Time Prediction in Construction Projects with Earned Schedule Longest Path (ES-LP)

By Mojtaba Zarei Kesheh

Introduction - Any construction contract contains at least one clause related to time. Several research efforts have shown the impact of poor time control on the outcomes of construction projects. One such research, done in 2008, in regard to managing the risk of delayed completion in the 21st century, showed that "on the whole complex construction projects in the UK are likely to be finished more than six months late, due to poor time control" (Pickavance, 2008). It is due to this uncertainty about the future that we feel a need to have prediction. This paper shifts the focus from individual Earned Schedule (ES) time forecast and Critical Path (CP) to applying ES to Longest Path (LP) as a better way to achieve more accurate and reliable project time forecasts.

Background

For more than three decades project managers have been relying on the 35 Cost/Schedule Control System Criteria (C/SCSC) (Fleming and Koppelman, 1988) and the 32 EVM American National Standard Institute/Electronic Industry Association (ANSI/EIA 748) (NDIA, 2006), whilst these standards do not define the analysis to be performed on EVM other than to state cost and schedule variances need to be computed.

The traditional budget-based earned value methodology of calculating Schedule Variance (SV) and Schedule Performance Index (SPI) is proven to be mathematically and technically incorrect (Lipke, 2003 p.10 & Henderson, 2003 p.13). This method for calculating schedule performance portrays schedule variance (SV) in units of money (Stratton, 2005). The erroneous values become evident when a project is delivered late and the schedule performance parameters calculated do not reflect expected results. Under this scenario, schedule performance and variance as calculated will start to return values nearing and ending at 1.00 for SPI and 0.00 for SV. This indicates a perfect schedule performance. In such cases, it would be expected to have SPI and SV as fractions of 1.00 and 0.00 respectively to reflect delays (Lipke, 2003).

Lipke (2003) was the first to apply nomenclature and mathematical analysis to the data to introduce Earned Schedule (ES) as a time-based method to resolve this problem at any point in time during a project's lifecycle. However, Fleming and Koppelman (2005), who are in time-is-money camp, do not endorse the earned schedule concept and other EVM methodologies regarding predicting project duration. In the opinion of these authors, only CPM is the most reliable method to predict the project's time dimension (Fleming and Koppelman, 2005 p.163).

The planned value rate (Anbari, 2003), earned duration (Jacob, 2003 & 2004), and earned schedule (Lipke, 2009) are the methods which have been presented regarding measuring schedule performance and forecasting project duration. ES is the latest development in EVM, recently recognized as a viable schedule analysis practice in the PMI Practice Standard for Earned Value Management (2011). However, if the work is accomplished incorrectly (non-critical or out of sequence), then the SV(t) and ES may show ahead of schedule while the project is behind and falling further behind. The ES method is already proven to be the best method of predicting final duration in comparison with PV rate (Anbari's method) and ED (Jacob's method) by Vandevoorde and Vanhoucke (2006) in several papers.

Problem Statement

Although, Earned Value Management and Earned Schedule have been proved to be one of the most impressive tools in project management, they cannot be used to determine how far ahead or behind schedule one is because there are too many variables that must be considered. For instance, if I have schedule variance, am I behind schedule if the task(s) that are behind are not on the critical path? What if I am just consuming float and will complete the task(s) before I perturbate the critical path? Am I 'behind' schedule? Many project managers make the same error that many do who are new to EVM/ES, and use the measurements in a deterministic fashion. It is difficult to resist because everyone wants absolute answers. However, the author believes that none of the measures used in EVM and ES are deterministic in any manner. If you see a negative cost variance, do not presume that you are over cost and more than you can presume you are behind schedule with a negative schedule variance. These indicators are intended as information which will cause you to do analysis, nothing more or less than that.

Earned Schedule Longest Path (ES-LP) Methodology

In the above, we pinpointed two elements: Earned Value Management/ Earned Schedule and Critical Path. Some of the recognisable textbooks and documents have contained some wisdom regarding the use of EVM and ES in parallel with Critical Path (CP) (PMI Practice Standard for Earned Value Management, 2011 & ANS/EIA-748-B, 2007 & NDIA PMSC EVMS Application Guide, 2007 & Measuring Time, 2009).

Vanhoucke (2009) has shown that the more serial network, the more accurate ES forecasts. Therefore, the deficiency of ES forecasts for parallel network has made practitioners question the reliability of the ES technique over the years. In thinking about how to resolve this problem and bridge ES with CP, Lipke (2012) came up with a revolutionary idea, i.e., using the ES forecasts to the current Longest Path (LP). Lipke called this "ES-LP" which means application of earned schedule to the longest path.

From the forensic planning and delay analysis perspective, we know that a programme may have more than one critical path. It is the Longest Path (LP) that is important in capturing the final completion duration and date of a project.

The author believes that the ES-LP philosophy concerning the current LP can give us an up-to-date view of the project status from the CPM standpoint; and that ES can produce more accurate outcomes when it is applied to the LP. This can resolve the dilemma which has been discussed above.

The formula for the ES time forecast has been discussed (Henderson, 2004) in other papers. For the sake of clarity, we explain it here again:

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

Where:
IEAC(t) = Independent Estimate at Completion (time units)
PD = Planned Duration
SPI(t) = Time-based Schedule Performance Index

Lipke (2012) has made three important statements regarding ES-LP based on notional project data:

1. The forecasts using the current LP are improved from those for the total project;
2. The total project forecast are the "lower bound" i.e., it is optimistic;
3. The current LP forecast overcomes the negative effect of parallel schedule topology;

Application of ES-LP Method

The ES-LP method has been shown with one notional data set by Lipke (2012). There is a big difference between artificial data and real-life project data. There will be no confidence to rely on simulated and artificial data since all real projects have their own unique characteristics. If a method provides an enhancement, it needs to be shown, both theoretically and practically with real-life project data. There is a need to have data from a prototype to show that theory provides the results predicted. To test the validity and reasonableness of the ES-LP idea on real-project data, one real construction project has been considered for this paper.

The data has been gathered in Oracle Primavera P6 Professional Project Management. This project was planned to be completed in 7 periods. In order to compute earned value (EV) credibly and consistently, a set of key performance indicators (KPI) have been used in this project to measure the physical percent of work accomplished for both design and construction phases. In order to keep the confidentiality of this project, the EVM and ES data have not been mentioned here and we have just shown the results of this analysis.

In order to apply the ES-LP method, all periodic updated programmes have been studied and reviewed to capture and extract the EVM data on the Longest Path at each period.

The results of ES-LP analysis has been shown in Figure 1. As it can be seen, the project was planned to be finished in 7 periods while it has completed with 7 periods of delay. In this specific construction project which appears to have many uncertainties, the ES forecasting method on the Total Project could not show accurate and reliable outcomes due to the high complex activity network and uncertainty involved with this project. However, this cannot be an excuse to bruise the ES method. Having applied the ES time forecast on the Longest Path (LP), it can be clearly seen that we have had a big improvement in our forecasts.

Period		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Duration	PCD	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	ACD	14	14	14	14	14	14	14	14	14	14	14	14	14	14
IEAC(t)	Total Project	7.75	7.92	7.37	7.61	7.52	7.82	8.74	9.23	9.76	10.74	11.52	12.33	13.11	14.00
	ES-LP	7.75	10.29	12.73	16.67	13.21	11.29	15.22	12.50	13.46	12.96	14.29	13.73	13.46	14.00

Figure 1. Forecast Comparison
(PCD= Planned Completion Duration; ACD = Actual Completion Duration)

Figure 2 shows the results graphically. The ES-LP begins to portray the delay at the early stage of project. The improvement of forecasts on the Longest Path is outstanding.

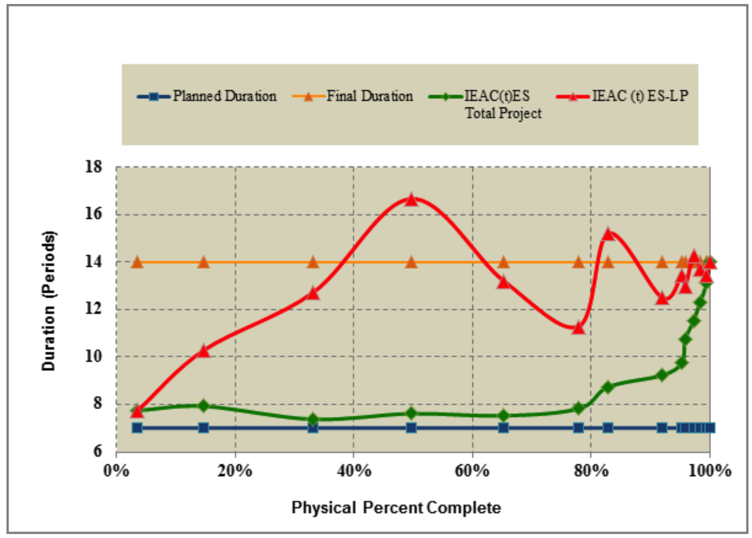

Figure 2. Project Duration Forecasts based on Total Project and Longest Path (LP)

The forecast trend has shown some fluctuations at the late stage of project but as it can be clearly seen this fluctuation is in a low range around the final completion duration.

The main observation from Figure 2 is that the time forecast has been improved significantly in comparison to ES time forecast on Total Project. The results directly confirm the theory.

Summary and Conclusion

This paper demonstrated the application of ES-LP with a real construction project. Applying ES to the Longest Path subset of the network is applicable and combines the power of CPM with ES. This marriage should stop the bickering between the ES camp and the CPM camp. Each makes the other's tool more effective and powerful.
So, whoever it was who said: "ES is not something new and it has nothing to offer" has never understood the power of this technique. The aforementioned limitation of ES is, however, essentially a limitation of the knowledge of using the technique properly where it should be used. There is an improvement in ES methodology every year, and the advancement of ES time forecasting on the longest path has begun to significantly contribute to project management. However, there is still more room for improvement in earned schedule methodology.

About the Author:

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