-out due to fact that are usually associated to higher costs and have implication with the work that has already been done. Even taking correctional measures must be something pondered, weighting the advantages and disadvantages of whether one should take these measures or accept and proceed with the deviations.

The cost management is still one of the primary tasks, especially because the profit margin is becoming scarcer by the minute. On the other hand, the delays on the execution of the projects continue to be one of the reasons that may explain the lack of competitive spirit of the civil construction market in Portugal, which brings serious losses to all the stakeholders and unfortunately is still a problem of difficult resolution. Seeing that time and cost are directly related and that the ability to analyze beforehand potential deviations is the best way to prevent future damages, it's advised the use of supporting methods that allow an integrated analysis of these two factors, namely Earned Value Management.

The ability to manage risk and uncertainty is nowadays one of the biggest challenges for project managers. However, it is crucial not to mistake these two concepts and clarify exactly the difference between them, in order to act differently towards each one of them. The study about this problematic was one of the aspects that provided an important contribution to lead this paper in its particular direction. These two phenomena are many times not synonymous: *Uncertainty* can be described as the phenomenon that represents the lack of sufficient data that would sustain a future decision; on the other hand, *Risk* is the described as the range of possibilities that are related to aspects that the decision-maker presumes but cannot predict with accuracy. (Perminova, Gustafsson, & Wikstrom, 2007)

Although both factors are part of a Project, assuming this distinction it is clear that they must be treated differently. For the decisions taken by the Project Manager, it is essential to try to collect as much data as possible in order to decrease the number of factors that constitute or bring uncertainty to the Project, which is to say that is important to take the decisions based on the maximum quantity of data available at a given moment. In what risk is concerned, the ability to deal with it is one of the major characteristics that distinguish a good project manager because facing such a competitive environment it is crucial to assume risks, in order to present competitive proposals but that still represent a positive result to the company.

For all the reasons mentioned above it has been chosen to direct the proposed model to the monitoring stage of a Project. It is a fact that there are already different models that are able to proceed with the planning of the project based on all the maximum data that is possible to obtain at that stage. Therefore, the solution is to continue to develop methods, as the presented in this paper, that collect, process and integrate in the existent plan all the new data input that emerges as the project advances.

Earned Value Management

Earned Value Management is a support technique to project management that enables to analyze time and cost in an objective way, providing pointers on how the project is progressing until the time the evaluation takes place. This technique allows to compare the actual results with the initial projections, as well as to establish future previsions.

It's based on three fundamental concepts:

- Planned Value (Budget Cost of Work Scheduled)
- Earned Value (Budget Cost of Work Performed)
- Actual Cost (Actual Cost of Work Performed)

The application of this method is achieved by relating an initial baseline with the status dates during the execution of the project. Based on the three main concepts referred, this technique provides a group of pointers that may be used to analyse the real state of the project, such as variation pointers, performance pointers and estimations about the future.

3. CASE STUDIES

This paper was conducted with the support of the company *Soares da Costa*. The analysis of its working methods and specifically three case studies that are currently used, served as the basis to develop the proposed model, in order to implement improvements on the already existent process rather than bring radical changes to the working methods. Therefore, there was also an attempt to analyse the common practices implemented by the company in a general way.

In the three case studies, direct and indirect observation were used to analyze the current method for monitoring cost and time, including conducting interviews, analyzing case files and the first hand observation in the field. The main purpose was, on one hand to try to identify the main demands, and on the other hand, also take advantage of the good processes that are already implemented in the company.

The fact that the three case studies were conducted by different teams and different project managers, helped to extrapolate the main conclusions so that the proposed model could be also applied to any similar civil construction companies.

The deadline planning is performed in *MS Office Project*, a fact that allows coordinating the time of all the activities of each project and its schedules, as well as their future monitoring. In what concerns the schedule monitoring it is made on a daily basis, being registered every two weeks in order to update the initial planning.

In what cost is concerned, it is used the *Construction Computer Software* and *MS Office Excel*. These two software are used in all cost related operations, including budgets, rebudgets, comparative analysis between different proposals and monthly cost control.

The three case studies approached in this paper were:

- "*Parque de estacionamento AH2 – Aparthotel Tulipamar*"
- "*Aparthotel Magnoliamar*"
- "*Embasamento Rosamar – Magnoliamar*"

Although the analysis of these three case studies was made, the researcher did most of the field work and followed the development of the project "*Parque de Estacionamento AH2 – Aparthotel Tulipamar*". Due to this fact, this was the case study chosen to create the foundations of the proposed model and so became the target of a more thorough investigation.

Parque de estacionamento AH2 – Aparthotel Tulipamar

This Project is inserted in a touristic enterprise that is currently taking place in Tróia, together with wide range of other projects. It is located on the north border of the peninsula and includes the construction of an underground park, that will be used by the Aparthotel Tulipamar, also currently under requalification. Both projects are coordinated by the same

project management team and share most of the resources. The construction contract establishes a closing date of a 189 days period to complete it, with the starting date on October 10th 2007.

The structure presents two floors that are located underground, with a total area of 2546m² and provides 106 parking spaces reserved for the hotel clients and staff, and the remaining are opened to the general public use.

This project, given its characteristics, is considered to be mainly structural and its execution is divided into two distinct phases. The first includes mainly operations of stability, land flattening and structure and the second the execution of the exterior finishing. In what concerns the plan of the project, it is divided in 161 activities, grouped according to six levels of WBS and organized according to their specifications and their respective subcontractors.

4. PROPOSED MODEL

The model of integrated time and cost management presented in this paper is the result of the research and data analysis referred in the second chapter. This working process was essential to define the aims to achieve and also to determine the aspects that can be improved with the proposed model.

In spite of the fact that we can already find a lot of research done in this area, both at a national and international level, it is considered there is still room to the arise of new perspectives, namely in what concerns the monitoring of the project, integrating time and cost factors. On the other hand, the proposed model is born of the need of keeping the existing methods up-to-date.

The main goals to achieve with this proposed model are the creation of reliable information about the current state of development of the project and making it available to the project manager in advance. It is believed that this increment of information can contribute to increase the efficiency of the project being used as support for the decision making during its execution and accessible to the other stakeholders. The field of application of the model is mainly the monitoring of medium sized projects in the construction civil scenery in Portugal, with a large percentage of the tasks executed by subcontractors; however, it can be easily adapted to other realities without needing substantial changes.

The Earned Value Management is the methodology suggested to be used as the main tool that is able to give quantitative pointers about the real state of the project, serving as a complementary element to the reports processed by the *MS Office Project*. Another advantage of the use of the EVM is that it runs automatically with the proposed software.

At the same time, putting into practice the set of the different steps necessary to run this methodology is already by itself positive, simply because they are good managing habits to start with. Without underestimate the importance of the initial investment for data research, this model is able to integrate the data input that emerges during the execution of the project and wasn't available at the beginning.

The application of the model can be divided into three main stages: inputs, data processing and outputs. Followingly it will be presented the main innovations or characteristics of the proposed model, divided through its three main stages:

Data Input: this stage includes mainly the data collecting and inputting the planned data in the model on the initial baseline, in order to create the required conditions for a more efficient monitoring. Comparing to the existent methods, it includes a new WBS structure, formatting the visual aspect of the software *MS Office Project* in order to use it as the main

tool during the monitoring stage and to use subprojects representing the subcontractors. The integration of time and cost together, despite not being a common practice, may not yet be considered an innovation but represents a crucial step for the proposed model. The changes proposed in this initial stage of the model are not included in its main goals, but are necessary in order to achieve better results and a bigger efficiency in the following stages.

Data Processing: in this stage are included all the processes of monitoring and updating the effective data during the execution of the project, namely the complete physical percentage of the planned tasks and their real costs. In this stage are also included the update of the baselines, according to the changes of the project that emerged during its execution, and time and cost data crossing, in order to apply the EVM methodology and create consistent information about the project.

Data Outputs: The main goal of the model, as it was mentioned before, is the creation of quality data about the project and guarantee that it is available during its execution, through visual reports and quantitative pointers of the project that provides valuable information to the decision making. The information created can also be used to plan more accurately future projects.

It is intended that the model may be generally used in medium size projects in Portugal, in companies that presents similar features as *Soares da Costa*.

5. TEST AND VALIDATION

The proposed model was already developed based on the data acquired at one of the case studies, namely the “*Parque de Estacionamento AH2*”. However, it is considered very important to effectively apply the model to this case study, in order to test if the group of innovations proposed can be efficiently used to a real project and to analyse the results, namely the main pointers and reports represents an asset when compared to the actual methods.

The main conclusions obtained in each stage of its application are followingly presented. It includes a comparison with the current methods and the main problems identified with the respective new solutions proposed, but also the main results for this case study in particular, such as the respective pointers, reports and conclusions.

In what concerns the application of this model to a real case study, despite most of the innovations had already been tested during its process of development, the effective application of the model demonstrated the necessity to improve some aspects and to adopt different options from the ones that were previously chosen.

One of the proposals in the model was the inclusion of subprojects inside the Masterplan. As it was already referred and tested before, it represents an important improvement as far as planning and monitoring are concerned, especially in two different aspects: possibility to adopt different schedules for each one and so to improve the quality of the planned work; and finally to reduce the number of activities needed to represent the project, although this advantage is more related to the new WBS structure also proposed. This option provides a better and easier way to represent the project and, at the same time, it is predicted that in the future it can be used to insert the plan of each subcontractor’s activities separately.

However, the 2007 version of the software *MS Office Project* used was the first one to provide the possibility of using visual reports as a complement to the traditional reports already available in previous versions. Its application during the process of validation of this model demonstrated that this was its main flaw, since that is still not possible to use it when there are more than three subprojects at the same time. The solution chosen to

avoid this limitation was the use of the traditional way to represent the activities and it is expected that future versions of the software will have this problem solved.

About the other innovations proposed, since that most of them has already been tested during the creation of the model, no serious problems have been noticed. However, it is important to say that this proposed method was applied to one case study, which is not enough to consider that it was effectively tested and to consider that all the objectives intended were validated with success.

Finally, in what concerns the results obtained by the application of this model to the case study, the results are negative for both time and cost, with a final deviation of 40 days and with a total cost 200.000€ superior to the planned budget. However, this information would already have been available even if the traditional method was to be used. So, the main point is to measure the amount of information that this new model can bring when compared with the traditional one, especially during the execution of the project. In this way, the main results obtained during this stage are followingly presented and compared with the ones that would have been available by using the traditional methods. Most of the reports and pointers are provided by the application of the EVM technique, which results reflect the interaction between time and cost that was not previously done and it is precisely in this point where the most important changes can be noticed.

The graphic with the two main pointers provided by the application of EVM correlating CPI (Cost Performance Index) and SPI (Schedule Performance Index) represents a fast and practical way to analyse the real state of a project during its execution because it gives a real idea about the correlation between time and costs. At the same time, the evolution of the three main indicators of EVM methodology can also be analysed: BCWS, BCWP and ACWP.

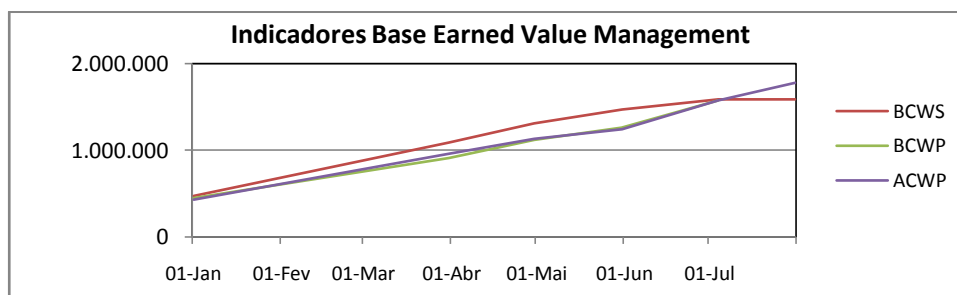


Figure 1 - Evolution of the main indicators of the EVM methodology through the execution of the Project

As it can be seen in this graphic, the real cost of the activities performed until July was always below the budgeted cost, a fact that could induce to conclude that the costs were going perfectly below the expected, if a simple analysis was done without the use of the EVM methodology. In fact, despite the real costs being below than the expected, also the quantity of work performed was below the planned and through the analysis of the real cost of the activities effectively realized, it can be concluded that not only the performance, in what concerns the planned schedule, was under the expectations but also their cost was going higher than planned.

This analysis represents the importance of the integration of time and cost as a basis to take the right decisions, making available to the project manager not only a bigger amount of information but also more reliable and complete.

Briefly, it can be concluded that the proposed model was in general successfully applied and validated. Nonetheless, it is still necessary to be applied and tested in more case studies so that all the main goals initially defined can be totally achieved and validated.

6. CONCLUSIONS

The study of the state of knowledge and the case studies that were analysed, which main conclusions are presented in the chapters 2 and 3 of this paper, allowed to conclude that the monitoring stage of a project is still the one that needs further improvements and the standardization of more support methodologies, as for instance, the application of Earned Value Management. On the other hand, the change of the working habits in the last few years also justifies the adaptation of those methods to the new demands.

In this dissertation it is proposed a model of integrated management of time and costs, based on a conducted study that aims to answer the expectations and needs of the civil engineering companies nowadays. It is considered that the proposed model is able to fulfil the main goals that were defined as the starting point for this paper, using the EVM methodology as the main tool to provide a bigger data input if compared to the one that is currently used, but also a whole set of innovations that are able to help the project manager during the monitoring stage of a project.

Through the analysis of the case study "*Parque de Estacionamento AH2*" which served as the basis to the construction of the model and also used to validate the main options, it was crucial to permit a continued evolution of the current methods without implying a significant rupture or the need to increase the initial investment for data collecting.

Although the main goals that were initially defined to this paper can be considered to be achieved, some limitations have arisen along its development. The application of this model to more case studies and its continuous development are crucial in order to be considered of general application.

Finally, it is also important to say that the study presented in similar papers and the combination of all its main proposals, in what concerns the project management applied to civil construction industry, with the ones presented in this paper may contribute to the continuous development in this field.

Contributions for Knowledge and Industry

This paper presents an analysis of the project management when applied to civil industry of today, introducing a model that aims to give an answer the main needs that were identified.

The proposed model is able to demonstrate the possible use of *MS Office Project* as a working environment during the monitoring stage of a project, presenting a group of innovations that are able to improve the efficiency of projects, by integrating time and cost analysis and using support techniques such as EVM.

Future Works

In order to continue the development of this area, it is suggested as future works:

- To continue to develop methods to support the monitoring stage of Projects and validate them through some different case studies
- To collect the information created on all the recently developed methods and join them in a simple methodology, easy to implement and referred to all the stages of a Project

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