*PM World **Journal***
Vol. II, Issue VI – June 2013
www.pmworldjournal.net

Schedule Adherence … a useful measure
for project management
Second Edition[1]   by Walt Lipke

Schedule Adherence
…a useful measure for project management [1]

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Abstract: *Earned Value Management (EVM) is a very good method of project management. However, EVM by itself cannot provide information as to how the schedule is being accomplished. Project accomplishment not in accordance with the planned schedule frequently has adverse repercussions; cost increases and duration is elongated. Thus, managers have a need to more fully understand project performance. This paper utilizes the new practice of Earned Schedule to discuss a proposed measure for further enhancing the practice of EVM. The measure, Schedule Adherence, provides additional early warning information to project managers, thereby enabling improved decision making and enhancing the probability of project success.*

Development of a plan for executing a project is a difficult undertaking. When the plan is being created, a work flow is envisioned along with constraints and resource availability. There is a considerable amount of effort invested in decomposing the constituents of the plan into manageable components and work packages. Detailed examination of the tasks themselves is made to prepare reasonable estimates for their cost and duration. Oftentimes, planning teams use historical project records, heuristics and statistical algorithms to determine best and worst case probable outcomes. Furthermore, to assure that the best possible plan is created, technical experts may be employed to make the estimates as accurate as possible.

Before assignments can be made to the team members of a project, the timing of their actions must be known along with their interdependencies. The intricate mechanism for consolidating all of this information and making it understandable to the project team, and senior management, as well, is the <u>schedule</u>. The schedule is an embodiment of our best understanding of how to accomplish the project …a truly important document. Possibly, the schedule is the single most important document pertaining to the project and it likely has more to do with success than any other aspect.

Well then ….if the planned schedule is so crucial to project success, it follows that project managers should do their utmost to ensure project execution conforms to it. Assuming the planned schedule is the most efficient path for executing the project, any deviation leads to inefficiency and very likely other problems ….such as constraint reduced production, idle time, skills mismatch and poor quality output, in turn, requiring rework. Thus, there is an extremely compelling case for following the planned schedule.

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This paper presents a proposed method for measuring the conformance, or adherence, for the schedule execution of a project. Utilizing the method and measure, the project manager has a better understanding of how well the execution follows the sequence and precedence of the tasks in the baseline schedule. Having an indicator for "schedule adherence" provides additional early warning information for managers to act upon.

Schedule Performance Efficiency versus Schedule Adherence

What is meant by *schedule adherence*? Does it mean that the project is performing such that objectives are achieved at the time predicted or planned? Certainly project managers want to know that interim products are being produced and delivered on time. This type of schedule performance indicator can be made a number of different ways, such as portion or percent of milestones, objectives, or interim products achieved on time. In fact, the Earned Value Management (EVM) Schedule Performance Indicator (SPI) is of this type.[1] However, SPI is much more resolute than the very coarse measures mentioned; its increment of measure is cost, earned and planned. This discussion for SPI is equally applicable to the time-based schedule performance efficiency indicator from Earned Schedule (ES), SPI(t).[2]

All of these indicators, including SPI and SPI(t), describe the efficiency of achieving the plan. However, they do not provide information about how the products, milestones, objectives or earned value were achieved. For example, these indicators cannot describe whether or not completion of milestone 2 followed milestone 1. If the milestone schedule indicates that at status period 3 we should have completed two milestones and we have completed two, it would appear from the indicator (milestone percent completed = 100 percent), that all is well. But, what if the two milestones are numbers one and three, while the second milestone is still in work? Is there anything possibly wrong? After all, the project has met its two milestone objective.

For the EVM schedule efficiency indicator, SPI, there is no concern as to whether the earned value (EV) accrued matches the expectation of the schedule. In most cases, project managers would celebrate an SPI = 1.0 because it is so seldom achieved, and consequently would not question whether the EV accrued is, in fact, the expected PV. Again, the question is raised, "Should the project manager be concerned with the performance sequence, i.e., how the achievement occurred?" Does it make any difference?

Over the last 20 years, nearly every industry experienced several initiatives intended to improve project performance and product quality: Statistical Process Control, Total Quality Management, the Software Engineering Institute Capability Maturity Model (CMM®), and the International Organization Standard for Quality Management Systems, ISO 9001. The fundamental idea from all of these process improvement efforts is*: undisciplined execution leads to inefficient performance and defective products.*

Doesn't this thinking apply to project plans, too? Of course it does; the planned schedule describes the execution process. Therefore, it is not enough to measure the

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execution efficiency. Additionally, project managers (PM) need to know how well the process is being followed. By maintaining process integrity, PMs can maximize the project's performance, and minimize its rework and delivery of defective products. An indicator for adherence to the schedule provides the measure needed by PMs for monitoring and controlling the project execution.

Measuring and Indicating Schedule Adherence

The idea for measuring schedule adherence is simply stated in this question, "Did the accomplishment match exactly the expectation from the planned schedule?" This is not the same as the preceding discussion of schedule performance efficiency, where the volume of actual work accomplishment is compared to the expected volume from the schedule. Schedule adherence is a more restrictive measure, and is independent from performance efficiency.

A recent enhancement to EVM, Earned Schedule (ES), provides a means to measure schedule adherence. ES is derived from two measures of EVM, planned value (PV) and earned value (EV) [2]. The accumulated planned value from the project start to its planned completion is the performance measurement baseline (PMB) [1]. ES is the time duration associated with the PMB where the PV is equal to the EV accrued.

The concept of ES is illustrated by Figure 1. Arrow A projects the accrued value of EV onto the PMB to identify the point at which PV equals EV. Arrow B identifies the time at which PV equals the EV accrued; i.e., the planned duration earned or ES. The time at which the EV accrued appears is period 7. Whereas ES is determined to be the duration of 5 periods; i.e., the time measure from the PMB where PV is equal to the EV accrued at Time Now, or Actual Time (AT).

Two comparative measures, SV_t and SV_c, are shown in the diagram to illustrate the difference between the cost-based and time-based indicators of EVM and ES, respectively. The traditional EVM schedule variance is SV_c, while the time-based schedule variance from ES is SV_t.[3] From the numbers shown in the diagram, SV_t can be easily computed: $SV_t = ES – AT = 5 – 7 = –2$. Assuming the units are months, the project is 2 months behind its planned schedule.

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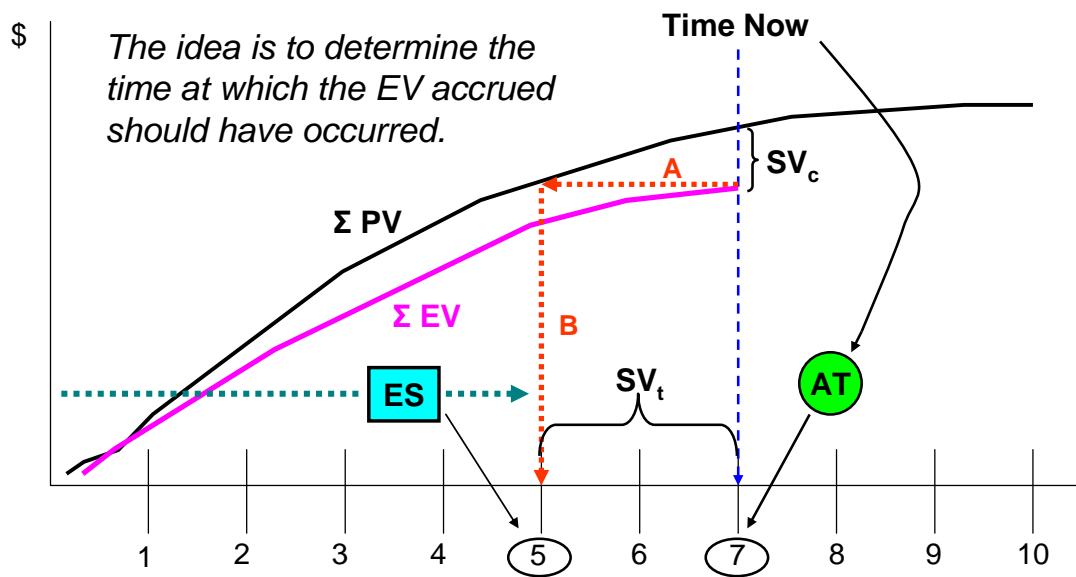Second Edition[1]   by Walt Lipke

Figure 1.   Earned Schedule Concept

The performance expectation for the planned schedule is embodied in the PMB. This is a consequence of the PMB being the result from summing time phased PV across all tasks in the schedule. Figure 2 is used to illustrate the relationship. The figure shows a network schedule at the top with the PV curve beneath it.

The connection between EVM and the schedule provided by Earned Schedule is remarkable. Regardless of the project's actual position in time, we have information describing the portion of the planned schedule which should have been accomplished. That is, for a claimed amount of EV at a status point AT, the portion of the PMB which should be accomplished is identified by ES. Another way of describing this relationship is the value of ES indicates where the task performance of the project should be for that amount of duration of the planned schedule.

As shown by Figure 2, specific tasks make up that portion of the schedule. The darker shaded areas of the task blocks indicate the portions planned to be completed. If the schedule is adhered to we will observe in the actual performance the identical tasks at the same level of completion as the tasks which make up the plan portion identified by ES. By adhering to the planned sequence of tasks, the manager is assured during project execution that the predecessors to the tasks in work are complete.
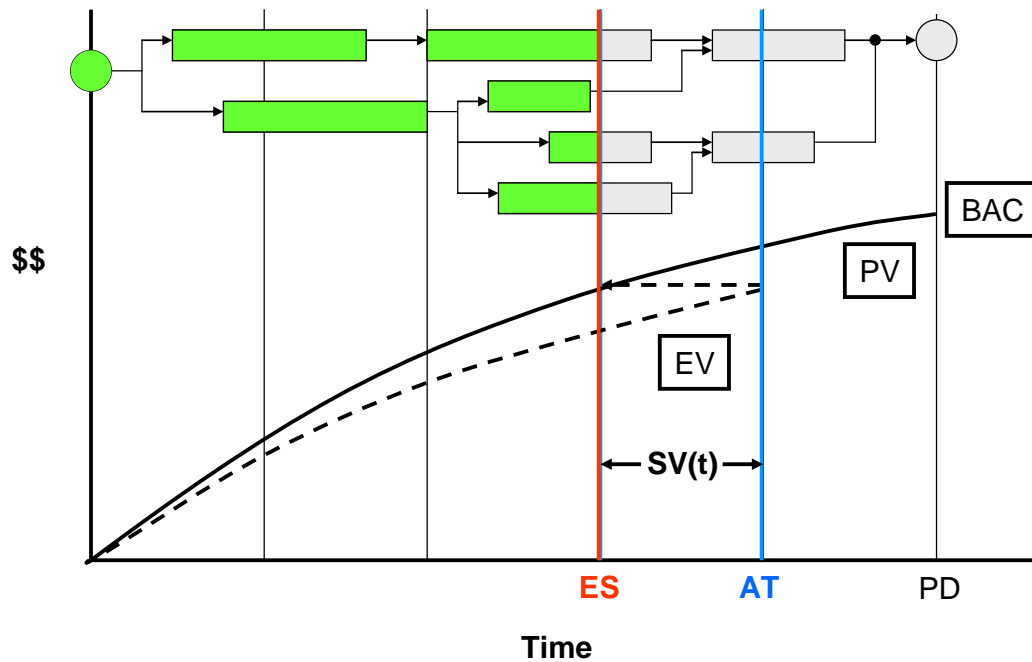
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Figure 2.   ES Connects EV to Schedule

It is more than likely the project is not performing synchronously with the schedule; EV is not being accrued in accordance with the plan. As seen in Figure 3, the accumulated earned value is the same quantity depicted in Figure 2, but its task distribution is different. Figure 3 is a graphical illustration of the earlier discussion of the reasons for process discipline. The lagging performance for tasks to the left of ES indicates the possibility of a constraint or impediment. Performance may be lagging the expectation due to something preventing it from occurring. The EV indicated to the right of ES shows tasks performed at risk; they will likely have significant rework appearing later in the project.

Both sets of tasks, lagging and ahead, cause poor efficiency. Of course, for the lagging tasks, impediments and constraints make progress more difficult. *Concentrating management efforts on alleviating the impediments and constraints will have the greatest positive impact on project performance.*

The darkened tasks to the right of ES indicate performance resulting from impediments and constraints or poor process discipline. Frequently, they are executed without complete information. The performers of these tasks must necessarily anticipate the inputs expected from the incomplete preceding tasks; this consumes time and effort and has no associated earned value. Because the anticipated inputs are very likely misrepresentations of the future reality, the work accomplished (EV accrued) for these tasks usually contains significant amounts of rework. Complicating the problem, the rework created for a specific task will not be recognized for a period of time. The need for rework will not be apparent until all of the inputs to the task are known or its output is recognized to be incompatible with the requirements of a subsequent task.
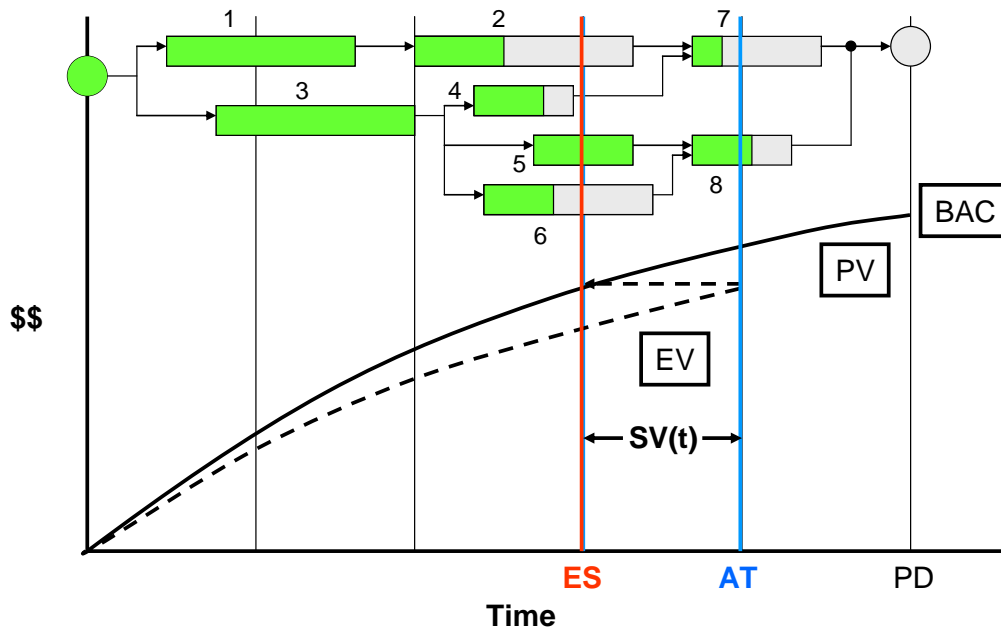
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Figure 3. Actual Distribution of EV

This conceptual discussion leads to the measurement of schedule adherence. By determining the earned value (EV) for the actual tasks performed congruent with the project schedule, a measure can be created. The adherence to schedule characteristic, P, is described mathematically as a ratio:

$$P = \Sigma \, EV_j \, / \, \Sigma \, PV_j$$

PV_j represents the planned value for a task associated with ES. The subscript "j" denotes the identity of the tasks from the schedule which comprise the planned accomplishment. The sum of all PV_j is equal to the EV accrued at AT. EV_j is the earned value for the "j" tasks, limited by the value attributed to the planned tasks, PV_j. Consequently, the value of P represents the proportion of the EV accrued which exactly matches the planned schedule.

Recall, the question with which we began, "Did the accomplishment match exactly the expectation from the schedule?" The P-Factor answers the question and thus is the performance indicator of schedule adherence sought after.

A characteristic of the P-Factor is that its value must be between zero and one; by definition, it cannot exceed one. A second characteristic is that P will exactly equal 1.0 at project completion. P equal to zero indicates that the project accomplishment thus far is not, at all, in accordance with the planned schedule. Oppositely, P equal to one indicates perfect conformance.

When the value for P is much less than 1.0, i.e., poor schedule adherence, the project manager has a strong indication the project is experiencing an impediment, the overload of a constraint, or there is poor process discipline. Conversely, when the value of P is very close to 1.0, the PM can feel confident the schedule is being followed and that milestones and interim products are occurring in the proper

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sequence. *The PM thus has an indicator derived from ES which further enhances the description of project performance portrayed by EVM alone.*

Example Application

Below is Table 1, containing notional data, relating to Figure 3 above. The task numbers from the table are identified, as well, in the network diagram of the figure. The total PV for the hypothetical project is 62 units. The total EV accrued at AT is 40 units; the task distribution of EV is beneath the column heading, EV@AT. The task distribution of PV for the ES duration is shown in the PV@ES column.

By calculating the difference, EV minus PV, between the two distribution columns we can determine which tasks may have impediments or where a constraint has developed. Those tasks are identified by the negative values in the EV – PV column and recorded as a possible impediment or constraint (I/C) in the last column of Table 1; they are tasks 2, 4 and 6. The PM should investigate those three tasks for removal of impediments or alleviation of the constraints.

Should no impeding problem be found, the PM has reason to suspect inappropriate performance by members of the project team, i.e., poor process discipline. It may be discovered that a person assigned one of the tasks identified is insufficiently skilled or trained. *This never happens, does it?* The employee, in order to maintain a satisfactory efficiency for his performance review, executed a downstream task because it was something he did know how to do. *(For this example the employee is compelled to do the wrong thing. Let us hope that management fully examines the problem and recognizes its own culpability.)*

The column, EV – PV, also indicates positive differences for three tasks: 5, 7 and 8. These tasks are not being performed synchronously with the schedule and are at risk of generating rework, as indicated by the letter R recorded in the table. It is obvious from Figure 3 that tasks 7 and 8 are at risk because some or all of the required inputs to them are absent. However, the risk of task 5 is not so obvious; all of its required inputs are available. With respect to ES, it should be only partially complete. Task 5 completion is not synchronous with the planned execution at the ES duration. Rework can be generated in this case as well, it is never wise to be too far "out in front."

To further explain, as the project progresses the detail for task accomplishment becomes much clearer. Oftentimes subtle changes to task requirements are made due to the learning gained during the development process from the prior task accomplishment. By working ahead, the developer unknowingly makes the presumption that his work is unaffected by the other facets of the project. When this occurs, the task worker is not performing synchronously with the plan and the risk of rework is created.

What is the value of the P-Factor for this example? From review of the PV@ES column, the tasks to be included in the calculation are 1 through 6; the sum of PV@ES equals 40. The sum of the EVs in agreement with the PVs is found from the values of tasks 1 through 6 in the EV@AT column. The sum of the values for these

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tasks is 36. However, recall task 5 is 3 units ahead of where it should be with respect to the amount of PV planned for that point in time. Subtracting the 3 units, the EV sum in agreement with the schedule equals 33. As can be seen, another way to calculate the EV in agreement is to add the sum of the negative entries in the EV – PV column to the total EV accrued; i.e., 40 + (– 7) = 33. P can now be calculated:

$$P = \Sigma\, EV_j\, /\, \Sigma\, PV_j = 33\, /\, 40 = 0.825$$

Thus, approximately 80 percent of the execution is in conformance with the schedule.

Task	PV	PV@ES	EV@AT	EV - PV	I/C or R
1	10	10	10	0	
2	12	9	5	-4	I/C
3	10	10	10	0	
4	5	5	3	-2	I/C
5	5	2	5	+3	R
6	8	4	3	-1	I/C
7	7	0	1	+1	R
8	5	0	3	+3	R
Total	62	40	40	0	

Table 1.   Schedule Adherence Example

Let us presume all of the claimed accomplishment not in schedule conformance requires rework, 7 units. For this worst case, nearly 18 percent of the claimed earned value must be re-accomplished for the project to complete satisfactorily. Unless this project has considerable reserves successful completion within the allocated resources is very unlikely. It is obvious; the manager for this project has work to do. However, without the P-Factor indicator and the analysis, it is not so obvious as to what he should investigate and take action to correct.

Real Data

Figure 4 is a graph of the indicators, CPI, SPI(t) and the P-Factor, from real project data. For the figure, CPI is the cost performance index from EVM and the Percent Complete of the x-axis is determined from EV divided by the Budget at Completion (BAC) [1]. As you can see, the schedule adherence (P-Factor) is extremely high, even from the beginning; at 20 percent complete, P is equal to 0.93. The fact that the P-Factor is very nearly 1.0 says that the precedence of the schedule is followed very closely throughout the period of execution shown.

Also observed is the curve fit of the P-Factor data points. The curve fit is an illustration of the previous discussion of the behavior of P: as the project percent complete increases, in general the value of P will approach 1.0; at completion, P = 1.0. This behavior is observed with the curve fit line.
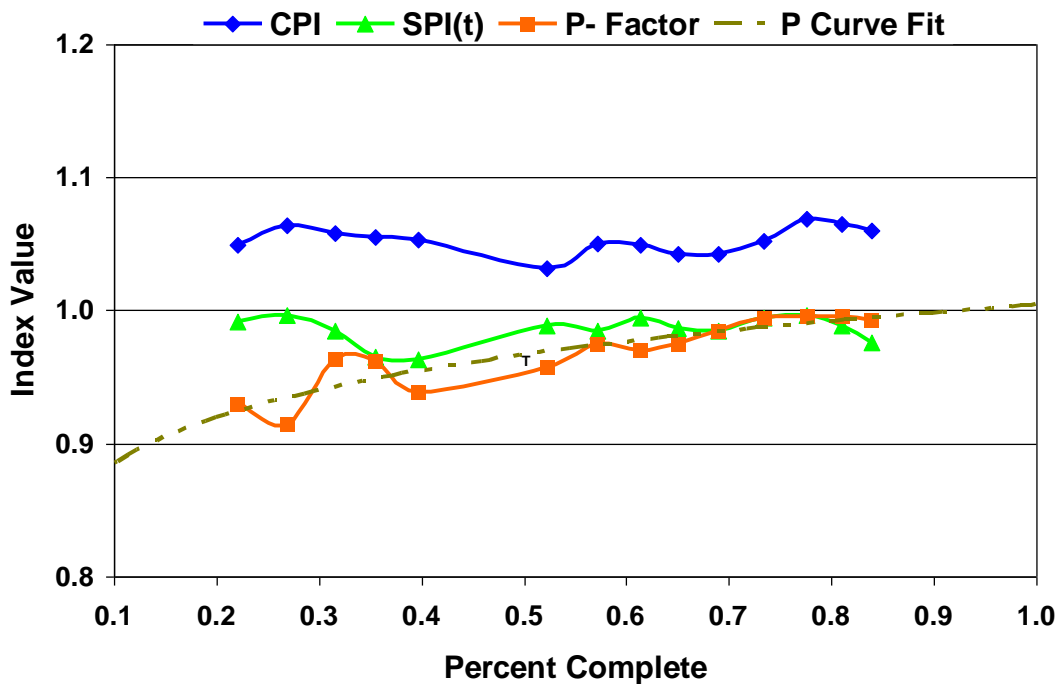
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Figure 4.   Project Management Indicators

The plots of CPI and SPI(t) indicate a very high performing project; CPI hovers around 1.05, while SPI(t) is generally greater than 0.98. The forecast for the project outcome is expected to complete under budget and slightly past its planned completion date. A logical conjecture from the comparison of the indicators is that when the planned schedule is closely followed, output performance is maximized, and the project has the greatest opportunity for success. In other words, when P is a high value, we can expect CPI and SPI(t) to be high, as well. Although this relationship needs verification from further research, the rationale appears reasonable.

Summary

Earned Schedule is a measure shown over the last four years of application and research examination to provide reliable schedule performance indicators, further enabling duration and completion date forecasting. In this paper, the application of ES is extended, thereby facilitating identification of those tasks which should have been accomplished for the EV accrued. From the comparison of the actual distribution of the EV to its planned distribution, it is shown that useful information is available to project managers concerning possible impediments or constraints along with the identification of potential future rework

The measure for indicating how well the project is following its planned schedule is Schedule Adherence, i.e., the P-Factor. Adhering to the planned sequence of tasks, assures that the predecessors to the tasks in work are complete thereby minimizing the potential for rework. The P-Factor enhances project control capability by providing additional early warning information. When employed with SPI(t) from ES and CPI from traditional EVM, the P-Factor yields more complete project performance

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information. In turn, the added measure enhances management decision making, and the probability for successful project outcomes.

Final Remarks

Some practitioners of EVM hold to the belief that schedule analysis can be accomplished only through detailed examination of the network schedule. They maintain the understanding and analysis of task precedence and float within the schedule cannot be accounted for by an indicator. However, detailed schedule analysis is a burdensome activity and if performed often can have disrupting effects on the project team.

ES offers calculation methods yielding reliable results, which greatly simplify final duration and completion date forecasting. Furthermore, as described in this paper, the development of ES has lead to a new and potentially powerful indicator of schedule performance, i.e., Schedule Adherence.

Future research of the proposed Schedule Adherence indicator is encouraged. To promote experimentation and usage of the measure, the P-Factor calculator is made available for download at http://www.earnedschedule.com/Calculator.shtml.

References

1. *Practice Standard for Earned Value Management*. Newtown Square, PA: Project Management Institute 2005.
2. Lipke, W. "Schedule is Different," *The Measurable News*, Summer 2003: 31-34

Notes

1. The schedule performance indicator from EVM is symbolized by SPI. SPI is equal to the earned value (EV) divided by the planned value (PV) at a specific time; i.e., $SPI = EV / PV$ [1].
2. The time-based schedule performance indicator from ES is SPI(t) and is equal to the earned schedule divided by the actual duration (or actual time, AT); i.e., $SPI(t) = ES / AT$ [2].
3. The EVM and ES definitions of SV_c and SV_t, respectively, are as follows: $SV_c = EV – PV$; $SV_t = ES – AT$ [1,2].

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Walt Lipke retired in 2005 as deputy chief of the Software Division at Tinker Air Force Base in the United States. He has over 35 years of experience in the development, maintenance, and management of software for automated testing of avionics. During his tenure, the division achieved several software process improvement milestones, including the coveted SEI/IEEE award for Software Process Achievement. Mr. Lipke has published several articles and presented at conferences, internationally, on the benefits of software process improvement and the application of earned value management and statistical methods to software projects. He is the creator of the technique *Earned Schedule*, which extracts schedule information from earned value data. Mr. Lipke is a graduate of the USA DoD course for Program Managers. He is a professional engineer with a master's degree in physics, and is a member of the physics honor society, Sigma Pi Sigma ($\Sigma\Pi\Sigma$). Lipke achieved distinguished academic honors with the selection to Phi Kappa Phi ($\Phi K\Phi$). During 2007 Mr. Lipke received the PMI Metrics Specific Interest Group Scholar Award. Also in 2007, he received the PMI Eric Jenett Award for Project Management Excellence for his leadership role and contribution to project management resulting from his creation of the Earned Schedule method. Mr. Lipke was selected for the 2010 Who's Who in the World.   He can be contacted at waltlipke@cox.net.