The Mathematics Behind Project Management
"Earned Value Management"

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TABLE OF CONTENTS

	page
LIST OF ABBREVIATIONS	**3**
LIST OF FIGURES	**4**
ABSTRACT	**5**
1. INTRODUCTION TO PROJECT MANAGEMENT	**6**
1.1. PROJECT MANAGEMENT INSTITUTE	6
1.2. DEFINITION OF PROJECT AND PROJECT MANAGEMENT	6
2. TIME MANAGEMENT	**9**
2.1. NETWORK DIAGRAMS	9
2.2. ACTIVITY DURATION ESTIMATION	10
2.3. CRITICAL PATH METHOD	10
2.4. PERT (PROGRAM EVALUATION AND REVIEW TECHNIQUE)	11
2.5. TECHNIQUES TO COMPRESS PROJECT DURATION	14
3. COST MANAGEMENT	**15**
3.1. BASIC CONCEPTS	15
3.2. COST ESTIMATION AND BUDGETING	15
4. EARNED VALUE MANAGEMENT	**17**
4.1. HISTORY	17
4.2. DEFINITION AND TERMINOLOGY	18
4.3. IMPROVEMENTS ON EARNED VALUE TECHNIQUE	22
CONCLUSION	**24**
REFERENCES	**25**

LIST OF ABBREVIATIONS

PMI	Project Management Institute
WBS	Work Breakdown Structure
PERT	Program Evaluation and Review Technique
O	Optimistic Time
P	Pessimistic Time
M	Most Likely Time
T_E	Expected Time
EVM	Earned Value Management
E_R	Effort
R_I	Resource usage intensity
EV	Earned Value
BCWP	Earned Value
PV	Planned Value
BCWS	Planned Value
AC	Actual Cost
ACWP	Actual Cost
CV	Cost Variance
SV	Schedule Variance
CPI	Cost Performance Index
SPI	Schedule Performance Index
BAC	Budget at Completion
EAC	Estimate at Completion
ETC	Estimate to Complete
VAC	Variance at Completion
TCPI	To-Complete Performance Index
Fs	Schedule Factor
Fc	Cost Factor

LIST OF FIGURES

Figure 1 Project Constraints “Triple Constraint”
Figure 2 Project Management Process Groups
Figure 3 A project WBS example from a banking project
Figure 4 The project activities of a project
Figure 5 Cost Estimation and Budgeting Example
Figure 6 President’s Management Agenda (PMA) Scorecard
Figure 7 Overall program view of EVM data
Figure 8 Illustrative Graphic Performance Report

ABSTRACT

Project Management is an important role in today's flattener organizations. As companies continue to reduce hierarchical levels and move toward more horizontal structures, more people with project management skills are needed. Also, in order to launch the new products on time and in budget, nearly all the important companies use project management skills, to coordinate people from manufacturing to marketing and finance.

On the other hand, related to other management disciplines, modern project management is pretty new. It first started to be used in the USA by government programs in 1950s, but it has been used widely in all sectors beginning from 1990s and it still improves. Today, it is seen that although human skills are important in order to establish the necessary coordination between people and departments, technical skills are equally important to measure the project performance objectively and to take necessary actions. This study concentrates on an important mathematical project management technique "Earned Value Management" in order to highlight these necessary technical skills.

In the first part we give necessary concepts about project management. In the following parts we highlight methods for management of two important project constraints "time" and "cost". "Earned Value Management" technique is highlighted in the final part.

1. INTRODUCTION TO PROJECT MANAGEMENT

1.1. PROJECT MANAGEMENT INSTITUTE

Project Management Institute (PMI) is a not-for-profit professional association, whose goal is to advance the practice, science, and profession of project management throughout the world in order organizations to embrace value and utilize project management and then attribute their success to it.

PMI was founded in 1969 by working project managers. Today the association has 420,000 members and credential holders. In order to ensure a basic project management framework PMI has set 11 global standards and 2 million "A Guide to Project Management Body of Knowledge (PMBOK Guide)" has been issued. (www.pmi.org)

In this study, concept descriptions will be given based on PMI standards and guides in order to maintain a global understanding.

1.2. DEFINITION OF PROJECT AND PROJECT MANAGEMENT

Project is:

- A temporary endeavor with a beginning and an end,
- Creates a unique product, service or result,
- Is progressively elaborated (distinguishing characteristics of each unique project will be progressively detailed as the project is better understood). (Project Management Institute Standards Committee, 2004)

Project Management is the discipline of planning, organizing and managing resources to bring about the successful completion of specific project goals and objectives.

The projects need to be performed and delivered – of course managed- under certain constraints. Traditionally, these constraints have been listed as scope, time and cost. The time constraint refers to the amount of time available to complete a project. The cost constraint refers to the budgeted amount available for the project. The scope constraint refers to what must be done to produce the project's end result.

These are also referred as the “Project Management Triangle”, where each side represents a constraint. One side of the triangle cannot be changed without affecting the others. For example, increased scope typically means increased time and increased cost; a tight time constraint could mean increased costs and reduced scope …

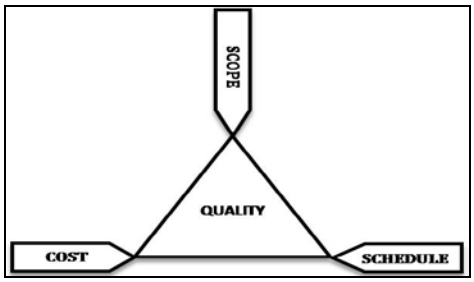


Figure 1: Project Constraints “Triple Constraint”

The Project Management Institute has broadened these traditional three constraints to modern 9 project management knowledge areas as:

1. Scope,
2. Time,
3. Cost,
4. Quality,
5. Human Resources,
6. Communications,
7. Risk,
8. Procurement,
9. Integration. (Project Management Institute Standards Committee, 2004)

For management of projects the process groups below should be followed:

1. Initiating
2. Planning
3. Executing
4. Monitoring and Controlling
5. Closing (Project Management Institute Standards Committee, 2004)

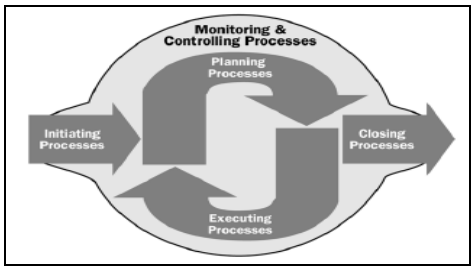
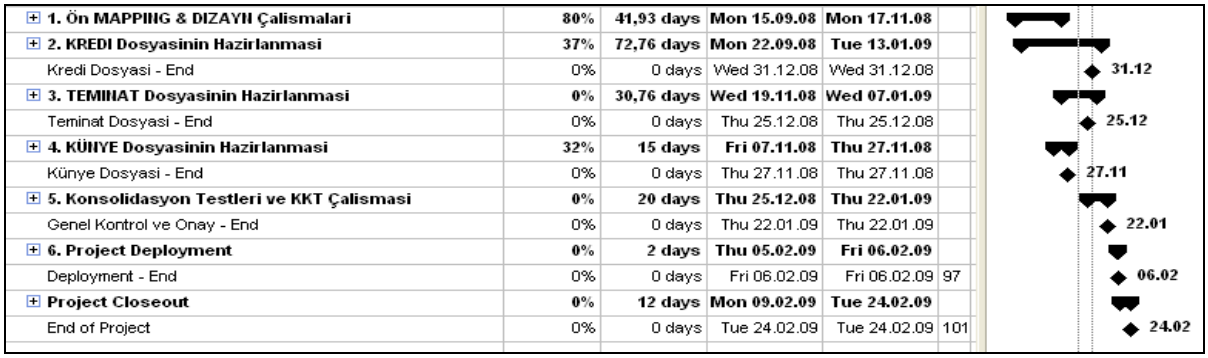


Figure 2: Project Management Process Groups Mapped to Plan-Do-Check-Act Cycle

In order to plan and manage a project, project work should be detailed to manageable parts. The WBS creation process is necessary for subdividing the major project deliverables and project work into smaller, more manageable components.

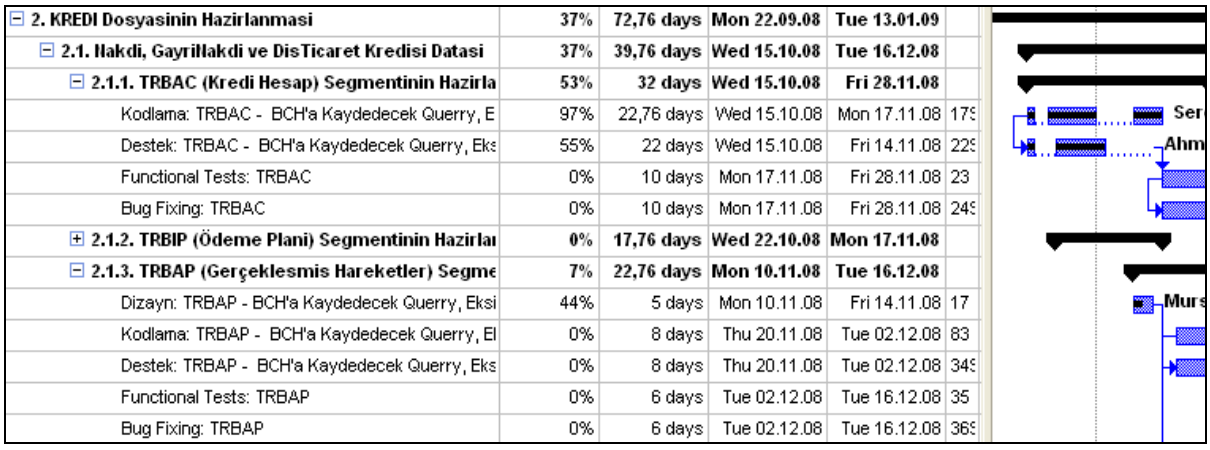
In activity definition, WBS is broken down further (decomposing) in order to reach the activity level; a level small enough to estimate, schedule, monitor and manage. These activities are then sequenced; resource, schedule and cost estimates are made in order. Parallel to these, project manager also makes, quality, human resources, communications, risk management and if necessary contract planning.

This study covers the mathematical concepts used for management of the most important constraints, “time” and “cost”.



1. Ön MAPPING & DIZAYN Çalismalari	**80%**	**41,93 days**	**Mon 15.09.08**	**Mon 17.11.08**	
2. KREDI Dosyasinin Hazirlanmasi	**37%**	**72,76 days**	**Mon 22.09.08**	**Tue 13.01.09**	
Kredi Dosyasi - End	0%	0 days	Wed 31.12.08	Wed 31.12.08	
3. TEMINAT Dosyasinin Hazirlanmasi	**0%**	**30,76 days**	**Wed 19.11.08**	**Wed 07.01.09**	
Teminat Dosyasi - End	0%	0 days	Thu 25.12.08	Thu 25.12.08	
4. KÜNYE Dosyasinin Hazirlanmasi	**32%**	**15 days**	**Fri 07.11.08**	**Thu 27.11.08**	
Künye Dosyasi - End	0%	0 days	Thu 27.11.08	Thu 27.11.08	
5. Konsolidasyon Testleri ve KKT Çalismasi	**0%**	**20 days**	**Thu 25.12.08**	**Thu 22.01.09**	
Genel Kontrol ve Onay - End	0%	0 days	Thu 22.01.09	Thu 22.01.09	
6. Project Deployment	**0%**	**2 days**	**Thu 05.02.09**	**Fri 06.02.09**	
Deployment - End	0%	0 days	Fri 06.02.09	Fri 06.02.09	97
Project Closeout	**0%**	**12 days**	**Mon 09.02.09**	**Tue 24.02.09**	
End of Project	0%	0 days	Tue 24.02.09	Tue 24.02.09	101

Figure 3: A project WBS example from a banking project (MS Project view).



2. KREDI Dosyasinin Hazirlanmasi	**37%**	**72,76 days**	**Mon 22.09.08**	**Tue 13.01.09**	
2.1. Nakdi, GayriNakdi ve DisTicaret Kredisi Datasi	**37%**	**39,76 days**	**Wed 15.10.08**	**Tue 16.12.08**	
2.1.1. TRBAC (Kredi Hesap) Segmentinin Hazirla	**53%**	**32 days**	**Wed 15.10.08**	**Fri 28.11.08**	
Kodlama: TRBAC - BCH'a Kaydedecek Querry, E	97%	22,76 days	Wed 15.10.08	Mon 17.11.08	179
Destek: TRBAC - BCH'a Kaydedecek Querry, Eks	55%	22 days	Wed 15.10.08	Fri 14.11.08	229
Functional Tests: TRBAC	0%	10 days	Mon 17.11.08	Fri 28.11.08	23
Bug Fixing: TRBAC	0%	10 days	Mon 17.11.08	Fri 28.11.08	249
2.1.2. TRBIP (Ödeme Plani) Segmentinin Hazirlar	**0%**	**17,76 days**	**Wed 22.10.08**	**Mon 17.11.08**	
2.1.3. TRBAP (Gerçeklesmis Hareketler) Segme	**7%**	**22,76 days**	**Mon 10.11.08**	**Tue 16.12.08**	
Dizayn: TRBAP - BCH'a Kaydedecek Querry, Eksi	44%	5 days	Mon 10.11.08	Fri 14.11.08	17
Kodlama: TRBAP - BCH'a Kaydedecek Querry, El	0%	8 days	Thu 20.11.08	Tue 02.12.08	83
Destek: TRBAP - BCH'a Kaydedecek Querry, Eks	0%	8 days	Thu 20.11.08	Tue 02.12.08	349
Functional Tests: TRBAP	0%	6 days	Tue 02.12.08	Tue 16.12.08	35
Bug Fixing: TRBAP	0%	6 days	Tue 02.12.08	Tue 16.12.08	369

Figure 4: The project activities of the same project.

2. TIME MANAGEMENT

2.1. NETWORK DIAGRAMS

In activity sequencing process necessary project activities are sequenced based on how the work will be performed. The result is a network diagram (or project schedule network diagram). There are 2 ways to draw network diagrams, "Precedence Diagramming Method" and "Arrow Diagramming Method".

2.1.1. Precedence Diagramming Method (PDM) or Activity-on-Node (AON):

In this method, nodes (or boxes) are used to represent activities, and arrows show activity dependencies as follows:

This type of drawing can have 3 types of dependencies between activities:

Finish-to- start An activity must finish before the successor can start.

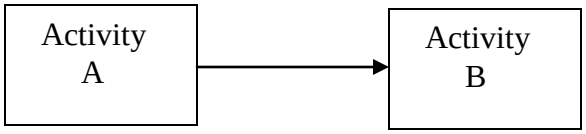
Start-to- start An activity must start before the successor can start.

Finish-to- finish An activity must finish before the successor can finish.(Mulcahy, 2005)

2.1.2. Arrow Diagramming Method (ADM) or Activity-on-Arrow (AOA):

In this method of drawing a network diagram, the arrows are used to represent activities. The nodes (in this case circles) represent activity dependencies. Any activity (arrow) coming into a node is a predecessor to any activity leading the node. This method:

- Uses only finish-to-start relationships between activities.
- May use dummy activities. Dummies are usually represented by a dotted line and are inserted simply to show dependencies between activities. (Mulcahy, 2005)



2.2. ACTIVITY DURATION ESTIMATION

Once activity definitions are made, the amount of time each activity is expected to take is needed. How is the estimating done? These techniques are used:

- **One-Time Estimate:** When estimating using a one-time estimate, one estimate per activity is received. One-time estimates should only be used for projects that do not require a detailed, highly probable schedule.
- **Analogous Estimating:** Analogous estimating is a form of expert judgment. For example: The last 5 projects similar to this one each took 5 months so this one should also**.**
- **Three-Point Estimates:** It is important to understand that statistically there is a very small probability of completing a project on any one date. Therefore, time estimates for an activity or a project must be in a range. In this form of estimating the activity provides an optimistic (O), pessimistic (P) and most likely (M) estimate for each activity. The resulting estimates for an activity will be stated like 7 days plus or minus 2 days, which means that the activity will take anywhere from 5 to 9 days.
- **Reserve Analysis:** It is required project management to accommodate the time and cost risk in a project through the use of reserves. There can be 2 kinds of reserves added: Contingency Reserve and management reserve. Contingency reserve is for the risks remaining after risk response planning. Management reserve is any extra amount of funds to be set aside to cover unforeseen risks. (Mulcahy, 2005)

After duration estimates are made, it is time to make the whole project duration and schedule estimation. In this study, 2 most widely-used methods are covered: “Critical Path” and “PERT” methods.

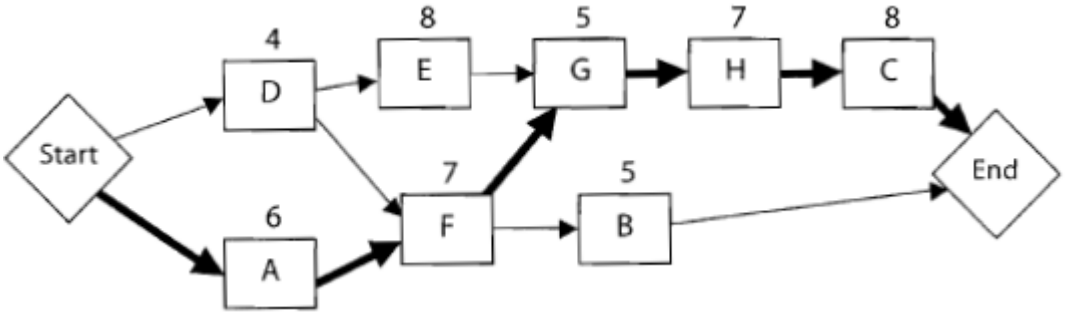
2.3. CRITICAL PATH METHOD:

The critical path method includes determining the longest path in the network diagram (the critical path) and the earliest and latest an activity can start and the earliest and latest it can be completed. An example will be helpful to define this concept:

Example: A project has the activities and durations below:

Activity	Preceding Activity	Estimate in Months
Start		0
D	Start	4
A	Start	6
F	D, A	7
E	D	8
G	F, E	5
B	F	5
H	G	7
C	H	8
End	C, B	0

In order to determine the critical path, network diagram of the project is drawn:



We see that this project has 5 paths and the duration of the critical path is 33 months. As a result the duration of the project is also 33 months. (Mulcahy, 2005)

Paths	Duration
Start, D, E, G, H, C, End	32
Start, D, F, G, H, C, End	31
Start, D, F, B, End	16
Start, A, F, G, H, C, End	33
Start, A, F, B, End	18

2.4. PERT (PROGRAM EVALUATION AND REVIEW TECHNIQUE):

The Program (or Project) Evaluation and Review Technique (PERT) is a method to analyze the involved tasks in completing a given project, especially the time needed to complete each task and identifying the minimum time needed to complete the total

project. It was developed primarily to simplify the planning and scheduling of large and complex projects. In order to find the duration and standard deviation for a project, PERT estimates for each activity on the critical path should be added.

Terminology:

- *Optimistic time* (O): The minimum possible time required to accomplish a task, assuming everything proceeds better than is normally expected.
- *Pessimistic time* (P): The maximum possible time required to accomplish a task, assuming everything goes wrong.
- *Most likely time* (M): The best estimate of the time required to accomplish a task, assuming everything proceeds as normal.
- *Expected time (duration)* (T_E): The best estimate of the time required to accomplish a task, assuming everything proceeds as normal.

Expected completion time (duration) (T_E) = $\frac{(P+4M+O)}{6}$ (1)

Variance of an activity (σ^2) = $\frac{P-O}{6}^2$ (2)

Standard deviation of an activity = $\frac{P-O}{6}$ (3)

- For every activity on the Critical Path, the Expected Completion Time (Duration) and Variance is calculated.
- Next, Expected Completion Times of all activities are added to calculate the Expected Completion Time for the whole project.
- Finally, the corresponding variance for each activity is added to calculate the variance for the overall project. (Mulcahy, 2005)

Example: An IT project consists of 4 activities as analysis, system design, coding and functional testing. The estimates of activities are below. What is the duration of the project?

Activity	O	M	P	Expected Duration	Activity Standard Deviation	Activity Variance	Range of the Estimate
Analysis	14	27	47	28.167	5.50	30.25	22.667 – 33.667 or 28.167 +/- 5.50
Design	41	60	89	61.667	8.00	64.00	53.667 – 69.667 or 61.667 +/- 8.00
Coding	39	44	48	43.833	1.50	2.25	42.333 – 45.333 or 43.833 +/- 5.50
Functional Tests	29	37	52	36.50	2.167	4.694	34.333 – 38.667 or 35.50 +/- 2.167

Calculations for the "analysis" activity:

Expected Completion Time (Duration) = $\frac{14 + 4 * 27 + 47}{6}$ = 28.167

Activity Standard Deviation = $\frac{47-14}{6}$ = 5.5

Activity Variance = $(5.5)^2$ = 30.25

Range of the Estimate for Analysis Activity = 28.167 +/- 5.50 = 22.667 to 33.667

The other activity durations are calculated with the same method and results are above.

Project Duration Calculations:

Expected Project Completion Time = 28.167 + 61.667 + 43.883 + 36.50 = 170.167

Project Variance = 30.25 + 64.00 + 2.25 + 4.694 = 101.194

Project Standard Deviation = 101.94 ^{½} = 10.060

Range of the Project Duration Estimate = 170.167 +/- 10.060 => 160.107 to 180.227

2.5. TECHNIQUES TO COMPRESS PROJECT DURATION:

- Fast Tracking – Doing critical path activities in parallel that are originally planned in series.
- Crashing – Adding or moving resources to critical path activities to decrease their duration.
- Reducing SCOPE
- Cutting Quality

3. COST MANAGEMENT

3.1. BASIC CONCEPTS

Project Cost Management includes the processes involved in planning, estimating, budgeting and controlling costs so that the project can be completed within the approved budget. Cost Management has 3 processes:

- *Cost Estimating*: Developing an approximation of the costs of the resources needed to complete project activities.
- *Cost Budgeting*: Aggregating the estimated costs of individual activities or work packages to establish a cost baseline.
- *Cost Control*: Influencing the factors that create cost variances and controlling changes to the project budget.

A cost can be either variable or fixed:

- *Variable Costs***:** Costs that change with the amount o production or the amount of work. Examples include the cost of material, supplies and wages.
- *Fixed Costs*: Costs that do not change as production changes. Examples include set up, rental, etc.

Also a cost can be either direct or indirect:

- *Direct Costs*: Costs those are directly attributable to the work on the project. Examples are team travel, team wages, recognition and costs of material used on the project.
- *Indirect Costs*: Overhead items or costs incurred for the benefit of more than one project. Examples include taxes, fringe benefits, etc... (Mulcahy, 2005)

3.2. COST ESTIMATION AND BUDGETING

A budget is merely a compilation of the individual cost estimates. Activity costs are rolled up to work package costs. Work package costs are rolled up to control account costs and finally into project costs. This process is called cost aggregation.

Also, the reserves should be added to the project. There can be 2 types of reserves added; management reserve and contingency reserve. Contingency reserve is for the risks remaining after risk response planning. Management reserve is any extra amount of funds to be set aside to cover unforeseen risks or changes to the project. (Mulcahy, 2005)

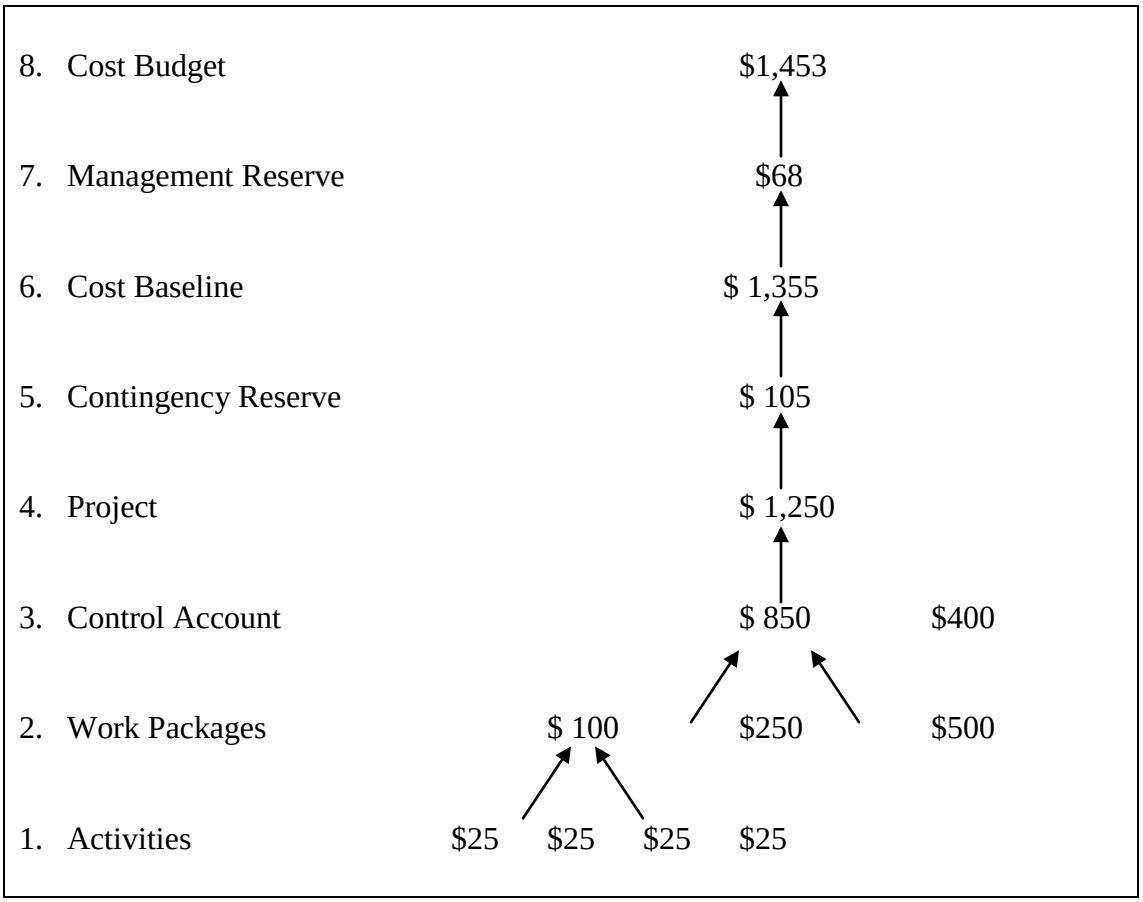


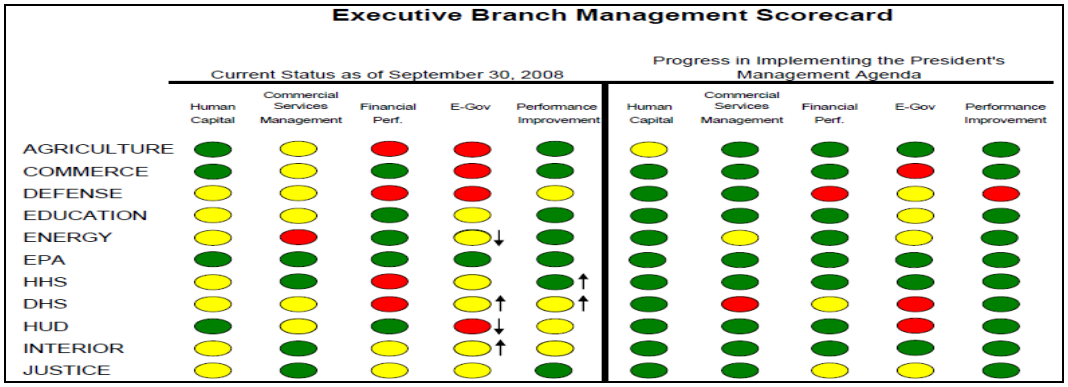
Figure 5: Cost Estimation and Budgeting Example

4. EARNED VALUE MANAGEMENT:

4.1. HISTORY

Earned Value Management (EVM) was born in the United States Department of Defense in the 1960s. However, until the 1980s EVM technique was often ignored or even actively resisted by project managers in both government and industry. In the late 1980s and early 1990s, EVM emerged as a project management methodology to be understood and used by managers and executives. In 1991, Secretary of Defense Dick Cheney canceled the Navy A-12 Avenger II Program due to performance problems detected by EVM. This showed that EVM started to matter to secretary-level leadership.

EVM was not limited to the DoD for long. It was quickly adopted by the National Aeronautics and Space Administration, United States Department of Energy and other technology-related agencies. Also, many industrialized nations also began to utilize EVM in their own procurement programs. Closer integration of EVM with project management profession accelerated in the 1990s. The primary professional association for EVM, called the Performance Management Association merged with the Project Management Institute (PMI). Efforts to simplify and generalize EVM gained momentum in the early 2000s. The United States Office of Management and Budget began to mandate the use of EVM across all government agencies and of course in the industry.
(http://en.wikipedia.org)



Green: Success – Implementation is proceeding according to plans agreed,

Yellow: Mixed Results – Some slippage/other issues requiring adjustment in order to achieve the objectives on timely basis,

Red: Unsatisfactory – Unlikely to realize objectives

Figure 6: President's Management Agenda Scorecard – 30/09/2008 (http://www.whitehouse.gov)

4.2. DEFINITION AND TERMINOLOGY

EVM combines three elements of budget, schedule and scope by using cost as the common exchange medium. Thus, the unit of a project's primary financial currency (e.g. dollars, the Euro, YTL...) becomes the unit for all earned value measures. One can therefore compare different measurements because they have a common basis.

For example, adding labor hours of an attorney and a bulldozer (or bulldozer operator) makes no sense. Earned value avoids this problem by reducing efforts to a common basis – costs – and measuring those costs in a common unit of currency.

To formalize the assumptions underlying earned value following definitions are made:

E_R : Effort,

R_I : Resource usage intensity,

Δt : Duration

$$E_R = R_I . \Delta t \qquad (1)$$

C_R : Cost rate : The units of these cost rates are currency units per unit effort (e.g. dollars per attorney units) and the subscript R reminds us that the cost rate varies with each individual resource. As a result C is the generic cost used in earned value calculations. (Cioffi, 2006)

$$C = E_R . C_R \qquad (2)$$

Related to EVM, the project manager determines the value of a project's fully completed or partially completed efforts in the context of the cost that was budgeted and agreed upon in the project plans. Only when a specified amount of task work is accomplished does a project earn value and the amount of that value is determined by the cost that was budgeted. This budgeted cost of work performed is referred as "earned value". (Project Management Institute Standards Committee, 2004)

Earned Value (EV-BCWP) **:** What is the estimated value of the work actually accomplished?

Planned Value (PV-BCWS) : What is the estimated value of the work planned to be done?

Actual Cost (AC-ACWP) **:** What is the actual cost incurred for the work accomplished?

Cost Variance (CV) $= EV - AC$ (4) (Negative over budget, Positive under budget)

Schedule Variance (SV) $= EV - PV$ (5) (Negative behind, Positive ahead of schedule)

As we see the differences between earned value and the two other costs tell whether a project is on, ahead of, or behind budget or schedule. These differences traditionally are referred as "variances", since the actual project varies from its plans. (http://www.gao.gov)

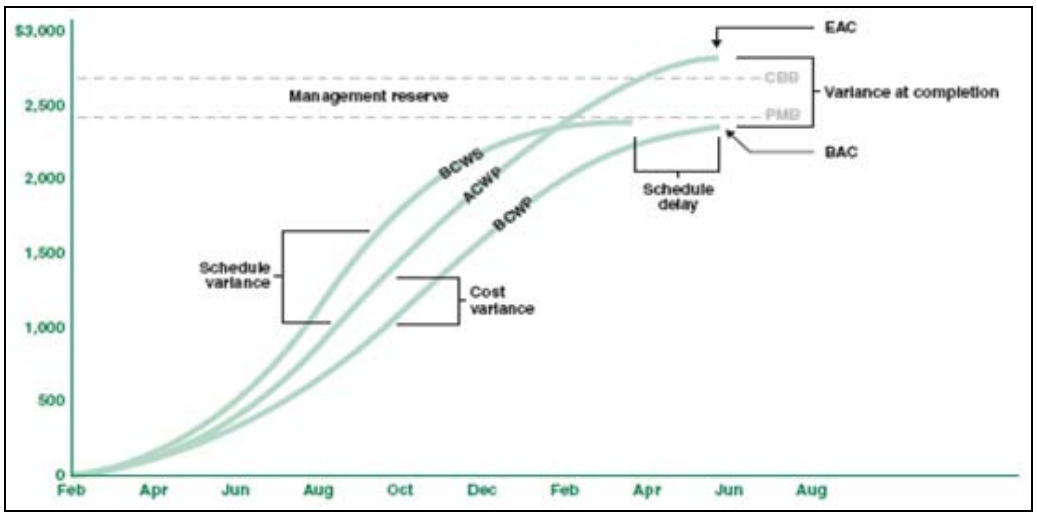


Figure 7: Overall program view of EVM data.

Cost Performance Index (CPI) $= EV / AC$ (6) (Getting X $ work, out of every $1 spent)

Schedule Perf. Index (SPI) $= EV / PV$ (7) (Progressing at X % of rate originally planned) (Lipke, Zwikael, Henderson & Anbari, 2008)

Budget at Completion (BAC) : How much did we BUDGET for the total project effort?

Estimate at Completion (EAC): What do we currently expect the total project cost?

$$EAC = BAC / CPI \quad (8)$$

Estimate to Complete (ETC) : From this point on, how much more do we expect it to cost to finish the project?

$$ETC = EAC - AC \quad (9)$$

Variance at Completion (VAC) : How much over or under budget do we expect to be at the end of the project?(Mulcahy, 2005) $VAC = BAC - EAC$ (10)

To-Complete Performance Index (TCPI) : This index tells management what performance factor must be achieved on the remaining work in order to stay within the financial goals. (Cioffi, 2006)

$$TCPI = \frac{Remaining\ Work}{Funds\ Remaining} = \frac{BAC - EV}{BAC - AC} \quad (11)$$

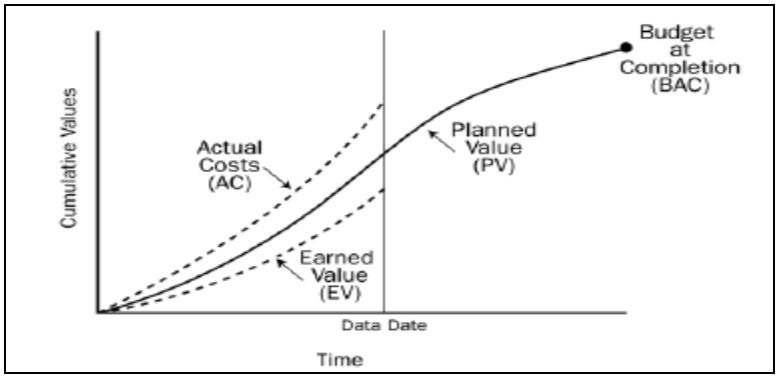


Figure 8: Illustrative Graphic Performance Report (Project Management Institute Standards Committee, 2004)

Example: You have a project to build a new fence. The fence is four sided. Each side is to take 1 day to build and is budgeted $ 1,000 per side. The sides are planned to be completed one after the other. Today is the end of day 3. Using the project status chart below, calculate planned and status values as of today. (Mulcahy, 2005)

Activity	Day 1	Day 2	Day 3	Day 4	Status End of Day 3
Side 1	S …… F				Complete spent $1,000
Side 2		S ……. PF	….F		Complete spent $1,200
Side 3			PS ..S… PF		50% done, spent $600
Side 4				PS …PF	Not yet started

What Is	Solution	Answer	Interpretation
PV	1000 + 1000 + 1000	$ 3000	We should have done $300 worth of work.
EV	1000 + 1000 + 500	$ 2500	We have actually completed $2500 worth of work.
AC	1000 + 1200 + 600	$ 2,800	We have actually spent $2800.
BAC	1000 + 1000 + 1000 + 1000	$ 4,000	Our project budget is $4000.
CV	2500 – 2800	-$300	We are over budget by $300.
CPI	2500 / 2800	0.893	We're getting 89 cents out of every $1 we put into project.
SV	2500 – 3000	-$500	We are behind schedule.
SPI	2500 / 3000	0.833	We're progressing at 83% of rate planned.
EAC	4000 / 0.893	$ 4,479	We estimate that the total project will cost $4,479.
ETC	4,479 – 2,800	$ 1,679	We need to spend $1,679 to finish the project.
VAC	4000 – 4479	-$479	We currently expect to be $479 over budget.

A sector example: Project Performance Monitoring Method of Turkish Bank

Project Duration Variance:

$$\frac{\text{Actual Analysis Duration + Actual Design Duration + Actual Coding Duration + Actual Test Duration}}{\text{Planned Analysis Duration + Planned Design Duration + Planned Coding Duration +Planned Test Duration}} - 1$$

Project Effort Variance:

$$\frac{\text{Actual Analysis Effort + Actual Design Effort + Actual Coding Effort + Actual Test Effort}}{\text{Planned Analysis Effort + Planned Design Effort + Planned Coding Effort + Planned Test Effort}} - 1$$

Project Performance Monitoring:

Project Performance Valuation Related to Duration and Effort Variance

Duration Variance %	
0-1	100
2-5	95
6-10	90
11-15	85
16-20	80
21-25	75
26-35	70
>36	65

Effort Variance %	
0-1	100
2-10	95
11-15	90
16-20	85
21-25	80
26-35	75
36-50	70
>51	65

This project management office aims project variances not to exceed %25.

Project Name	Duration Variance	Effort Variance	Duration Valuation	Effort Valuation
……	11%	58%	85	65
……	8%	0%	90	100
……				
……				
Total	16%	22%	80	80

(9th National Project Management Congress, 2008)

4.3. IMPROVEMENTS ON EARNED VALUE TECHNIQUE

Schedule Factor (Fs) = ***1 / CPI*** = ***AC / EV*** (12)

Cost Factor (Fc) = ***1 / SPI*** = ***PV / EV*** (13)

Both the actual cost and the scheduled cost are compared to the same quantity: the budgeted cost (earned value). Because they have a common denominator, they can be added together directly, suggesting the possibility of a new, combined parameter that examines both cost and schedule together. To see how the health of various projects compares to their original plans, an executive in charge of more than a few projects wants to examine a minimum number of indicators per project. *This can be the cost-schedule performance factor (Φ):*

$$\Phi = Fc + Fs - 1 + [(Fc - Fs)^2 / 2]^{1/2} \quad (14)$$

- The subtraction of 1 allows the combined factor to equal 1, if a factor is both on schedule and on budget.
- The square root of the difference between the factors, squared, adds to the sum so that the effect of one high individual factor cannot be hidden by a low number in the other factor.

For example, if Fc = 3 / 4 and Fs = 4 / 3 => Fc + Fs – 1 = 1 (approximately)
The square root term adds 0.41 so that Φ = 1.5, which highlights quickly the problem waiting to be discovered in the project's schedule.

Some earned value advocates maintain that the product of the standard cost and schedule indices, called the "Critical Ratio", crates a good combined factor, but in the example just provided, that product is 4 / 3 . 3 / 4 = 1. A critical ratio of 1 says everything is proceeding according to plan, but most executives would want to know if one of their projects was 33 % behind schedule (Fs – 1 = 0,33); when glancing down a single column of numbers, Φ = 1.5 would alert them quickly. (Cioffi, 2006)

CONCLUSION

Earned Value Management doesn't used only for the past of a project, but used for the future. If earned value measurements show that a project is 15% behind schedule and no management changes are made (unfortunately, sometimes the case), a project will continue to run at that rate and will finish 15% behind schedule. As a result EVM instrument should start to be used as soon as the project starts in order to complete the project in schedule and budget limits.

On the other hand, EVM has no provision to measure project quality, so it is possible for EVM to indicate a project is under budget, ahead of schedule and scope fully executed, but still have unhappy clients and ultimately unsuccessful results.

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