GUIDELINES FOR IMPROVING COST MANAGEMENT IN FAST, COMPLEX AND UNCERTAIN CONSTRUCTION PROJECTS

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ABSTRACT

Existing traditional cost management systems are mostly based on the same principles that have been conceived for cost accounting in the mid Twenties. Cost information is usually produced too late, and it is too aggregated and too distorted to be relevant for production management. Consequently, traditional cost accounting systems often fail to support decision making in product development and production control. Particularly in the construction industry, the inadequacy of cost accounting systems has resulted in the dissociation between cost management and other managerial processes, contributing to increase the fragmentation of construction management. In general, construction cost control consists of simply monitoring actual performance against cost estimates and identifying variances.

This paper discusses traditional cost management practices in the construction industry and proposes some guidelines for improving cost control in fast, complex and uncertain construction projects. Such guidelines involve the integrated application of operational cost estimating, target costing and S-curves.

KEY WORDS

Cost management, cost information, production control.

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INTRODUCTION

Despite the environmental, managerial and technological changes that have occurred in the last thirty years, the existing traditional cost management systems are very similar to the ones that have been used since the mid Twenties (Johnson & Kaplan, 1987). In the face of all those changes, traditional cost account information has become mostly irrelevant and even dangerous for managerial purposes (Ploss, 1990). According to Johnson & Kaplan (1987), traditional management accounting information tends to be too late, too aggregated and too distorted to be relevant for production planning and control.

The failings of the traditional management accounting systems have three important consequences. Firstly, such systems cannot provide accurate product cost. Costs are distributed to products in a simplistic and arbitrary way that usually does not represent the real demand imposed by each product on the company's resources (Johnson & Kaplan, 1987). Secondly, traditional management accounting systems fail to stimulate decisions that can affect the overall production result. Managers are sometimes encouraged to accomplish short-term goals by reducing expenses with training and investment, or even produce to stock. Although effective in short term, such decisions can seriously affect future results (Goldratt and Cox, 1992). Finally, the cost management information provided by the traditional systems is of little help to managers in their effort to improve production performance. The information provided is past-oriented and too aggregated to be useful in planning and control decisions, because these systems are developed mostly to satisfy fiscal and financial needs. The lack of transparency allied with the lack of timeliness prevents the traditional cost information to help in the identification and correction of production flow inefficiencies.

Particularly in the construction industry, the inadequacy of cost accounting systems has resulted in the dissociation between cost management and production management. In general, construction cost control consists basically of monitoring actual performance against cost estimates and identifying variances.

This paper discusses traditional cost management practices in the construction industry and describes the preliminary results of a research project that aims to improve cost management of construction projects, based on the adaptation of some operations management concepts, principles and techniques. Some initial guidelines are proposed, concerned with the integrated application of operational cost estimating, target costing and S-curves. It is focused on fast, complex and uncertain construction projects, which are very common in several segments of the construction industry.

TRADITIONAL COST MANAGEMENT PRACTICES IN THE CONSTRUCTION INDUSTRY

A review of existing literature indicates that the main problems that account for the poor performance of traditional cost management systems are related to flaws in the cost estimating and cost control processes, inadequate information modeling, and the lack of integration of cost management and production management systems (Ostrenga *et al., 1992;* Barnes, 1977; Fine 1982). In addition, there is the fact that the measurements produced by

traditional cost management systems are not linked to the goals set by the business (*i.e.* quality, time, profitability).

Ostrenga *et al.* (1992) argue that cost estimates, in general, are not reliable due to the oversimplifications made when costs are attributed to products and services. By contrast, traditional cost control processes are also criticized because they simply identify variances by monitoring actual performance against cost estimates. Cost projection is usually not taken into consideration (Barnes, 1977).

Moreover, cost information is made available too late, and is too aggregated and too distorted to be relevant for production planning and control. This traditional cost management approach has also been adopted in construction, typically emphasizing the production of external reports, and lacking managerial focus (Howell & Ballard, 1996).

The gap between the information made available by cost management systems and the goals set by the business makes project assessment in relation to strategic goals difficult. However, this kind of analysis is essential in order to reflect the real project dynamics and to signal situations requiring special attention (Ostrenga *et al.,* 1992).

According to Koskela (2000), in the construction industry, traditional management has been identified as ineffective mainly for the fact that it does not take into consideration the nature of the product and the production processes involved, due to the inadequacy of its conceptual base. From the traditional point of view, production is understood solely as the transformation (or conversion) of raw material into products. As a consequence, it is difficult to understand and deal with the peculiar characteristics of construction, such as the inherent uncertainty of this environment and the interdependence of its activities.

Unlike other industries, the product of the construction industry product is one-of-a-kind and most of the production takes place in a haphazard temporary environment, which is vulnerable to weather conditions. As a result, substantial changes may occur during product development and production processes and these pose a risk to the early estimates on which the business case is based (cost estimates, design, contracts, production planning).

Due to the unique characteristics of the product involved, specific information is necessary for each new project. This means that cost management models developed for industries in which processes are repetitive, cannot be easily adapted to construction projects.

Thus, uncertainty, variability, interdependence and complexity play a key role in the construction scenario and the challenge facing management practices is to eliminate or to reduce the impact of these features (Koskela, 2000). Moreover, the uncertainty related to the financial environment must also be considered due to the significant amount of capital required by construction projects (Barbosa and Pimentel, 2001).

COST MANAGEMENT IN CONSTRUCTION

Horngren *et al.* (1990) regards a cost management system is regarded as a framework for project cost information. According to Berliner and Brimson (1998), those systems consist of a set of principles, methods and tools whose main objectives are to estimate costs and to generate information in order to support different managerial decisions during the distinct phases of a project.

Horngren *et al.* (1999) argue that cost management must not be isolated from other managerial functions, and should play a key role in the implementation of the company

strategies. In addition, as a consequence of the peculiarities of the construction environment, cost management systems must be dynamic, proactive and able to support different decision-making processes, as well as to protect the business from the harmful effects of uncertainty.

According to Kim (2002), particularly in the construction industry, cost management systems must include the processes required to ensure that the project is completed within the approved budget. These processes include cost estimating, cost control and cost projection.

In this study, cost management is considered to be a managerial process, which aims to generate information to support decision-making and to stimulate cost reduction, value improvement and continuous improvement in the organization. Cost management systems are understood as being composed of two main processes: cost estimating processes and cost planning and control processes, as presented below.

COST ESTIMATING PROCESS

The objective of a cost estimating process is to estimate the cost of products and processes involved in production. This requires a thorough understanding of the design, contracts and production in order to properly model the consumption of resources by transformation and flow (non-value adding) activities.

In construction, the cost estimating process usually starts by producing a budget, normally at the early phases of the project (CII, 1998). It is a very important cost document throughout the project and it is often part of the project main contract. This initial estimate also serves as a reference for production planning and control.

As project cost estimating is a very complex task due to the inherent uncertainty and variability of construction, the cost control process must provide feedback on the cost estimating process in order to improve the quality of the information available in the cost database that will be used in future cost estimating processes.

COST PLANNING AND CONTROL PROCESSES

After costs have been estimated, the financial performance must be planned and controlled during the production phase by means of a cycle composed by two sub-processes, cost planning and cost control.

Cost planning involves refining the initial cost estimate and generating a project cash flow, based on additional information that is generated along the project, such as the schedule of payments for the main material suppliers and subcontractors, which should be based on production plans. This sub-process may support decision-making in a proactive way, so as to increase the likelihood of achieving the business goals. Examples of such decisions are changes in production plans and contracts, establishment of new contracts, payment negotiations and financial investments.

In addition to cost estimating, this process relies heavily on feedback from the cost control process. Plans have to be changed whenever necessary and situations that need special attention must be highlighted.

The aim of the cost control sub-process is to monitor actual cost performance and identify improvement opportunities, which must be dealt by corrective actions. It should not be

limited to comparing current and estimated performance but be also focused on value generation.

COST MANAGEMENT PROCESSES

Figure 1 illustrates provides an overview of the proposed cost management processes. It indicates that that cost estimating processes uses information from existing cost databases, contracts, design and production plans. On the other hand the information generated by the cost management system supports the design and production planning and control process and should be used to update the cost database. Similarly to production planning and control, cost planning and control is a cyclical process. It uses information from the cost estimating and production control processes to provide feedback to the cost database that will be used in future projects. As contracts, designs and production planning and control are dynamic, cost management systems must assume a pro-active character and be flexible to absorb changes that may occur.

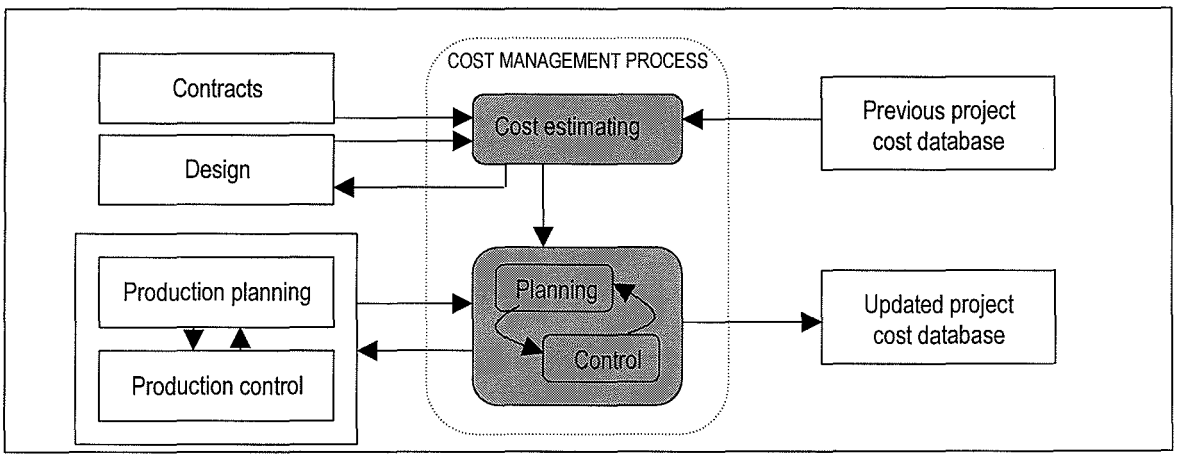


Figure 1 Cost management processes

A PROPOSAL FOR THE INTEGRATED APPLICATION OF COST MANAGEMENT TOOLS

Due to the different processes and distinct objectives found in construction project cost management systems, it can be assumed that different management techniques and tools are necessary. This article suggests changes on the way construction costs are modeled, by introducing an operational approach to cost estimating. This approach aims to enable the cost planning process to properly assess the effects of changes in the production process in the final cost of the project. This kind of approach has already been proposed in previous studies, some of them carried out several decades ago (Skoyles, 1964; Heineck, 1986; Russel *et al.*, 1997), without much success. One of the propositions of this research study is that the use of more robust operations management concepts will provide the necessary support for this approach to become more effective, compared to those previous studies.

This study also proposes the systematic application of target-costing (Cooper, 1995; Csillag, 1995; Maskell, 2003) with the aim of focusing the production planning and control on the business goals while guaranteeing satisfactory levels of performance, quality and profitability.

Finally, S curves are proposed as a both cost and production real time control tool. The S curve tool links several managerial processes, including production planning and control and cost estimating, since it expresses the cash flow projection according to current production plans and cost estimates (Kim and Ballard, 2001; Heineck, 1986; Neale and Neale, 1989; Stallworthy, 1980).

AN OPERATIONAL VIEW OF COST ESTIMATING

Traditional cost estimates are strongly based on the transformation view of production, usually containing activities that are measured according to the quantification of finished elements, *e.g.* walls (m^2), concrete (m^3), windows (units), obtained from design drawings. This approach is strongly based on the standard cost method (Kaplan and Cooper, 1998). As a result of this perspective, flow activities tend to be neglected in cost control. Such activities do not add value to the product but have a high impact on the final cost of the product. Moreover, factors such as production complexity, team productivity and the learning effect are not usually taken into consideration by traditional cost estimating practices for the same reason.

Moreover, in the cost estimating process it is very important to consider the interaction between the duration of the production process and its cost (Kaka, 1991). This means that in addition to direct costs, the final cost of a project also depends on the uncertainty and the interferences to which the project is exposed (Turner, 1993).

This study proposes the simultaneous use of different cost modeling principles, according to the type of resource that is considered. For instance, the standard cost approach may be effective for estimating the cost of some materials, while the cost of labor requires the use of the concepts of operation and process proposed by Shingo (1996). Moreover, fixed costs depend to a great extent on the duration of some construction stages (Barnes, 1977). By keeping the nature of the production process into perspective during the estimating process, for instance, by making flow activities more explicit, it is expected that it will become easier to align production planning and control and cost estimating.

TARGET COSTING

Target costing is widely used as a cost management technique that supports the product development process in companies that claim to have a lean production system (Maskell and Baggaley, 2003). Its main objective consists of reducing the final cost of the product in order to obtain the expected profitability while ensuring satisfactory quality levels (Cooper, 1995).

According to Cooper (1995), target costing can be considered as a structured way of establishing the cost and quality that must be achieved in the development of a product in order to reach the desired profitability. Basically, it requires two main steps. Firstly, the target cost of the product has to be established by subtracting the product's desired profit

margin from its expected selling price. Secondly, the target cost of the product is distributed to its components, materials or systems, depending on the technique chosen.

In this technique, cost is seen as an input and not as an outcome of the design process. By setting target costs based on market-driven selling prices, target costing transmits the cost pressure that is placed on the firm by the marketplace to everyone involved in the process of product design. As it includes this pressure, target costing focuses the creativity of the firm's product designers on developing products that satisfy customers and can be manufactured at their target cost (Cooper and Slagmulder, 1997). Although the emphasis of this technique is mostly in product development during the design process, the concept of reducing cost to ensure the expected profitability can also be applied during the production process, particularly by construction companies that are not in charged of product development as a whole, which is the case of the companies investigated in this study.

S CURVES

Cost control systems must necessarily be integrated to production control systems because of the interaction that exists between production duration and cost (Tucker, 1984; Navon, 1995). Moreover, due to the uncertainties of the construction environment, cost management must be dynamic, flexible and enable real time control, reflecting the impact of the changes that may occur in design, contracts and production in the final project cost (Peer, 1982; Navon, 1986).

In this respect, S curves can be seen as a project control tool that integrates production programming and cost (Kim and Ballard, 2001). According to Heineck (1989), they consist of the integration of cost estimating and production planning, being also named resource aggregation curves. Their main objective is to express the development of the consumption of resources during the production process (Heineck, 1989; Kim and Ballard, 2001). By using this tool, the progress of the project in terms of time and cost can be monitored, allowing users to visualize the cash flow of the project or even to perform cost forecasting (Neale and Neale, 1989; Stallworthy, 1980).

Although S curves do not solve problems concerning limitations in cost process estimates (Bazarra et al., 2000). Neale and Neale (1989) state that this tool can be helpful for construction companies since it shows the development of the project and the amount of capital needed in each period of the production phase according to cost estimating and production planning.

As they are easy to use, several simulations of different scenarios can be performed and visualized by managers. Thus, different economic and financial performance can be evaluated and analyzed, supporting decision-making during the production phase, and contributing for cost control systems to take on a proactive character.

INTEGRATED COST MANAGEMENT TOOLS AND TECHNIQUES IMPLEMENTATION GUIDELINES

Some guidelines involving the integrated application of the techniques and tools suggested in this paper are presented bellow. Those guidelines are based on the results of three case studies undertaken in small sized construction companies from the South of Brazil. Two of

the companies have been involved in low-cost housing, while the third company operates mostly in the industrial and commercial building market.

COST ESTIMATING PROCESS

Regarding its objectives in a cost management system, cost estimating process requires:

- The introduction of an operational view of cost estimating requires the involvement of production management staff in the cost estimating process. In addition, it is also necessary to make available a wide range of information from previous projects, such as time related costs, cost of inventories, and contracts with suppliers.
- The information produced by this process must be clear and understood by all people involved, so that they are able to understand and use cost estimates and the targets that have been established for the project. This requires both graphical and numeric information.
- At the end of the project, cost estimates and the process itself must be assessed by the people involved with the objective of improving future estimating processes. This analysis include a reflection on the cost variances causes, such as, for instance inadequate cost database, uncertainties, estimating mistakes, and design changes.

PLANNING AND CONTROL COST PROCESS

The proposed guidelines for this process involve the use of both S curves and target costing, aiming to plan and control costs during the production phase of a project using short control cycles.

Planning process

- The cost planning process should start before the beginning of the production phase and must be integrated with the cost control process until the end of the project.
- S curves should be produced from cost estimates and production plans, and be updated frequently, for instance every time a new look-ahead plan is produced.
- Several S curves must be produced for the same project, concerning different purposes: cost control, time control, target-costing, financial control. The level of detail may vary depending on the project and the focus of the cost control. In fact, For instance, project cost can be divided into different categories such as: direct and overheads costs; labor and material costs; committed and not committed costs; fixed, time related, quantity related and cost related costs. Some examples are shown in Figures 2, 3 and 4.
- Cash flow can be visualized and simulated by using S curves. Different scenarios can be simulated by changing payments and revenue dates, in order to improve

the cash flow situation for the project. Thus, S curves can support the negotiation of contracts with suppliers in terms of payments, prices or even for production planning changes, if necessary.

Control process

- The control process must be integrated to production planning and control process, and be undertaken in real time.
- The necessary information to compare the actual cost to the planned cost must be available from different departments (or sectors) of the company, including material supply and finance.
- Production planning changes that may impact project costs must be taken into consideration in a proactive way, rather than reactive.
- When the actual project cost is higher than the planned cost, threatening the business profitability, target-costing can be used for lowering production costs to the desired level. This tool may encourage people to be creative in finding new solutions concerning product design, production process and technology, and arrangements with sub-contractors.
- Due to the fact that cost planning and control process is strongly linked with production planning and control, production managers must be in charged of ("own") both processes. They must create a cost management environment, involving people from other departments or sectors, and making indicators and S curves available and visible for everyone.
- Considering the large number of different resources involved in a construction project, more attention should be given to the higher cost resources compared to the lower cost ones. A Pareto diagram is useful for selecting those resources that will be controlled at a more detailed level.

EXAMPLE OF AN INTEGRATED USE OF TOOL AND TECHNIQUES PROPOSED

Table 1 shows an extract of a cost plan, in which an operational view to cost estimating was introduced to some extent. Costs were divided into labor and material cost, and distributed along the project duration according to payments dates, based on contracts and agreements with suppliers.

Table 1 – An example of cost plan

Production planning activities	Activities cost estimates		Target Cost	January		February	
	Labor cost	Material cost		Labor cost	Material cost	Labor cost	Material cost
Pile marking	30.000.000	9.360.000	12.000.000	3.000.000	9.360.000		5.078.000
Formwork foundation beam production	500.000			500.000			
Formwork foundation beam assembly	500.000			500.000			
Steel reinforcement preparation	600.000	3.633.320	4.000.000	600.000	3.633.320		
Steel reinforcement assembly	600.000			600.000			
Foundation beam concrete	600.000	3.164.000		600.000	3.164.000		
Beam formwork removal	200.000			200.000			
Plumbing kit assembly	600.000	3.055.000		600.000	3.055.000		
Internal landfill	300.000			300.000			

Concrete slab	1.500.000		1.200.000	1.500.000			
Ground floor brick wall	3.600.000	4.116.280	7.000.000			3.600.000	4.116.280
Precast slab assembly	1.800.000	1.168.900					1.168.900
Electrical pipes	1.200.000	247.000	1.200.000				247.000
Slab reinforcement	300.000	998.850					998.850

Target-costing was also applied in that project, but only for the building systems that had a higher potential of cost reduction, i.e. foundation, steel reinforcement, plumbing, concrete slab and brick-wall (Table 1). Figure 2 shows an example of S curves, representing costs and revenues, according to cost estimates, production plans and payment dates.

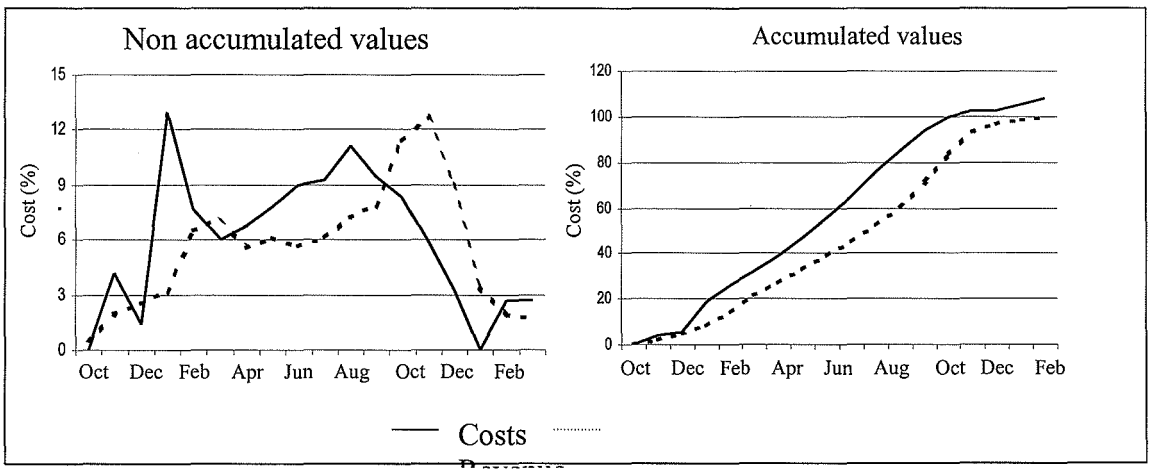


Figure 2 – An example of initial project S Curves

Figure 3 shows updated S curves, based on due to changes that were introduced in the production process, in order to improve the cash flow situation. In these examples, costs are considered as a whole, and compared against the expected project revenue.

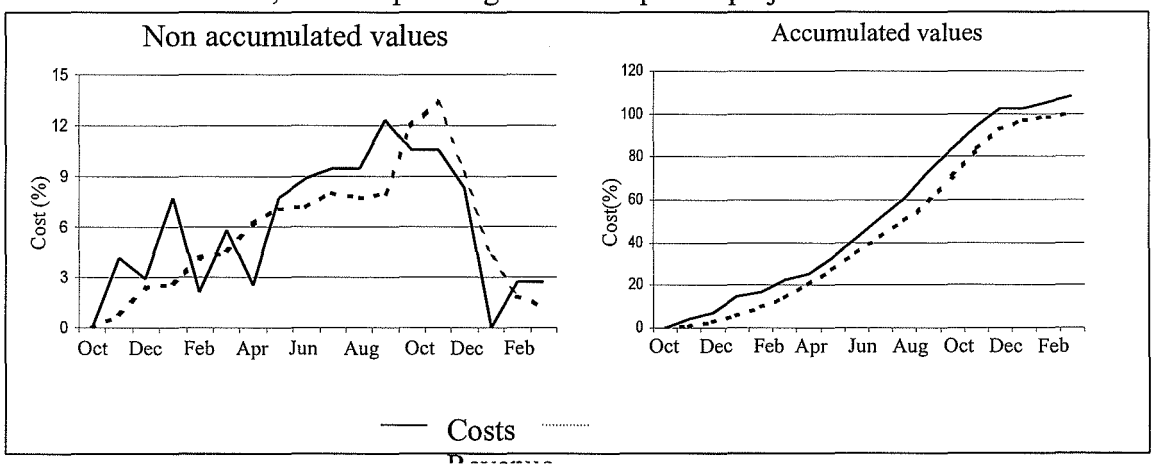
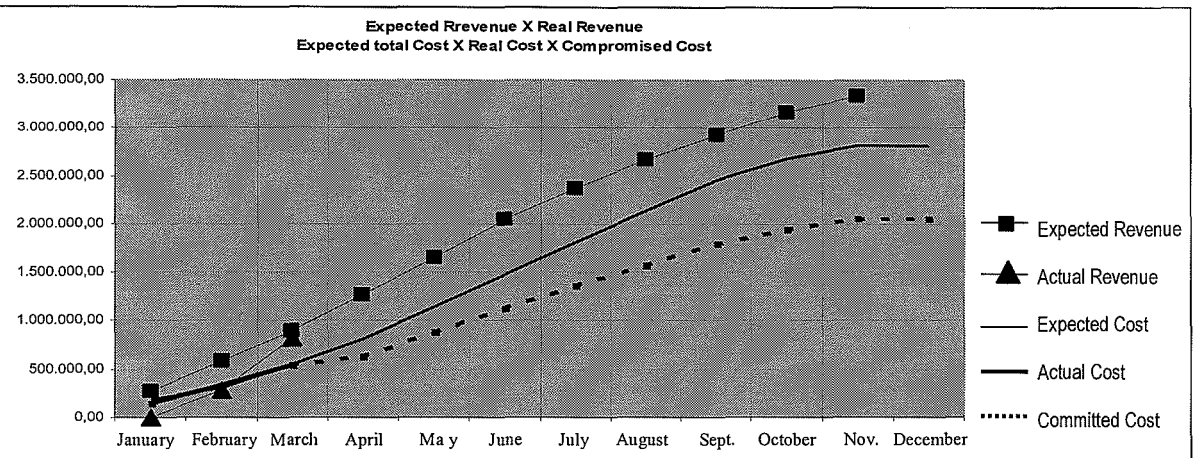


Figure 3 – An example of updated project S curves

Figure 4 shows of S curves developed in another construction firm. In this example, costs are divided in "committed" and "not committed", and than compared to the revenue._The comparison between the expected cost and revenue with the actual cost and revenue are

shown in the same picture, using accumulated values. A table with the numeric values is also presented since it made easier for the managers to make decisions.



	January	February	March	April	May	June	July	August	September
Expected Cost	182.307,28	304.304.53	542.299,72	712.929,74	1.147.001,86	1.471.571,49	1.810.471,18	2.131.482,97	2.451,597,96
Actual Cost	150.041,45	330.590,69	542.388,42						
Committed Cost				639.003,42	882.261,20	1.125.736,49	1.359.749,73	1.575.365,07	1.795.734,61
Expected Revenue	270.341,04	585.126,27	892.225,67	1.262.484,62	1.656.456,41	2.048.777,37	2.375.926,79	2.668.657,01	2.930.978,04
Actual Revenue	0,00	281.642,09	812.967,49						

Figure 4 - An example of S curves showing expected and actual cost and revenue of a project

As shown in Figure 4, the way this company is using S curves allows managers to compare the expected and actual costs and project revenue. Also this tool makes them able to see the amount of resources that are not committed, indicating the items for which it is still possible to negotiate price and payment forms with suppliers. In both firms, S curves are controlled and updated in real time, strongly based on the production control, under the close supervision of the production manager.

CONCLUSIONS

This paper briefly discusses traditional cost management systems used in construction. Based on existing bibliography, the main factors that account for the poor performance of these systems were depicted. It is argued that traditional management has been identified as ineffective mainly for the fact that it does not take into consideration the nature of both the product and the production processes involved, due to the conceptual base on which these are founded.

Thus, an integrated application of operational cost estimating, S curves and target costing has been outlined, aiming to improve cost management in construction. By using this set of tools, it is expected that cost management will become more proactive, and able to deal with the dynamic, uncertain and complex construction environment that exist in many projects. This approach is also expected to encourage people from different departments to get involved in cost management. Due to the unique character of each project, the way in which this set of tool is used may vary considerably.

Besides the utility of the information that is produced, the implementation of these tools can also benefit production management by increasing process transparency, revealing some problems related to the firms organization. The main obstacles to their implementation id the inadequacy of the existing cost database and the ineffective flow of information between different sectors of the company.

Finally, it must be emphasized that cost management ought to be understood as a process, and its implementation requires learning, involvement and commitment from people. Thus, an appropriated management environment is necessary, in which everyone should be working as a team.

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