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Speculations on Project Duration Forecasting

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Abstract

Project duration forecasting has been enhanced with the introduction and application of the techniques derived from Earned Schedule (ES). The computed forecast results from ES have been shown to be better than any other EVM-based method using both real and simulated performance data. However, research has shown that as the topology of the network schedule becomes more parallel, the accuracy of the ES forecast worsens. This paper examines a possible approach for overcoming the dilemma to further improve the effectiveness of ES forecasting.

Introduction

Earned Schedule is a measure of time duration indicating how much of the Earned Value Management performance baseline has been completed. Having the measure, allows for the creation of schedule performance efficiency. The ES schedule performance index, SPI(t) is equal to ES divided by AT, the duration from the project start to the status point [Lipke, 2003]. The concept is illustrated in figure 1.

The derived schedule efficiency, SPI(t), is utilized to forecast project duration though the simple formula [Henderson, 2004]:

$$IEAC(t) = PD / SPI(t)$$

where IEAC(t) = Independent Estimate at Completion (time units)
PD = Planned Duration

The forecasting capability of the formula has been shown to be reasonably good. It has been verified by simulation and application to real project data. A comprehensive examination of the capability of two Earned Value Management (EVM) based methods and ES was made by the research team of Vanhoucke and Vandevoorde, who applied schedule simulation techniques for assessing project duration forecasting performance [Vanhoucke & Vandevoorde, 2007]. The conclusion from their work indicated, "The results …confirm…that the Earned Schedule method outperforms, on average, the other forecasting methods."

The following year, real data from 16 projects were used for comparing the EVM time conversion forecasting methods to ES [Lipke, 2008]. The comparison was constructed to determine whether the four EVM methods, as an aggregate, produce better forecasts than does ES. The analysis strategy segregated the project data into seven ranges of percent complete in order to isolate possible forecasting characteristics or tendencies among the methods. Conclusively, ES was shown to be the best method of forecasting project duration.

This evidence is compelling for applying ES forecasting when EVM is employed for project control. However, recent research has demonstrated that the topology of the schedule has impact on the "goodness" of the forecast. The ES forecasts are more accurate for schedules which are more serial and less so when parallel [Vanhoucke, 2009].

In turn, this deficiency has lead practitioners and researchers to seek additional techniques for schedule control when schedule topology is predominantly parallel. The approach recently examined combines two techniques, ES forecasting and Schedule Risk Analysis (SRA) [Vanhoucke, 2012]. The combination has shown promise in the testing performed on both simulated and real data. However, it does complicate the analysis and significantly add work to the project control process.

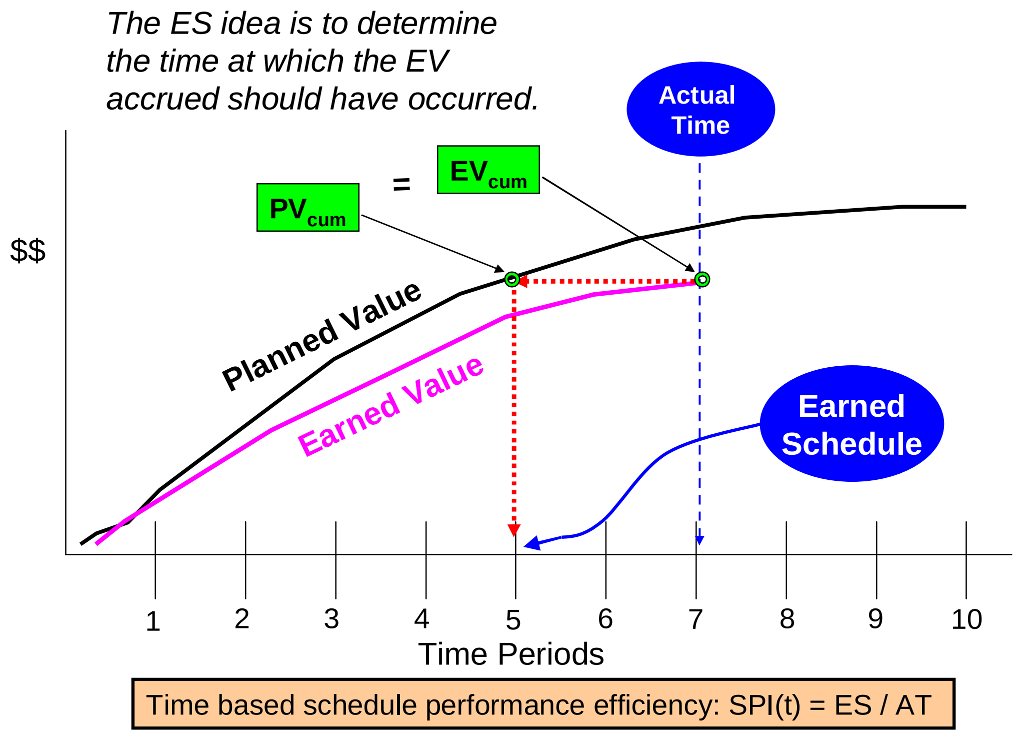

Figure 1. Earned Schedule Concept

Possibly, there is a second approach to the analysis and project control dilemma. If the ES deficiency for parallel topology schedules can be overcome, more reliable and significantly improved forecasting can be expected. Achieving this, the project control process discussed previously may be simplified, as well.

The idea for resolving the problem is to apply ES forecasting to the current longest path of the schedule. The remainder of the paper describes the theory and explores its application using notional data.

Theory

The fundamental idea for utilizing the longest path (LP) is that the ES forecast is from a schedule topology that is completely serial. As discussed earlier, research has shown the best ES forecast is for a serial schedule. Thus, the ES forecast should be improved if the LP, as it evolves in the project execution, reflects the likely duration outcome.

The concept of the current LP is an extension of the planned CP. The current LP is the longest duration from among the paths remaining to be executed from the present status point. The longest duration is determined by applying ES forecasting to each remaining serial path. This methodology has been described in the literature for comparison of planned CP performance to the total project [Lipke, 2006]. Fundamentally, the remaining Planned Value (PV) for the serial path examined is used as the Performance Measurement Baseline (PMB). The Earned Value (EV) accrued for the tasks on, say, path m is used with its PMB to calculate the path earned schedule, ES_m, and the associated duration forecast.[a]

The longest duration forecast from the remaining executable paths must be longer than the forecast made for the total project. It can be deduced that with shorter paths included in the total project, its forecast must be less than for the path having the longest forecast. Assuming this is true, it answers a question posed not long after the creation of ES, "Is the duration forecast from ES, the "lower bound?"[b] For the total project, it must be. Thus, the duration forecast for the total project is always optimistic.

The theory proposed is the LP forecast at each status point resolves the described limitations of the ES forecasts, thereby providing better and more direct information for project control.

Methodology

Using notional data, duration forecasts are computed for the various serial paths to project completion. The forecasts are compared to the corresponding forecast for the total project. The results from the comparisons are used to assess the validity of the following statements:

[a] For a description of EVM and its terminology reference [Project Management Institute, 2011]

[b] The idea of a "lower bound" comes from the research studies of the forecast of final cost using EVM [Christensen, et. al., 2002].

1) The forecasts using the current LP are improved from those for the total project
2) The total project forecasts are the "lower bound"
3) The current LP forecast overcomes the negative effect of parallel schedule topology

To perform the forecasting calculations the ES (special case) calculator is used.[c] The calculator takes into account periods for which no work is planned. This capability is needed because the tasks begin at various times during the project execution.

Project Data

The notional data used for the analysis is displayed in figure 2. There are ten tasks in the project. For each task the periodic values for PV and EV are shown. It is assumed that the precedence relationships between the tasks are finish to start.

Knowing the precedence, the reader should be able to identify various serial paths to completion. For example, the planned CP includes tasks 1, 4, 8 and 10, symbolized by 1-4-8-10. It should be noted that task 9 does not feed into task 10. Thus, Task 9 is another outcome which has the potential of becoming the LP.

		••• Performance Period •••												
Task Nr	Measure	0	1	2	3	4	5	6	7	8	9	10	11	12
1	PVp	◆	5	5	5									
	Evp		◆	4	5	6								
2	PVp			◆	10									
	Evp				◆	7	3							
3	PVp			◆	10	10	10							
	Evp			◆	8	13	9							
4	PVp				◆	5	5							
	Evp			◆	3	4	3							
5	PVp				◆	5	5	5						
	Evp				◆	5	3	5	2					
6	PVp					◆	5	5						
	Evp						◆	6	4					
7	PVp			◆	10	10	10	10	10					
	Evp				◆	8	9	7	13	8	5			
8	PVp						◆	5	10	5				
	Evp							◆	12	8				
9	PVp							◆	5	5	5			
	Evp									◆	4	5	3	3
10	PVp									◆	5	5		
	Evp										◆	10		

Figure 2. Notional Project Data

[c] The ES (special case) calculator (ES calculator vs1) is available from the Earned Schedule website (http://www.earnedschedule.com/Calculator.shtml). For more information reference [Lipke, 2011].

Analysis

The identification of various executable paths with their associated task aggregated PV and EV is shown in figure 3. The cumulative values, PVc and EVc, are the data used with the special case calculator to compute ES for each of the paths at each status point.

To complete the understanding of figure 3 a brief explanation of the symbol "XX" is needed. When used in the PV row, the XX indicates no work was planned for the period. In the EV row, the interpretation is the execution was delayed for that period. For example, performance was not planned to begin for path 2-4-8-10 until period 3, as shown in the PVp row. For performance path 2-5-9, it is observed that although execution was planned to begin in period 3, it did not commence until period 4. This is shown with XX in the EVp row for periods 1 through 3.

Two paths, 2-5-9 and 6-9 indicate completion two periods past the planned duration of 10 periods. Thus, we know from simple inspection of the figure that execution of the planned CP (1-4-8-10) did not complete the project and that the longest path must have changed during project execution.

Figure 4 contains the computed forecasts for all of the paths and the total project. For the various paths the longest duration forecast for each status period is identified in the chart by the lime color. It is clearly seen that the current LP was identical to the planned CP for only one performance period, period two. Path 7-10 indicated the current LP for periods 4 through 7, while from period 8 through project completion, period 12, the longest duration forecasts were for path 6-9.

Results

A significant observation from figure 4 is that for every period the LP forecast is greater than the forecast for the total project. This result supports the expectation postulated earlier in the theory section. Likewise, it supports the idea that the forecast for the total project is the lower bound; i.e., it is optimistic.

Figure 5 indicates variation from the actual duration using the standard deviation. As shown, excluding periods 2 and 3, the standard deviation for the current LP is fairly constant with respect to the mean value of 0.446. The standard deviation for the total project behaves differently. It is significantly larger than the value for LP and, in general, improves from a beginning value of approximately 1.60 to a project completion value of 1.16. This comparison strongly suggests, forecasting is improved through the use of the current LP.

Performance Path	Period	1	2	3	4	5	6	7	8	9	10	11	12
1-4-8-10	PVp	5	5	5	5	5	5	10	5	5	5		
	EVp	XX	4	8	10	3	0	12	8	0	10		
	PVc	5	10	15	20	25	30	40	45	50	55		
	EVc	XX	4	12	22	25	25	37	45	45	55		
2-4-8-10	PVp	XX	XX	10	5	5	5	10	5	5	5		
	EVp	XX	XX	3	11	6	0	12	8	0	10		
	PVc	XX	XX	10	15	20	25	35	40	45	50		
	EVc	XX	XX	3	14	20	20	32	40	40	50		
2-5-9	PVp	XX	XX	10	5	5	5	5	5	5			
	EVp	XX	XX	XX	12	6	5	2	0	4	5	3	3
	PVc	XX	XX	10	15	20	25	30	35	40			
	EVc	XX	XX	XX	12	18	23	25	25	29	34	37	40
3-8-10	PVp	XX	XX	10	10	10	5	10	5	5	5		
	EVp	XX	XX	8	13	9	0	12	8	0	10		
	PVc	XX	XX	10	20	30	35	45	50	55	60		
	EVc	XX	XX	8	21	30	30	42	50	50	60		
7-10	PVp	XX	XX	10	10	10	10	10	XX	5	5		
	EVp	XX	XX	XX	8	9	7	13	8	5	10		
	PVc	XX	XX	10	20	30	40	50	XX	55	60		
	EVc	XX	XX	XX	8	17	24	37	45	50	60		
6-9	PVp	XX	XX	XX	XX	5	5	5	5	5			
	EVp	XX	XX	XX	XX	XX	6	4	0	4	5	3	3
	PVc	XX	XX	XX	XX	5	10	15	20	25			
	EVc	XX	XX	XX	XX	XX	6	10	10	14	19	22	25
Total Project	PVp	5	5	35	30	35	25	25	10	10	5		
	EVp	XX	4	16	43	27	18	31	16	9	15	3	3
	PVc	5	10	45	75	110	135	160	170	180	185		
	EVc	XX	4	20	63	90	108	139	155	164	179	182	185

Figure 3. Path Performance

Performance Path	**** **** **** Period **** **** ****											
	1	2	3	4	5	6	7	8	9	10	11	12
1-4-8-10		13.50	9.33	7.82	9.00	11.00	9.96	9.75	11.00	10.00		
2-4-8-10			28.67	10.89	10.00	12.67	10.51	10.00	11.33	10.00		
2-5-9				8.00	8.38	8.83	10.00	11.75	11.75	11.45	11.75	12.00
3-8-10			12.00	9.62	10.00	12.67	10.51	10.00	11.33	10.00		
7-10				12.75	12.24	12.75	11.57	10.78	11.40	10.00		
6-9						9.17	10.00	12.50	12.14	11.58	11.82	12.00
Total Project		13.50	9.75	9.33	10.03	11.12	10.74	11.29	11.81	11.11	11.64	12.00

Figure 4. Forecast Comparison

Period	1	2	3	4	5	6	7	8	9	10	11	12
Longest Path		1.50	11.83	0.43	0.39	0.49	0.48	0.48	0.45	0.45	0.43	0.41
Total Project		1.50	1.91	1.54	1.66	1.53	1.49	1.41	1.32	1.28	1.22	1.16
				Omitted periods 2 & 3 in Std Dev calculations								

Figure 5. Standard Deviation Comparison

Figure 6 provides a good visual supporting the improvement in ES forecasting provided by using the current LP. As can be observed, the variation of the LP forecast is reasonably uniform around the actual duration, whereas the total project forecast has much more variation in converging to the actual duration.

As discussed earlier in this section, two of the three statements outlined in the preceding methodology section have been demonstrated. However, the third (LP forecasting removes the effect of parallel schedule topology) has not been shown through the exercise with the notional data; performance was not examined for varying topologies. Even so, logically it is plausible because the LP forecasting is applied to completely serial networks.

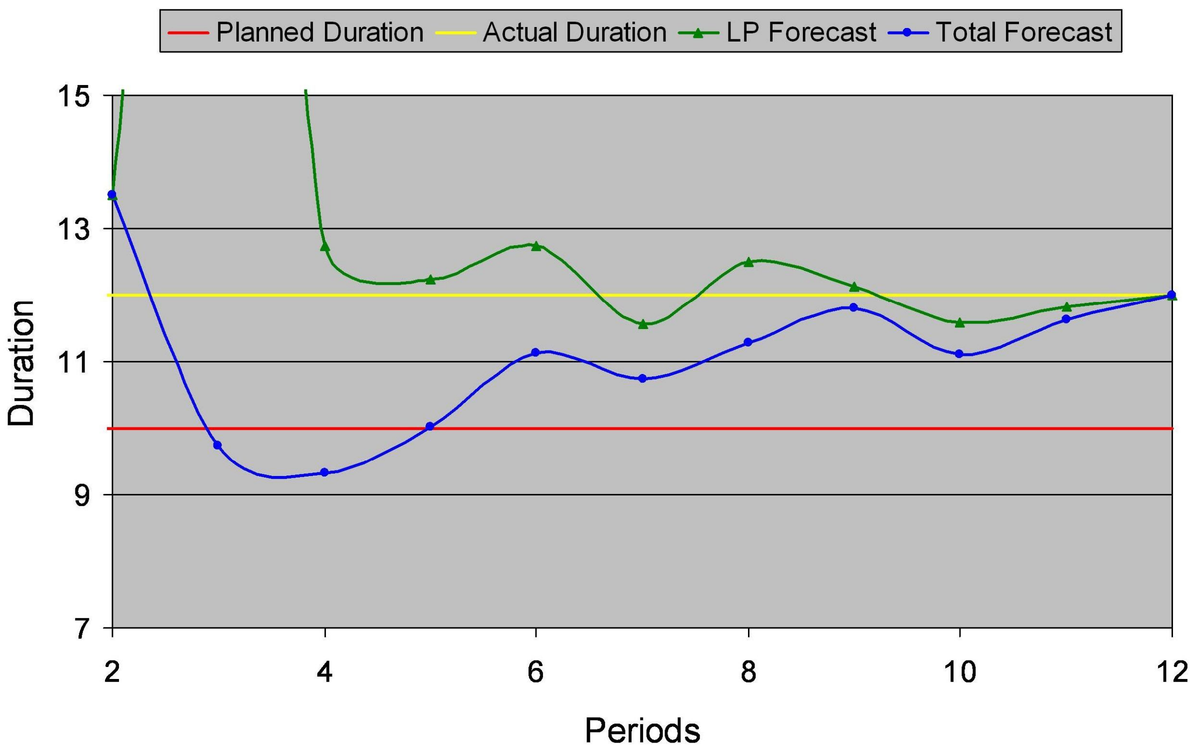

Figure 6. Longest Path vs Total Project Forecasts

Summary and Conclusion

The point of this paper is to demonstrate that ES forecasting is improved by using the current LP. The results from application to the notional data indicate achievement of the objective. Figures 5 and 6 illustrate the improvement theorized, while figure 4 indicates the forecast for the total project is optimistic, i.e. the lower bound.

Although it is more complex than the normal application of ES, the LP methodology is reasonably straightforward. The added complexity is thought to be a good trade-off for gaining the reliable information needed for project control.

A secondary improvement is that the LP forecasting may reduce the effort for the project manager and the EVM analysis staff. The combined approach of SRA with ES forecasting are indicated to be labor intensive. The two project control methods appear to require a significant amount of analysis and threshold establishment to successfully apply the combined methodologies.

The results from the notional data example are compelling. However, they are insufficient to say LP forecasting should be adopted and employed without further examination and testing. It is recommended that those with EVM data experiment using the methods described in this paper and report their results. For those researchers that have the capability to create schedules of various topology characteristics and simulate task performance, you are challenged likewise to examine the LP approach to forecasting.

Should LP forecasting become a topic of research and application, it is proposed that the method be referenced as "ES-LP." The terminology creates common language necessary for understanding.

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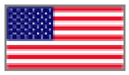

Walt Lipke retired in 2005 as deputy chief of the Software Division at Tinker Air Force Base in the United States. He has over 35 years of experience in the development, maintenance, and management of software for automated testing of avionics. During his tenure, the division achieved several software 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 (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. 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.