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EARNED VALUE ANALYSIS - A PROVEN AND EVOLVING METHODOLOGY

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ABSTRACT

The main purpose of this approach is to present the main lines of this project management technique: basic concepts, modern formulations and details of some more advanced concepts that arouse interest among EVA practitioners. The idea behind this system is simple and wise: before the project starts, the project team is asked to describe the pace at which the project should acquire value. Once the project has started, the project team reports on the progress achieved by reporting a valued physical progress on the one hand, and the amount of costs incurred on the other hand. In analyzing this instantaneous performance, constituents and stakeholders have an objective assessment of the of the project health. If necessary, they can make decisions: review the mandate given to the project team, grant an additional budget allocation, review the project schedule ... even in certain circumstances, put an end to the project altogether!

Keywords: project management, schedule, earned value, budget

1. INTRODUCTION

Many project managers, who practice EVA, or EVM (Earned Value Method), in other words project management by the value acquired, and this, without always knowing it. But before going any further in understanding what lies behind this concept, let's first point out that this project management approach, unlike approaches such as the Critical Chain or methods like Prince2 or Hermes to name a few, is not self-sufficient in itself. Very modestly, EVA only complements the classical project management approaches, especially those promoted by the professional associations of project management, giving them a more formal framework to report on the progress of a project.

The description of a project management system, some would say of a technique, which when attached to the planning framework, the time and economics of the project allows the project team to know where it is and to provide the constituents with reports that accurately reflect the progress of the project. There are many project managers who practice EVA without knowing it! Maybe this concept is known by different names? And this is indeed the case. A little bit of history. What lies behind EVA was born in the United States of America at the end of the 60s. Forced to see far too bad drifts in the realization of major military projects, the US Department of Defense decided to impose a formal reporting framework for all projects as soon as they could claim significant public funding. This system of control of the progress imagined by economists has received the name of C/SCSC, odd acronym for Cost / Schedule Control System Criteria.

2. BASIC CONCEPTS

Until the end of the 1980s, the use of C/CSGC in projects remained relatively confidential. Only a few major American public projects used it, for the simple reason that they were forced by their contractors. Why so few projects have used it while this technique is described as simple and judicious in the previous paragraph? Certainly there were several reasons for this, among which:

- American military standards, and especially those devolved to management, are generally perceived as heavy implementation and binding use,
- more generally, any management task is perceived as expensive and often non-value-generating,
- the acronyms associated with the C/SCSC technique are easily confusing (BCWS = Budgeted Cost of the Work Scheduled; BCWP = Budgeted Cost of the Work Performed; ACWP = Actual Cost of the Work Performed),
- finally, on the basis of the principle "to live happily, let's live in hiding", why do transparency work and see the constituents and other stakeholders interfere in the affairs of the project teams ...

A spot in the democratization of C/SCSC was felt in the late 80s with the advent of project management software packages for microcomputers. But the appropriation of this technique by the projects did not really start until 1996 when the American military standard passed under the ANSI - the American National Standard Institute and the American Electronic Industry Alliance. At the same time, a number of changes have been made:

- the name of the C/SCSC concept was renamed Earned Value Management and popularized under the acronym EVM in the United States and named Earned Value Analysis under the acronym EVA in the United Kingdom; two names for rigorously the same technique!
- the three main EVM parameters were given a more easily remembered and less ambiguous denomination (PV = Planned Value; EV = Earned Value; AC = Actual Cost).

2.1. AN NTH TECHNIQUE OF ANGLO-SAXON ORIGIN

Two types of forces caused by the inertia of moving parts exists:
Since the mid-1990s, EVA has been a project reporting methodology that has received a lot of attention from a standardization body. The two main standards are:

- American National Standards Institute/Electronic Industries Alliance (1998) Earned Value Management Systems. (ANSI /EIA-748-A-1998, rev. 2, reaffirmed August 28, 2002) American National Standards Institute, Wash. DC, USA,
- PMI Standard Committee (2005) Practice standard for Earned Value Management. Project Management Institute, Newton Square, PA, USA.

This technique has also received a lot of attention from professional associations. In the mid-1970s, an association was formed in the United States to promote C / SCSC then EVM in professional circles. For the past ten years, this association has joined the American Project Management Institute (PMI) by forming a specific college: the CPM, College of Performance Management. Under the umbrella of the PMI, this association organizes two annual conferences.

The United Kingdom is not left out. The promoters of EVA are part of a special interest group of the Association for British Project Management (APM).

The fact is: C/SCSC then EVM and EVA have benefited for some decades from a certain interest in the Anglo-Saxon countries. What about the rest of the world? EVA is a prescriptive technique, and it is clear that it was "seriously used" when it was "firmly prescribed" by the project constituents! This was and remains the case in the United States and the United Kingdom where projects are required to report using this technique when they receive a share of public funding. But the project teams who have taken a liking to it are still using it, even on projects that do not benefit from public funding. The project offices (PMOs) of large companies also saw the benefits they could derive from a reasoned use of EVA and also promoted this project reporting technique. Finally, with the help of globalization, non-Anglo-Saxon projects were also strongly encouraged to use EVA because part of their funding was British or North American, or because EVA regulars insisted that this approach be used.

In other words, the need to federate know-how in EVA is not only Anglo-Saxon, it is global. The British and North American forums are excellent places for the exchange of know-how, but it is nevertheless clear that Anglo-Saxon prescriptive approaches dominate most of the discussions. Non-Anglo-Saxon participants could sometimes be skeptical about the nature of these exchanges and their relevance in other project contexts.

3. MODERN FORMULATIONS

EVA is above all based on a common sense principle:

- before the project actually starts: presenting the pace, the rate at which the project will (or should) acquire value; in other words, give the expected physical advancements that should be obtained at the next reporting dates
- while the project is in progress, report on the value actually acquired, and compare it with that projected.

Experience has shown that this information alone is not sufficient to effectively report on the progress of a project. There may indeed be situations for which the project is in advance, which may appear quite satisfactory, but this rate results from particularly high costs incurred, which is not satisfactory at all!

To keep a sympathetic eye on this kind of possible drift, EVA also takes into account the costs incurred; in other words, past times and expenditures of all kinds made to reach the earned value reported.

The transition from principle to practice essentially proceeds from the formalization of vocabulary.

3.1. ESTIMATED VALUE

Before the project starts, the project manager will define the pace with which the project will move forward. To do this he will establish the PV curve of his project. PV is an acronym for Planned Value, that is, predictive value. PV is not a constant value. It's a value that evolves over time. So it is certainly more rigorous mathematically to formulate it as a function: PV(t).

As long as the project has not started, this forecast value is zero. Once the project is completed, it is equal to the budget allocated to the project; more specifically, to a particular value that in the EVA jargon is called the budget at completion, BAC (Budget at Completion). The PV (t) curve is a cumulative curve: the value acquired over a period is added to those acquired over previous periods. Also this curve is increasing. The profile of the PV (t) curve usually looks like an "S", hence the S-curve name that is sometimes given to it.

In the first moments of the project, the PV (t) curve increases rather slowly. This is logical: the start of the project can only be done gradually; the essential coordination needs dictate that the human resources - project contributors - assigned to the project should be gradually, as and when needed! In a second time, this curve sees its slope grow. This is normal: sooner or later the activity of the project must be in full swing; each contributor to the project having learned of the work expected of him, he can work on his task. This higher growth can be explained by the fact that several contributors can work together. When the project is close to completion, it is necessary to move on to the integration of the various contributions, and perhaps also to the commissioning of the whole. The coordination requirements for integration and commissioning mean that the slope of the PV (t) curve decreases again.

Figure 1 illustrates all that has just been said. Time runs from left to right; the cumulative value is expressed in units of resources on the vertical axis. Depending on the nature of the project, it may be units of charge (hours, person-day, person-week, person-month ...) or monetary units (euros, dollars, Swiss francs ...). In this figure, $D_{project}$ marks the projected start date of the project, $F_{project}$ marks the projected end date of the project.

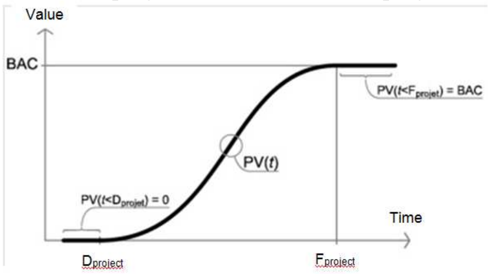

Fig.1. Curves PV(t)

But in practice, how is this PV(t) curve established? In his Discourse on the Method, Descartes wrote: "The second [principle], to divide each of the difficulties that I would examine, in as many plots as possible, and that it would be required to better solve them". This is the same approach that is required for the project manager:

- break down the project into elementary activities (or tasks)
- assign a PV(t) function to each of the basic activities of the project
- aggregate these basic functions to obtain the PV(t) curve of the project as a whole.

3.2. BUDGET AT COMPLETION

The budget at completion, BAC (Budget at Completion) is another concept specific to EVA. It is important and deserves a bit of attention. As a preliminary to the introduction of this notion, let us recall what a project is: a complex system of actors, means and actions, constituted to provide an answer to a need. The term "complex" has most certainly been deliberately chosen to reflect the inherently speculative character of a project. Cyberneticians hold things complex for entities that can be described in their entirety, but for which it is impossible to assign precise and absolute properties to the elements that constitute them. The concept of "black box" has been advanced to reflect the difficulty of describing their content. A project is therefore speculative by nature. It necessarily contains a part of randomness that all the protagonists have the obligation to manage. It is the purpose of risk management in projects to take into account this element of hazard to prevent unexpected events from jeopardizing the project.

The promoters of EVA have of course taken this into account, considering that a team that receives a project mandate, in other words the care of achieving a tangible or intangible object in budgetary and time constraints, must constitute a budgetary and/or temporal reserve to face the unexpected. The importance to be given to these reserves is then a function of the more or less speculative nature of the project. A budget reserve of 5% of the resources allocated to the project may be sufficient for a low speculative project. This percentage can be increased to 50% for highly speculative projects.

How to size this reserve? The exercise is not very simple, and rare are the authors who also venture in this field! Experience shows that some prerequisites are essential to properly size these reserves. It is essential that all the stakeholders, constituents and agents of a project are fully aware of:

- a project is by nature an activity that includes a share of unforeseen
- that in order to complete a project, the project team must have reserves, both in terms of budget (resources allocated to the project) and time (the calendar deadlines to be respected)
- that these reserves are there to be consumed, partially or totally, if necessary
- that the project team must have authority over the appropriate use of part of these

reserves, within certain limits: trust does not exclude control from the principal
- rules for distributing the remaining amounts must be defined at the beginning of the project: 50% to the principal and 50% to the project team, for example.

These few considerations may appear to be mere common sense. But it is clear that project stakeholders, who are actually concerned about these issues in a timely manner, are a tiny minority.

The promoters of EVA have given a name to all these values:
- the amount of all resources earmarked for the implementation of the project is the total budget allocated to the project, TAB (Total Allocated Budget)
- the share of the TAB reserved for the unforeseen is the PMR (Project Management Reserve)
- completion budget, BAC, is the share of the TAB allocated to identified and approved activities.

Retain this: TAB = BAC + PMR

3.3. NATURE OF RESOURCES

The nature of the resources, and hence the way they are quantified, are of prime importance in an EVA context. The resources of a project are generally of two types: human resources and material and financial resources.

Human resources: These are the natural persons who will coordinate or execute the project activities. They are the contributors of the project. They are quantified in units of charges (hours, person-day, person-week, person-month ...).

Material and financial resources: These are all required resources that are not human resources. It may be material resources: tools, equipment, premises ... that the project team can acquire (and sell at the end of use), rent, borrow ... It can also be raw materials or utilities (electric energy for example). It may be financial means: to acquire raw materials, supplies ... to enter into contracts of all types, for various disbursements of the project team (general services, stewardship fees, logistics, etc.). These resources are given in monetary units (euros, dollars, Swiss francs, etc.). It is the responsibility of the project team to assess the nature of the resources involved in the project, as well as to take them into account correctly in the BAC and the TAB.

Consider that the project has started; that the first activities - the earliest - are in progress, some even completed; that the first expenses are recorded. The task of the project manager and his team is to report this by superimposing this information on the realized, the PV(t) curve, or the various S curves established for analysis. In the case of the reporting date, also known as the progress report date, the information reported is the value acquired on the one hand and the costs incurred on the other hand.

3.4. EARNED VALUE

Earned Value, EV is defined as the budgetary valuation of the work actually performed on the status of advancement. Just as the planned value is a function of time, so is the acquired value; it should then be noted EV (t). This is the denomination given to the curve obtained point by point.

Let T be the date on which the advancement status is established. Because this curve is obtained by positioning successive points (at successive progress dates), it is preferable to note EVT the acquired value of the project at the date T. EV_T is obtained by aggregation of $EV_{i\,T}$ of each of the activities i of the project. At the level of elementary activities, three cases can be met:
- activity i is completed; in which case the acquired value of the activity is equal to its budget: $EV_{i\,T} = BAC_i$
- activity i has not started; in which case its acquired value is equal to zero: $EV_{i\,T} = 0$
- activity i is in progress; in which case its acquired value is proportional to the physical progress (let's call it φ) of the activity: $EV_{i\,T} = \varphi_i \times BAC_i$

The physical progress φ_i of an activity is a value between 0 and 1, or more commonly in the form of a percentage between 0% (an activity that has not started) and 100% (a completed activity).

Once EV_T is reported to the PV (t) curve, three situations can occur:

- EV_T is coincident with the points of the curve PV (t), that is, EV_T = PV (T); the project is neither early nor late, it is just on time
- EV_T is below the PV (t) curve, ie, EV_T <PV (T); the project is late: the acquired value is lower than the planned value
- EV_T is above the PV (t) curve, ie, EV_T > PV (T); the project is then in advance: the acquired value is greater than the planned value.

The lead or delay can be quantified by differentiating between EV_T and PV (T). In EVA jargon, this difference is called schedule variance (SV): $SV_T = EV_T - PV (T)$

If this difference is positive, it means that the project is ahead. If it is negative, then the project is late (see Figure 2).

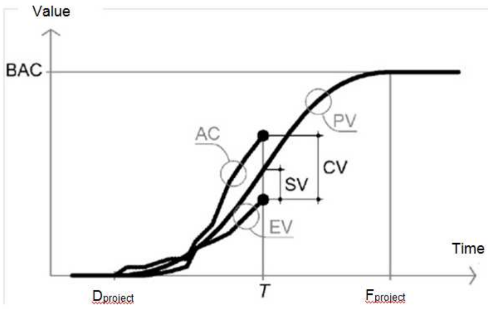

Fig.2. Curves PV(t), EV(t) and AC(t); planning gap SV_T and costs gap CV_T

3.5. COSTS INCURRED

The costs incurred, AC (Actual costs) are defined as the actual or committed expenses at the date of advancement. To record this information, the project must have a means of taking into account all the expenses attributable to the project.

Monetary expenditure: the recording of monetary expenditure is generally not a problem. One would be tempted to say that it is sufficient to ask the Accounting department the cumulative amount of costs incurred attributable to the project. It is still necessary that the accounting system of the company allows making this extraction.

Time spent: not all companies have a time recording system. In which case, the project team must have one. If the company has such a system, the project team has every interest in building on the existing system; unless she is obliged to do so.

What is a time recording system? This is a tool that regularly asks employees of the company or project to give for the period elapsed, the projects and/or activities they have worked on, the times they spent on each of them. Again, there is no general rule. The practices depend strongly on the cultures of companies, the field of activities of the organization, the place of the projects in the company, the requirements of the principals of the projects ... The periodicals of recording of the past times can be daily, weekly or monthly.

That being said, how are the costs incurred taken into account in the EVA system? If T remains the date at which the progress situation is established, the AC_T point is obtained by simply postponing the amounts extracted from the accounting systems and / or the recording of the past times, and this at time T.

Once AC_T is reported to the PV (t) and EV (t) curves, three situations can occur:

- AC_T and EV_T are the same, i.e. AC_T = EV_T ; the project is, at the moment T, neither deficit nor beneficiary; the realization was therefore at the expected cost
- AC_T < EV_T ; the project is rather profitable: the realization cost less than expected
- AC_T > EV_T ; the project is in deficit: the project cost more than expected.

The economic health of the project can be quantified by differentiating between EV_T and AC_T. In the language of EVM this difference is called the cost difference, CV: $CV_T = EV_T - AC_T$

If this difference is positive, it means that the project is profitable. If it is negative, then the project has a deficit (see Figure 2)

Just as the acquired value may have a bias, the information conveyed by the costs incurred may also be biased. For the interpretation of CV to be good, it is necessary that EV and AC are correctly synchronized. It's not always the case. Let's take a couple of examples to illustrate this point.

First example: a manufacturing activity of a constituent of a project, entrusted to a third party through a performance obligation contract. As long as the activity is not completed no expense is incurred. As soon as the constituent is delivered, the activity is deemed complete: EV = BAC. The invoice can be sent by the subcontractor, but at this time: AC = 0. If we are interested in the cost gap: CV = EV - AC = BAC. It is positive, translating a profit situation. But it is not so! False joy: the bill will eventually arrive even if payable at 30 days, it will pay!

How to get around this difficulty? Once again, there are several ways to proceed:

- consider that the costs incurred are costs incurred (here it is the opposite fault that can occur!)
- "pre-charge EV", ie to ensure that AC is at least equal to EV for activities performed by third parties, as long as a more precise value of AC is not known
- compare EV to PV, but AC to projected cash flows

Second example: an engineering activity that only requires resources from company employees who record the time spent performing an activity using periodic reports. If the activity in question covers several periods, the contributor(s) will have the opportunity to record the time spent several times. But it may well be that by the very nature of the activity, the physical progress is only recordable in all or nothing. In which case, at a given moment while the activity is in progress, the costs incurred will be non-zero while the acquired value will be zero.

Some may try to circumvent this bias by artificially synchronizing EV on AC. It is wrong. It must be admitted that a slightly positive cost difference does not necessarily mean a start of fiscal drift. An EVA system relies on a model, in other words a simplified representation of reality; simplification necessary for the return understandable and controllable. The part of imprecision highlighted is the result of this desire for simplification. It is essential to admit it!

3.6. ESTIMATE AT COMPLETION

To have at any given moment information on the programmatic health of the project: early or late, economic situation, profit or loss, can prove to be very useful, both for the constituents and for the members of the project team in their projects decision-making process. Being late at a given moment does not necessarily mean that it will grow inexorably until the end of the project! Similarly, a slightly worrying economic situation upstream of the project does not necessarily compromise the final success of the project! Let's reiterate that management reserves (PMR) are designed to cope with the unexpected, to mitigate the consequences of the occurrence of unwanted events.

Estimate at Completion (EAC) is intended to draw the final situation that may be obtained by extrapolating successive advancement situations. Completion estimates can be obtained in three ways.

The first is to say that what is done is done, and that the best way to appreciate the rest is to estimate it analytically or to re-estimate it, it being understood that it must have already been estimated! The estimate at completion is then determined as follows: $EAC_T = AC_T + RTC_T$, in which AC_T is the cost incurred at the time of advancement situation T and RTC_T is the remaining to be done (Remaining to Complete) at the same date of advancement status.

Estimate the remaining to be done is to inventory all the activities required to complete the project to completion, to schedule these activities over time, to value them one by one to rebuild by aggregation a new PV (t) curve of the project. This new curve is based on the AC_T point, and ends with an RTC_T ordinate point. The abscissa of this point may be earlier or later compared to the projected end date of the project (see Figure 3). The resulting EAC_T estimate has a good chance of being accurate. But it requires a lot of work to analyze the rest to do; for this reason, it is deemed relatively expensive to obtain!

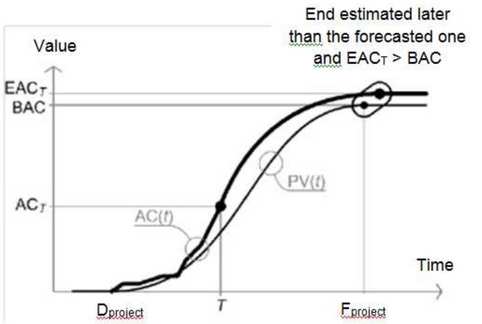

Fig.3. Estimate at completion obtained from the rest to be done

The following two ways can get estimates to completion much faster. They are based on the assumption that "past performance" is likely to continue. These two ways of calculating are also more prone to caution! The simplest method is to calculate EAC_T as follows: $EAC_T = BAC / CPI_T$, where BAC is the budget at completion of the project, and CPI_T (Cost Performance Index) is the cost performance index at the stage of progress status T. This way of calculating does not take into account the acquired value. It assumes that the economic performance applicable to future activities will be the same as that achieved until the date of advancement!

The other way to calculate EAC_T is: $EAC_T = AC_T + (BAC - EV_T) / (CPI_T \times SPI_T)$, where BAC is the budget at project completion, AC_T are the costs incurred, EV_T is the value earned , and CPI_T and SPI_T (Schedule Performance Index) are respectively the cost and schedule performance indices at the stage of progress status T. The latter takes into account the realized: costs incurred; the past performance seen as the $CPI_T \times SPI_T$ product only applies to the remaining to be established as the total value of the BAC project which is none other than the planned value of the project at its projected completion date, to which subtracts the value already acquired EV_T.

Of these last two ways to estimate EAC_T, which is the best? To date, no convincing study has been conducted on this issue. The pragmatic practitioner calculates EAC_T by means of these two expressions and feels that the truth is somewhere between these two values!

What was tried to show consecutively with the determination of the estimates at completion: that EAC_T <TAB. In other words, that the economic drift of the project is absorbed by the management reserve: $EAC_T - BAC_T$ <PMR.

4. EVA, THE AXES OF IMPROVEMENT

With these concepts presented, what are the challenges EVA presents to practitioners? Although this method has acquired a certain maturity, the fact remains that it presents biases for which specialists give analyzes and bring different. Among these biases that make a lot of noise, let us mention two: the calculation of the estimate at completion (EAC) of a project; the benefits of EVA in relation to the effort that a project team consents. These were two themes that present a variant to EVA called Earned Schedule (ES) which provides indicators that could bring much better estimates at completion and simulation exercises to evaluate the benefit that EVA can bring to the project management decision process.

4.1. RELIABILITY OF THE ESTIMATES AT COMPLETION

Of the two themes mentioned above, the first is based on a bias observed in the estimation of the remainder to be done. Recall that the EVA methodology has two virtues: to establish the progress of a project through EV and AC indicators, SV and CV deviations, and SPI and CPI performance indices; use these to derive the remainder to be done (RTC) and the estimates at completion (EAC).

It can be easily noticed that the evoked bias surely results from the fact that the SPI performance index is necessarily equal to 1 when the project is finished, when 100% of the physical progress is noted. Indeed, when the project is finished: EV = PV, and therefore SPI = EV / PV = 1.

In other words, whatever the delay or the advance that may have taken the project, it is or this is not reflected in the SPI index. When analyzed through this index - it is the same through the gap SV - this delay or this advance tends to diminish as the project approaches its end.

This complementary approach to EVA is called Earned Schedule, which could be translated as "acquired time". It is based on the determination of the temporal progress and the use of it to deduce deviations and indicators which themselves will be used for the calculation of the estimates at completion.

One of the confusing aspects of EVA is the interpretation of delays. As much as it makes sense that the difference between cost and CV is expressed in monetary units (in euros, Swiss francs, etc.), it is surprising that the SV planning gap can also be expressed in monetary units. We would be more likely to expect calendar units: days, weeks, or even months. This situation results from the desire of the initiators of EVA - of CSCS/C itself - to promote a simple analytical mechanism: in order to be able to aggregate the planned values PV, the costs incurred AC and the values acquired EV, it was essential that these they are expressed in the same unit.

These were essentially financiers; it is the monetary units that have been preferred. The new judicious idea was to take into account a planning gap expressed in calendar units, and not in financial units, so that the bias mentioned above cannot be manifested.

Let us insist that this approach is not self-sufficient in itself; it only complements the EVA approach by providing some additional health assessment of an additional project. Figure 4 shows the main information associated with EVA and is supplemented by those of Earned Schedule.

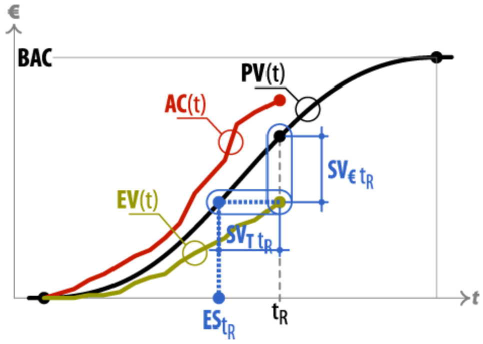

Fig.4. Analytical Elements of the Earned Schedule Approach

Before the project starts, the PV(t) curve is constructed. When a progress situation is established, say at the date tR, the costs incurred AC are counted and provide a point additional to the curve AC(t): the point which has the coordinate tR along the horizontal time axis, and ACtR along the vertical economic axis; at the same time, the acquired value EV is calculated by adding together the values acquired from each of the elementary activities of the project.

The acquired value of a completed activity is equal to the budget allocated to this activity; the acquired value of an activity remaining to be made is nil; the acquired value of an activity in progress is the proportion of its budget proportional to the physical progress of the activity in question. The resulting point has the coordinate tR along the horizontal axis, and EVtR along the vertical axis.

Once this information collection work is completed, it is possible to determine the deviations: the planning gap SVtR = EVtR - PV(tR); the cost difference CVtR = EVtR -

ACtR. A negative difference means that the project is doing worse than expected; a positive gap means that the project is doing better than expected.

The Earned Schedule approach suggests that an additional gap is sought. Obtaining this point requires that one draws the horizontal at the point EVtR - of ordinate EVtR - and that one localizes the intersection of this horizontal line with the curve PV(t). The point obtained will be to the left of the EVtR point if the physical progress of the project is less than expected; to his right if the project is globally ahead.

This intersection point is EStR coordinated along the horizontal time axis and is the date at which the current project progress level should have been reached. A later date if the project is rather early; an earlier date if the project is late. The situation in Figure 4 reports a delay: EVtR <PV(tR) and EStR <tR; the sign '<' in this last expression expresses the temporal anteriority.

A planning gap of a new nature can be determined: SVTtR = EStR - tR. This is a gap between two dates because it is measured horizontally. It is therefore well expressible in calendar units. From a conceptual point of view, some will agree that it's still better! It is then quite conceivable that a project that has fallen behind would retain an SVTtR (negative in this case), translating this delay, until the completion of the project.

This approach also offers a schedule performance index. According to EVA, this is obtained by calculating the ratio EVtR / PV(tR); according to the Earned Schedule approach, we can calculate another one: SVTtR = (EStR - tD) / (tR - tD); expression where tD is the start date of the project. This last calculation does, it becomes possible to use this result to bring another estimate to completion.

For the record, EVA offers two formulas to obtain this estimate:

- EACtR = BAC / CPItR
- EACtR = ACtR + (BAC – EVtR) / (SPItR x CPItR).

The results of these estimates are given in monetary units.

Earned Schedule also offers two formulas:

- EACTtR = (tR - tD) / SPITtR
- EACTtR = tR + (tF - EStR) / SPITtR; expression where tF is the projected end date of the project.

The results of these estimates are given in calendar units, ie estimated completion dates for the project.

By convention and in order to avoid any confusion between the planning differences measured vertically and horizontally, the one expressed in monetary units can receive a '€' in index (one '$' across the Atlantic and one '£' across the Channel ...); the one expressed in calendar units receives a 'T' in index. This convention applies identically for the performance index. If the index is omitted, it means that it is EVA's SV and not Earned Schedule's.

Before showing how the Earned Schedule approach is a useful complement to EVA, let us point out a small operational difficulty mentioned on many occasions but which, thanks to the computer science, finds a finally painless treatment.

As much as it is easy to get PVtR at a tR date (just accumulate the PV of each of the planned activities up to this date) or to obtain ACtR by simple accounting of all the expenses incurred, so much it is a little more difficult to determine EStR! Indeed, the PV(t) curve is nothing other than a discrete aggregation of small segments, and it is not certain that the intersection of the horizontal at EVtR cuts PV(t) at the hinge between two segments and that the date associated with this point is known. PV points may have been calculated only on regular dates.

Also a small linear interpolation exercise is necessary as shown in Figure 5.

The result is: EStR = tn + (EVtR - PVtn) / (PVtn+1 - PVtn). Some sorrowful spirits will certainly be munching on the small error made following this interpolation exercise, but it is easy to show that this error diminishes as we approach the end of the project. So as soon as the indicators of the Earned Schedule approach become really useful.

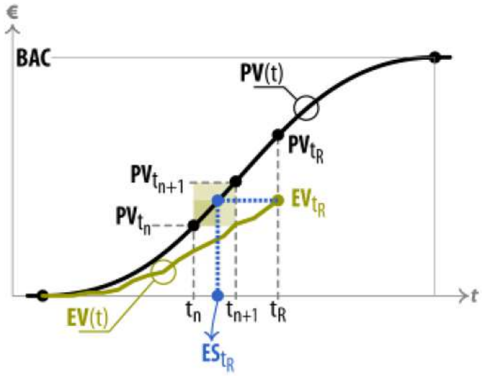

Fig.5. Interpolation determination of EStR

4.2. THE BENEFITS OF THE EARNED SCHEDULE APPROACH

Some of the benefits that could be seen from using Earned Schedule:

- It provides an updated estimate of the duration of the project and its completion date (EACTtR).
- It fits in perfectly with the logic of the EVA approach and indicators; it is complementary to him.
- It provides project practitioners with additional indicators that can refine the accuracy of the estimates, especially for projects that have fallen behind.
- Like EVA, it interfaces very well with risk management by offering a way to manage the reserves: economic reserves for EVA; Temporal Reserves for Earned Schedule.
- Like EVA, it offers a way to identify those activities that cause delays and require the greatest attention from project managers.
- Through an indicator called the P-factor, calculated as the ratio of the sum of the acquired values (EV) of the activities planned before the EStR date to the sum of the planned values (PV) of these same activities, Earned Schedule also offers the ability to measure the level of compliance against the project schedule, ie the ability of project contributors to carry out the activities in the initially planned sequence.
- Earned Schedule enriches the portfolio with strong indicators that are useful for piloting a project without requiring the project practitioner to make the slightest effort to collect additional information: the only data required are those already collected for EVA purposes.
- For most projects under analysis, the Earned Schedule indicators fairly accurately accounted for actual delays and gave good estimates of completion dates, whereas the EVA indicators were much less explicit about the extent of these delays, particularly in as projects approached their terms.

5. CONCLUDING REMARKS

Viewed as a slave system, such a model would necessarily be divergent. The dilemma then lies in finding the right balance between the analysis effort and the quality and usefulness of the results. From this point of view, EVA and its Earned Schedule complement seem to be a good compromise.

For this several reasons:

- By definition projects are unique businesses, aiming to produce unique results as well.

- The projects are ephemeral; at the end of these, the teams are dissolved and the management information disappears shortly after the completion of the projects.

- When this information is kept, it is too often disparate, uneven quality, produced on principles not always consistent, both within the same project and between projects conducted within the same organization.

- Not to mention the very heterogeneous nature of projects: projects in construction and infrastructure, new product or service development projects, IT projects, organizational projects, mergers, acquisitions, event projects, resource development projects human, etc.

Static and dynamic models rely on datasets that must be invented and validated. The generation of fictitious projects is not a problem in itself; the validation of these, in other words the assertion that they are very similar to real projects, leaves some questions unanswered: "What is a real project?".

Static models could be described of open-loop simulation models as illustrated in Figure 6. In other words, starting from initial data (activities with known durations, constraints of dependencies between activities) and an initial planning, the model simulates successive progress situations until the completion of the project. For each of them are calculated all the possible indicators: in particular the estimates with completion EAC€tR and EACTtR.

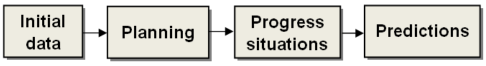

Fig.6. Static model for EVA and Earned Schedule assessment

These successive predictions are then compared to the actual dates and costs that result from the simulation as well. The results of these simulations show that the reliability of the predictions depends on the topology of the networks of activities and the criticality or otherwise of the activities in advance or late.

Dynamic models are those in closed loop. They are designed in such a way that successive advancement situations are brought to the attention of virtual managers and decision-makers so that they envisage corrective measures for the eventual recovery of the bar, provisions included in the subsequent situations of advancement (see Figure 7). These models better reflect reality.

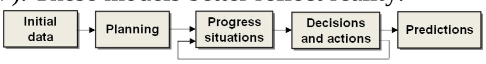

Fig.7. Dynamic model for EVA and Earned Schedule assessment

It was showed that the topology of the networks of activities influenced the quality of the predictions. The EVA and Earned Schedule indicators are rather reliable for networks consisting of highly serial activities with little parallelization, and much less reliable for networks with highly parallelized and non-serial activities. Earned Schedule indicators outperform those of EVA when the project enters its third part of realization.

Other concepts could have been exposed:
- taking into account inflation when projects run over several years.
- the "deliverable" orientation of the earned value registration mechanism.
- taking into account uncertainty and inaccuracy in EVA through the integration of project risk management.

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