

Comparison of Project Monitoring and Controlling Methods: Earned value management (EVM) & Earned Duration Management (EDM)

Chitti Babu Kapuganti, Balaji K.V.G.D, T. Santhosh Kumar

Abstract— *Planning, Scheduling, Monitoring and Controlling are four phases of project management. In these four phases, Monitoring and Controlling are two main phases in which any deviation occurs, it will have major effect on scheduled completion date and budgeted cost of the project. Earned value management (EVM) is one of most popularly known and used project monitoring and controlling techniques. As EVM represents the time in terms of budget, some researchers have derived an extensions for that process. Comparison of Earned value management (EVM) and its derivative Earned Duration Management (EDM) with help of case study is presented in this paper.*

Index Terms— *Earned Duration Management, Earned Schedule, Earned Value Management, Project Monitoring and Controlling Methods, Schedule Performance.*

1. INTRODUCTION

The prosperity of any project depends upon 3 major conditions - Budget, Time and Quality. Earned value management (EVM) is one of most popularly used project monitoring and controlling techniques. EVM predicts future performance of the project (completion time and completion budget) based on implementing actions and present trend. In schedule point of view, there are some drawbacks in applying technique. EVM evaluates the schedule in budgetary terms which couldn't represent the perfect situation. To overcome these drawbacks, Earned Duration Management was introduced. In this present study, we compare EVM and EDM with help of a completed residential building project.

II. LITERATURE REVIEW

Traditional EVM was first introduced in 1967 by United States federal government agencies standardize assessment of the project performance. By using traditional EVM, project managers can examine the project progress with the help of cost variance and schedule variance. These variances can suggest managers to enforce any corrective actions required to reach the project objectives beforehand.

EVM requires so much of effort to record, analyze and to implement the corrective actions. But correct implementation

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of EVM gives a fruitful results. Recently, many researchers are working on the extensions of EVM, which will account schedule, quality, resources, scope, safety, inventory, etc.

EVM is very efficient in generating cost performance index but it cannot develop schedule performance index that much compared to cost performance index. In spite of advantages in using EVM, there are some mistakes occur in measuring schedule performance in budgetary terms.

Due to this, at some point of time, Managers will feel that 'they had wrong belief about schedule performance indicators'. From this point of time onwards they cannot depend on these EVM indicators.

Some managers give more importance to cost compared to time. Time is interlinked with cost but, no mathematical relationship defined between them. Time is also as important as cost. So we cannot measure the correct schedule performance index using EVM.

Lipke in 2003 represented that "from the time of the development of the EVM indicators, it has been known that the schedule indicators are flawed and exhibit strange behavior over the final third of the project when performance is poor" and he proposed Earned schedule (ES) concept. It can be considered as a fundamental contribution for EVM's schedule management. This is not a new concept, Paige in 1963, have suggested to separate scheduling aspects from monitory aspects to avoid schedule monitoring errors.

Fleming and Koppelman (2004) stated that "Schedule Performance Index should be used just as a warning mechanism and not as a real tool to analyze how the project is performing with regard to schedule".

In 2014, Homayoun Khamooshi et.al developed a derivative of EVM – "Earned Duration Management". EDM compares the planned duration, actual duration and earned duration. EDM deals mainly with duration aspect, so this method gives more accurate results compared to EVM.

Batselier and Vanhoucke (2015b) evaluated two techniques which integrate activity sensitivity and rework as extensions in EVM time forecasting along with EDM.

Batselier et.al in 2015 have used EVM and EDM in their study and concluded that EDM performed the best. EDM have estimated the completion time of project similar to actual.

III. METHODOLOGY

The PMI (2004) has defined a project as “A temporary endeavor undertaken to create a unique product or service”. Project management consists of four phases: Planning, Scheduling, Monitoring and Controlling.

A. Earned Value Management

Earned Value Management starts in Scheduling phase and continue till completion of project. After completion of project schedule, tracking period of project have to fix based on the duration, budget and sensitivity of project. It may be weekly or fortnightly or monthly or bimonthly, etc.

Based on tracking period, PV – Planned Value for each tracking period is calculated by adding the planned cost of all activities to executed in that period of time. TPV – Total Planned Value is summation of planned values of all tracking periods up to point of time in consideration.

AC – Actual Cost of work is the value actually spent on all activities executed in a tracking period. TAC – Total Actual Cost is cumulative actual cost of all tracking periods up to point of time in consideration.

EV – Earned value represent the planned value corresponding to actual work executed. It is sum of earned values of all activities up to point of time in consideration. Finding Earned Value is the crucial part of EVM process.

To find out EV of an activity, Practice Standard for Earned Value Management (PMI, 2011) have suggested any one of following methods:

1. Percent-Complete(PC)
2. 50/50 method
3. 25/75 method
4. Milestone Method
5. Weighted Milestone method.
6. Physical Measurement

Performance indicators like ES – Earned Schedule, CV – Cost Variation, SV – Schedule Variation, CPI – Cost Performance Index, SPI – Schedule Performance Index and EAC(t) – Estimate at completion for time can be find out using TPV, TAC and EV.

B. Earned Duration Management

Earned Duration Management mainly concentrate on project schedule. EDM also starts in scheduling phase and continue till completion of project. EDM is similar to EVM but only accounts the activities duration. After completion of project schedule, tracking period of project have to fix based on the duration and schedule sensitivity of project. It may be weekly or fortnightly or monthly or bimonthly, etc.

PD – Planned duration is the duration of an activity in a tracking period according to project’s baseline. TPD – Total Planned Duration is summation of all activities up to point of time in consideration.

ADi – Actual Duration of an Activity is the duration taken by an activity to execute the specified work. TAD – Total Actual Duration is the summation of actual duration of all activities.

EDi – Earned Duration of an Activity is planned duration corresponding to actual work executed. Edi can calculated either by percentage-completion or by weighted milestone method or by physical measurement. TED – Total Earned Duration is summation of earned duration of all activities.

ED – Earned Duration at any point of time is the duration corresponding to TED S – Curve. It indicates earned duration of total project at any time.

DV – Duration Variance, DPI – Duration Performance Index, EDI – Earned Duration Index, EDAC – Estimated Duration at completion, EDTC – Estimated Duration to Complete are performance indices can be found out by using TPD, TAD, TED.

IV. CASE STUDY

A Residential building named as “Building a Dream” project completed in September 2013 is considered as a case study in this paper.

Project details are

- Planned Duration: 145 days
- Budget at Completion: 241,015 €
- Total No. of Activities: 33
- Number of Workdays per week: 5

Table – 1 EVM and EDM Formulae

Terminology	Earned value management (EVM)	Earned Duration Management (EDM)
Schedule Variance / Duration Variance	$SV = \text{Earned Schedule} - \text{Actual Time}$	$TDV = TED - TPD$
Schedule Performance Index (T)/ Duration Performance Index	$SPI = \frac{\text{Earned Schedule}}{\text{Actual Time}}$	$DPI = \frac{\text{Earned Duration}}{\text{Total Actual Duration}}$
Cost Variance	$CV = \text{Earned Value} - \text{Actual Cost}$	-
Cost Performance Index	$CPI = \frac{\text{Earned Value}}{\text{Actual Cost}}$	-
Estimated Duration at Completion	$EAC_{(t)} = AT + \frac{BPD - ES}{SPI_{(t)}}$	$EDAC = \frac{BPD}{DPI}$

V.RESULTS

Project Planned Start Date : 04-03-2013
Project Planned End Date : 20-09-2013
Tracking Period : 1 Week

Table – 2: Earned Value Analysis at 14 Weeks

Week	Planned Value (PV) (€)	Actual Cost (AC) (€)	Earned Value (EV) (€)
1	2490.00	2490.00	2490.00
2	3700.00	3700.00	3700.00
3	12566.67	8020.00	7440.19
4	20780.00	22796.67	16009.91
5	39580.00	28663.33	19299.63
6	59380.00	44343.33	32664.18
7	70434.00	57143.33	43362.69
8	75430.00	81347.33	61942.34
9	78630.00	94147.33	69567.87
10	102770.00	101907.33	74342.00
11	112570.00	105107.33	76536.29
12	126860.00	108307.33	78730.57
13	138652.57	132447.33	99318.70
14	145880.00	142247.33	105283.91
15	150088.00		
16	152680.00		
17	152680.00		
18	152680.00		
19	154540.00		
20	156940.00		
21	159340.00		
22	162997.00		
23	165037.00		
24	167917.00		
25	172717.00		
26	191277.00		
27	221408.43		
28	240915.00		
29	241015.00		

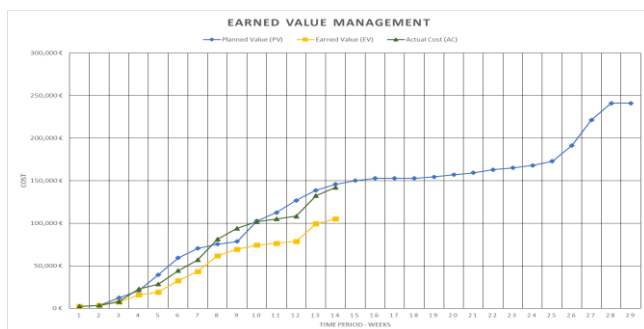


Figure – 1: Earned Value Management at 14 Weeks

Table – 3: EVM – Performance Indices at 14 Weeks

Performance Indices	Value
ES – Earned Schedule	50.256 Days
CV – Cost Variation	(€ 36963.42)
SV – Schedule Variation	(19.744 Days)
CPI – Cost Performance Index	0.740

SPI _t – Schedule Performance Index (T)	0.717
SPI – Schedule Performance Index	0.721
EAC _(t) – Estimate at completion	202.139 Days

Table – 4: Earned Duration Analysis at 14 Weeks

Week	Total Planned Duration (TPD) (Days)	Total Actual Duration (TAD) (Days)	Total Earned Duration (TED) (Days)
1	2	2.25	2
2	7	7	4.76
3	12	12	7.64
4	16.5	20.38	12.44
5	21.5	25.38	15.24
6	26.5	30.38	18.8
7	31.88	35.38	22.98
8	37.13	45.75	29.24
9	42.13	50.5	32.22
10	47.13	55.5	35.43
11	52.13	60.5	38.86
12	57.63	65.5	42.29
13	67.38	70.75	45.37
14	74.38	75.5	48.41
15	79.38		
16	82.38		
17	82.38		
18	82.38		
19	86.63		
20	91.63		
21	96.63		
22	101.63		
23	105.88		
24	110.63		
25	115.63		
26	121.63		
27	128.63		
28	139.63		
29	144.63		



Figure – 2: Earned Duration Management at 14 Weeks

Table – 5: EDM – Performance Indices at 14 Weeks

Performance Indices	Value
ED _t – Earned Duration	50.254 Days
DV – Duration Variance	(25.97 Days)
DPI – Duration Performance Index	0.717
EDI – Earned Duration Index	0.65
EDAC – Estimated Duration at completion	204.23 Days
EDTC – Estimated Duration to Complete	132.23 Days

Table – 6: Earned Value Analysis at 29 Weeks

Week	Planned Value (PV) (€)	Actual Cost (AC) (€)	Earned Value (EV) (€)
1	2490.00	2490.00	2490.00
2	3700.00	3700.00	3700.00
3	12566.67	8020.00	7440.19
4	20780.00	22796.67	16009.91
5	39580.00	28663.33	19299.63
6	59380.00	44343.33	32664.18
7	70434.00	57143.33	43362.69
8	75430.00	81347.33	61942.34
9	78630.00	94147.33	69567.87
10	102770.00	101907.33	74342.00
11	112570.00	105107.33	76536.29
12	126860.00	108307.33	78730.57
13	138652.57	132447.33	99318.70
14	145880.00	142247.33	105283.91
15	150088.00	152047.33	111249.13
16	152680.00	161847.33	117214.35
17	152680.00	179961.91	131140.90
18	152680.00	192499.05	138861.27
19	154540.00	200847.05	145101.89
20	156940.00	207175.05	150056.27
21	159340.00	211175.05	152496.95
22	162997.00	211475.05	152680.00
23	165037.00	211475.05	152680.00
24	167917.00	211475.05	152680.00
25	172717.00	211475.05	152680.00
26	191277.00	214061.72	154856.06
27	221408.43	216461.72	156884.23
28	240915.00	218861.72	158912.40
29	241015.00	222518.72	161898.54

Table – 7: EVM – Performance Indices at 29 Weeks

Performance Indices	Value
ES – Earned Schedule	105.699 Days
CV – Cost Variation	(€ 60620.18)
SV – Schedule Variation	(39.30 Days)
CPI – Cost Performance Index	0.7275
SPI _t – Schedule Performance Index (T)	0.728
SPI – Schedule Performance Index	0.6717
EAC _(t) – Estimate at completion	197.912 Days

Table – 8: Earned Duration Analysis at 29 Weeks

Week	Total Planned Duration (TPD) (Days)	Total Actual Duration (TAD) (Days)	Total Earned Duration (TED) (Days)
1	2	2.25	2.00
2	7	7.00	4.76
3	12	12.00	7.64
4	16.5	20.38	12.44
5	21.5	25.38	15.24
6	26.5	30.38	18.8
7	31.88	35.38	22.98
8	37.13	45.75	29.24
9	42.13	50.50	32.22
10	47.13	55.50	35.43
11	52.13	60.50	38.86
12	57.63	65.50	42.29
13	67.38	70.75	45.37
14	74.38	75.50	48.41
15	79.38	80.50	51.46
16	82.38	85.50	54.50
17	82.38	95.00	60.48
18	82.38	112.88	71.70
19	86.63	120.38	76.18
20	91.63	125.38	79.10
21	96.63	130.38	82.15
22	101.63	130.75	82.38
Week	Total Planned Duration (TPD) (Days)	Total Actual Duration (TAD) (Days)	Total Earned Duration (TED) (Days)
23	105.88	130.75	82.38
24	110.63	130.75	82.38
25	115.63	130.75	82.38
26	121.63	136.38	87.04
27	128.63	141.38	91.26
28	139.63	146.38	95.49
29	144.63	151.38	99.12

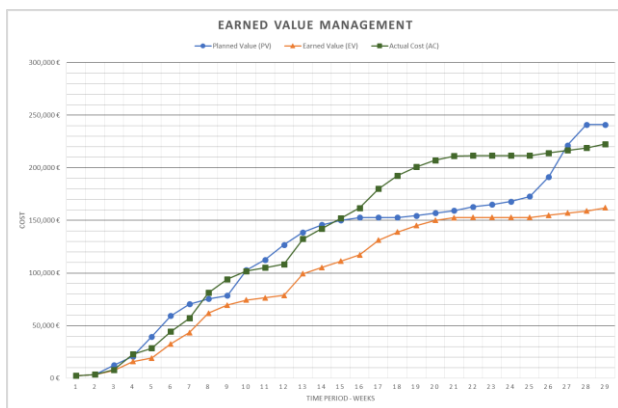


Figure – 3: Earned Duration Management at 29 Weeks

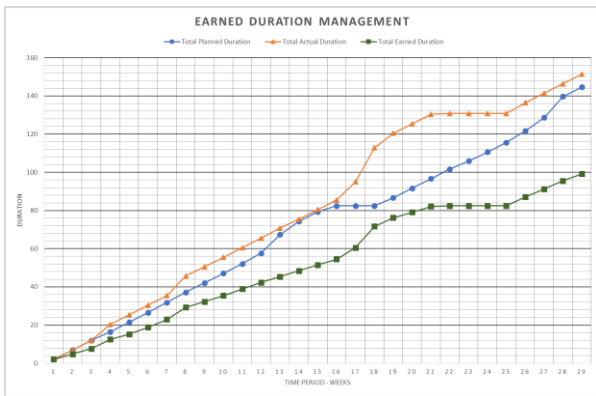


Figure – 4: Earned Duration Management at 29 Weeks

Table – 9: EDM – Performance Indices at 29 Weeks

Performance Indices	Value
ED _t – Earned Duration	105.498 Days
DV – Duration Variance	(45.51 Days)
DPI – Duration Performance Index	0.727
EDI – Earned Duration Index	0.654
EDAC – Estimated Duration at completion	199.29 Days
EDTC – Estimated Duration to Complete	54.29 Days

Table – 10: Earned Value Analysis at 41 Weeks

Week	Planned Value (PV) (€)	Actual Cost (AC) (€)	Earned Value (EV) (€)
1	2490.00	2490.00	2490.00
2	3700.00	3700.00	3700.00
3	12566.67	8020.00	7440.19
4	20780.00	22796.67	16009.91
5	39580.00	28663.33	19299.63
6	59380.00	44343.33	32664.18
7	70434.00	57143.33	43362.69
8	75430.00	81347.33	61942.34
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11	112570.00	105107.33	76536.29
12	126860.00	108307.33	78730.57
13	138652.57	132447.33	99318.70
14	145880.00	142247.33	105283.91
15	150088.00	152047.33	111249.13
16	152680.00	161847.33	117214.35
Week	Planned Value (PV) (€)	Actual Cost (AC) (€)	Earned Value (EV) (€)
17	152680.00	179961.91	131140.90
18	152680.00	192499.05	138861.27
19	154540.00	200847.05	145101.89
20	156940.00	207175.05	150056.27
21	159340.00	211175.05	152496.95
22	162997.00	211475.05	152680.00
23	165037.00	211475.05	152680.00
24	167917.00	211475.05	152680.00
25	172717.00	211475.05	152680.00
26	191277.00	214061.72	154856.06
27	221408.43	216461.72	156884.23
28	240915.00	218861.72	158912.40
29	241015.00	222518.72	161898.54

30	241015.00	224918.72	163129.31
31	241015.00	227318.72	164360.08
32	241015.00	229278.72	165373.84
33	241015.00	231838.72	166721.21
34	241015.00	236246.72	169236.14
35	241015.00	241046.72	171998.73
36	241015.00	245846.72	174761.32
37	241015.00	265726.72	192565.42
38	241015.00	294735.29	221193.36
39	241015.00	298256.14	224415.00
40	241015.00	314756.14	240915.00
41	241015.00	314856.14	241015.00

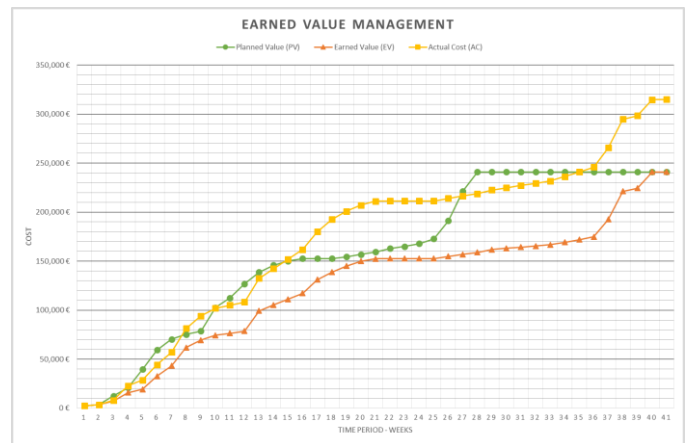


Figure – 5: Earned Duration Management at 41 Weeks

Table – 11: EVM – Performance Indices at 41 Weeks

Performance Indices	Value
ES – Earned Schedule	145 Days
CV – Cost Variation	(€ 73841.14)
SV – Schedule Variation	(60 Days)
CPI – Cost Performance Index	0.765
SPI _t – Schedule Performance Index (T)	0.707
SPI – Schedule Performance Index	1

Table – 12: Earned Duration Analysis at 41 Weeks

Week	Total Planned Duration (TPD) (Days)	Total Actual Duration (TAD) (Days)	Total Earned Duration (TED) (Days)
1	2	2.25	2
2	7	7	4.76
3	12	12	7.64
4	16.5	20.38	12.44
5	21.5	25.38	15.24
6	26.5	30.38	18.8
7	31.88	35.38	22.98
8	37.13	45.75	29.24
9	42.13	50.5	32.22
10	47.13	55.5	35.43
11	52.13	60.5	38.86



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12	57.63	65.5	42.29
13	67.38	70.75	45.37
14	74.38	75.5	48.41
15	79.38	80.5	51.46
16	82.38	85.5	54.5
17	82.38	95	60.48
18	82.38	112.88	71.7
19	86.63	120.38	76.18
20	91.63	125.38	79.1
21	96.63	130.38	82.15
22	101.63	130.75	82.38
23	105.88	130.75	82.38
24	110.63	130.75	82.38
25	115.63	130.75	82.38
26	121.63	136.38	87.04
27	128.63	141.38	91.26
28	139.63	146.38	95.49
29	144.63	151.38	99.12
30	144.63	156.38	101.77
31	144.63	161.38	104.42
32	144.63	165.38	106.54
33	144.63	170.38	109.17
34	144.63	175.38	112.00
35	144.63	180.38	114.88
36	144.63	185.38	117.76
37	144.63	192.13	122.10
38	144.63	202.00	128.45
39	144.63	209.00	134.41
40	144.63	218.25	140.85
41	144.63	223.63	144.63

70 days of actual duration. Schedule variation is less than zero indicates that project is behind schedule. Project completion can be estimated as 202.139 days based on schedule performance index and earned schedule.

At 29 weeks (Planned Completion) earned value is not equal to planned value, which represents project not yet reached its end objectives. As schedule performance index (t) increases from 0.717 to 0.728, estimated project completion decreased from 202.139 days to 198.912 days.

At 41 weeks, earned value is equal to planned value. Project is delayed by 60 days. Project is over budgeted by € 73841.14.

At 14 weeks, earned duration (50.254 days) is less than actual duration (70 days) and Duration Performance index (0.717) is less than one indicates that project behind the schedule.

At 29 (Planned Completion) weeks project is 45.51 days behind the schedule. Duration performance index is 0.727. Estimated duration at completion is 199.29 days.

At 41 weeks, all activities reached their completion duration. Total actual duration (223.63 days) is more than total planned duration (144.63 days) which indicates project is behind the schedule. Earned Duration index at completion of project is 1. At 14 weeks, 29 weeks, 41 weeks Earned schedule from EVM and Earned Duration from EDM are approximately same which can be observed that both methods represent same work in terms of duration.

V. CONCLUSIONS

1) Earned Duration Management gives appropriate time estimates compared to Earned Value Management. So, EDM can be used for controlling schedule sensitive projects.

2) Schedule Performance Index with respective time in EVM and Duration Performance Index in EDM give similar result and indicate the performance of project schedule.

3) Earned duration index is important indicator which represents performance of all activities and the whole project. At completion stage of project earned duration index reaches to 1.

4) At starting stages of project EDM and EVM gives larger estimated duration at completion due to lesser values of performance indices. But in later stages, increase in indices values decreases the estimated duration at completion.

5) As observed in the case study, earned duration (105.498 Days) in EDM and earned schedule (105.699 Days) in EVM are similar. But, duration variance (45.51 Days) in EDM is higher than schedule variance (39.30 Days) in EVM. Larger variance gains more attention from managers which results implementation of best corrective actions.

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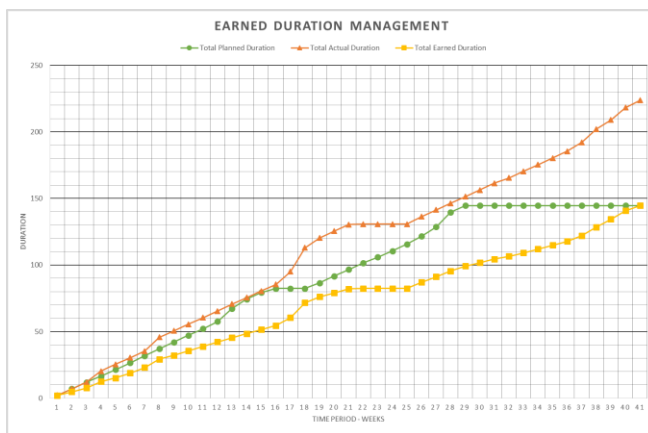


Figure – 6: Earned Duration Management at 41 Weeks

Table – 13: EDM – Performance Indices at 41 Weeks

Performance Indices	Value
ED _t – Earned Duration	145 Days
DV – Duration Variance	(60 Days)
DPI – Duration Performance Index	0.707
EDI – Earned Duration Index	1

Project Actual Start Date : 04-03-2013

Project Actual Completion Date : 13-12-2013

Actual Project Duration : 205 Days

At 14 weeks, Earned schedule is 50.256 days compared to

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