Why EVM Is Not Good for Schedule Performance Analyses
(and how it could be…)

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Abstract

Project performance researchers are unanimous that the conventional EVM (Earned Value Management) is a very good tool to calculate project cost performance. On the other hand, they have much more divergent opinions about the EVM capacity to provide reliable schedule performance indicators. Nevertheless, even though they recognise that the schedule performance indicator – SPI is useless after the planned end of the project, most of them don't question its use and reliability over the first two thirds of the project. My researches show that the schedule performance indicators are not reliable and are essentially erroneous over entire project life cycle for most commercial projects with a non-linear cumulative cost curve.
But, getting the good performance indicators is not enough. In analyzing what to do with EVM results, I propose a new performance indicator which, in my opinion, is very significant for project managers.

The main objective of project performance analysis is to tell as how the project is performing related to three principal project factors: scope (size), cost and time. It has to indicate how our process of product development is performing, are we delivering our product (scope) on time and within planned costs. We are practically measuring the effectiveness of our process by measuring its attributes, efforts (cost) and time [1]. We are measuring how are we delivering the product (instead in product scope, which is often very difficult to measure when the process is in progress, a product is expressed in its other attribute, its value, either planned or earned) comparing to the attributes of process – costs (cost performance analysis) and time (schedule performance analysis)[1].
The fundamentals of EVM are based on this concept. EVM is supposed to indicate how our process (project) is performing by measuring and comparing the costs (actual costs-AC) and the time spent in order to produce a certain amount of a product (earned value-EV). While the EVM works well when calculating cost performance, it is much more different when we talk about schedule performance. Because of that, the cost performance is not a subject of this analysis and the following article is focusing principally on time or schedule performance.

EVM - Schedule Performance

The EVM concept is graphically presented on two-dimension diagram. The planned as well as the earned value of the product is presented as a curve, for which each point is determined by the corresponding points on a vertical (cost) axis and on a horizontal (time) axis.
Cost performance indicators are based on the difference between earned value and actual costs at a given time. All this is projected on a vertical (cost) axis. Following this logic, time (schedule) performance should be calculated by measuring the value of product delivered at a given time (earned value) and by comparing this time to the time when this value was supposed (planned) to be delivered. The difference (called schedule variance) should be presented on a horizontal (time) axis.
But, for some reason, the conventional EVM calculates schedule performance by comparing EV delivered at a given time to the value planned to be delivered at the same time. Instead of calculating and expressing the results as the amount of time and presenting them on a

horizontal (time) axis, the conventional EVM expresses the result as value and presents it on a vertical (cost) axis as we see in Figure 1.

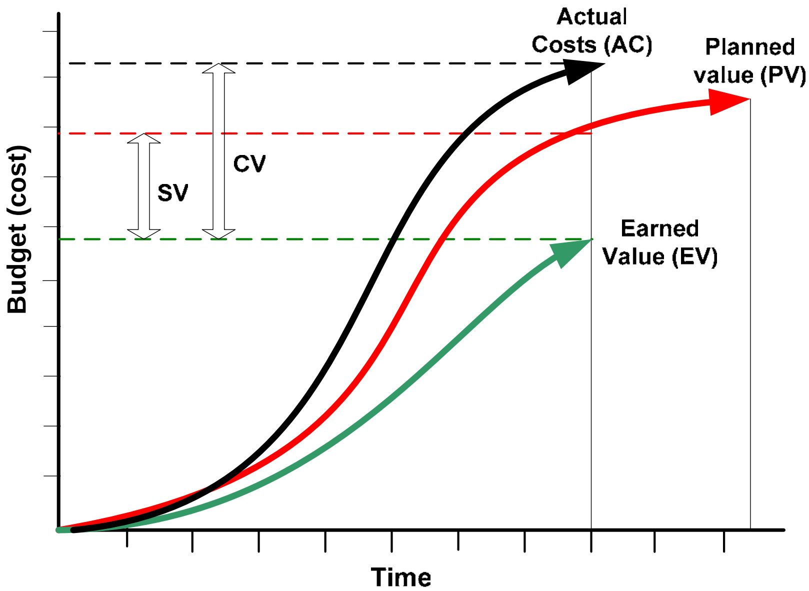

Figure 1 – *Conventional EVM Approach*

This fundamental mistake is not just semantic. It has important implications not just on the unit of measure in which results are expressed (in measure of value instead of measure of time), but more importantly, it influences the schedule performance indicators in a way that make them practically useless and often even misleading.

The first EVM indicator, the schedule variance (SV), is expressed in product value and it is not of a great use for project managers. If you say to a project manager that his project is $500 000 late, you can expect a question: Yes, but how many months or days is it? Classical EVM cannot provide a valid response.

The second EVM indicator, the schedule performance indicator (SPI), is a ratio between EV and PV and at the end of the project, if the project has delivered all what was planned, EV and PV must be equal. This characteristic makes SPI useless after the planned end of the project because it tends to be 1 near to the project end. After the planned end of the project, planned value remains constant while the earned value is supposed to grow until the real end of the project. If your project is planned to be finished in 10 months, for example, and your EV after 10 months is 70%, you are obviously 30 % behind schedule. But, when you continue your project (you have to finish it eventually), and for some reason you do nothing for three months, your schedule performance will remain the same! At the end of the project your EV will be equal to your PV which, according to EVM, means that you have finished your project on time even though you are couple of months late. Great, isn't it? But I don't think that the client will share your enthusiasm.

EVM Schedule Indicators Are Wrong

This weakness of EVM is already very well explained by many authors (Fleming and Koppelman [2], Lipke[4], Henderson[3], Vandevoorde&Vanhoucke[8]) and even included in PMI Practice Standard of EVM[6]. Most of them argue that the EVM is not a reliable predictor of project duration and even recommend that EVM, relating to project schedule performance, should be used just as warning mechanism [2] and not as a real tool to analyze how the project is performing in time. Certain researchers maintain that SPI is good and reliable in first two thirds

of the project [3] [4] [8]) and it starts to be defective over the final third of a project's life cycle. All this could give the impression that the classical EVM, even though imperfect, could be used to calculate schedule performance over the first two thirds of a project.
However, my research shows that the *conventional EVM schedule indicators are unreliable and deficient even in the early project stages for projects in which a cumulative cost curve is not linear* (the vast majority of commercial projects are characterized by non-linear cumulative cost curves).
To illustrate this, we will take one IT project for which cumulative costs are presented in Figure 2. The planned project duration is 10 months and the budget at completion (BAC) is $1M. I calculated the project schedule performance with conventional EVM indicators and I have obtained the following results:

A) Calculated at June1st

EV_1= $233,000	Schedule variance (SV_1) = EV- PV = $-450,000
PV_1= $683,000	Schedule Performance Indicator (SPI_1) = EV/PV= 0.34

Real delay $_1$ = 1.6 months[1]

B) Calculated at September 1st

EV_2= $ 775,000	Schedule variance (SV_2) = EV- PV = $-183,000
PV_2= $ 958,000	Schedule Performance Indicator (SPI_2) = EV/PV= 0.81

Real delay $_2$ = 2.7 months

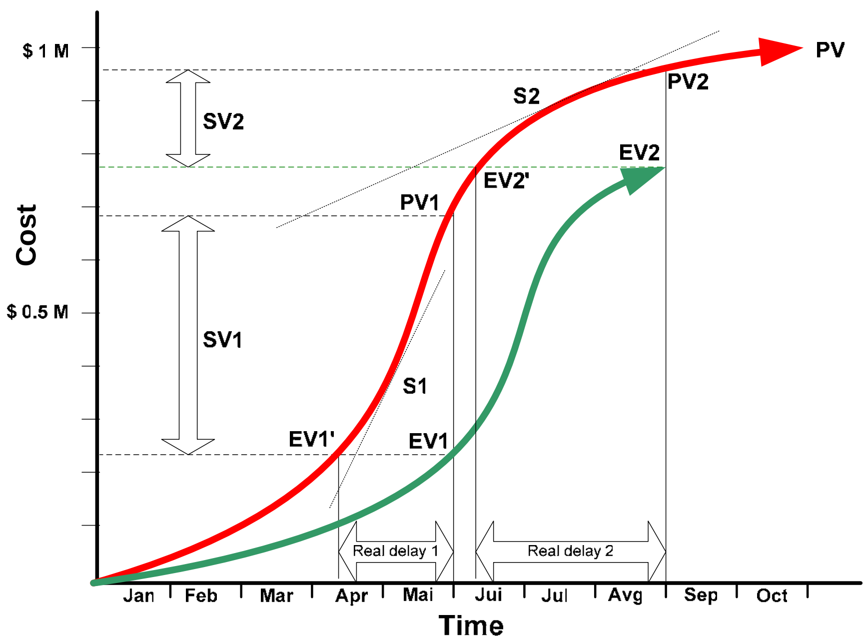

Figure 2 – *EPM versus Earned Schedule*

[1] Real delay is calculated with Earned Schedule (ES) methodology which will be explained later.

We can see that in the first case (A), where real delay is 1.6 months, SV and SPI are showing worst performance than in the second case (B) where real delay is 2.7 months. How this can be explained?

It can be explained with the slope of the cumulative costs curve portion determined by the point representing the planned value at a given time and the point on the PV curve when the actual earned value should have been done. In Figure 2 those points are respectively PV1 and EV1' (Case A) and PV2 and EV2' (Case B). The slopes of these portions are determined by the tangents lines (S1 and S2). If the slope of this portion is greater than the average slope of the cumulative cost curve, the EVM schedule performance indicators will show the results which are worse than they actually are. In the opposite case (slope of the measured portion smaller than the average cost curve slope), the EVM schedule performance results will indicate that the delay is smaller than in reality.

Figure 3 shows an example of a real IT project whose schedule performance was measured on five consecutive occasions. Those measurements were performed with a tool capable of automatically calculating EVM indicators by identifying the value on a PV curve corresponding to the earned value at a given time and the time when this EV should have been .

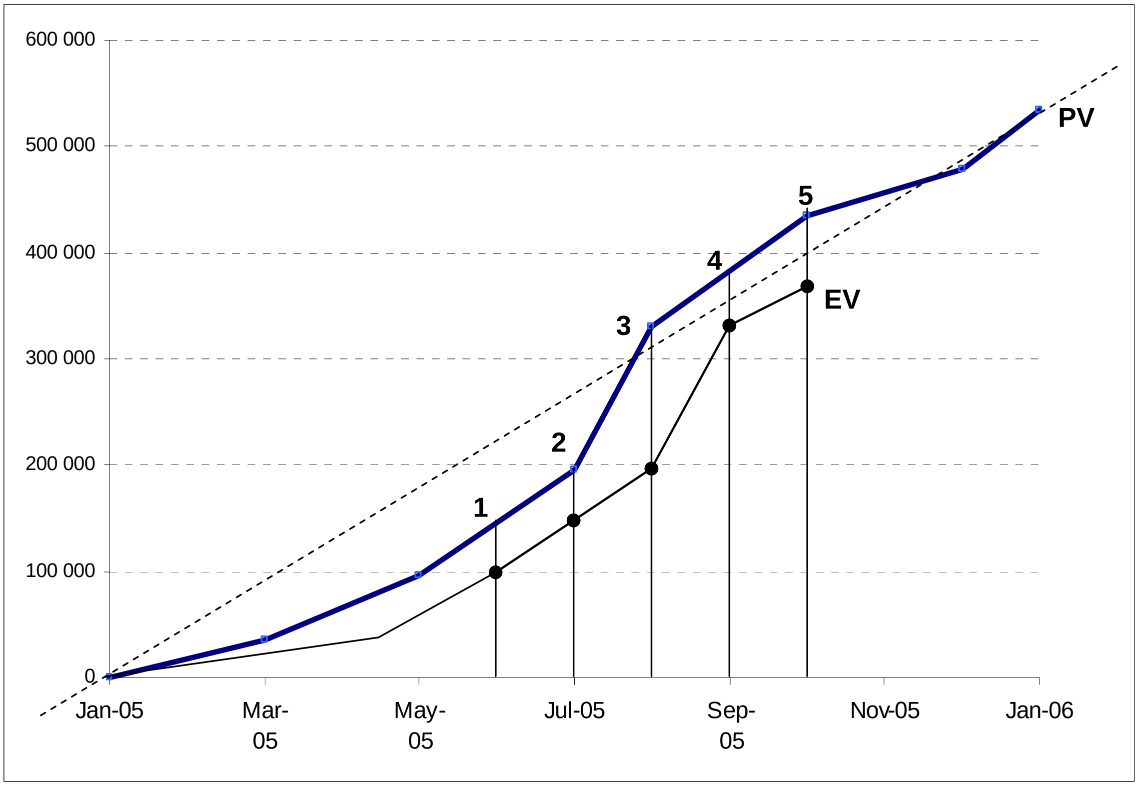

Figure 3- *Example of a real IT project measurement*

The schedule performance indicators were calculated in conventional EVM as well as with Earned Schedule (ES) methodology. The schedule variance (real delay) was also calculated and the results were compared as shown in Table 1.

	Number of performance measures				
	1	**2**	**3**	**4**	**5**
SVt (Real Delay) in days	**31**	**31**	**31**	**31**	**31**
Earned Value (EV) ($)	**96 000**	**145 000**	**195 000**	**331 000**	**382 000**
SPI (EVM)	**0.66**	**0.75**	**0.59**	**0.86**	**0.88**
SPI (ES)	**0.79**	**0.83**	**0.85**	**0.87**	**0.90**

Table 1 – *Comparative results of an IT project*

In a case where the schedule variance is constant, as in our example, SPI should be gradually growing and the increments should be smaller near to the project end. But, as we can see, even though the schedule variance in all measurements is the same (31 days), we can see that SPI calculated with conventional EVM was behaving in a non-regular way. Sometimes it increases (0.75) and after that, for some reason, it declines (0.59).

Its behaviour is not random because, as explained above, it depends on the slope of the PV curve portion between planned value at a given time and the point on PV curve where the actual EV should have been done.

On the other hand, the SPI calculated with ES methodology has relatively consistent behaviour. When the schedule variance - SV is constant for a certain time (as shown in Figure 3), SPI is supposed to grow slightly, but steadily and with the smallest increments toward the project end (that is due to the fact that, even though schedule variance remains the same in absolute numbers, the earned schedule grows faster than the actual time).

In order to confirm these findings, I've made the simulations with a project whose cumulative cost curve is linear. For projects with linear cumulative cost curves, schedule performance indicators calculated with conventional EVM are identical to those calculated with Earned Schedule and both have consistent behaviour. This corroborates the finding that the non-linearity of cumulative cost curves is a principal cause of distortion of EVM schedule indicators.

All these examples clearly confirm that the **schedule performance indicators, as presented and standardised in conventional EVM methodology (PMI Practice Standard of EVM, EIA Standard ANSI-EIA-748), are basically wrong for the projects with non-linear cumulative costs curve[2].**

How can we explain that the EVM schedule indicators, even though clearly deficient, were used for decades without being seriously questioned and eventually changed? The possible explanation has to take into account that EVM was used mostly to analyze project cost performance which works very well. Fleming and Koppelmann, probably the most cited EVM authors, advocate the use of earned value management primarily for cost management. They recognise that EVM is not reliable for schedule performance analyses, especially to predict the end of a project. Instead of EVM, they recommend the use of the critical path method – CPM as the most reliable way to forecast project duration.[2]

Another explanation is related to the fact that the researches about EVM do not address explicitly the non-linearity of a cumulative cost curve. It is interesting because, in those research works, cumulative cost curve is often presented as an S curve, so non-linear, but analyzed as if it were a straight line.

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[2] As stated before, the non-linear curve is a common curve for the majority of commercial projects. It is especially true for a project in IT and construction where the costs start to grow exponentially when, after the phases of feasibility analysis and architecture, the project enters into a construction stage.

Earned Schedule Is Better

However, all that doesn't mean that the EVM is useless in calculating how a project is performing in time. As I mentioned in the beginning, EVM is very useful when calculated as the difference on the horizontal (time) axis. This concept is already explained and described as Earned Schedule (ES) approach. It is now included in PMI Practice Standard of EVM, but just as an emerging practice and not as the standardized and recommended methodology to calculate schedule performance.
The concept of Earned Schedule corrects the fundamental weakness of the classical EVM concept and proposes the schedule performance indicators which are time and not cost-based. The ES is presented in Figure 4.

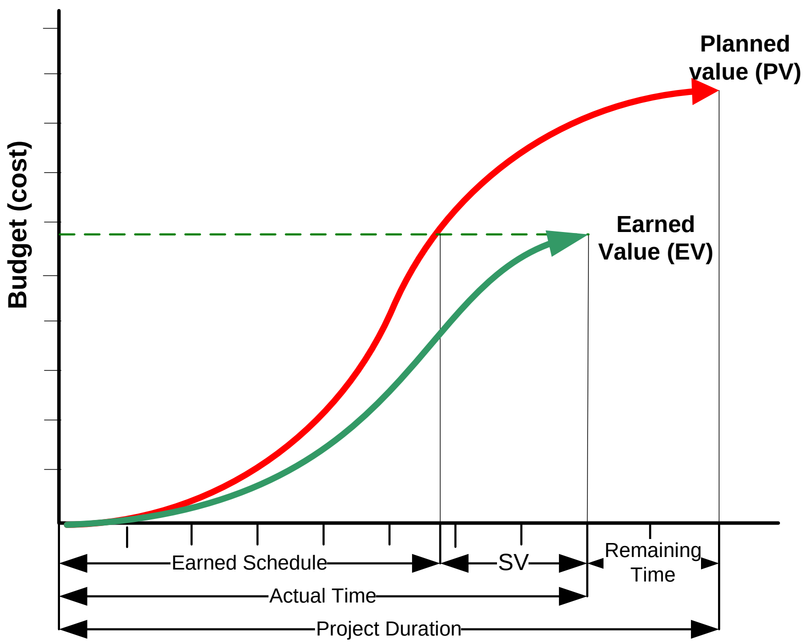

Figure 4 – *Earned Value Concept*

Schedule Variance (t): SV(t) = ES – AT
Schedule Performance Index: SPI(t) = ES / AT
Estimate at Completion: EAC(t) = PD / SPI(t)

As we can see, Earned Schedule indicators are analogous to the EVM cost performance indicators. The first two ES indicators (SV and SPI) are logical and should be reliable if correctly calculated. They basically say whether the project is behind or ahead of planned schedule and they quantify it.

Project Duration Estimate

The third EVM indicator, EAC, should reveal when the project is supposed to be completed considering its current status. Most of the EVM authors (PMI Standard proposes the same) think that the future project performance (cost or schedule) is, to some extent, influenced by its past performance.
In my opinion, this way to estimate the time needed to complete the project is rather simplistic, because the time is influenced by many factors and has to be more carefully calculated. To know if and how the past performance is likely to influence a future project performance, the

project manager has to make an analysis of the factors which have caused the bad (or good, which is less frequent) performance.
The project, for example, may be late a couple of months in the beginning because of missing infrastructure. Or, the needed resources may not have been available on time. In these cases, once the causes of delay are resolved, the project is likely to continue according to the planned dynamic. If you apply the proposed formula for EAC that is driven by past performance, you will probably overestimate the schedule. Therefore, the best way to predict the time at completion in this case is to simply add the recorded delay to the remaining planned time.
On the other hand, if the causes of the project delay are more structural (unrealistically compressed planned schedule or the lack of expertise), they will probably, to some extent, influence the future project performance. In this case using the past performance to forecast the end of the project could be justified.
Consequently, the estimated time at completion should be calculated as follows:

EAC(t) = Actual Time + (Planned Project Duration – Earned Schedule) *Cf

Cf is an adjustment factor representing the degree by which the past performance is supposed to affect project performance in the remaining time. It should be determined by the project manager and depends on the level with which the causes of a bad performance are likely to influence the rest of the project. It is expressed as 1 plus percentage by which the causes of a bad performance are likely to affect the remaining time. If the schedule compression, for example, is expected to augment the remaining time by 15 %, Cf is 1.15.
If the causes of a project delay are structural and expected to continue to influence project performance, Cf should be higher than 1, but it shouldn't exceed the value of 1/SPI.
If the factors responsible for the bad performance are rather temporary and not likely to influence the rest of the project, Cf should be 1.
I recommend that, even in the case where causes of bad project performance are of a temporary nature, Cf should be >1. That is because the accumulated delay, even though not likely to influence directly the rest of the project, will probably change a project dynamic, which could result in certain delay.
For the reasons cited above, I believe that the adjustment factor should be calculated as well while estimating the budget at completion. Nevertheless, we must remember to not apply automatically the same factors for the budget and the schedule estimate. The factors likely to affect the schedule and budget estimate may not be the same, or they may not influence both with the same intensity. For example, if you fail to include in your project plan an important task, executing the plan will result in delay and an increase in the project costs. Yet, this is not likely to influence too much the rest of the project. On the other hand, if your team is less experienced than expected, your schedule as well as your cost will probably be affected for the whole project and the adjustment factor will be much higher than 1.

What to Do With EVM Data

It is certainly very important to know a project's status. EVM is a very good tool to indicate if a project is within planned parameters or not. EVM indicators, if correctly calculated, should give a reasonably accurate picture of current project performance.
However, knowing that is not enough. The prime objective of a project manager is to assure that his project is going according to the baseline. If it's not the case, he has either to take the corrective actions to finish the project according to the planned schedule or he must establish a new baseline.

It is clear that the EVM indicators, in addition to providing an early warning about the project performance, should also give an unambiguous lead to the project manager on what is the most appropriate action. Because of that the quantitative value of EVM indicators is very important.
To make an analogy, if your cholesterol is high, it is an early warning that you have to do something. However, what you have to do depends principally on the cholesterol level. If it's not too high, you can consider changing your lifestyle, doing more exercise, etc. On the other hand, if the cholesterol level is too high, your doctor will probably recommend more drastic measures, like medication, for example.
It's the same with a project. But, as your doctor, before prescribing a treatment, will probably perform additional exams, so the project manager has to analyze other factors to decide what the most appropriate action is.
One of the important factors he has to take into account is schedule compression. If the schedule is already compressed, it could be very dangerous to try to recover the lost time by adding new resources. The best way may be to reschedule the project and to establish a new baseline. On the contrary, if the project schedule is comfortable (planned duration is much longer than the critical path), adding people could solve the problem.
Another important factor which project manager has to consider is the point of a project's life cycle in which the performance is measured. If the project is late 4 months and the remaining time is also 4 months, putting additional resources and trying to finish the project within the planned time is probably not the best solution. Sometimes adding people to a late project can even make it more late (especially for IT projects).
On the other hand, if the project is late 4 months and the remaining time is 10 months, adding people or/and putting some activities in parallel could be the reasonable solution in order to recover the lost time.
For these reasons I recommend another ES indicator (I named it Schedule Variance Criticality – SVC).

Schedule Variance Criticality: CVC = SV / RT

As we can see, CVC is expressed as a ratio between schedule variance (SV) and remaining time (RT). It could be very useful indicator for a project manager when he has to decide what to do with a late project. In any event, this indicator is much more useful than the SPI needed to finish the project on time. If you say to a project manager that he must have SPI equal to 1.3 until the end of the project if he wants to finish the project on time, it doesn't have any practical meaning to him. But, if you say that the delay represents 80 % of the remaining time in one project and 20 % in another, it is certain that he will not take the same actions in both projects.

Conclusion

The majority of recent research suggests that the results concerning the schedule performance obtained with Earned Schedule are better than results calculated with conventional EVM. Nevertheless, many of them claim that EVM shows good results in the first two thirds of a project's life cycle, which may be understood as the conventional EVM still provides usable results.
My research shows that schedule performance indicators calculated with conventional EVM are deficient for the majority of commercial projects and, as such, they shouldn't be used in schedule performance management. They are not just less precise, they are fundamentally wrong.
On the other hand, the alternative practice called Earned Schedule works very well. It expresses schedule delay in time units and, if applied well, it's reasonably reliable. In my opinion, there is no doubt that the EVM rules and standards related to schedule performance should be changed and established according to the proposed Earned Schedule approach. It is much more

important if we know that through the efforts of the Office of Management and Budget (OMB), the application of EVM is now required for all major acquisitions throughout the U.S. Federal Government.

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About the Author

Radenko Corovic has over 20 years experience in public and private sectors. He is specializing in the areas of software measurement, IT performance, business process improvement and IT strategy. His interest focuses on IT management, particularly on business aspect of IT and IT contribution in organizational productivity.
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