Earned Value and Earned Schedule explained, finally!

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Abstract

When I was hired to manage the famous *ProjectC*, the company that hired me had just delivered $ProjectC - 1$ for a total cost of four times the price for which it was sold. The project manager before me, $PM - 1$, was known for his good humor and for the *positive attitude* of his status reports which always said, "No Problemo!" When *Project* $ProjectC - 1$ was finally delivered, $PM - 1$ was encouraged to "move on" and I was hired. I met the CEO on my first day and we chatted about project management. I asked him, "What is *your* idea of a good project manager?" Here's what he said:

> "A project manager's job is to predict the future of the project. He must estimate costs, delivery dates, etc. A good project manager makes accurate and precise predictions. That's what I want from you."

So after that talk, I spent a while trying to figure out how to make good predictions. Since then, I've learned more about prediction. In particular, since "God doesn't roll dice," I don't like to do it either, especially when my job is at stake. I've come to use mathematics and logic instead. Mathematics provides us with some good tools: probabilities and proportions. In this text, I will explain how to use the latter, under the name of *Earned Value Analysis,* to help predict a project's cost and delivery date.

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Chapter 1

To Fail to Plan is to Plan to Fail

Everything we will discuss in this paper is based on the concept of planning. Each and every task that is needed must be planned. This means that each task has a planned start, planned finish, and a planned cost associated with it. This is the starting point for everything that follows; it is the baseline against which our performance will be measured and upon which predictions will be based.

Earned Value Analysis is a simple technique which provides both cost-based measurement of the performance of a set of activities and a forecast of their final cost. In addition, when the cost measurements are combined with schedule tracking, schedule performance and completion time can also be forecast.

When applied during a project's execution, *Earned Value Analysis* provides indicators which enable the prediction of the final outcome and thus permit the project manager to initiate corrective actions before it is too late. Measurement of performance allows the project manager to take appropriate actions to correct manifest weaknesses; without measurement, he can only make guesses and hope.

This technique is based on the very simple mathematical concept of the *proportion.*

The idea is that if, for example, the cost of completion of 1/2 of the activity is 10, then it is reasonable to forecast that the total cost will be 20. In other words, one-half of the cost is to ten in the same proportion that one is to twenty. This can be represented by the simple mathematical formula:

$$\frac{\frac{1}{2}}{10} = \frac{1}{20}$$

Similar reasoning can be applied to schedule accomplishment. If for example, it takes 10 days to complete 1/2 of the work, then it is reasonable to predict that it will take 20 days to complete it all. Note that this prediction is based on the assumption that performance will continue in the future as it was in the past.

Most people perform *earned value analysis* on a regular basis although they probably don't call it that. Examples in everyday life could be:

1. when driving to a distant destination, estimating the total travel time as the total distance divided by the current average speed,
2. when painting a room, estimating the time to paint the entire surface as the average time to paint $1m^2$ multiplied by the total surface to be painted.

We have seen in the above examples that *average* values for the rate of achievement of present results were used to predict the cost of future results. It's as simple as that.

$$\frac{CurrentCost}{CurrentAccomplishment} = \frac{TotalCost}{TotalAccomplishment}$$
$$\frac{CurrentElapsedTime}{CurrentAccomplishment} = \frac{TotalElapsedTime}{TotalAccomplishment}$$

In the following sections, we will explore in more detail the semantics of the terms we have employed so far. In particular, we will explain the following concepts in terms of what we have just seen:

planned accomplishment : the tasks or activities that we planned to have completed at the time of analysis,

planned value : the measure of the litres, €'s, man-hours, or whatever cost unit that was the planned expense corresponding to the planned accomplishments at the time of analysis,

actual accomplishment : the tasks or activities that we have actually completed at at the time of analysis,

earned value : the value, according to the plan, of the actual accomplishments at the time of analysis,

actual cost : how much currency, time, effort, or whatever cost-unit was actually spent to perform the accomplishments at the time of analysis,

earned schedule : the point in time at which the planned value will be, or was, equal to the earned value at the time of analysis.

Sounds confusing? Don't worry! I said that we'll explain all that, so just keep reading! Remember one thing: the *plan* is the key to everything in *Earned Value Analysis*. So as *Stan Tang* used to say:

> "To fail to plan is to plan to fail."

Chapter 2

An Informal Look at Earned Value Analysis

We will now discuss the concepts used in *Earned Value Analysis*. These will be anchored in the example of a driving trip in which the cost is measured in litres of fuel, the accomplishment is the total distance driven, and the schedule is simply the time spent driving.

2.1 Planning

Remember what I said earlier, we need a plan. Here it is. Let's suppose that we would like to drive from Brussels to Toulouse (1000km) and arrive in time for dinner at 20:00. It's reasonable to assume that we can drive at a rate of 100km/h (for the sake of example, we will suppose that the route is always the same and permits the same speeds). Thus, we conclude that a departure at 10:00 will allow us to arrive on time (everyone will agree that this is a rather optimistic assumption since many events such as traffic congestion or getting lost could significantly hinder our progress). Also, let us say that our car consumes 10 litres of fuel per 100 km, making our total planned cost 100 litres.

Our Plan (first approximation):

Planned Departure : 10:00

Planned Arrival : 20:00

Planned Distance : 1000 km

Planned Cost : 100 litres

Now, suppose that our parents-in-law are waiting for us to arrive, and intend to serve us a big French dinner, requiring many hours of preparation. As parents-in-law, they are particularly sensitive to anything which could be interpreted as lack of respect towards them. In this case, arriving late and ruining the meal would be considered as a great insult.

To prevent perceived insult, and the painful consequences (e.g. divorce), we will report by phone, every hour on the hour, our probable arrival time. This will allow our beloved parents-in-law to have the dinner ready exactly when we arrive. Modern technology, i.e. the cell-phone, will allow us to easily provide these reports.

Furthermore, to ensure a proper reception, we would like to purchase a nice bouquet of flowers for our parents-in-law from the florist shop which is conveniently situated across the street from their house. Since we have a limited budget, we will track our expenses along the trip so as to know how much money we will have left for the bouquet. We will use the arrival time prediction to ensure that the bouquet is purchased and available, even if we arrive after the shop closes (they will leave it outside for us).

The night before we leave, we decide to make a list of the distances we intend to have driven at each phone call as well as the cumulative cost at each call. This is our true plan (Table 2.2 on page 11).

Some straightforward but important points to note:

- *Fuel* is the cost unit that is used in this example; it is measure in litres,
- the planned cost for each segment of 1 hour is 10 litres,
- the cumulative cost for the trip at a given stage is the sum of the costs of the individual segments,
- the times were chosen so that the hourly report would be easy to produce!

Now we can prepare what we expect to report to the parents-in-law. This is in fact our calling plan (Table 2.3), which out of courtesy and respect we have emailed to our parents-in-law on the evening before the trip[1].

If we refer to *reporting period* rather than the sequence number of the phone call, and include the expected costs for the segments, we then have the table of planned values, or simply the *Project Plan*, in the standard terminology of *Earned Value Analysis*.

The example plan is presented in Table 2.4. Note that the value/cost information is not interesting to our parents-in-law, which is why we did not send it to them. This demonstrates an important aspect of reporting: Reports must always be presented in a way that is meaningful to the target stake-holder group.

At this point we have informally encountered some important concepts in *Earned Value Analysis*

Project Plan : The project plan in its simplest form is a table of the planned value of the planned accomplishment at each reporting period,

Reporting Period : the **RP** is the interval of time at which we track progress and report to the project stake-holders,

Planned Value : the **PV** is the planned gain that is obtained by the accomplishment of an item in the plan; it is measured in cost units, that is in

[1] One may wonder if parents-in-law are able to read email. Unfortunately there is no space in this document to discuss this very interesting question ...

our example in *litres of fuel.* don't worry if this sounds confusing, we'll see in a few lines how it works,

Total Planned Value : a.k.a *Budget At Completion* or **BAC** is the total value that the project is supposed to deliver.

2.2 Planned Value & Task Accomplishment

In our plan, we have stated:

- We plan to spend 10 litres per 100 km. This is our *cost,*
- We plan to drive 100 km per hour. This is our *accomplishment.*

Now pay attention here, this is important!

We measure the value of our accomplishment in terms of the planned cost for that accomplishment. This means that every time we drive 100 km we earn the value corresponding to the planned cost of driving 100 km, which is 10 litres. This *earned value* has no relation to the actual cost of doing the driving. Suppose that every time we went downhill we stopped the motor. We might consume less that 10 litres, but we would still earn 10 litres for having driven 100 km. So remember:

Earned Value: the **EV** for the accomplishment of a task is defined as the *planned cost* for that task.

2.3 Metrics (that's management-speak for "Measurements")

In the above discussion we have somewhat glossed over the concept of the *cost* of our driving project by simply equating it to the amount of fuel consumed. Indeed, there are many ways to measure the cost of the drive to see our parents-in-law. Examples of cost metrics could be:

- the monetary cost for the petrol consumed by the car,
- the number of crises that occurred in the car during the drive,
- weight lost by the driver during the trip,
- the amount of coffee consumed by the driver,
- etc.

Despite the usefulness of each of these metrics, only one thing would seem to count for the parents-in-law: our time of arrival. We *could* therefore discard all the other measures and concentrate on providing them with the best possible estimated time of arrival during each of our telephone reports.

Our planned trip time is 10 hours. We are scheduled to arrive at 20:00. In EVA terminology, the scheduled finish time is called the *Planned Schedule at Completion* or simply " **PSAC**."

In each phone report, we will provide an estimated time of arrival, which is simply the sum of the starting time plus the estimated total trip time. This estimated total trip time, or more abstractly, the Estimated Schedule at Completion **ESAC** is a key concept of the *earned value analysis.* It is re-evaluated at each reporting period.

There's another side to all this. Industry standards for dinner with parents-in-law require that after driving like mad for 10 straight hours, we arrive with a beautiful fresh bouquet of flowers to thank them for going to the trouble of cooking dinner for us. Since we have a limited budget, if we were to overspend on fuel, there would be nothing left for flowers; This would lead to disappointed parents-in-laws, confirmation of their suspicion that their child deserved better, and ultimately messy divorce, and potentially an outbreak of serial killings. In conclusion, we'd better keep an eye on the costs, too.

Remember, *earned value analysis* is simply the application of a proportion. The cost of the whole is proportional to the partial cost of the part accomplished, e.g. the whole will probably cost 3 times the cost of one third.

So, a question we must ask ourselves is: *what is the cost we have incurred at each reporting period?* In our example, since we are measuring cost in terms of fuel consumption, and we report every hour, the cost is simply the fuel consumed since the previous report.

In EVA terminology this value is known as the *Actual Cost.*

> *The actual cost of the accomplishment of a task is equal to the cost directly associated with the execution of that task.*

Suppose we leave on time, at 10:00. Our actual costs could look like Table 2.5.

Does this mean that we will spend less fuel than planned (remember, we planned on 10 L/100km, so we seem to be in the black at this point)? Of course not! It simply means that at the present point in time, we are ahead of budget. Will this continue? We cannot say, but we can guess that it *might.* We can also see that we are right on schedule, in terms of distance driven after three hours. This would seem to indicate that we will arrive on time. Now let's look at another case:

Table 2.6 presents another example of actual values. In this case we have consumed 31 L for 310 km of route, which corresponds to our planned budget of 10L/100km. So we are right on budget. But, oddly we have managed to drive 310 km in only three hours, i.e. 10 km further than planned. We are ahead of schedule and that's good news - a rare thing indeed. That would tend to say that we may arrive *early.* Let's look at one more example of actuals:

The example in Table 2.7 is similar to the previous one, the only difference being that the fuel consumption is much higher. In this case we are ahead of schedule (Driven 310 km in the time planned for 300 km), but over-budget since we had planned to consume 31 L for 310 km but we actually consumed 34 L. We may not have any money left for the flowers ...

2.4 Earnings and Value

We have now discussed the budget and the actual costs as well as planned and actual schedule. This should be clear, in as much as the hand waving explanation in the previous section could be called "clear." Let's move on ...

We are now almost ready to drive!

Before departing, we need a way of measuring our accomplishments. This measure must be commensurable with the way we have measured cost. Since we have measured cost as litres of fuel consumed, we should measure accomplishments in this manner also. What?! That's got to be crazy! How can we measure the accomplishment of driving in litres of fuel? Surely, I must have lost my marbles and there's no point in reading any more of this drivel. Well, even if that were the case, you are reading this so you must have decided to continue, which is good since it is all about to become clear as rain in the Himalayas.

We are going to use our original plan, remember we had a plan? Our plan said that we would consume 10 litres of fuel for every 100 km driven. That means that every time we drive 100 km we *earn a value of 10 litres.* Does that look like cheating? Well, maybe it does and maybe it doesn't but in any case that's how EVA works:

In EVA terminology, this is known as the *Earned value*, or **EV**.

> *The value earned by the actual accomplishment of a task is equal to the planned cost of that task.*

Let's suppose that we drive 100km in the first hour, 110 in the second, 120 in the third. This would produce the Earned Values in Table 2.8.

While we're talking about values let's look at another one. The *planned value* or **PV** is simply the earned value that would be obtained for the accomplishment of a task according to the plan. This value is completely independent of any actual cost or actual accomplishment. It's just what was planned. The planned value is obtained by looking at the planned cost for the tasks.

> *The planned value for the accomplishment of a task is equal to the planned cost of that task.*

At any point, we can say which tasks are planned to be accomplished when and can thus determine the planned value for the entire *project* as shown in Table 2.9.

2.5 Definitions

It seems like things have gotten confusing enough to be worth a quick summary. We have discussed three fundamental concepts: *planned value, earned value* and *actual cost.* These concepts will be further illustrated by examples in Chapter 3, but for now we've put all the definitions together in the box in Table 2.1.

Planned Value **PV**	:	The planned cost for the accomplishment of a task.
Earned Value **EV**	:	The planned value of the task actually accomplished.
Actual Cost **AC**	:	The cost actually spent in the accomplishment of a task.

Table 2.1: Important Value and Cost Definitions

2.6 Tables

Time	Cumulative Distance	Cumulative Cost(fuel)
10:00	0 km	0L
11:00	100 km	10L
12:00	200 km	20L
13:00	300 km	30L
...		
20:00	1000 km	100L

Table 2.2: List prepared the Night Before Departure

Call Number	Time	Planned Accomplishment
1	11:00	100 km
2	12:00	200 km
3	13:00	300 km
...		
10	20:00	1000 km
		(at your door!)

Table 2.3: Calling Plan for our Parents-in-Law

Reporting Period	Schedule	Planned Accomplishment (km)	Planned Value (litres)
1	11:00	100	10
2	12:00	200	20
3	13:00	300	30
...			
10	20:00	1000	100

Table 2.4: Project Plan in Earned Value Analysis Terminology

Report Time	Cumulative Distance	Cumulative Fuel Consumed
11:00	100	8 L
12:00	200	18 L
13:00	300	28 L

Table 2.5: Example of Actual Costs: on schedule, under budget

Report Time	Cumulative Distance	Cumulative Fuel Consumed
11:00	90	9 L
12:00	190	18 L
13:00	310	31 L

Table 2.6: Example of Actual Costs: ahead of schedule, on budget

Report Time	Cumulative Distance	Cumulative Fuel Consumed
11:00	90	10 L
12:00	190	22 L
13:00	310	34 L

Table 2.7: Example of Actual Costs: ahead of schedule, over budget

Report Time	Distance Driven	Earned Value	Cumulative Distance	Cumulative Earned Value
11:00	100 km	10 L	100 km	10 L
12:00	110 km	11 L	210 km	21 L
13:00	120 km	12 L	330 km	33 L
...				

Table 2.8: Example of Earned Values

Report Time	Distance Planned	Planned Value	Cumulative Distance Planned	Cumulative Planned Value
11:00	100 km	10 L	100 km	10 L
12:00	100 km	10 L	200 km	20 L
13:00	100 km	10 L	300 km	30 L
...				

Table 2.9: Example of Planned Values

Chapter 3

Plan your Drive, Drive your Plan

We'll now take a look at the use of all this stuff on a real example. We'll look at the drive south, step by step, using the predictive capabilities of *earned value analysis* to ensure that our parents-in-law remain happy and we remain married.

Hey, Hello! Is anyone paying attention? I haven't discussed the use of *EVA for predictions!* Well, I guess I did mention it when talking about proportions. In any event, congratulations to any reader who noticed or cared about the unexplained leap forward into prediction.

Why prediction? Didn't you read the abstract? The reason we're doing all this is to predict our arrival time and budget so as to be able to provide sufficiently early warning to our parents-in-law in the event that we would be delayed. Now, pay attention to this next bit: *If we could do this, then our driving project would be a success, even if delivered late.* As project manager, we want our project to be a success, no matter what. The provision of early warning for non-conformity to schedule, cost (and why not scope[1]?) is one way of accomplishing this.

3.1 The Data

For the sake of simplicity, we provide Table 3.1 on page 24 containing the trip status information at every report. Beware though: in a genuine project, we only have a view on the state up to the present. This will become clear in the explanation that follows.

[1]Indeed, why not talk about scope? Well, the triple constraint under which all projects operate is Schedule/Cost/Scope. Only two of these can be taken as free variables with the third becoming dependent on the other two. In our driving example, if we were running very late we could introduce a *scope change* and plan to stop over for a night in a hotel - warning our parents-in-law well in advance... Similarly, if we noticed an incredible sale in a fashion boutique, our wife (the true project manager) could decide on a budget increase and introduce a delivery delay while buying everything in sight... Thus scope performance can be consdered as a consequence of cost and schedule performance.

We will look at the trip and decide on the content of each hourly report that we will make to the parents-in-law. We will report on schedule (estimated time of arrival or ETA), and cost (estimate at completion or EAC). We won't tell anyone about Estimated Schedule at Completion (ESAC) since that's a technical project manager term, and will scare non project managers. ETA is a word they've hear on TV, so it can be considered harmless.

3.2 Report 0: 10:00 Departure

Yo! There's no data for 10:00, so what do we do? We call the parents-in-law and tell them that we're on the road on schedule (they've received the plan in email, but weren't able to read it, yet are too embarrassed to admit it!)

ETA: 20:00, (this is ESAC, but don't tell anyone...)

EAC: 100 litres (we'll keep this information to ourselves since it's of no interest to our parents-in-law.)

3.3 Report 1: 11:00 All Well

It's now 11:00. We've driven 100 km, and consumed only 9 litres of fuel. So we are on schedule and *under* budget! How can we predict the total cost of fuel? remember the proportion? We have spent 9 litres and driven 100 km, so how much will we spend to go 1000 km? In mathematics land, this looks like:

$$\frac{9}{100} = \frac{EAC}{1000}$$

$$EAC = \frac{9 \cdot 1000}{100}$$

$$EAC = 90$$

ETA: 20:00,

EAC: 90 litres.

We should have some extra cash for a *real* nice bouquet of flowers!

We tell the parents-in-law that all's well, we *should* be there at 20:00. Note the use of the conditional in *"should"* we are predicting arrival on time, not guaranteeing it!

What about the EVA computations?

First, PV (planned value, remember?). This is the planned cost of what we planned to accomplish at 11:00.

Planned Accomplishment: 100 km

Planned Cost: 10 litres

Planned Value: *10 litres*

An observant reader might remark that this will be the same for every report, i.e. the planned value will increase linearly by 10 litres every hour.

Next, EV. This is the planned cost of what we actually accomplished at 11:00.

Actual Accomplishment: 100 km

Planned Cost: 10 litres

Earned Value: *10 litres*

Finally, AC, the actual cost. This is simply what we actually spent to accomplish what we did at 11:00.

Actual Cost: 9 litres

In summary:

PV: 10 litres

EV: 10 litres

AC: 9 litres

But what does it all mean? Are we doing well? Obviously yes, since we have driven the planned distance at less than the planned cost. Can we express this more formally? Of course, just keep reading.

3.4 Report 2: 12:00 oh oh ...

It's noon. We've driven 190 km, but we should have driven 200 km so we are behind schedule. What is our ETA? Again, we must apply a proportion, but which one?

We've consumed 18 litres of fuel, we've gone 190 km, what does it all mean?

We are stumped, there's no hope, we may as well stop at the next law office and file divorce proceedings, or maybe not!

Let's first look at the EVA computations.

As we mentioned earlier, the PV will increase every hour by 10 litres, and this regardless of any actual progress or fuel consumption.

Planned Value: 20 litres

EV, the planned cost of what we actually accomplished at 11:00.

Actual Accomplishment: 190 km

Planned Cost: 19 litres

Earned Value: *19 litres*

Is anyone wondering how we got the value 19 litres? The answer is another proportion! Our planned value was 20 litres for 200 km, so what would have been the planned cost for 190 km?

$$\frac{20}{200} = \frac{EV}{190}$$
$$EV = \frac{20 \cdot 190}{200}$$
$$EV = 19$$

Finally, the AC is simply:

Actual Cost: 18 litres

In summary:

PV: 20 litres

EV: 19 litres

AC: 18 litres

So what about all this? Well, first let's look at the planned budget and actual costs. What do we see?

- we planned to spend 20 litres,
- we only *earned* 19 litres,
- we only spent 18 litres.

Pay attention now, we are about to see something important!

Our *cost performance index*, or ratio of earnings to costs is 19/18 or 1.06. As its name implies, the *Cost Performance Index* tells us how well our project is performing in terms of cost, or *value for money.* As its name also indicates, we're dealing with an *index* so its value relates to the number 1. A CPI of 1 means that earnings equal costs. If $CPI > 1$ then earnings are greater than cost, i.e. *Good!*. If $CPI < 1$, then earnings are less than cost, i.e. *Bad.* This is important and gets a box.

Cost Performance Index: The ratio of *Earned Value* to *Actual Cost*

$$CPI = \frac{EV}{AC} \tag{3.1}$$

We will use this index to predict future costs, again by means of a proportion. We have currently earned a value of 19 litres, the total value of the drive is 100 litres, so there are $100 - 19 = 81$ litres remaining. Our cost performance index is 1.06 and we *assume that it will remain at that rate* so the remaining cost, or *Estimate To Completion* is $81/1.06 = 76.8$ litres. This produces a total *Estimate At Completion* of $18 + 76.8 = 94.8$ litres. We are under budget and should have 5.2 litres of fuel left over to spend on flowers! Wow!

Let's have a box to celebrate!

$$ETC = \frac{BAC - EV}{CPI} \tag{3.2}$$

Estimate To Completion **ETC**:	The predicted *remaining* cost to complete all the planned accomplishments.
Estimate At Completion **EAC**:	The predicted *total* cost to complete all the planned accomplishments.
Budget At Completion **BAC**:	The *planned total* cost of all the work to be accomplished.

$$EAC = AC + ETC \tag{3.3}$$

At this point we should reflect on all these strange new variables. First, we saw the basic elements: PV, EV and AC. Next, we used those to compute the CPI. Finally, we used the CPI (a ratio) to compute ETC and EAC (predictions). In other words, we calculate some values, then a ratio, then apply the ratio to some other values and predict final values. It's both simple and complex.

At this point we have the first part of our report, unfortunately it's the part that doesn't interest our parents-in-law:

PV: 20 litres

EV: 19 litres

AC: 18 litres

CPI: 1.06

EAC: 95 litres

All this is well and good, but the final cost is not what most interests our parents-in-law. They won't even look at the bouquet of flowers if they aren't informed of schedule variances resulting in overcooked food[2]!

So fasten your seat-belt and let's look at the schedule!

We're going to play the same game as with costs and apply a technique which is derived from Earned Value and is called *Earned Schedule*. It goes like this:

- At 12:00, our earnings (**EV**) are 19 litres,
- but our earnings should have been (**PV**) 20 litres,
- ask yourself this question: "When should we have earned 19 litres?"

Well, the answer isn't so easy to guess without doing some math. At 11:00 we should have earned 10 litres. At 12:00 we should have earned 20 litres. We should be able to find a proportion that helps us out here!

We have earned $19-10 = 9$ litres more than our planned earnings at 11:00. One hour after 11:00, we should have earned 10 more litres. So, in terms of *schedule* we have earned 9/10 of an hour (54 minutes) since 11:00. In other words, our *Earned Schedule* is 11:54. In other words, we have only earned at 12:00, what we should have already earned at 11:54.

Does this sound a bit strange? Well it should because it is! The worst is yet to come. What is our *Earned Schedule Performance Index?* You already guessed

[2] Did anyone notice how I subtly threw in the technical term "schedule variance"?

that this will be used to predict the ETA, right? Well, just as the **CPI** was defined in terms of *Earned Value* and *Actual Cost*, the **ESPI** is defined in terms of *Earned Schedule* and *Total Elapsed Time* - be careful of the time units. Before we calculate our **ESPI**, let's have a box:

Earned Schedule Performance Index:	The ratio of *Earned Schedule* to *Actual Time*

$$ESPI = \frac{ES}{AT} \tag{3.4}$$

Being mindful of the time units, we will convert everything to minutes since that is the most convenient unit. In a project of greater duration, it may be easier to use days, weeks, months, etc. as the unit of duration. The computation:

$$ESPI = \frac{60 + 54}{60 + 60} = 0.95$$

Can you guess what's coming next? Yep, we're going to use the **ESPI** ratio to predict the total trip time, a.k.a. ETA, a.k.a. *Estimated Schedule at Completion* **ESAC**. We'll do it like this: The **ESAC** is simply the total planned schedule divided by our **ESPI**, i.e. 600/0.95 = 632 minutes. Converted into time, that means we should arrive at 20:32.

So, we tell them that we're now planning to arrive at 20:32 and they say, "Fine, no problem, thanks for letting us know."... **Never in a million years!** They go bananas when they hear that we've exaggerated a few minutes delay (remember we're only 6 minutes late according to all those clever schedule computations) into more that a half hour off the target arrival time! Although, they say nothing, we can feel their anger some 800 km away. So, why can't they understand? The answer is *not,* "because they're parents-in-law."

It's simply a fact that most people don't have a good understanding of logic and mathematics. Think this through:

- After approximately 20% of the trip, our schedule performance is only 95% of what it should be,
- Unless we've kept something secret, there is no reason to assume that schedule performance will change for the better or for the worse, so we assume that it will remain constant at 95%[3],
- A number divided by 0.95 produces a number bigger than the original number,
- Performance of the division is the only way to see what the resulting bigger number, i.e. later time, will be.

[3]Perhaps you wonder why we don't assume that our schedule performance will improve? If you do wonder, then ask yourself why empirical evidence, i.e. current schedule performance, would change? Change occurs when a new element comes into play. Are there any new elements in view on the horizon? If not, then assume constant ESPI and CPI.

Think of loans and interest rates. Even though interest rates may be low, when applied to a big number, they add up to a significant sum of money.

Here's a question for you: *Do you think your boss would understand any better than my parents-in-law?* If the answer is, "No!", then she/he is probably in dire need of a course in "Maths and Logic for executives[4]".

So how to explain this apparently incomprehensible ESAC to the parents-in-law? Good question. If I had an answer I'd give it to you, but I don't. One suggestion is to explain *Earned Value* and *Earned Schedule* to your parents-in-law one afternoon when you've got their full attention, for example, after their favorite team just won the World Cup - wake up! This is not a course in psychology!

Here's the full report for 12:00:

Cost

PV: 20 litres is the value of the *planned accomplishment.* This is taken directly from the plan,

EV: 19 litres is value of the *actual accomplishment.* This is the *planned value* that our actual accomplishment should have cost,

AC: 18 litres is what was *actually spent,*

CPI: 1.06 is the proportion EV/AC. This combines planned and actual data.

EAC: 95 litres is the result of dividing the total planned value (or **BAC**) by the CPI ratio. This recombines the previous result with a total taken from the plan.

Schedule

PS: 120 minutes, i.e. the planned elapsed time since the start of the drive. This is taken directly from the plan.

ES: 114 minutes, i.e. the *planned elapsed time* corresponding to our *actual accomplishment,*

AT: 120 minutes, the *actual elapsed time* since the start,

ESPI: 0.95 is the proportion ES/AT. This combines planned and actual data,

ESAC: 632 minutes is the result of dividing the total planned time by the ESPI ratio. This again recombines the previous result with a total from the plan,

ETA: 20:32 is the translation of elapsed minutes into a time of day.

What do we retain from all this? Only these key indicators:

- **CPI:** 1.06
- **ESPI:** 0.95

[4] One may wonder what would qualify a person to be a boss if she/he had trouble with the powerful concept of *the proportion.* Check the following seminal work for answers to this and many related questions: "*Dogbert's Top-Secret Management Handbook*", Scott Adams, 1996.

What do we conclude in our heart of hearts? That:

- we're ahead of budget by 6%,
- we're behind schedule by 5%,
- we should be able to buy a nice bouquet to excuse our late arrival.

What do we tell the parents-in-law?

- "Expect our arrival at 20:32. We're terribly sorry, the traffic has been murderous!"

3.5 A Reflective Pause

Before continuing the example, let's sit back and consider what we've seen so far.

First, remember our goal: *preserve our marriage,* i.e. avoid disappointing the parents-in-law. To do this, we keep them informed of some of the predicted final outcomes of our trip/project, in particular our arrival time. Also, we need to know ourselves what will be the outcome of our trip concerning the costs.

The motivation for everything is prediction.

Then, we made a plan of the cost and schedule of what we thought we could reasonably accomplish in our driving project. We informed our parents-in-law of the schedule. We took private note of the costs. We used this plan as the basis for all our predictions.

The basis for everything is a reasonable plan.

Next, we measured actual cost and schedule accomplishment, in terms of the original plan, and calculated how much we had earned in terms of both.

Actual accomplishment, cost and schedule measurements are the elementary data.

We were able to determine indices for both of these called *Cost Performance Index* and *Earned Schedule Performance Index* which were unit-less proportions of our actuals with respect to the corresponding planned values.

Actuals are compared to planned values to determine performance indices.

These performance indices told us how well we were doing and enabled prediction of final cost and schedule by the application of the proportional rule: $PlannedTotal/PerformanceIndex = PredictedTotal$.

The originally planned total value divided by its performance index results in a prediction of the future total value.

That's all there is to it. That's so nice that I'm going to say it again!

1. The motivation for everything is prediction,
2. The basis for everything is a reasonable plan,

3. Actual accomplishment, cost and schedule measurements are the elementary data,
4. Actuals are compared to planned values to determine performance indices,
5. The originally planned total value divided by its performance index results in a prediction of the future total value.

Do you feel like you've learned something? Is there some little thing with which you don't quite feel comfortable, yet? (hint: there should be!) We'll look at that little thing, whatever it is, a little bit later. For now, let's run through one last report.

3.6 Report 7: 17:00

This is the last example report that will be fully worked out in this document. By now, the reader should have a pretty good understanding of the concepts needed and will easily (and probably happily) move on to the real meat of *EVA* in the remaining sections. In the mean time, let's get on with it!

If we look at the seventh line of Table 3.1 on page 24, we see that we've only driven 670 of the planned 700 km, but we've used 4 litres less fuel than planned. Sadly, we are behind schedule but ahead of budget. I say sadly because the schedule is the critical element in this project. If we get schedule prediction wrong, we may be spending most of our remaining life at speed-dating sessions.

Here's our data:

PV: 70 litres

EV: $\frac{670km}{700km} \cdot 70L = 67$ litres

AC: 66 litres

For memory, the *Earned Value* is the planned cost for the actual accomplishment. We drove 670km but don't know what the planned cost was for that distance. We do know that the planned cost for 700km was 70 litres so we can use a proportion and find, to no surprise, that the *EV* for driving 670km is 67 litres.

Now we can use those values to predict cost:

CPI: $CPI = \frac{EV}{AC} = \frac{67}{66} = 1.02$

EAC: $EAC = \frac{BAC}{CPI} = \frac{100}{1.02} = 99\ litres$

Easy as pie[5]. Sorry for the round-off errors. Did everyone remember that BAC is the Budget at Completion, i.e. the originally planned total cost?

Now let's look at our schedule data:

PS: 420 minutes

[5] and everyone knows that apple pie without cheese is like a kiss without a squeeze.

ES: if $d = 420$, the current date in minutes, then:

$$
\begin{aligned}
ES(d) &= d' \text{ such that:} \\
&PV(d') = EV(d) \\
ES(420) &= d' \text{ such that:} \\
&PV(d') = EV(420) = 67 \\
&PV(360) = 60 \text{ and} \\
&PV(420) = 70 \\
\text{interpolating: } &d' = 360 + (420 - 360) \cdot \frac{(67 - 60)}{(70 - 60)} \\
&d' = 402 \\
&ES(420) = 402
\end{aligned}
$$

AT: 420 minutes

ESPI: $ESPI = \frac{ES}{AT} = \frac{402}{420} = 0.96$

ESAC: $ESAC = \frac{SAC}{ESPI} = \frac{600}{0.96} = 627$ minutes

ETA: 20:27 (10:00 + 627 minutes).

And so it goes. We retain the indicators:

- **CPI:** 1.02
- **ESPI:** 0.96

We conclude that:

- we're ahead of budget by 2%,
- we're behind schedule by 4%,
- By spending more, we seem to have made up some lost time. We should still be able to buy a reasonably nice bouquet to excuse our late arrival.

What do we tell the parents-in-law?

- "Expect our arrival at 20:27. Traffic is still tough, but we've made up a little time!"

That is the last report example that we'll work through. All the data is available in Section 3.8.1 on page 24.

3.7 One Last Thing

Wouldn't it be nice to see all this data in charts? Of course it would! In fact, earned value data is most often presented graphically. Three graphs are needed.

Cost Performance: PV, EV, AC, EAC are plotted for each reporting period. This graph is often called the *S-curve* even though our graph is more linear that S-shaped[6].

Schedule Performance: PS, ES, ESAC are plotted for each reporting period,

Performance Indicators: CPI, ESPI are plotted for each reporting period.

We've plotted these in the figures at the end of section 3.8.2 on page 25.

This ends our little example. In the next sections we will revisit the terminology and provide the formal definitions of all the terms that we've seen.

[6]If you are wondering why that is, then I'm happy to say that you are one sharp cookie! The reason that the curve is normally S-shaped is that most projects incur cost slowly at their start, then the spending rate increases during the main realization phase, and finally it tapers off at the project close. This typically produces an S-shaped curve. Our curve is linear because we are spending fuel at an approximately constant rate from departure to arrival.

3.8 Drive South Tables & Graphs

All the data and corresponding graphs from the previous example of the Drive South are presented below.

3.8.1 Data Tables

Please excuse round-off errors in the following tables.

Reporting Period	Planned Distance (km)	Actual Distance (km)	Planned Cost (Litres)	Actual Cost (Litres)
1	100	100	10	9
2	200	190	20	18
3	300	290	30	27
4	400	390	40	36
5	500	480	50	46
6	600	580	60	56
7	700	670	70	66
8	800	770	80	76
9	900	870	90	85
10	1000	970	100	94
arrival	1000	1000	100	97

Table 3.1: Plan & Actuals for The Drive South

Reporting Period	Planned Value (L)	Earned Value (L)	Actual Cost (L)	CPI	EAC (predicted) (L)
1	10	10	9	1.11	90
2	20	19	18	1.06	95
3	30	29	27	1.07	93
4	40	39	36	1.08	92
5	50	48	46	1.04	96
6	60	58	56	1.04	97
7	70	67	66	1.02	99
8	80	77	76	1.01	99
9	90	87	85	1.02	98
10	100	97	94	1.03	97
arrival	100	100	97	1.03	97

Table 3.2: Cost Performance & Prediction for The Drive South

Reporting Period	Planned Schedule (mins)	Earned Schedule (mins)	Actual Time (mins)	ESPI	ESAC (mins)	ETA (predicted) (hh:min:ss)
1	60	60	60	1.00	600	20:00:00
2	120	114	120	0.95	632	20:31:35
3	180	174	180	0.97	621	20:20:41
4	240	234	240	0.98	615	20:15:23
5	300	288	300	0.96	625	20:25:00
6	360	348	360	0.97	621	20:20:41
7	420	402	420	0.96	627	20:26:52
8	480	462	480	0.96	623	20:23:23
9	540	522	540	0.97	621	20:20:41
10	600	582	600	0.97	619	20:18:33
arrival	600	600	618	0.97	618	20:18:00

Table 3.3: Schedule Performance & Prediction for The Drive South

3.8.2 Data Graphs

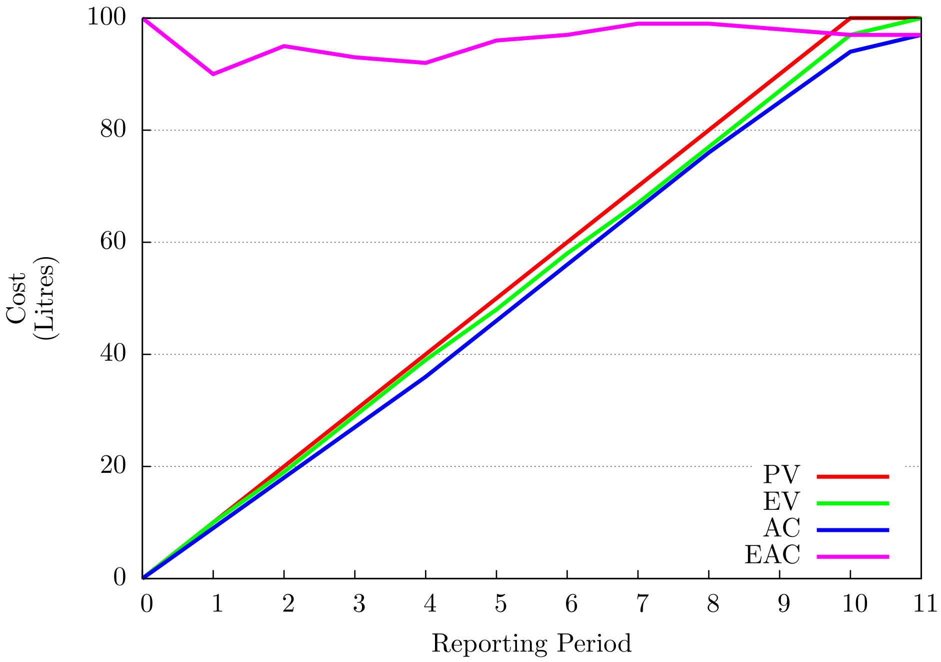

Figure 3.1: Cost Performance & Prediction

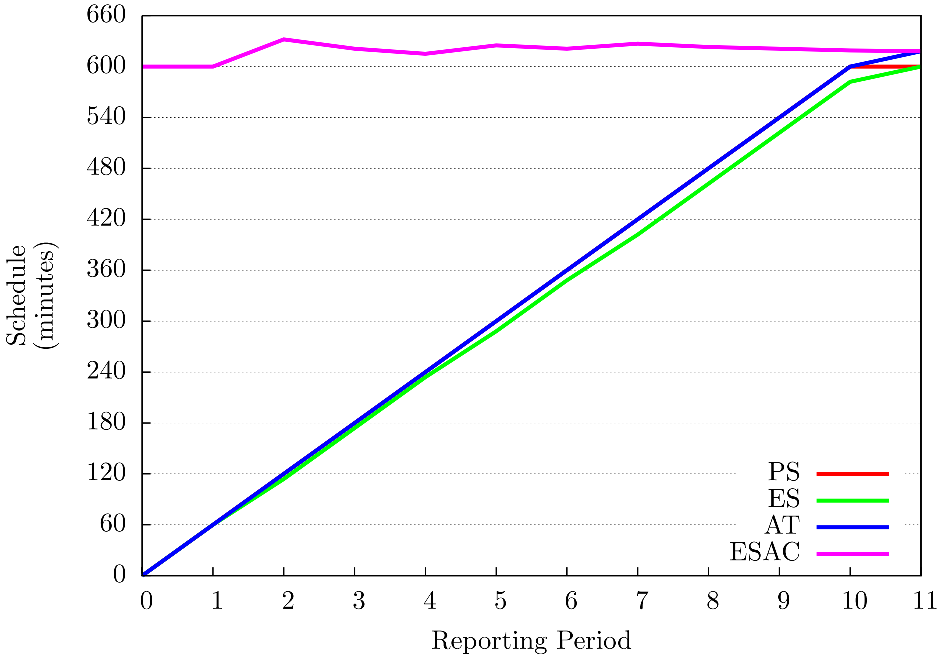

Figure 3.2: Schedule Performance & Prediction

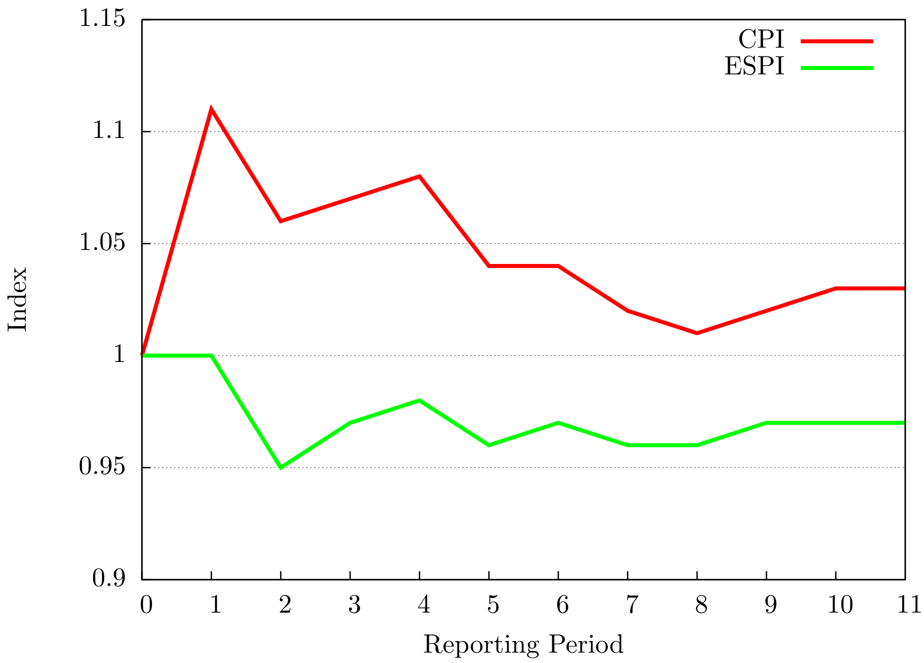

Figure 3.3: Performance Indicators

Chapter 4

A (more) Formal Look at EV Analysis

We will now formalize what was introduced above and visualize the whole scene in Earned Value terminology. We situate the definitions below in the framework of a set of activities which produce results by means of some form of expenditure. Activities have well defined beginning, end, and cost. At any point in time, the full set of activities is also well defined, even if it may change over time. This set of activities is called a *project*. In our discussion, a project is simply a set of activities. The concept of work breakdown structure is not needed in this discussion. Activities are all atomic, with their associated attributes.

Note that items prefixed with *actual* refer to values for the *cost* attribute that have been recorded at a given point in time. Thus, an actual value is non-decreasing over time. For example, before going on a holiday the actual cost is zero, after buying the airline tickets, the actual cost has a new value, after going to the airport and paying for the taxi and lunch the actual cost of the holiday is already much more than zero - it will continue increasing (or not decreasing) until the holiday is finished.

We will now look at some formal definitions.

4.1 EVA Definitions

The following terms are defined so as to clarify subsequent discussion.

Date : as its name indicates, a measure of a point in time; the exact time format in use is a parameter of a project. Here, **date** will refer to a specific point in time, e.g. a time and date, with the precision determined as a parameter of the project,

Reporting Period : a period of time which determines the rhythm at which *earned value analysis* will be performed. An **RP** has a start and end **date**.

Cost : cost is a measure of expenditure involved in the production of some result, it can be measured in units such as man-days, dollars, €'s, bails of hay, litres of milk[1]. In the discussion we will abstractly refer to cost in terms of *Cost Units* or **CU**. The value associated with a **CU** is a parameter of the project.

4.2 EVA Input Parameters

These parameters are required as raw input to the computations in *earned value analysis.*

Activity : an activity is an atomic unit of a project, producing a measurable value (measured in **CU**). The attributes of an activity are:

- **Planned Start** : a **date** value indicating the point in time when the activity is planned to start,
- **Planned Finish** : a **date** value indicating the point in time when the activity is planned to be finished,
- **Actual Start** : a **date** value indicating the point in time when the activity is really started; this value is only available when the activity has really begun,
- **Actual Finish** : a **date** value indicating the point in time when the activity was really finished; this value is only available when the activity is completed,
- **Planned Value** : a **CU** value indicating the planned cost or *value* to us of the activity,
- **Earned Value** : a **CU** value indicating the *value* to us of the part of the activity which has been completed at a specific **date**,
- **Actual Cost** : a **CU** value indicating the total expenditure for an activity at a specific **date**,

Project : A Project is simply a set of activities as defined above; For our purposes *Project* and *Project Plan* are synonymous. All *planned* values refer to a specific version of the project plan; all *actual* values refer to a specific **date** during the execution of the project.

The sharp reader will note at this point a subtle ambiguity. How does one measure the value obtained from an activity before it is finished? Intuitively, we can say that when an activity is not yet started, we have not yet obtained any value, so we have earned *zero* **CU**. Likewise, when it is finished, we have earned what it is worth, which is what we declared it to be worth to us, i.e. the *planned value* in **CU**.

But what about the grey area in between start and finish? Depending on the type of activity, it may be possible to measure exactly what percentage of it has been accomplished. For example, if we have to paint a wall, we can measure how

[1]Strange as it may seem, these latter measures are still in use today in western Europe!

much surface we have painted and compare that with the total surface to obtain a value of our partial work[2]. This was the case in the *Drive South* described above: it was easy to measure progress since it equated to the distance recorded on the car's odometer.

However, in the general case it is not possible to make an objective measure of the percentage completion of an activity. One can only guess, or ask those involved, which is the same thing, or worse.

It is standard practice to avoid subjective measurement of percentage complete by the use of the following simple rule:

$$\text{percent complete} = \begin{cases} 0 & \text{if the activity has not started,} \\ v_s & \text{if the activity has started,} \\ 100 & \text{if the activity is finished.} \end{cases}$$

Where v_s is a fixed percentage value given to all activities that have been started. This value is usually 50%. Other values are possible[3].

If we use the above mentioned rule to determine the actual percentage of completion of an activity, then we must apply the same rule in the determination of the planned percentage completion at a given time. In this case, we take the planned start and finish instead of the actuals to determine the percentage value.

The use of the algorithmic determination of percentage complete leads to the following formulæ:

For an activity of cost C, planned start ps and planned finish pf, the planned value at date d is such that:

$$PV(d) = C(v_s DateLE(ps, d) + (1 - v_s)DateLE(pf, d)) \tag{4.1}$$

Where $DateLE(d1, d2)$ is a function that returns 1 if $d1 \leq d2$ or 0 otherwise.

Similarly, we compute the earned value with actual start as and actual finish af:

$$EV(d) = C(v_s DateLE(as, d) + (1 - v_s)DateLE(af, d)) \tag{4.2}$$

4.3 Another EVA Example

Let's take a look at an example.

[2] Even this simple example leaves room for ambiguity. What if the surface of the wall must be prepared before painting? What if there are several coats? How do we account for the time while the paint is drying? Yes, life is indeed more complex than the average high-level manager would like to believe.

[3] 20% is another common value, but will produce reports which appear pessimistic in comparison to those generated when $v_s = 50\%$.

Suppose we have the following activity *toto*:

Planned Start : 12:00,

Planned Finish : 15:00,

Planned Value : 100 **CU**.

We will take the **RP** to be one hour, i.e. we report every hour, and the standard $v_s = 50\%$. Table 4.1 shows the planned value figures

Report Time	Start Contribution	Finish Contribution	Planned Value (cu)
11:00	0	0	$0 + 0 = 0$
12:00	(0.5)100	0	$50 + 0 = 50$
13:00	(0.5)100	0	$50 + 0 = 50$
14:00	(0.5)100	0	$50 + 0 = 50$
15:00	(0.5)100	(0.5)100	$50 + 50 = 100$
16:00	(0.5)100	(0.5)100	$50 + 50 = 100$

Table 4.1: Example of Planned Value Computation

The example in Table 4.1 shows how the start and finish of a task contribute to the total planned value. When $v_s = 0.5$ we note that the start and finish of an activity contribute equal value. This is the industry standard. We also see that planned value is non-decreasing over time, as expected.

Now suppose we execute the activity *toto* as follows:

Actual Start : 12:30,

Actual Finish : 14:00

Table 4.2 shows the earned value figures.

Report Time	Start Contribution	Finish Contribution	Earned Value (cu)
11:00	0	0	$0 + 0 = 0$
12:00	0	0	$0 + 0 = 0$
13:00	(0.5)100	0	$50 + 0 = 50$
14:00	(0.5)100	(0.5)100	$50 + 50 = 100$
15:00	(0.5)100	(0.5)100	$50 + 50 = 100$
16:00	(0.5)100	(0.5)100	$50 + 50 = 100$

Table 4.2: Example of Earned Value Computation

Finally, suppose the cost of the execution of the activity *toto* is as follows.

Actual Cost : 75 **CU** distributed evenly over the period of execution, i.e. 25 **CU** per 30 minutes.

This leads to the Actual Costs in Table 4.3.

Finally, one can see how these three values fit together when combined in the single Table 4.4 below:

Report Time	Actual Cost (cu)
11:00	0
12:00	0
13:00	$0 + 25 = 25$
14:00	$25 + 50 = 75$
15:00	$75 + 0 = 75$
16:00	$75 + 0 = 75$

Table 4.3: Example of Actual Cost Computation

Report Time	PV (cu)	EV (cu)	AC (cu)
11:00	0	0	0
12:00	50	0	0
13:00	50	50	25
14:00	50	100	75
15:00	100	100	75
16:00	100	100	75

Table 4.4: Example of Basic EVA Values

The astute reader will note that the use of the fixed percentage technique will produce less meaningful results if activity durations are long compared to the length of the reporting period. It is also standard practice to construct the *Work Breakdown Structure* such that the duration of most atomic activities is approximately equal to the length of the reporting period.

4.4 Basic EVA values and their Formulæ

In the general case we will be interested in projects with many activities. The computation of planned and earned values as well as the actual cost at a reporting period is then simply the sum of the respective values of each activity for that reporting period. Formally, for n activities, the total planned value PV, earned value EV,and actual cost AC for a reporting period rp are given as follows (for those who already forgot the formulæfor the computation of pv and ev for individual activities, please refer to equations 4.1 and 4.2):

$$\text{total } PV(rp) = \sum_{i}^{n} PV(activity_i, rp) \tag{4.3}$$

$$\text{total } EV(rp) = \sum_{i}^{n} EV(activity_i, rp) \tag{4.4}$$

$$\text{total } AC(rp) = \sum_{i}^{n} AC(activity_i, rp) \tag{4.5}$$

4.5 Earned Schedule Analysis Formulæ

The basic EVA values can be used to derive *Earned Schedule* values. As explained in the *Drive South* example, the *Earned Schedule* value for a given reporting period is defined as the maximum date at which the project's planned value is equal to the earned value of the reporting period. More formally:

$$ES(rp) = \max(date) \text{ such that total } PV(date) = \text{ total } EV(rp) \tag{4.6}$$

Since *planned values* are only computed at the end of reporting periods, it is likely that the date value will need to be interpolated from the end dates of two reporting periods. An example of this type of interpolation is illustrated in Figure 4.5 below. In this figure, we see how to compute the value of *Earned Schedule* for the date "40":

1. First, let's assume some example values for the data:
   - $EV(40) = 103cu$,
   - $PV(20) = 100cu$,
   - $PV(30) = 110cu$.

   where 20, 30, and 40 are the number of elapsed days in the project at the end of various reporting periods.
2. The *Earned Value* at $date = 40$ is somewhere between $PV(20)$ and $PV(30)$, i.e. $20 \leq ES(40) \leq 30$,
3. We use the following ratio:

   $$\frac{EV(40) - PV(20)}{PV(30) - PV(20)} = \frac{ES(40) - 20}{30 - 20} \tag{4.7}$$

   to calculate the value of $ES(40)$:

   $$\frac{103 - 100}{110 - 100} = \frac{ES(40) - 20}{30 - 20} \tag{4.8}$$

   $$\frac{3}{10} = \frac{ES(40) - 20}{10} \tag{4.9}$$

   $$ES(40) = 3 + 20 = 23 \tag{4.10}$$

4. And we see how the interpolated value can be obtained by means of a proportion, once again!

What is the significance of $ES(40) = 23$? Well, that means that after 40 days into our project, we have only obtained the results that were expected for 23 elapsed days. In other words, we are 17 days late!

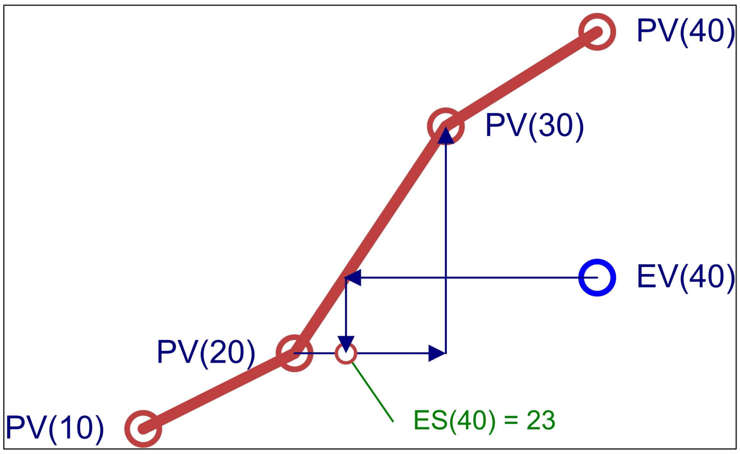

Figure 4.1: ES Interpolation Example

4.6 Derived EVA Indicators

In this section we will look at *indicators* which are derived from the three basic EVA values and the value of ES. These values have proven to be most useful in predicting overall project outcome in terms of cost and schedule[4].

The first of these is the *Cost Performance Index* or **CPI**. This index is simply the ratio of the *Earned Value* to the *Actual Cost*. Its value indicates the how much value the project is producing (*earning*) compared to the cost of the production. If the value is equal to one, then the earnings are equal to the cost: the project is costing what is expected. If the value is superior to one, then the project is earning more than it is spending: the project is costing less than expected. Finally, if the value is less than one, then the project is costing more than expected.

These conditions are summarized:

$$CPI = \frac{EV}{AC} \begin{cases} > 1 & \Rightarrow \text{ project cost is less than expected,} \\ = 1 & \Rightarrow \text{ project cost is exactly as expected,} \\ < 1 & \Rightarrow \text{ project cost is more than expected.} \end{cases}$$

In plain English: if the $CPI < 1$, then the project is over budget.

Next, we can use the **CPI** in a very simple proportion to estimate the total project cost or *Estimate At Completion* **EAC**:

$$\frac{EV}{AC} = \frac{\text{Total Planned Value}}{EAC}$$

[4]Another indicator, the *Schedule Performance Index* or **SPI** is sometimes used to measure schedule performance. However, its theoretical foundation is not easily understood and will not be discussed here.

Or, more simply:

$$EAC = \frac{\text{Total Planned Value}}{CPI}$$

And finally, we can estimate how much the project will cost to complete, the *Estimate To Complete* or **ETC** by taking the difference between the *Estimate At Completion* and the *Actual Cost*:

$$ETC = EAC - AC$$

We can apply similar reasoning on schedule performance. First we can calculate the *Earned Schedule Performance Index* or **ESPI**. This is defined as the ratio of *Earned Schedule* to *Actual Time*. Obviously, the units must be taken as elapsed time since the start of the project and usually conversion of time and date values will be necessary. The **ESPI** indicates the how fast the project is producing earnings compared to how fast it was planned to produce those earnings. If the **ESPI** is equal to one, then the project is earning value at the planned rate: the project is on schedule. If the **ESPI** is superior to one, then the project is earning faster than planned: it's ahead of schedule. Finally, if the **ESPI** is less than one, then the project is behind schedule.

These conditions are summarized:

$$ESPI = \frac{ES}{AT} \begin{cases} > 1 & \Rightarrow \quad \text{project progress is better than expected,} \\ = 1 & \Rightarrow \quad \text{project progress is exactly as expected,} \\ < 1 & \Rightarrow \quad \text{project progress is worse than expected.} \end{cases}$$

In plain English: if the $ESPI < 1$, then the project is slipping.

As above, we can use the **ESPI** in a very simple proportion to estimate the total project duration called the *Estimated Schedule At Completion* or **ESAC**:

$$\frac{ES}{AT} = \frac{\text{Total Planned Time}}{ESAC}$$

Or, more simply:

$$ESAC = \frac{\text{Total Planned Time}}{ESPI}$$

And finally, we can estimate how much more time the project will take to complete, the *Estimated Schedule To Completion* or **ESTC** by taking the difference between the *Estimated Schedule At Completion* and the *Actual Time*:

$$ESTC = ESAC - AT$$

In summary, we have the following derived indicators:

Cost:

Cost Performance Index: $CPI = EV/AC$, a comparison of earnings with actual cost,

Estimate At Completion: $EAC = \text{Total PV}/CPI$, how much the full project will cost,

Estimate To Completion: $ETC = EAC - AC$, how much of the EAC remains to be spent in order to complete the project.

Schedule:

Earned Schedule Performance Index: $ESPI = ES/AT$, a comparison of earned schedule with actual schedule,

Estimated Schedule At Completion: $ESAC = \text{Total Planned Time}/ESPI$, when will the project finish,

Estimated Schedule To Completion: $ESTC = ESAC - AT$, how much more time is required in order to complete the project.

4.7 Computation of Earned Value Values

4.7.1 Inputs to Earned Value Analysis

The inputs to *Earned Value Analysis* are of two types. The first is configuration data needed by the eva calculator, the second is the project data that will be processed by the eva calculator. Both of these inputs must be provided by the user at computation time.

The Configuration data is:

Reporting Period: day, week (default), month, quarter, year, etc.

Start Value v_s: generally 0.5 (default), but 0.2 is also a common value.

There are three sources of project data:

Project Plan: containing for each activity the planned start and finish dates as well as planned value (i.e. cost),

Project Tracking: containing actual start and finish dates for activities that have either started or finished,

Project Actuals: project cost per reporting period.

4.7.2 Outputs from Earned Value Analysis

The output of *Earned Value Analysis* is the full set of eva values described above, computed for each reporting period. Note that the **PV** is the only value that can be computed for activities that have not started.

These are easily presented as per the Tables 4.5 - 4.7 :

Most often the (**CU**) values from this table are plotted per reporting period as curves in a first chart, then the (date) values are plotted in a second chart, and finally the indices are plotted in a third chart. Examples of these were provided in Figures 3.1 - 3.3 in the *Drive South* example.

Reporting Period	PV (cu)	EV (cu)	AC (cu)	EAC (cu)	ETC
...					

Table 4.5: Earned Value Calculator Output: CU Values

Reporting Period	ES (date)	ESAC (date)	ESTC (time interval)
...			

Table 4.6: Earned Value Calculator Output: Date Values

Reporting Period	CPI	ESPI
...		

Table 4.7: Earned Value Calculator Output: Indices

Chapter 5

Conclusion

Well this certainly was a long story! More important, what have we learned?

We have seen that *earned value analysis* allows us to predict two of the three fundamental characteristics of a project: *Time* & *Cost*[1].

We have seen that *earned value analysis* is both algorithmically simple and conceptually a bit complex.

We noted:

1. The starting point is a plan in which every activity has a planned start, finish and cost. These are combined by means of a very simple formula to produce the *planned value* for each reporting period.
2. As the project is executed, actual start, finish and cost is tracked for each activity. These produce the *earned value* and *earned schedule* for each reporting period,
3. All the above are then combined to produce the *Cost* and *Schedule* performance indicators which tell us how well we are performing in terms of cost and schedule,
4. The performance indicators are combined with total planned cost and schedule to predict the final actual cost and schedule.

This is *earned value analysis.* Are you wondering how any serious project could be managed without it? If you are, then you understood. If not, ...

[1] The third, *Scope* has not been considered.