

THE USE OF EARNED VALUE ANALYSIS (EVA) IN THE COST MANAGEMENT OF CONSTRUCTION PROJECTS

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Keywords: Earned Value, Cost Control, Cost Parameters, Performance Indicators

Abstract:

The objective of this article is to present and discuss the main factors involved in the use of Earned Value Analysis (EVA) in the cost management of civil construction projects. These factors include advantages and disadvantages, difficulties and benefits, problems and solutions and criteria and results based on the experience of a real case study in Brazil.

EVA was applied in the civil construction of an indoors amusement park, named Monica Park, inside the Citta America Shopping Center, in Rio de Janeiro, Brazil. The park has 30 attractions, covers an area of 10,000 square meters was built in 10 months from January to October 2000, for US\$ 5 million.

The case study was is documented with reports, graphs, analyses and comments. A critical review of the application of EVA for the Amusement Park is provided in this paper. It shows that EVA had a relevant role in the integrated management of the project scope, time, progress, cost and risks and the procurement of the main project supplies and services.

EVA contributed to the success of the case study project which finished on time and on budget. The findings of the case study will contribute to the further use of EVA on other projects in Brazil by identifying the main problems and solutions. The case study results are analysed and the article concludes with 10 recommended steps for future implementation of the EVA process.

1. INTRODUCTION

This paper describes how to effectively implement Earned Value Analysis (EVA) on construction projects in Brazil. EVA is a valuable technique to determine real gains and losses on projects and provides a means to balance gains/losses and maximize the gains. EVA is a powerful tool to control simultaneously physical and cost performance. It provides integrated schedule (time), progress and cost management information related to scope and procurement, quality and risks.

Harold Kerzner (1998) considers EVA a relevant maturity differential in project management. Managing costs using EVA is referred to as “managing with open eyes” because the manager can clearly see what was planned, what was performed and the actual costs. This is a powerful tool in the decision making process. In the day-to-day activities of the project manager, EVA provides “alarm” signals and facilitates decisions that keep the project on time and on budget.

Cost management on construction projects includes the planning of budgeted costs and their control. This is related to all the knowledge areas in the project. The actual costs are related with the work performed but the work performed is not often exactly equal to the work scheduled. The solution is the control, measurement and determination of the budgeted cost of the work performed and then compare this to the actual costs. A major difficulty lies in the determination of the proper accounting system to deal with scope changes. The solution is the use of an appropriate Work Breakdown Structure (WBS) and a suitable accounting plan. The solution requires the project manager to be able to distinguish between financial control and cost control.

Kenneth Humphreys (1991) explained that “financial control is concerned with the receipts and expenditures of importance to good bookkeeping and accepted accounting practices. The structure for such accounting must be in accordance with accepted rules of accounting and serve whatever requirements that may relate to contract payment provisions, taxation, regulation, or project capitalization. Financial accounting will also reflect the pricing of a contract which may differ significantly from its costing because of unbalancing and the tracking of indirect accounts such as profits and undistributables. Field construction managers are concerned with costs – what specific operations should cost and what they do cost. Cost control should be approached as an application of Pareto’s law which essentially states that 80 percent of the outcome of a project is determined by 20 percent of the included elements. Thus, in establishing a cost control system, the idea is isolate and control in detail those elements with the greatest potential impact in final cost, with only summary-level control on the remaining elements”.

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2. RESEARCH METHODOLOGY

The research methodology for the study involved the descriptive analysis of a real study case, the Monica Park project.

Case studies can be exploratory, explanatory or descriptive. The research methodology, in this case, comprises a simple descriptive real case study by the authors. The reports from the Monica Park were used to get data for the study. Some tables are reproduced in this article. Case studies are particularly suitable to answer questions like “How?” and “Why?”. They are also useful to elaborate theories where little data is available (YIN, 1994). Case studies allow the researcher to use “controlled opportunism” so that the answers can be achieved as far as new data that is collected (EISENHARDT, 1989). Yin’s approach (1994) for case studies was used in this paper through external validation of the content as the comments and concerns of the participants of the Monica park project have been considered.

As a simple descriptive study case, the replication logic was used verifying the possibility to repeat the EVA process in other construction projects and 10 steps used in the Monica Park project are modelled and provided for future use. Confidentiality is assured in the results and reports provided. All the data, reports, databases, perceptions and concerns were obtained from the participants of the project. They were the primary source of information in this study case in addition to the reports. The data is partially reproduced in this paper.

According to Morra e Friedlander (1999), descriptive cases describe what occurred, why and how, so we can get a clear picture of the actual status. In addition to this methodology, action research was also applied by the authors. Action research is a method which deals with research as well as action (DICK, 1999): action to generate change in an organization or in a community, in order to enhance understanding by the researcher. In this method, according to Checkland and Holwell (1998), the researcher should participate with the action team such as occurred in this case study. In this method, accuracy and relevance are searched. According to West e Stansfield (2001), a method not based in theory can generate questionable results.

The EVA method is already considered relevant by the community of project managers and cost engineers. So, theoretical references related to EVA were researched in order to compare

them with practical results and guarantee value to this real case study through conclusions that compare the action research with the actual theory. So, the simple descriptive case was complemented with action research, as far as the first author participated actively with the project team.

3. EARNED VALUE ANALYSIS (EVA) - BASICS AND CONCEPTS

According to Flemming (1996), EVA originated in the USA Department of Defence from the former Cost/Schedule Control Systems Criteria (C/SCSC). The EVA technique is used in several countries to get better cost and schedule control.

A variety of terminology is used as a descriptor for this approach. These include Earned Value Analysis (EVA), Earned Value Management (EVM), Earned Value Management System (EVMS) and Earned Value Technique (EVT).

The main EVA variables (indicators) are:

BCWS (Budgeted Cost of Work Scheduled) - PV (Planned Value)

BCWP (Budgeted Cost of Work Performed) - EV (Earned Value)

ACWP (Actual Cost of Work Performed) - AC (Actual Cost)

SV (Schedule Variance): $VP = EV - PV$; CV (Cost Variance): $VC = EV - AC$

SPI (Schedule Performance Index): $SPI = PV / EV$; SPI = 1 (project on time)

SPI < 1 (performing less than planned); SPI > 1 (performing more than planned)

CPI (Cost Performance Index): $CPI = EV / AC$; CPI = 1 (project on budget)

CPI < 1 (spending more than planned); CPI > 1 (spending less than planned)

EVA now has an American standard produced by the American National Standard Institute (ANSI) for electronic industry through the standard ANSI-EIA-748-98, (American National Standards Institute/Electronic Industries Alliance – 1998 - Earned Value Management Systems). The use of EVA is guided by 35 criteria stated by the USA Department of Defence. According to DOD/5000-2R, the main EVA processes are: model definition, planning activities, resources and costs in an accounting plan, register of results for financial control, EVA Progress Report elaboration and monitoring/control with actions.

These processes are related with the Project Management (PM) processes (planning, execution and control) according to the following table 1, provided by the Project Management Institute - Practice Standard for Earned Value Management (2003):

EVA processes related with Project Management processes		
PLANNING	EXECUTION	CONTROL
Model Definition	Register of results for financial control	EVA Progress Report elaboration
Planning activities, resources and costs in an accounting plan		Monitoring and Control with actions

Table 1 – EVA processes related with PM processes

These criteria are very important. They shall be read, studied and applied as key procedures to achieve success in the application of EVA.

4. EVA APPLIED TO MONICA AMUSEMENT PARK PROJECT

The Monica Park is an indoor amusement park based on the concept of a Family Entertainment Center (FEC) located at the Citta America Shopping Center, in Rio de Janeiro City, Brazil. The park has 30 attractions with an instantaneous capacity for 1,300 people, a daily capacity of 4,000 people and an annual capacity of 300,000 people. The park has an area of 10,000 square meters, including areas for fast food, special parties and a shop with products related to the theme of Monica, a child book character famous in Brazil. The construction works took 10 months and was completed in 2000.

The construction works were contracted to several suppliers:

- Architecture, Engineering and Construction Consultants;
- Civil construction contractors, erection, assembly and industrial facilities;
- Electronic and eletromechanics equipment manufacturers;
- Construction materials manufactures and resellers;
- Urban equipment manufacturers, including garden equipment;

Thematization is the complex services related to provide the park with thematic elements related to the theme of the park: Monica Park. One of the main suppliers was the company which priveded the thematization of the park, hereinafter called “Thematizer”. The operation of the park was largely implemented through contracts for fast food operators, thematic shop operators, cleaning services, safety services, attraction operations and maintenance.

The success of EVA requires clear responsibilities in each work package. The Monica park project has the following tables showing the responsibility of the main participants (“actors”) in the specific areas of the project: conceptual and detailed design (show below in table 2), planning and control, attractions and thematization, special equipments, civil construction works and pre-operations.

The main participants are identified in the tables by letters O: Owner / M: Manager / C: Contractor (Civil Construction, erection, assembly & facilities) / T: Thematizer / A: Architect.

The code in table means: R = Responsible (Responsability by); A = Approval

Nr.	CONCEPTUAL AND DETAILED DESIGN	O	M	C	T	A
1	Design. conceptual, thematization and specifications	A			R	
2	Design. Architecture detailed compatible with complimentary	A	A			R
3	Monitoring the development of conceptual and detailed design		R		A	
4	Analysis and comments of conceptual and detailed design	A	A		R	
5	Design review after comments from Thematizer	A	A			R
6	Compatibility of conceptual and detailed design	A	A		R	
7	Discussions for approval of detailed design		A		R	
8	Distribution of the detailed design approved for construction		A			R
9	Approval of the detailed design in local authorities		A			R
10	Technical specifications, memorials and supporting details				A	R
11	Maintenance of the Technical File and “as built” documentation		A			R
12	Interfaces between approved design and construction works		A			R

Table 2 – Responsibility Matrix – Conceptual and Detailed Design

According to Humphreys (1993): “the Work BreakDown Structure (WBS) can graphically display the work to be done. The WBS acts as a vehicle for integrating baseline cost and time plan, and, thus, is an aid in relating plans to objectives”. See also AACE standards Nr. 10-S-90, in appendix B.

The Monica Park WBS has the following levels:

- Level 1: Monica Park Project
- Level 2: Physical area of Monica Park;
- Level 3: Services to be done in Monica Park
- Level 4: Work Packages (lowest level).

The reports from the Monica Park EVA Cost/Schedule Control System were obtained from a suitable database of activities, cost and schedule data implemented by the project manager .

The baseline cost for Monica Park civil construction, including erection, assembly, thematization and attractions total approximately US\$ 5 million (in Brazilian currency (reals) R\$ 12.563.452,00).

PARQUE DA MÔNICA - ANÁLISE DO VALOR AGREGADO

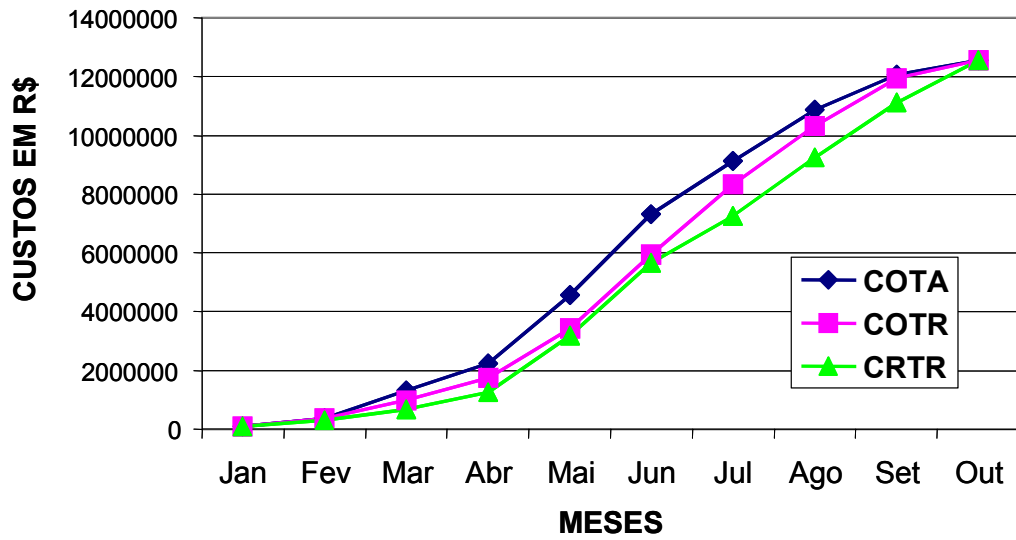


Figure 1 – Monica Park – Earned Value Analysis – PV, EV and AC

Month	Jan-2000	Feb-2000	Mar-2000	Apr-2000	May-2000
BCWS	92.056	370.777	1.304.180	2.230.579	4.549.520
BCWP	92.056	354.873	983.046	1.736.853	3.418.739
ACWP	92.056	304.723	666.667	1.241.629	3.183.890
Month	Jun-2000	July-2000	Aug-2000	Sept-2000	Oct-2000
BCWS	7.314.093	9.139.223	10.876.349	12.083.202	12.563.452
BCWP	5.931.429	8.318.485	10.328.637	11.935.279	12.563.452
ACWP	5.652.853	7.247.690	9.237.411	11.112.156	12.563.452

Table 3 – Monica Park - EVA – Values in R\$ (Brazilian reals)

Following , the EVA indexes SPI and CPI are presented in figure 2, below.

IDP = CPI, IDC = SPI, MESES = MONTHS

**PARQUE DA MÔNICA
INDICADORES DO VALOR AGREGADO**

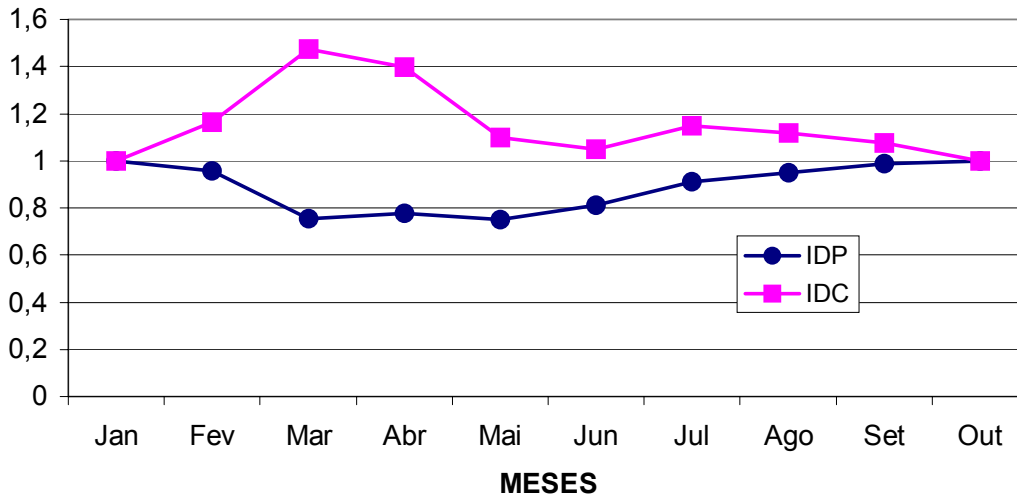


Figure 2 – Monica Park – EVA indexes CPI (IDP) and SPI (IDC)

Mes	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out
SPI	1,00	0,96	0,75	0,78	0,75	0,81	0,91	0,95	0,99	1,00
CPI	1,00	1,16	1,47	1,40	1,10	1,05	1,15	1,12	1,07	1,00

Table 4 – Monica Park – EVA Indexes SPI and CPI – Mes = Month

5. CRITICAL ANALYSIS OF EVA IN MONICA PARK PROJECT

The main objectives with implementing EVA on the Monica Park project were to ensure that the project finished on time and on budget, to educate the project team in the EVA criteria and procedures and training the project team in EVA related software.

<u>without EVA</u>	<u>with EVA</u>
Blind management	Management with open eyes
Cost, time and progress separated	Integrated cost, time and progress
Planned values compared with actual cost	Earned Value Analysis

Table 5 – differences with EVA and without EVA

The main problems of EVA are the cultural change needed in the first implementation, the negative resistance of some people in the project due to the effort to implement, without seeing clearly the benefits. EVA demanded great effort on the Monica park project in order to:

- Plan the Cost/Schedule Control System, database and reporting

- Orient and train the relevant people in the Monica Park project software
- Collect, digitize and analyse consistency of information to database
- Elaborate reports, analyse consistency of results, deal with scope changes;

The main benefits of EVA identified in the Monica Park Case were: integrated cost, progress and time management, better vision of the project in terms of scope and procurement, early alert to problems, foreseeability of project deviation trends, reduced time to perceive and understand problems and solutions, support for negotiations and the decision making process, and the motivation of people to implement the project control process.

6.10 STEPS TO SUCESSFULL EVA IMPLEMENTATION

The findings of the case study have led to the following recommended steps for the successful implementation of EVA:

1. Obtain top level organization commitment with EVA
2. Education and training of the people in the project in EVA
3. Scope well defined, detailed and identified, with proper WBS and packages
4. Schedule and budget organized according to the WBS
5. Clear Project Responsibility Tables, with clear responsibility descriptions
6. Clear flowchart of activities and relationship with the main participants
7. Cost/Schedule Control System with database and data collection procedures
8. Suitable reports related to EVA, well planned, analysed and distributed
9. Procedures to consistency analysis and validation of information
10. Lessons Learned - continuous improvement process

7. CONCLUSION

The main conclusion is that EVA can provide an important contribution to the cost management of construction projects. The case study Monica Park Project was finished on time and on budget.

Some additional findings were made to the ones found in the main EVA literature. EVA is very sensitive for scope changes. This was very clear in the use of EVA in Monica Park. One

perception that reduced difficulties was that the reports allow easy and fast debugging of mistakes. Not only mistakes on digitizing numbers but mistakes in the assumptions related to the measuring criteria. The data base and reporting system provide easy consistency analysis of data. Wrong data was easily detected and corrected. Error detection allowed improved practices and provided support for decision-making processes, as well as, negotiations with suppliers and 3rd parties.

EVA allowed scope change management to keep the final budget of the project within check by providing alternatives to decide in what activities to reduce scope or reduce specifications/performance to save money in order to fit cost overruns in other activities. Another interesting contribution is the perception that the Schedule Performance Index (SPI) is NOT a “time” performance index - it is really a “progress” performance index related only to physical progress. The SPI index deals with the variables planned values (PV) and earned values (EV) expressed in costs, in the vertical axis, but the time is the horizontal axis. Project managers can measure delays on the horizontal axis. We suggest to change the name from the Schedule Performance Index to the Progress Performance Index. It is related to progress, not time.

The Work BreakDown Structure (WBS) is called the “soul” of the management process. It is very important to define a suitable structure for control and the accounting. The work packages must have clear responsibilities and criteria for measurements. Is important to balance greater or smaller packages in order to get better results in the process. Greater or smaller packages do not directly mean better or worse results, regarding precision and effectiveness. Good judgement is necessary to define the level of control and the amount of results to deal with.

The main contribution of the EVA process was the motivation of the project manager and his staff concerning the cost management and the goal to finish the project on budget. The EVA process provided more perception about the costs and their related elements of scope, contracts, performance, suppliers, risks, procurement, communications, quality, people and negotiations. The EVA process provided clearer information about scope issues because the scope was better modelled through the WBS and appropriate account packages.

EVA provides the means for integrated management of schedule, progress and cost based on 3 variables: Planned Value (PV), Earned Value (EV) and Actual Costs (AC) , as well as the related indexes Schedule Performance Index (SPI) and Cost Performance Index (CPI). EVA inspires the participants to pay more attention to costs and progress, motivates the participants to discuss the cost elements with more intensity and optimize the costs resulting in a project that was finished on time and on budget.

The participants of the Monica Park Project are concerned that the charts displaying the SPI, CPI index were of less value than the process itself. The process to determine the indexes identified perceptions and supported the decision making process. The proper application of the criteria were considered more important than the graphs themselves.

REFERENCES

1. Humphreys, Kenneth; Bent, James A., Effective Project Management Through Applied Cost and Schedule Control, Marcel Dekker, Inc, New York, USA, 1996.
2. Humphreys, Kenneth; Wellman, Paul, Basic Cost Engineering., 3rd Ed.,Marcel Dekker Inc, New York, USA, 1996.
3. Humphreys, Kenneth; English, Lloyd M., Project and Cost Engineers HandBook, 3rd Ed.,Marcel Dekker Inc, New York, USA, 1993.
4. Humphreys, Kenneth ; Jelen's Cost and optimization Engineering", 3rd. Edition, MacGraw-Hill Inc., New Yourk, USA, 1991
5. Flemming, Quentin W.; Koppelman, Joel M., Earned Value Project Management, Project Management Institute – PMI, 2nd. Ed., 1999.
6. Flemming, Q. W. Cost / Schedule Control Systems Criteria. The Management Guide to C/SCSC. England: Probus Publishing Company, 1988.
7. Smith, Nigel J., Project Cost Estimating, Ed. Thomas Telford, London, UK, 1995
8. Kerzner, Harold, Project Management, A Systems Approach to Planning, Scheduling and Controlling, Harold Kerzner, 6^a Edição, Van Nostrand Reinhold, 1998.
9. American National Standards Institute/Electronic Industries Alliance (1998). ANSI-EIA-748-98, Earned Value Management Systems. Arlington, VA: Electronic Industries Alliance; USA, 1998
10. PMI - Project Management Institute - Practice Standard for Earned Value Management <http://www.pmi.org>, access in November 15th, 2004.
11. YIN, Robert.; Case Study Research and Design, SAGE Publications, Thousand Oaks, California, USA,1994
12. YOUNG, S. David; O'BYRNE, Stephen F. Eva and value-based management. United States of America: McGraw-Hill Book, New York, USA,2001.
13. DOD/500-2R Department of Defense - Earned Value Management <http://www.acq.osd.mil/pm> – access in November 15th, 2004.
14. CHECKLAND Peter e HOLWELL Sue. “Action Research: Its Nature and Validity”, Systemic Practice and Action Research, 11, 1, 1998, pp.13-16.
15. DICK Robert. What is Action Research, 1999, disponível em <http://www.scu.edu.au/schools/gcm/ar/whatisar.html>, access in July, 29th, 2002.
16. EINSENHARDT Karen M. “Building Theories from Case Study Research”, Academy of Management Review, vol. 14, No. 4, pp. 532-550, 1989.
17. MORRA LINDA G. & FRIEDLANDER AMY C. “CASE STUDY EVALUATIONS”, WORLD BANK OPERATIONS EVALUATION DEPARTMENT, THE WORLD BANK, WASHINGTON D.C., MAY 1999.
18. Earned Value WebSite <http://www.earnedvalue.com>. Access in November 15th, 2004