The TCPI Indicator
Transforming Project Performance

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Abstract: *The To Complete Performance Index (TCPI) from Earned Value Management describes the performance efficiency required to achieve a cost objective. This paper discusses the common use of the index, examining and confirming the underlying basis. Beyond its usual application, the TCPI indicator has a significant role in transforming project performance to effect a project recovery. This virtually unknown aspect is discussed and illustrated. A discussion of the To Complete Schedule Performance Index (TSPI) from Earned Schedule is included to describe the parallelism between cost and schedule analysis.*

Earned Value Management (EVM) with its emphasis on describing project performance numerically has provided a scientific method for project management. The application of EVM is a truly significant improvement to the practice, especially when differentiated from the gross estimation and intuitive impulses historically employed for assessing and reporting project status.

For those project managers (PM) and organizations applying EVM, data is available for analysis, thereby facilitating detailed understanding of the cost performance of the project from its beginning through to the present time. The most often used and understood indicator from EVM is the Cost Performance Index (CPI), defined as the ratio of the earned value (EV) accrued divided by the actual cost (AC); i.e., CPI = EV / AC [1]. CPI is a description of the efficiency of achieving the accomplishment with respect to the investment cost made.

A companion cost indicator, the focus of this paper, is the To Complete Performance Index (TCPI). The indicator is defined as the work remaining to be accomplished divided by the amount of unspent funding. The work remaining is calculated from the difference between the total project budget (Budget at Completion or BAC) and the EV accrued, whereas the funds remaining can be assessed in several different ways. For simplicity, the funds remaining is calculated in relation to the total cost desired (TC). Thus, the index is defined as follows: TCPI = (BAC – EV) / (TC – AC) [1]. A common application of TCPI is the computation for when the desired final cost is the project budget. In this instance, TCPI = (BAC – EV) / (BAC – AC).

What does TCPI tell us? The index value describes the cost performance efficiency required for the remainder of the project to achieve the desired final cost. The value of TCPI can have a very powerful influence on how a PM views the need or urgency for intervention and management action.

With this understanding of TCPI, the remainder of the paper will address how the indicator is used in cost analysis and examine the validity of the premise. As will be realized in the discussion, the performance of the TCPI function has some unusual characteristics. The application of TCPI in project recovery is subsequently described revealing intriguing information useful to project managers.

Evaluation of EAC

Traditionally, TCPI is used by customers or oversight organizations to assess the reasonableness of an estimated final cost or Estimate at Completion (EAC). The EAC is included in the periodic project report made by the performing organization, generally prepared under the direction of the PM. For this application, TCPI = (BAC – EV) / (EAC – AC). The customer evaluates the EAC provided by the PM from the value of the TCPI computed. When TCPI is equal to or less than 1.00, there is confidence that the EAC can be achieved. Conversely, when TCPI is equal to or greater than 1.10 the project is considered to be "out of control;" the EAC is very likely unachievable. And, between the two declarative values, 1.00 and 1.10, the PM's actions become ever more critical to project success. Management intervention to improve cost performance very probably will be required to achieve the EAC.

Obviously, when TCPI $\leq$ 1.00 there is confidence that the EAC is achievable; it indicates the accomplishment efficiency can be less than needed for the project to complete within the estimate of final cost. However, it is not so clearly understood that the project is irrecoverable when TCPI $\geq$ 1.10.

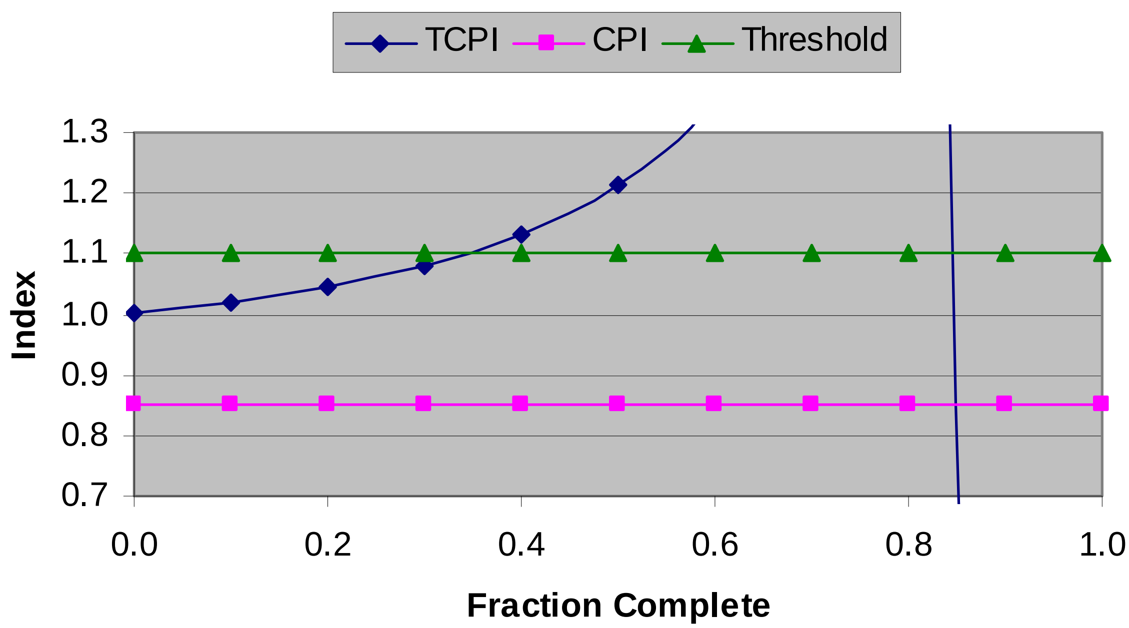

Figure 1. TCPI versus Fraction Complete

From a cursory review of the EVM literature, there does not appear to be any theoretical or empirical studies to establish the criterion value for TCPI. However, by viewing Figure 1 we can gain an understanding as to why the value of 1.10 may have credence. Figure 1 graphically depicts the behavior of TCPI as the project moves toward completion for the condition of CPI $\leq$ 1.00. For the purpose of discussion, CPI = 0.850 and is invariant throughout the period of performance; thus, it is known that the planned final cost (BAC) will not be achieved if this performance continues.

As observed in Figure 1, with TC equal to BAC and CPI = 0.850, TCPI continually increases as the project progresses, exceeding the threshold value of 1.10 at fraction complete of approximately 0.35. The fraction complete for the project is defined to be EV divided by BAC.

Another observation is that the rate of TCPI increase becomes ever larger as fraction complete increases. From the project start to fraction complete equal 0.35, TCPI increased by 0.10; from that point, TCPI increases another 0.10 by the time the project is 50 percent complete.

Further Examination

Another view of the threshold value for TCPI can be obtained from calculus. For this examination, the TCPI equation is algebraically transformed to the following:

$$TCPI = (1 - EV\%) / (CR - CPI^{-1} * EV\%)$$

where, CR (Cost Ratio) = 1.0 (BAC/BAC) or EAC/BAC and EV% = EV/BAC

For simplicity of notation, let y = TCPI, x = EV%, a = CR, and b = CPI^{-1}. Applying the substitutions, the TCPI equation above becomes: $y = (1 - x) / (a - bx)$. The examination of the rate of increase can be made from the first calculus derivative, denoted as dy/dx. Performing the derivative, the equation for the rate of increase of TCPI with respect to fraction complete (EV%) is determined:

$$dy/dx = (b - a) / (a - bx)^2$$

By applying the calculus equation, the rate of increase can be evaluated for poor cost performance. The point of interest is when TCPI equals the threshold value (1.10). For the purpose of this examination, CPI^{-1} = 1.20 and CR = 1.10. These values have no special meaning other than they satisfy the condition that the cost performance will not achieve the cost objective. To evaluate the rate of increase for TCPI, the equation for y above is solved for x to obtain the fraction complete at which the threshold is exceeded. For the values assigned, the computation indicates this occurs when the fraction complete is equal to 0.656.

EV%	dy/dx
0.656	1.024
0.700	1.479
0.750	2.500

Table 1. The Rate of Increase of TCPI

Having the value for the fraction complete, the rate of increase at that point can be evaluated. For comparison purposes, the rate of increase is then calculated for subsequent values of project fraction complete (EV%). These values are presented in Table 1.

Clearly, for modest increases in EV% (project fraction complete), it is seen from the numbers recorded in the table that dy/dx (i.e. the TCPI rate) has larger and larger rates of change. The message to all concerned from this analysis is, subsequent to exceeding the threshold, the project is very rapidly becoming “out of control.” Once the threshold is exceeded, there is little hope that management intervention can have positive impact. Thus from the discussion of Figure 1 and the calculus analysis presented here, it appears the threshold value of 1.10 for TCPI is reasonable for making the assertion that the EAC put forth by the PM in the project status report is unachievable.

Application to Project Recovery

Project Managers through the use of the CPI possess the capability to recognize problems early enough that actions may be taken to avert the foreseen cost overrun. By calculating the Independent Estimate at Completion (IEAC), PMs can forecast a final cost and have additional information for making the decision to take management action for project recovery.

Most generally, the final cost forecast is calculated using the following formula: IEAC = BAC / CPI. As an example, let’s use CPI equal to 0.850, the same value in Figure 1 above. With BAC = \$1000, IEAC is computed to be equal to \$1176. Obviously, the value indicates that if this performance continues, project completion within the planned cost will not occur. Additionally, let’s assume the Management Reserve (MR) is \$100, making the Total Allocated Budget (TAB) equal to \$1100. The TAB is defined to be the sum of BAC and MR [1]. The IEAC computed forecast of \$1176 indicates that not only will the planned cost for the project be exceeded, but the reserves will be more than consumed; the project is headed for a cost overrun.

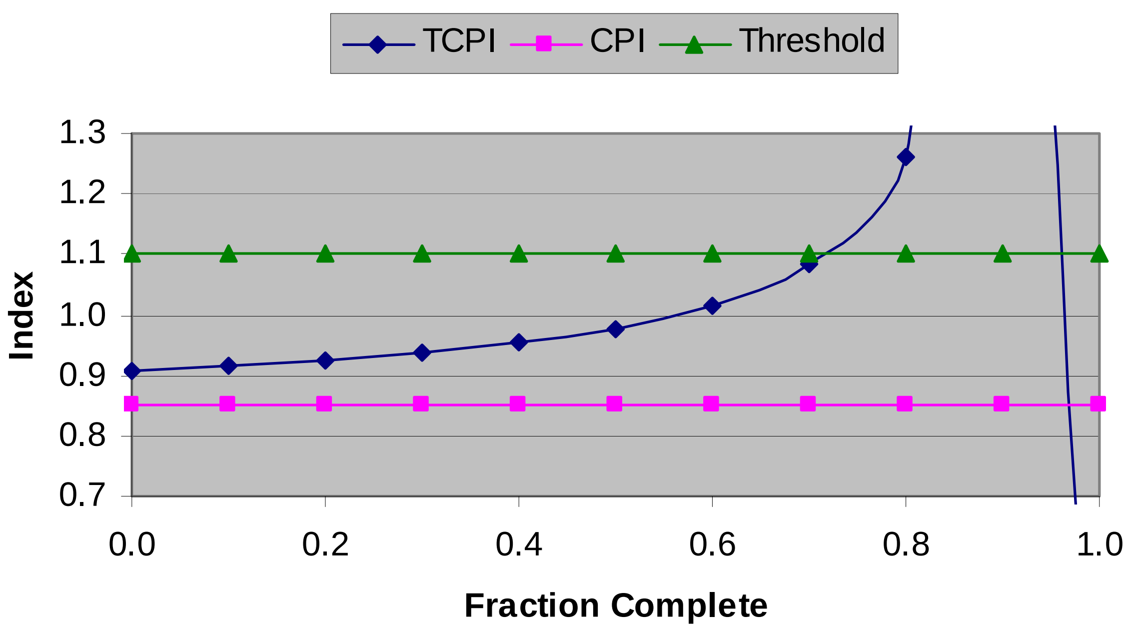

Figure 2. Evaluation of Opportunity for Project Recovery

What is the PM’s prerogative when the project is 80 percent complete? By calculating TCPI using TAB as the desired final cost and graphing it as shown previously in Figure 1, the answer is readily seen. As observed from Figure 2, the value of TCPI is so large it is nearly off the chart; the computed value is 1.259. From our previous discussion, the PM knows that when TCPI ≥ 1.10 the project is regarded as irrecoverable and that additional funding is very likely needed. In this instance, as uncomfortable as it may be, negotiation with the customer cannot be avoided.

Does the PM make the same decision when the project is 30 percent complete? The simple answer is ‘No.” At 30 percent complete, TCPI = 0.937, a good number, yet the PM knows if the current performance does not improve the project will overrun the funding available (TAB). With this value for TCPI, the PM has an opportunity to take action thereby avoiding the overrun and the embarrassment of the impending negotiation if he allows the cost performance to continue.

What is the period of opportunity for the PM to make a positive performance change? Again, the TCPI and the graph of Figure 2 provide this information. Viewing the graph, the PM has from the fraction complete equal to 0.30 until TCPI exceeds 1.10, which occurs when fraction complete is 0.72. For a project of reasonable size, having more than 40 percent of the period of performance to create and make an effective change, the PM has a very good chance for being successful with the recovery action.

Evaluating the Recovery Strategy

The TCPI has application, as well, in creating a viable recovery strategy. Involved in creating a strategy is developing a trade-off between cost and schedule performance to achieve the commitments to the customer. Generally, those commitments are the TAB and the negotiated delivery date. To resolve the condition of unsatisfactory cost performance, the PM creates a plan for transforming the cost performance from the present value of CPIa (actual value) to an improved efficiency, CPIs (strategy value).

TCPI plays a role in evaluating whether the change desired can realistically be achieved. For this purpose, the following formula for TCPI is used:

$$\text{TCPI} = (1 - \text{EV\%}) / (\text{CPIs}^{-1} - \text{CPIa}^{-1} * \text{EV\%})$$

As a rule of thumb, the envisioned performance change has a good likelihood of being achievable when the calculated value for TCPI is less than or equal to 1.00. That is, as discussed in the previous section on project recovery, the calculated value indicates whether there is sufficient opportunity for the improvement to succeed.

Schedule Analysis

The discussion in this paper has concentrated on cost management and control using EVM. With the advent of Earned Schedule [2], the To Complete Schedule Performance Index (TSPI) has been created. The TSPI is defined similarly to the TCPI; TSPI is equal to the planned duration for the work remaining divided by the duration available:

$$\text{TSPI} = (\text{PD} - \text{ES}) / (\text{TD} - \text{AT})$$

where PD is the planned duration
ES is the Earned Schedule
TD is the total duration desired
– generally: PD, the negotiated duration (ND), or estimated duration (ED)

AT is the actual time or duration at the time of computation

All of the preceding description for applications of TCPI can be made analogously for TSPI. That is, the use of TSPI is available for schedule management and control in a parallel manner to cost and TCPI. Both indexes are needed to have complete capability for the cost–schedule performance trade-off necessary for project recovery [3].

Summary

Hopefully by this point, the reader has gained an appreciation for the expanded use of TCPI. The index is definitely more than the simple calculation for determining the performance rate needed for the remaining work. As discussed in this paper, the TCPI has application in evaluating the realism of the bottom up derived EAC. Further, it was shown that the TCPI value of 1.10 is a reasonable criterion for determining when a project is not recoverable and is "out of control." The use of the index was then extended to the evaluation of the opportunity and the performance transformation envisioned for project recovery. Although not discussed in this article, the TCPI may also be used in creating the tactical changes of personnel and overtime adjustments [3]. Certainly, the TCPI has much to offer to the project manager in his efforts for controlling and managing the project. Finally, through Earned Schedule the methods described for TCPI are made applicable to schedule analysis, as well.

References

1. *Practice Standard for Earned Value Management*. Newtown Square, PA: Project Management Institute 2005.
2. Earned Schedule website: www.earnedschedule.com
3. Lipke, W. "Project Recovery …It Can Be Done," *CrossTalk*, January 2002, 26-29

About the Author

Walt Lipke retired in 2005 as deputy chief of the Software Division at Tinker Air Force Base. 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 (ΣΠΣ). Lipke achieved distinguished academic honors with the selection to Phi Kappa Phi (ΦΚΦ). During 2007 Mr. Lipke received the PMI Metrics Specific Interest Group Scholar Award and 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.

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