The Forgotten Art of Graphical Earned Value Management
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Introduction

The article "The Mysterious 'S' Curve" authored by Midori Media and published in Project Controls Professional Magazine in 2011 was instrumental in prompting me to prepare a paper on what I will call Graphical Earned Value Management which was eventually presented to the Southern Region group of the A.Cost E in January 2012. This article will try to capture and convey the essence of the paper as presented and include as far as possible answers to questions raised but without expressing them as such.

Having first prepared the paper I must thank Stephen Allen, the A Cost E Southern Region co-ordinator for allowing me to present a paper on what many would consider to be a well established discipline and also those who turned out to listen and raise thought provoking questions.

The original 'S' Curve article dealt with types of 'S' curves and how they may be used. In this article I have tried to move things on based on experiences in the defence, energy and ship building and repair industries

Why 'The Forgotten Art'

Having received my first taste of EVM in the days when computer access was a rare and expensive I gained a clear insight into the creation and interpretation of critical path analysis, resource limited scheduling, budgeted cost of works planned (early and late), budgeted cost of scheduled work, budgeted cost of works completed, schedule and cost performance indicators and the use of graphics to communicate project situations.

With this sort of background it is not surprising that I frequently question the validity of contemporary project snapshot reports. Such output, often presented in terms of a project or data dashboard or KPI's presents what I would term as an Accountant's view of the project i.e. where we are at the moment with no indication of how we got here or where we may be heading. In other words "**data without context**", which is rarely very helpful.

I first became aware of such situations when I was approached by a project manager who said "My cost engineer says we are OK, we are earning as much as we spend. My planning engineer says that we are OK as we are well ahead of programme. Somehow I feel that something is not quite right on the project." A brief data mining exercise later I was able to confirm his concerns. I will return to this later in the article.

Questions for Project Managers

Most managers of large projects are reliant on project controls teams who provide their planning, cost, risk and project governance services. In order for these services to be provided at an affordable cost it is inevitable that some sort of software will be used. How many project controls engineers can say that they can fully understand the algorithms which turn their raw data into an EVM progress 'S' curve?

Thus the question that a project manager might ask is "Am I running the project or am I working for some faceless software developer with a 'one size fits all' solution to any project?"

Assuming it is drawn, the progress 'S' curve is potentially the most important line drawn on the whole project and its form should be of great interest to the project manager who is keen to get greatest efficiency out of his available resources. Sadly, however, the project manager and project controls department too often approach EVM from the point of view that its output is gospel or even that it is a target to be beaten.

So what does Graphic EVM mean and how did we arrive at it?

Earned Value Management is a simple way of allocating value, usually in terms of budgeted man hours to planned activities and summating the planned daily use of resources through the project life cycle.

Assuming that we have initially carried out just critical path time analysis the only time/resource data that we will have available to us will be the overall project duration as determined by the critical path, and the resource usage based on activity early and late activity start and finish dates.

This seemingly simplified data actually gives us one of the most useful tools available to project controls engineers; the early / late envelope. (Budgeted Value of Work Planned (Early) (BVWP(E)) and Budgeted Value of Work Planned (Late) (BVWP(L)).

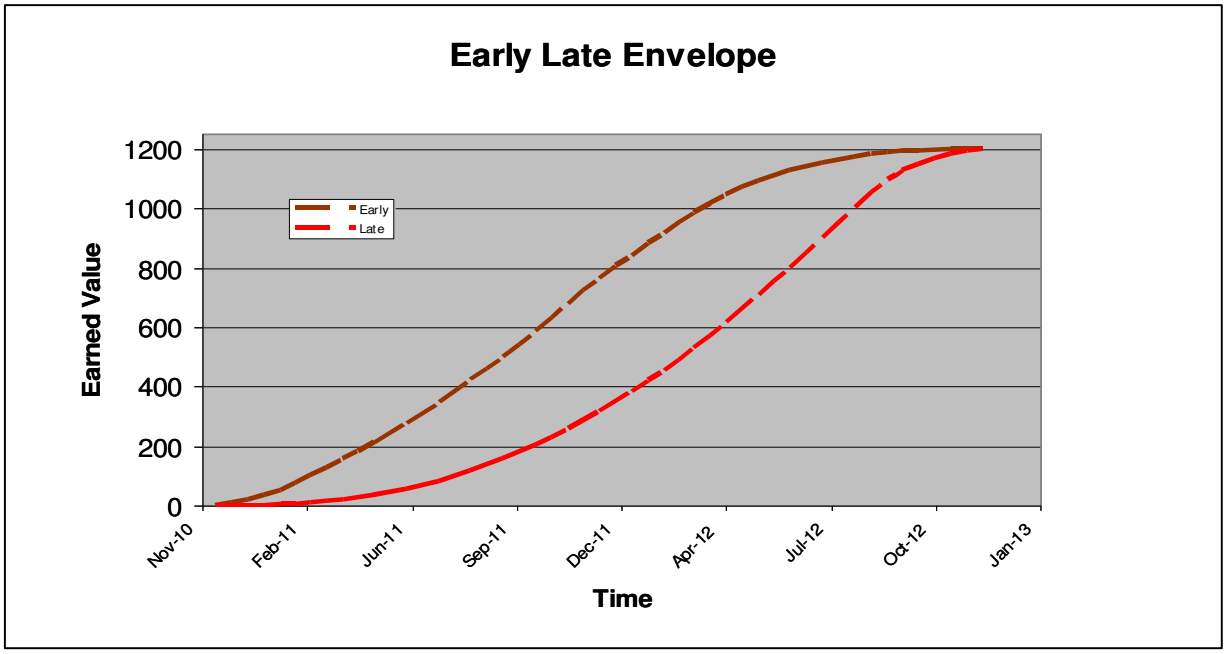

Figure 1; Early Late Envelope

Regardless of any other considerations the scheduled progress curve (Budgeted Value of Work Scheduled (BVWS)) must fit between the early and late curves if it is intended for the project to end at the critical path end date. However it is possible for the late start end date to be set later than the early start date, thus introducing float to the critical path and facilitating resource scheduling with limited resources.

Nonetheless the scheduled 'S' curve (Budgeted Value of Work Scheduled (BVWS)) needs to be carefully spaced between the early and late 'S' curves and it is here that the project manager should start taking an interest.

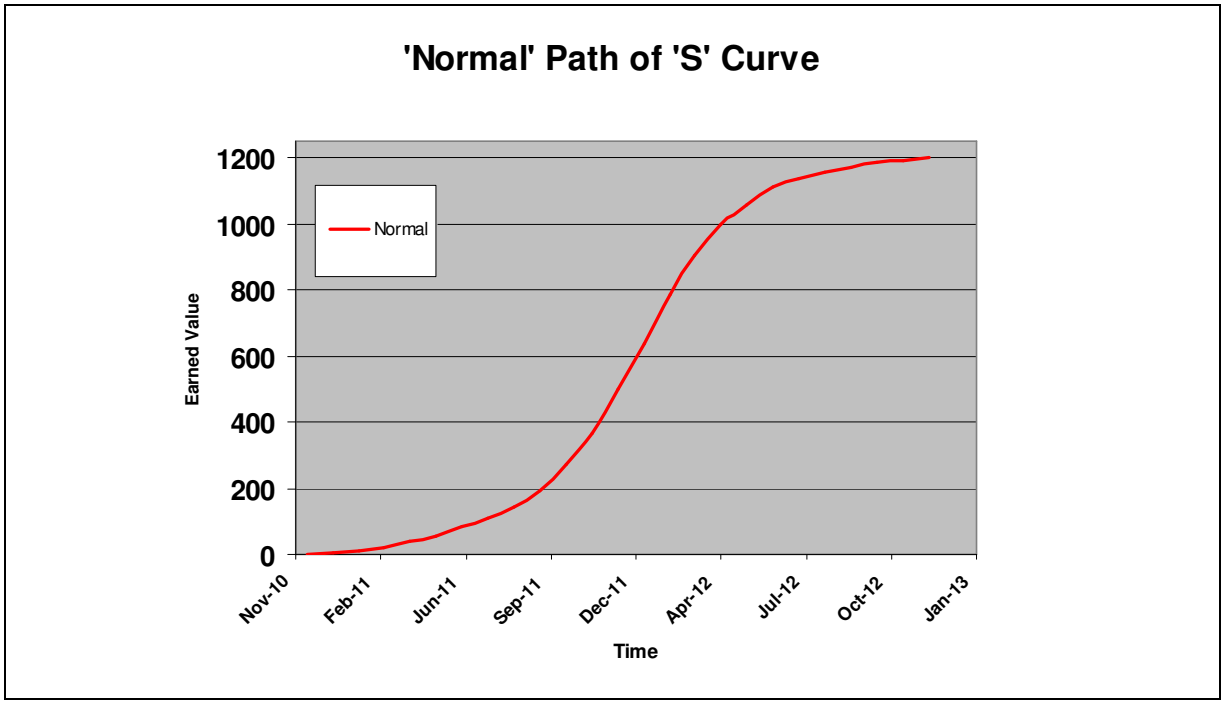

Figure 2; Normal 'S' Curve

Figure 2 shows a type of 'S' curve which would probably be considered 'normal' when viewed in isolation.

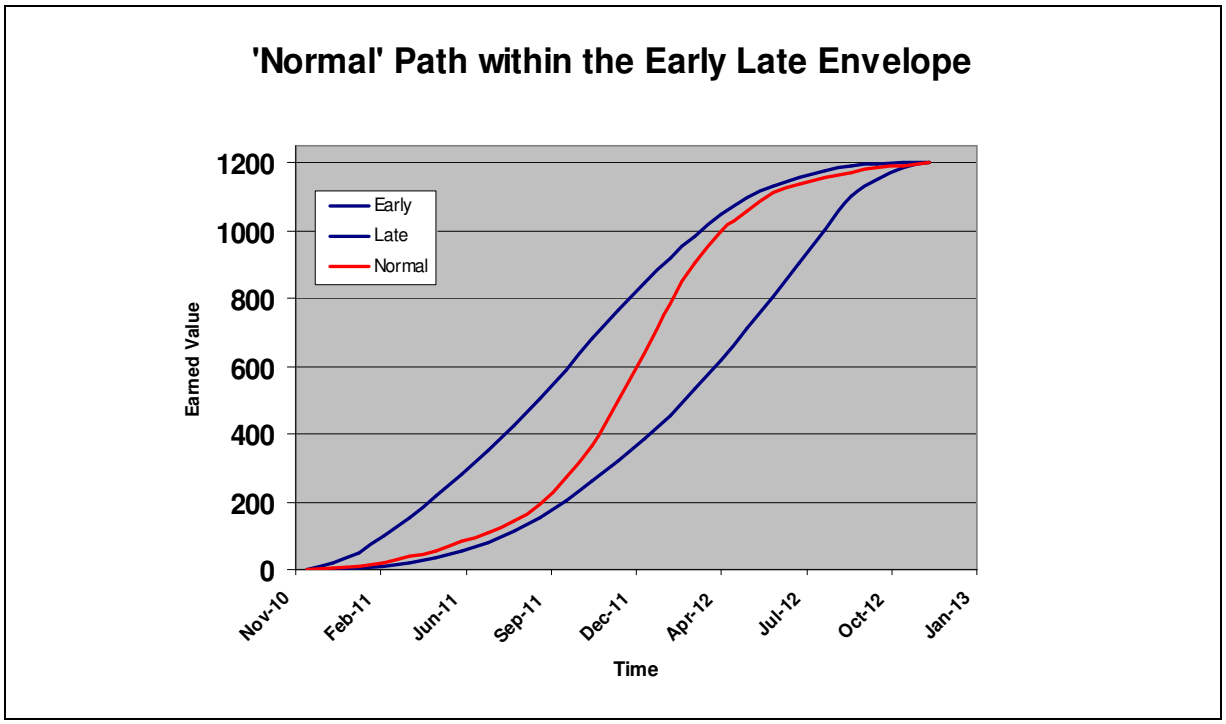

Figure 3; Early, Late and 'Normal' 'S' Curves.

When compared with the Early / Late envelope (Fig.3), however, this normal 'S' curve does highlight slow start and finish phases with a busy mid phase. Implications of this are that the

resource levels are very high in the mid project phase which could lead to high costs in resource facilities such as car parking, canteen etc as well as potential inefficient working due to overcrowding the site with labour. This would be far from ideal and should prompt the project manager to start asking some questions.

Can we do better?

In determining just where to draw the BVWS the project team must look at the particular project requirements. For example if an early project end date is important the team would probably bias the scheduled curve toward the early side of the early/late envelope as shown below. As a general rule and in the absence of good resource scheduling tools I would place scheduled progress (our target) at one third of the EV difference between the early and late lines below the early start values. (Note that this is a measure of the earned value not of schedule duration).

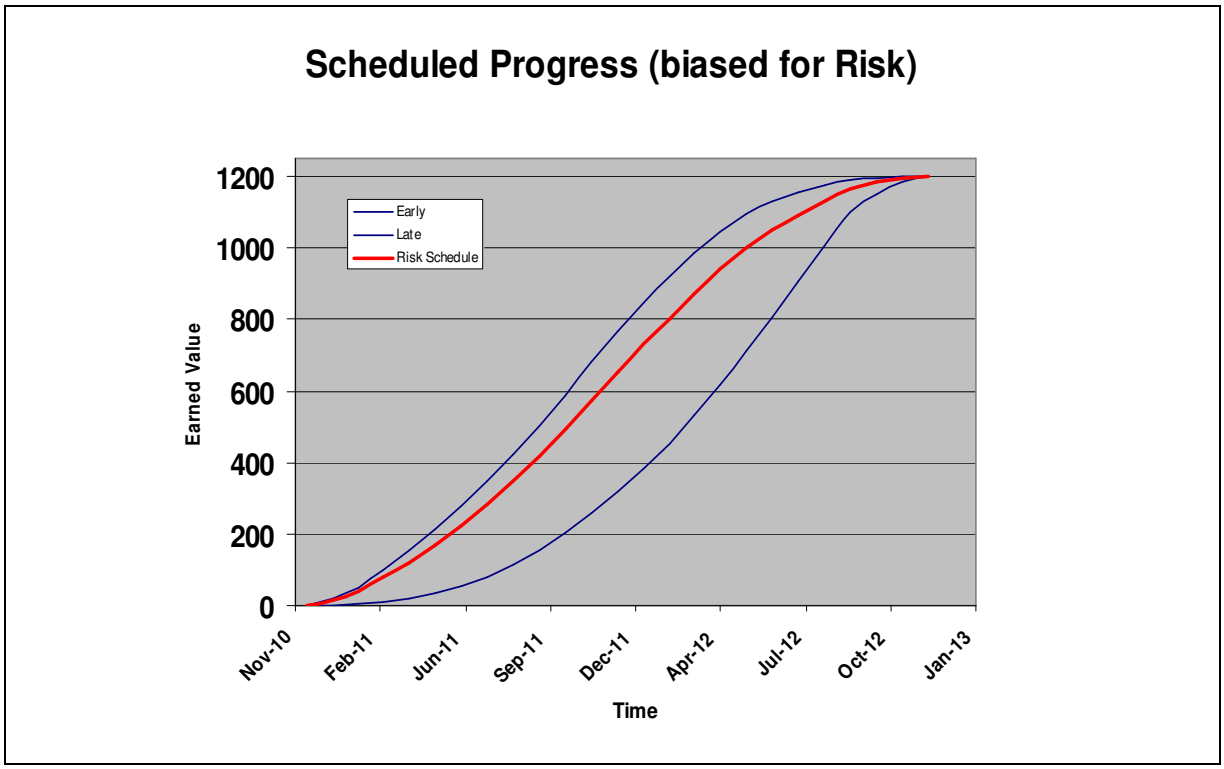

Figure 4; BVWS Biased for Risk

Figure 4 shows a project which aims to have a fairly rapid start and maintain a lot of float in the programme without ever seeing very high resource levels but aiming to deliver on time through having float in which to accommodate any schedule risks which may occur.

Many projects, such as oil extraction or refining facilities which have very high cost and long lead times before producing revenue will wish to delay spending as late as they dare without jeopardising the end date will try to schedule work late in the early/late envelope in order to achieve the best economic case as shown in Fig; 5. This may be interpreted as following the late start curve but with an allowance for risk and weather downtime.

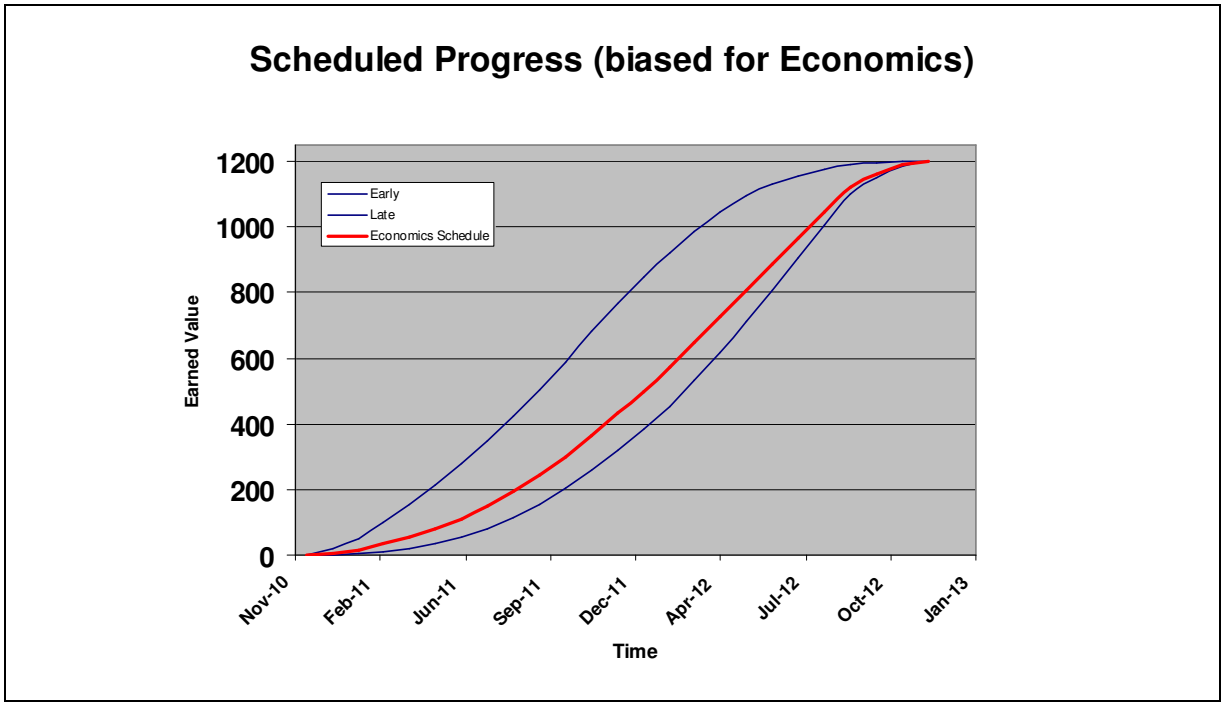

Figure 5; BVWS Biased for Economics

What is ideal

A third or middle way may be preferred where there are restrictions on the resource levels which can be employed. This could be where the project is in a remote location where accommodation is limited or expensive to establish or it may be that the project is being carried out by a small team of dedicated specialist staff. In either case we would be aiming for a constant resource level. It also means that where the contractor has to work on a hire and fire basis that the numbers hired for the project are minimised and also the number of redundancy payments on completion are kept to a minimum. This type of schedule is considered by some project managers to be the optimum and the easiest to maintain the plan on schedule once the project has started. An example of this is shown in Figure 6.

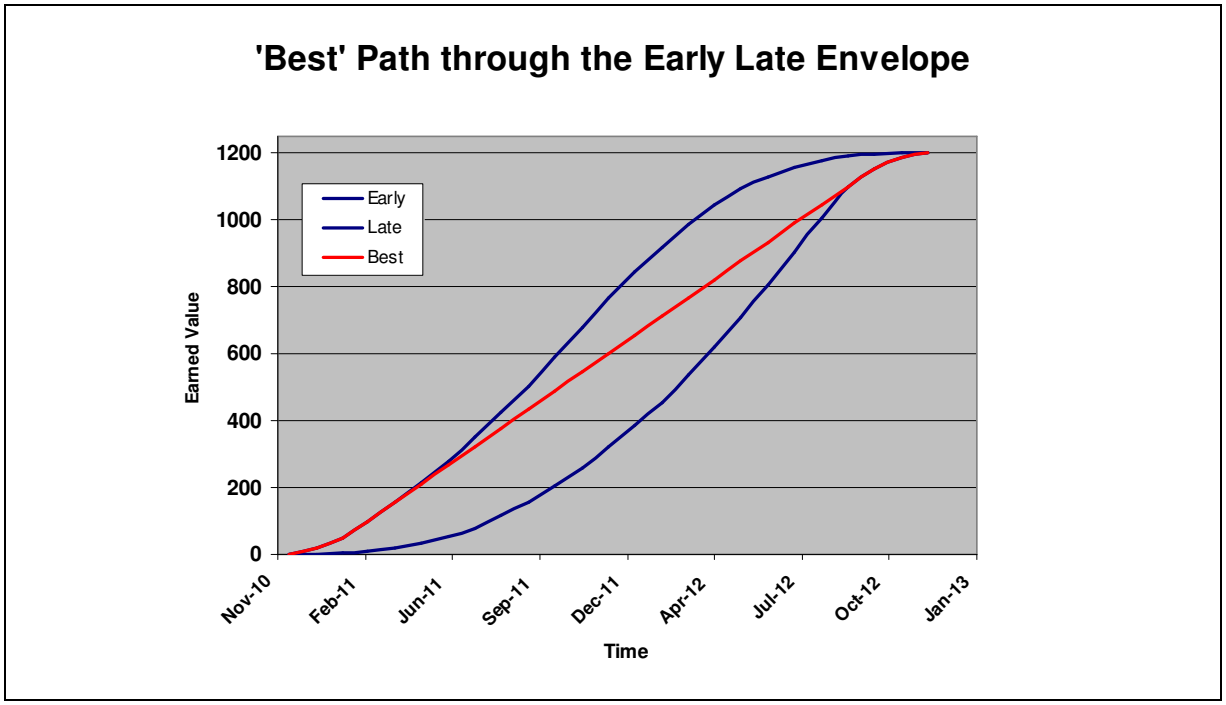

Figure 6; Ideal Path of BVWS

What else can EVM provide us with?

EVM can prove useful during forensic claims against clients. For example when a bid assumed a certain availability of work through a project but in reality that level of available work is fulfilled much later, as illustrated in Figures 7 and 8.

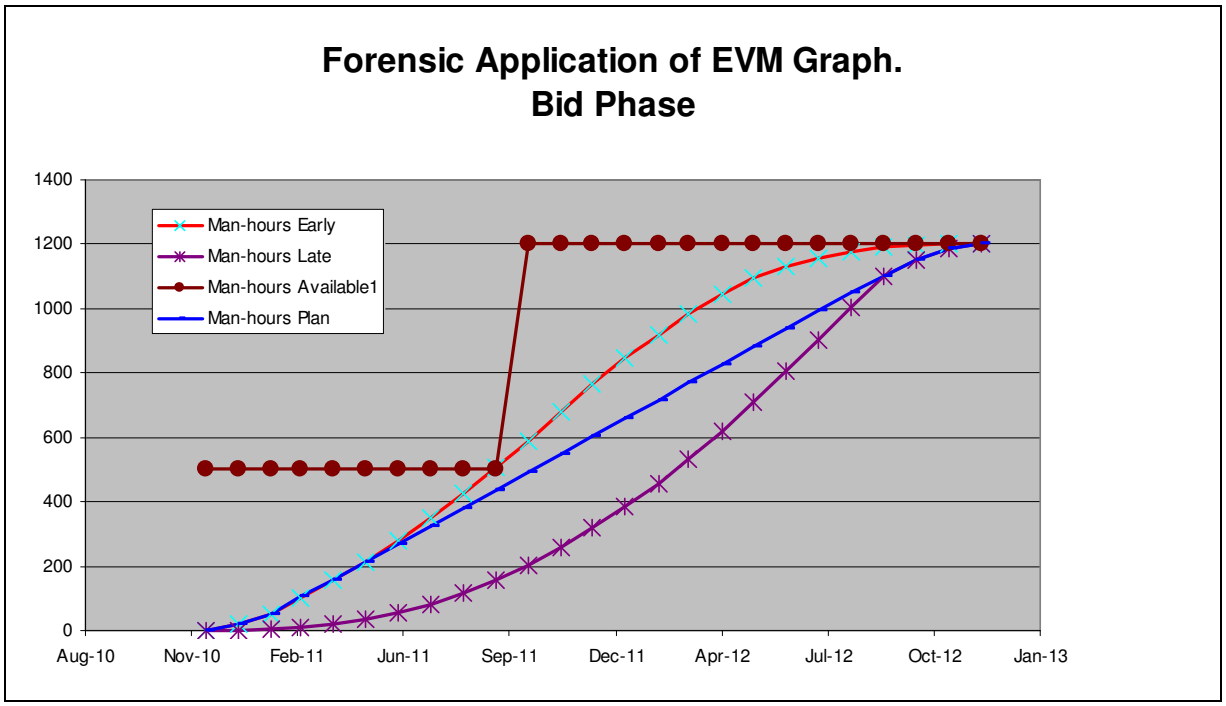

Figure 7; Assumed Available Work at Bid

Figure 7 shows the planned work based upon information supplied with the bid document.

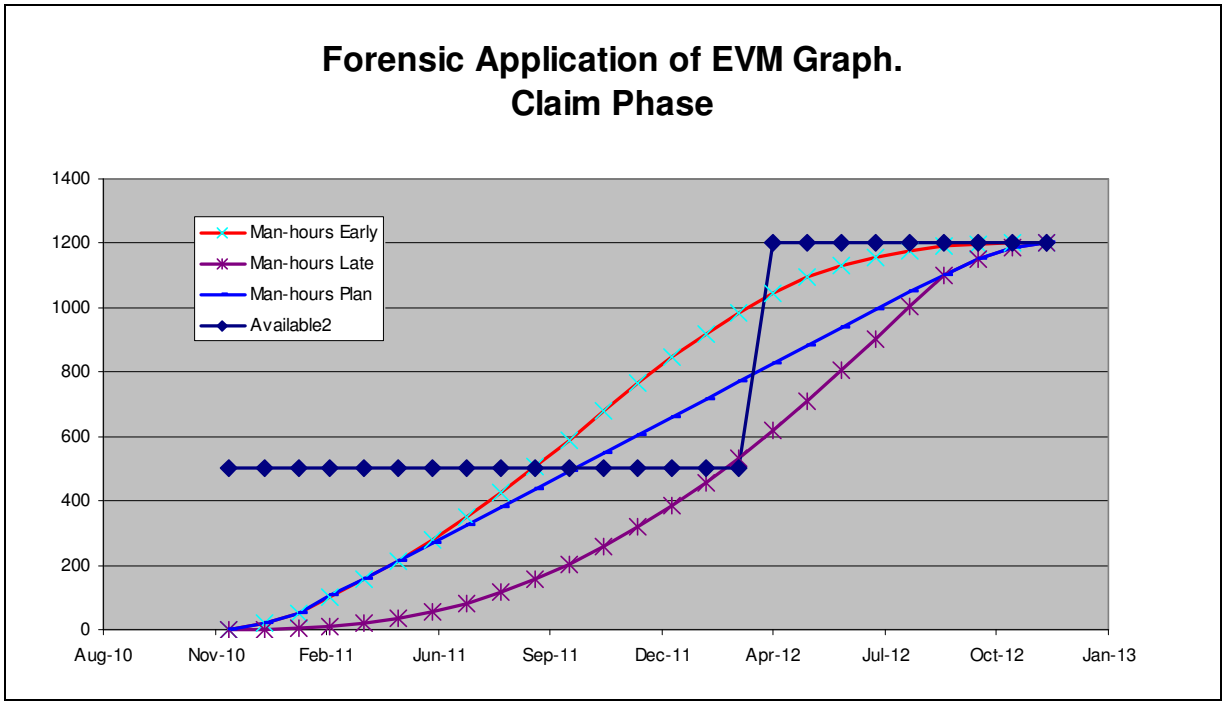

Figure 8; Actual Work Available

Figure 8 shows that having worked to a schedule from the start of work the contractor reached a point in September 2011 where no further work was available until March 2012. This graph was instrumental in a successful claim for Delay and disruption.

Once the project is underway

Once projects have started using a graphical approach to EVM will allow trends to be identified much more readily than when using a data dashboard approach. Figure 9 shows a project where a much higher resource level than scheduled was initially applied.

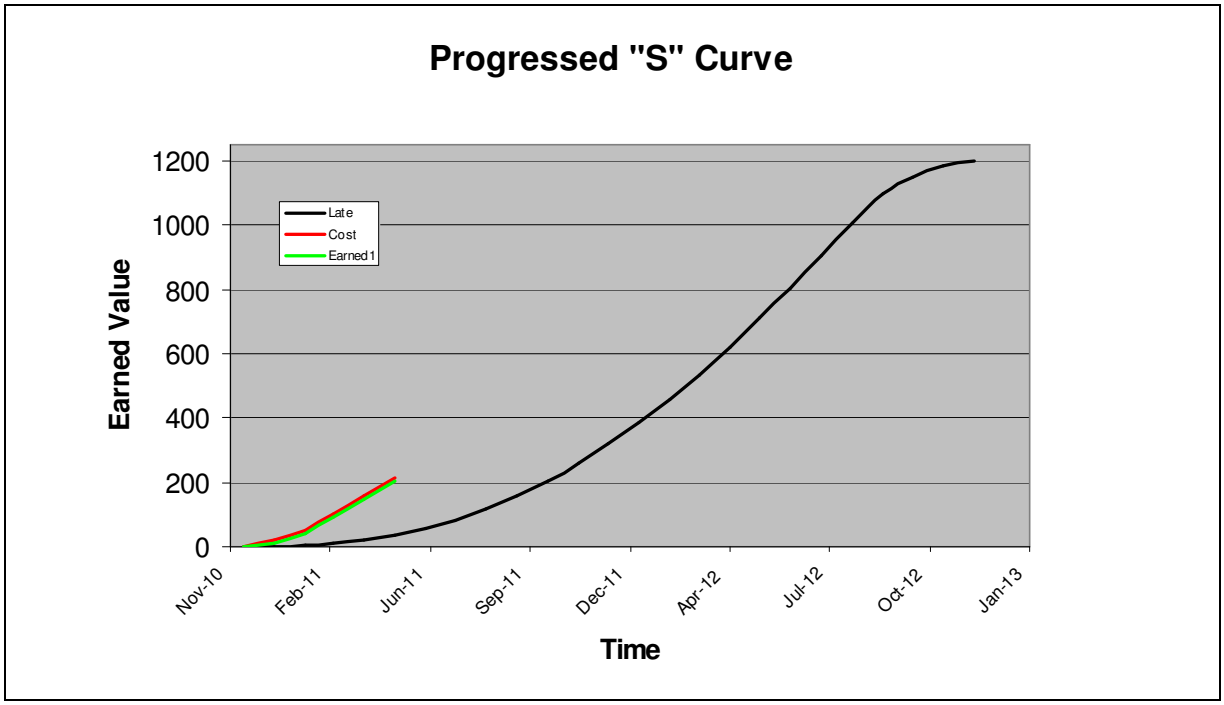

Figure 9; A Rapid Project Start

In Figure 9 the resource overload and rapid progress was immediately apparent from the first report period and exacerbated in the following reports prompting some immediate and substantial action. However when shown within the context of the early/late envelope as shown in Figure 10;……

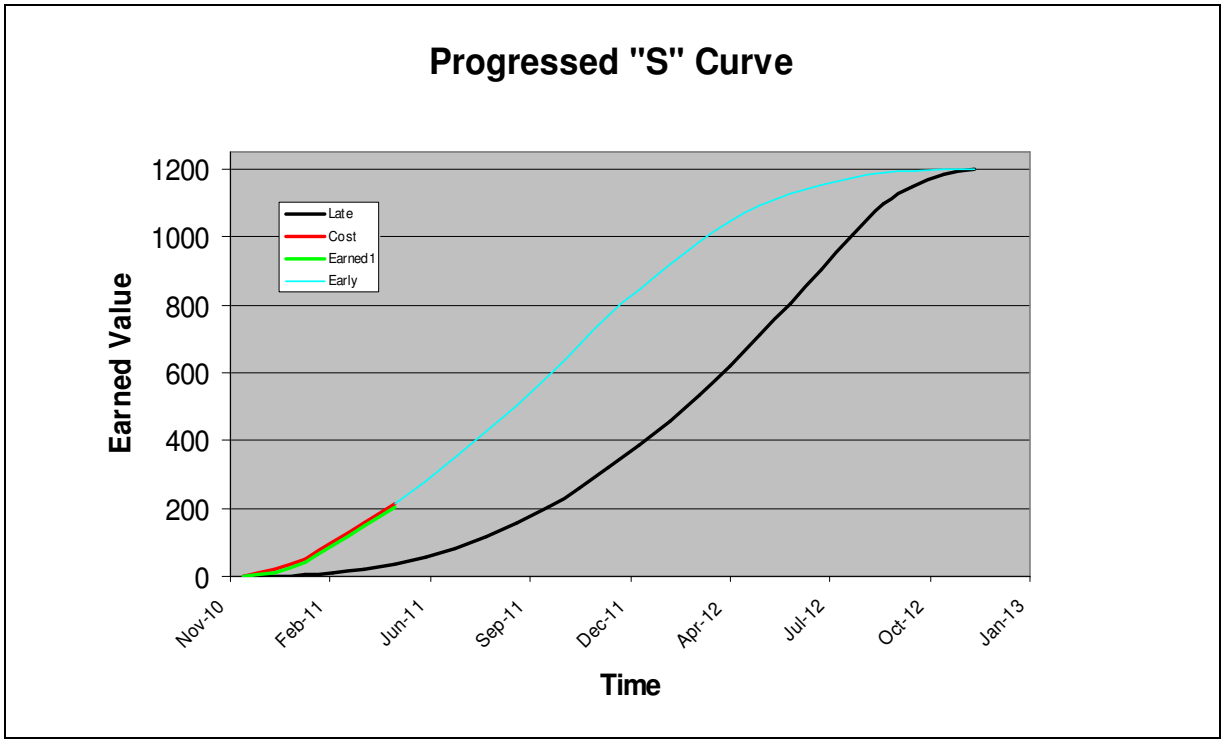

Figure 10; Rapid Start Project in Context of Early / Late Envelope

….the rapid start appears to be more in line with the planned early start values and although not following the scheduled expectations should be manageable without disruptive project realignment.

When to take Action

Returning to my original problem, Figure 11 illustrates a project which has got off to a very rapid start which is significantly different to plan as to deserve examination. Additionally the project has passed the nominal 15% complete barrier after which trends are said to become very difficult to correct. True the project has earned man hour for man hour what it has expended and is well ahead of schedule but is it going to be a success.

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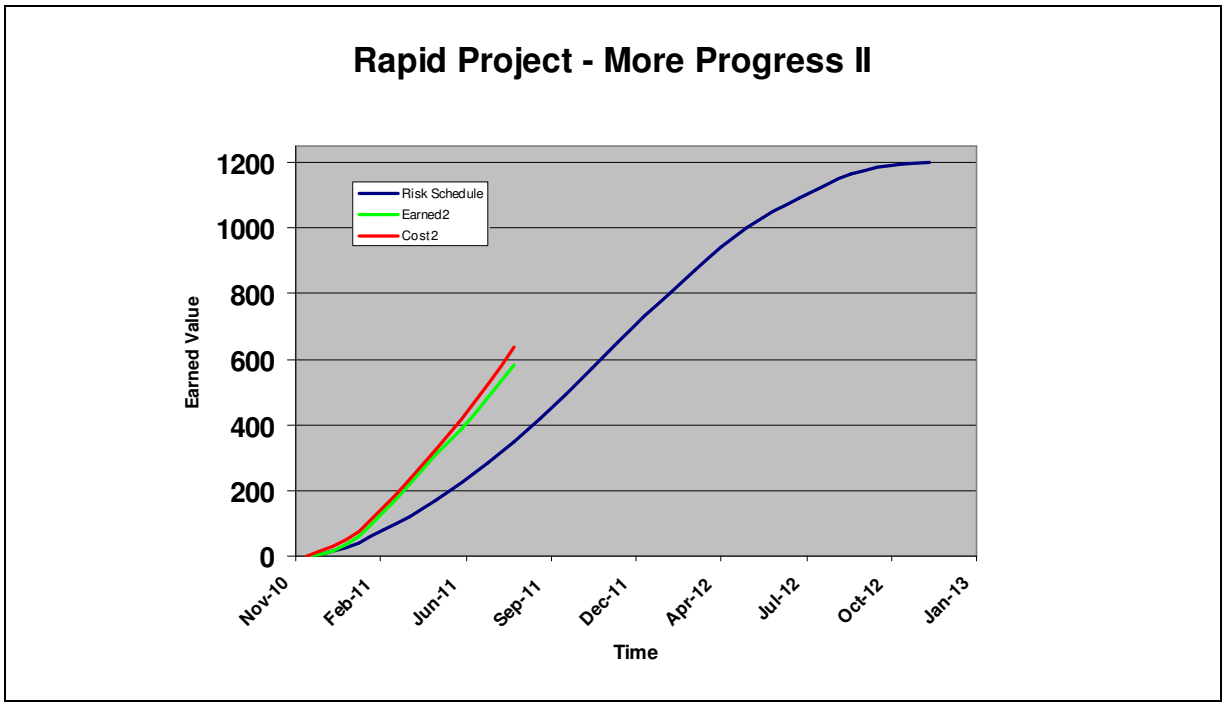

Figure 11; Even More Rapid Progress

Very soon the rapid progress of the project was halted due to the fact that some restraints like key resources and component deliveries being in line with schedule rather than far ahead of time as with the majority of the resource on the project. Figure 12 shows the type of out-turn that the project achieved. Delivery on time or even slightly ahead but at the cost of a massive overspend on resources.

The key faults of this project were:

- initial over-manning in certain areas
- unnecessary overtime and weekend working
- failure to interpret progress data adequately
- unwillingness to take early corrective action

- unrealistic workforce expectations, threatened walkout if current wage levels were constrained (contract workforce had promised spouses holidays / furniture / automobiles, etc. at end of contract)
- management fear of losing key skills

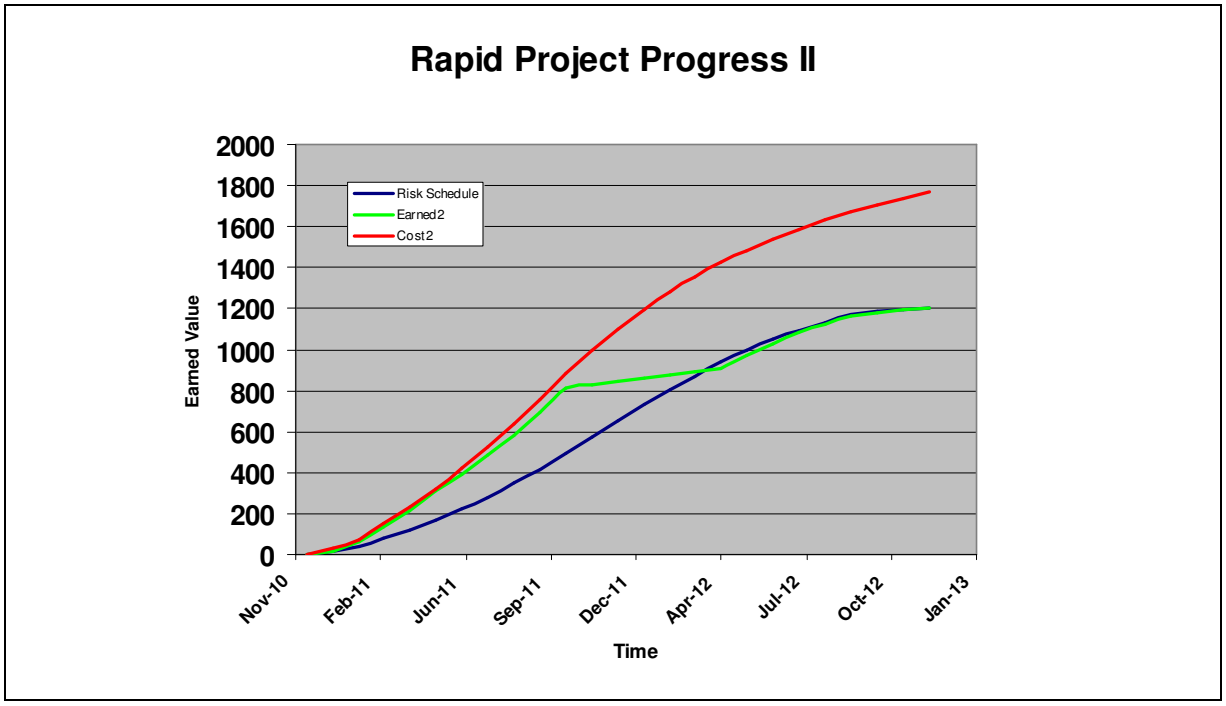

Figure 12; Not the Out-Turn Expected

Isn't EVM very time consuming?

It can be said that EVM takes an awful lot of work to create planning network diagrams and populate activities and is only suitable for major projects. That really should not be the case as the simplest form of EVM is a straight line drawn from planned start date/ zero EV to finish date budget EV (Basically as Figure 6). This may be an over simplification but if progress EV and cost are plotted against a straight line does give a perspective view of where the project is heading and when changes to resource loading may be required.

Whilst the above may be the ultimate in simplification many small companies, such as house builders, have practiced a form of EVM since long before the term was coined. Builders or developers will divide house construction into phases which correspond to trades involved. E.g.: Groundworks, brickwork, first floor joists, second floor joists, roof, first fix, internal wet trades, second fix, clean and paint, landscaping. Some of these phases will overlap and this can be planned for. We now have a plan of only 9 or 10 activities to work with and some of which can have float on their start and finish dates. This will allow for the creation of early late envelope (Figure 1) which with no further development can be used as the basis against which to plot EV and cost. Provided then that EV remains within the Early / Late envelope and Cost remains close to EV there is a very good chance that the project will be successful.

I have even used a version of the above simplified technique by placing activities between project milestones. For example, a project with only four phases and 5 milestones may have only 10 activities (MS 1 to MS2, MS1 to MS3, MS1 to MS4, MS1 to MS5, MS2 to MS3, MS2 to MS4, MS2 to MS5, MS3 to MS4, MS3 to MS5 and MS4 to MS5) against which to load resources. This can however be used to generate fairly smooth EV curves and certainly proved adequate for more than one multi-million pound project.

When things go wrong

As previously stated, once a project has passed the 15% progress point it gets progressively more difficult to alter any established trends. This means that the rate of man hour burn up and productivity tend to become fixed, the workforce have probably gelled into some sort of team which will resist changes in working practices and any forced change in team members. Additionally the front line managers may resist changes to trade gangs where they are familiar with each gang members strengths and weaknesses and want to retain specific members for upcoming work. So when things start to look as if they are going awry we can assume that they will more or less continue along established lines. Graphic EVM can be used by simply projecting current EV until it reaches project budget and feel confident that the corresponding date is probably their earliest completion date, projecting the current cost expenditure to the same earliest completion date will also give a reasonable forecast of final cost. Taking these projections into account it is the project manager's call as to whether he is willing to bring about difficult and possibly expensive changes to work patterns or to sit out the inevitable for the remainder of the project.

As mentioned with regard to Figure 12 too rapid progress can be as damaging to project out-turn as too little. Whilst many project teams will feel more comfortable in being ahead of schedule it is very much a case of "a little of what you fancy does you good" By making more progress than has been scheduled for may mean that we have to re-plan when we are ready for deliverables that are not ready for us, the customer may not wish to accept the completed project early as there may not be feedstock available to commission the plant or finances to pay the final account. This may in turn lead to more critical acceptance inspections or the contractor being responsible for the cost of care and maintenance of the works until the contracted handover date. The key role of the project controls engineer in all this is to ensure that the PM has the right information in time to take action. Remember also that that time is early enough to take adequate corrective action without major upheaval

Key Messages

- The use of Graphic EVM helps engage Project Managers with the Project Controls Team.
- Adverse trends in project progress or spend become apparent early in the project life.
- The use of even simple Graphic EVM puts project progress reports into perspective assisting rational and proportionate response to deviations from plan.
- Use of Early / Late envelope provides context even if a scheduled curve is not included.
- Out-turn implications are easily assessed.
- Earlier than scheduled is not necessarily better.
- **THE PLAN** should be the best we can aim for, it is not there to be beaten, it **IS THE TARGET** which we aim to hit not overshoot.
- **And remember:**
  "Having planned the work it does not make sense not to work the plan".

(In preparing this paper I discovered an excellent paper entitled Intelligent Scheduling for Reduced Project Duration byRob Richards, Ph.D. of Stottler Henke Associates, Inc. provides some illuminating information on the benefits of different resource constrained scheduling tools can be found at: http://goo.gl/p7mhd

The "Mysterious 'S' Curve article may be read online and/or downloaded as a PDF file from the Midori Media website: www.midorimedia.com

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