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The trend of Earned Value Management as a Cross-Industry Best Practice: Conclusions and Lessons Learned From Real-Life Implementations

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Introduction

The Earned Value Management (EVM) method has been introduced to the Project Management community for a number of decades. Initially developed in 1962 as a result of a joint effort between NASA and the US Department of Defense, the practical application of this project controlling technique was for a long period of time confined to specific industries and types of projects, particularly to the defense sector and to large projects. This phenomenon has mistakenly created the perception that EVM is only applicable (or worth applying), to these scenarios. Our practical experience over the last ten years of using and applying EVM in the field, has demonstrated exactly the contrary: Earned Value can be used effectively in any type of project and industry sector, very often requiring little effort in small projects. Ranging from small consulting projects with durations from 1 to 2 months and teams of 1 to 3 consultants, to large multi-year complex projects in the defense or telecommunications industries, we have been using Earned Value successfully. This is not only because Earned Value is, per se, a very complete and effective method for project performance measurement and controlling, but also because we developed a set of unique extensions to the basic method along with additional supporting tools and procedures. In this paper, we briefly present this extended version of Earned Value Management along with the critical factors for successful implementation, in particular communication and data quality issues.

Basic Concepts and Metrics

The Earned Value Management method is grounded on some key concepts which are important to understand and communicate to stakeholders in a very clear manner.

There are three key concepts behind the EVM model:

- As time elapses in a project, there is certain amount of work that, according to the schedule, should have been accomplished. This amount of work is to be measured: *how much work should have been accomplished to date*?
- As time elapses in a project, work is accomplished in the field. This amount of work is to be measured: *how much work did we actually accomplish to date?*
- As work is accomplished, resources of various kinds are consumed and cost is incurred. This cost is to be measured: *how much did the work accomplished cost?*

These concepts are so fundamental that one can hardly imagine how a project can be managed without a Project Manager being able to answer these three simple questions: what should have been done? What as actually done? How much did it cost? Producing the three measures that answer these questions is practically all that is needed to have an Earned Value control system in place. All the analysis and decision-making process in Earned Value stem from these three measures.

There is an additional fourth element that is crucial to understand, which often creates confusion and less clarity about EVM: **work is measured in monetary units** ($, €, Pound, or other, say MU). For example, consider a project with the simple scope of painting four walls and paving the floor of a room, with each wall of 10m2 being budgeted in 100€, and the floor also of 10m2 budgeted in 200€; the walls are to be painted sequentially with each wall taking one week according to the plan, and the floor being paved in parallel to the painting of the walls throughout the four weeks; so, overall we have a 4 weeks projects with a total budget of 600€. Let's suppose that two weeks have elapsed: how much work should have been done? The answer seems obvious: two walls painted and half of the floor paved. But how do we measure this? We could simply use the total m2 accomplished; however, it is clear that having the whole floor paved (10m2 worth 200€) is better than having one wall painted (10m2 worth 100€). So the m2 of the wall and of the floor *do not represent the same value and therefore do not represent the same progress*. So we *cannot* say that 25m2 of work was done, because 5m2 (floor) are not of the same nature *and value* as the other 20m2 (walls). So we need another way to measure the *aggregate work* accomplished in the project.

In fact, in real projects, the physical measures of most work packages cannot be added because of their different nature (e.g. test cases, nº of pages, meters, m2, m3, and so on). The answer to this problem is to **measure work by its value in the budget**. So, in this case, after two weeks, two walls worth 200€ in the budget, and half of the floor worth 100€ (50% of 200€, its total budget), should have been accomplished. In other words, 300€ of work should have been done – we can also read: "300 units of work should have been accomplished". By measuring units of work as monetary units in the budget, the problem of aggregating work (i.e. adding scope), both actual and planned, is resolved. The other important advantage of this strategy is that work can be directly compared with its cost, which is also measured in monetary units – in this way, each unit of work is budgeted in one monetary unit; this is 1 € = 1 Unit of Work.

To finalize our simple example we can now consider the following scenario:

- Work that should have been done – 300 € (two walls and half floor);
- Work that was actually done – 250 € (one wall and ¾ of the floor);
- Cost incurred with resources consumed – 320 €.

By comparing these three measures it is easy to conclude that:

- There are 50 units of work behind schedule (250€ - 300€): this is the amount of work that should have already been done and is not done;
- The 250 units of work actually accomplished have cost 320 €: so an excess of 70 € (250€-320€) was spent;

- Since 300 units of work should have been done then 300€ should have been spent to date. However, the actual expenditure was 320€, so the project budget is being spent faster since 20€ (300€-320€) were spent ahead of schedule.

While it is not the purpose of this paper to describe in detail the full list of existing formulae and acronyms of the Earned Value Management method, it is relevant to present here the more essential standard metrics, described in an informal manner:

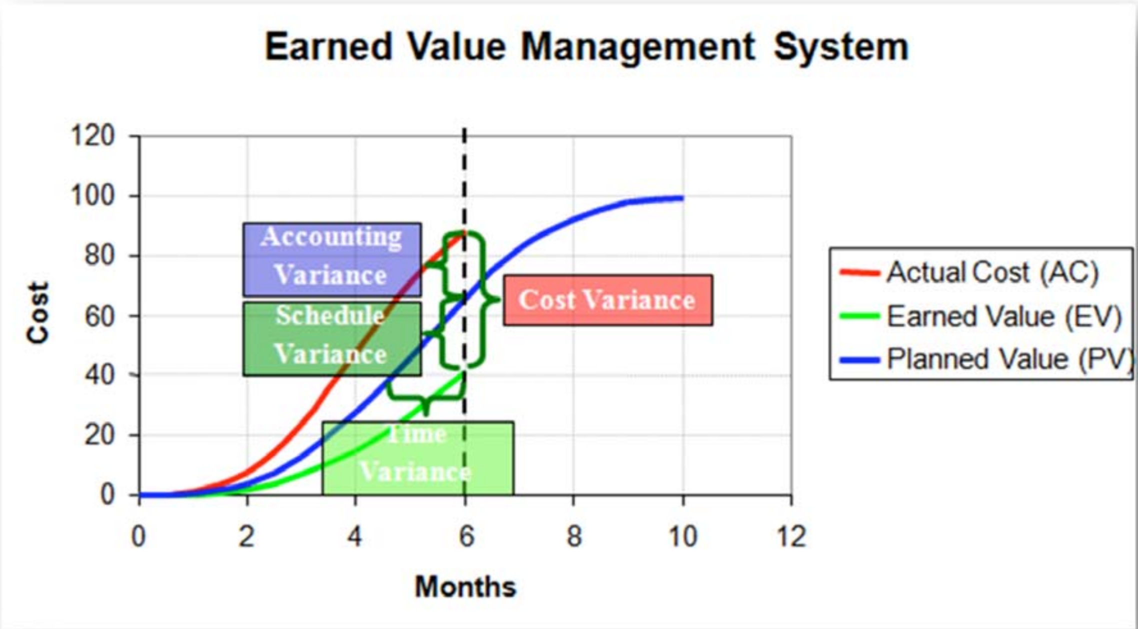
- PV/BCWS – amount of work that should have been done;
- EV/BCWP – amount of work that was actually done;
- AC/ACWP – cost of the work actually done;
- CV = EV-AC – how much cost has been over or under-spent for the work done;
- SV = EV-PV – how much work is currently ahead or behind schedule;
- CPI = EV/AC – how much work is being produced for each 1€ spent (this is a measure of productivity);
- SPI = EV/PV – how much work is being accomplished in each unit of time planned to accomplish one unit of work (this is a measure of work rate);
- TCPI = what is the required productivity to complete the scope within the available budget (this indicates the feasibility of the current budget);
- TSPI = what is the required work rate to complete the scope within the available schedule (this indicates the feasibility of the current schedule);
- IEAC = AC + (Budget – EV)/CPI – the estimated cost at completion assuming that past productivity will apply to the remaining scope (i.e. no intervention). This is meant to be an "independent estimate", not influenced by corrective or re-planning actions, and often a warning sign that stimulates management intervention;
- EAC = AC + (Budget - EV)/CPI-Future – the estimated cost at completion assuming that a certain productivity (i.e. CPI-Future) will apply to the remaining scope. This expected productivity should reflect the expected results from management intervention, and so it is not "independent";
- Estimated Schedule at Completion = Schedule / SPI – the estimated schedule at completion, assuming that past work rate will apply to the remaining scope (i.e. no intervention). This is meant to be an "independent estimate", not influenced by corrective or re-planning actions, and often a warning sign that stimulates management intervention.

The use of time performance metrics in EVM has always deserved a high level of reservation from practitioners, since it may seem that EVM is primarily a cost control method (a perspective we do not share from our experience). Some non-standard time performance metrics are also available in the literature:

- ES (Earned Schedule) – this is a name recently given to a concept reported in the literature since the early 1990s (if not earlier). This is the moment in time where, according to the baseline schedule, the current amount of work done should have been accomplished. For example, if you are behind schedule, then you have done less work than planned for the current time elapsed. Therefore, the moment in time when you should have achieved your current progress is somewhere in the past;

- TV (Time Variance) = ES – Current Time – how much time is the project behind or ahead of schedule. Even though this measure is more intuitive than SV, it can be less informative and even misleading. The real impact of a schedule delay has more to do with the volume of the delay (i.e. the amount of work not done), than with the delay itself. For example, a one month delay can be easily recovered if the only work scheduled for that month was a meeting, whereas a one week delay can be very severe if the amount of work that was scheduled for that week was very high.

The picture below illustrates these key concepts:



Where:

- **PV** – how much work should have been done;
- **EV** – how much work was actually done;
- **AC** – how much did the work done cost;
- **Accounting Variance (AV)** = PV – AC – cost incurred ahead or behind schedule. In this case, about 25 MU (monetary units) were spent ahead of schedule, so the budget is being spent faster than planned. Why? There can be two reasons: work costing more than planned and/or work being done faster. We cannot understand this “visible” variance without looking at the EVM variance metrics;
- **Cost Variance (CV)** = EV-AC – cost over or under expenditure. Is the work done costing more or less than budgeted? In this case, work budgeted for 40 MU cost 85 MU, therefore there is an overrun of 45 MU. However, only 25 MU seem to have been spent above the expected expenditure (see AV). Why? We need to look at the other variance metric to answer this question;
- **Schedule Variance (SV)** = EV – PV – amount of work ahead or behind schedule. In this case, 20 MU (or units of work) are behind schedule, so less work was done than planned and therefore because of this less budget should have also been spent. So the cost overrun implies spending more 45 MU than

planned to date, and the delay implies spending less 20 MU than planned to date. The balance is 25 MU being spent ahead of schedule, as indicated by the Accounting Variance (AV). The conclusion is that we cannot understand the meaning of variation over-time (AV) without looking at CV and SV. Without Earned Value (EV), both CV and SV cannot be calculated, and therefore we cannot understand where the project stands without using an EVM system;

- **Time Variance (TV)** = Time Elapsed – Earned Schedule – amount of time that the project is behind schedule. In this case, the amount of work done to date (i.e. 40 MU) should have been accomplished by month 4,5 (see PV). So, the project has reached in 6 months a point of progress that should have been reached in 4,5 months and therefore it is behind schedule by 1,5 months. It is important to note that this is independent of any re-planning of the remaining future and therefore the schedule may well show a planned completion date within the original schedule. If that is the case, then it means re-planning actions have been implemented intended to bring the project back on schedule. Yet, there is a current delay of 1,5 months – this is a fact that cannot be changed but only recovered as the project progresses into the future.

Key Benefits and Limitations

As demonstrated in the previous examples, an EVM system can answer some of the fundamental questions for managing a project; so its benefits appear obvious. However, experience shows that EVM provides many other additional benefits, not only due to the possibility of a more complete set of metrics being used, but also because of what the use of EVM implies in terms of managing people and organizational processes.

Specialized Metrics for "What-if" Analysis Models

A major benefit of EVM is to allow for the development of metrics specialized in answering management questions specific to certain environments. As an example, we consider a man-power based environment, such as software development or process re-alignment projects, where in the face of a delay two typical questions are often raised:

- How many more people do we need to complete the project on the original schedule?
- If we can only increase the team size by a certain amount (constraint), what is the likely completion date?

Let us consider as a simple example the following scenario:

- Total project budget = 1000 MU
- Fixed team size = 10 FTE (full-time equivalent persons)
- PV (should have been done) = 300 MU
- EV (done) = 200 MU
- SPI (past relative speed) = 200/300 = 0,67

To answer the first question we need to calculate what is the required speed (or work rate) to complete the project on time:

- TSPI (required speed to complete on time) = 800/700 = 1,14

This means that in the time remaining, the project work needs to be executed at a work rate 14% faster than originally planned for that period. If this is to be achieved by adding people into the project, then 1,4 FTE needs to be added, which implies at least 2 persons at a 70% allocation level.

Additionally, if we consider that the past slower work rate was not caused by a lower allocation of resources to the project but due to work complexity or other constraints, then this implies that in the project environment 1 nominal FTE can only produce the work rate of a 0,67 FTE. Assuming that these same factors or constraints will also apply into the future, then 2 FTE needs to be added (i.e. 1,4/0,67) – this is two persons at 100 % allocation are required.

By applying similar types of mathematics, EVM provides the possibility to develop models that answer "what-if" analysis questions for re-planning scenarios, thereby significantly improving the level of support provided to the decision-making process in project management.

Our experience in using EVM in several industries has demonstrated that a wide range of specialized metrics can be developed to answer industry and/or environment specific management questions. The development of these specialized metrics requires a good mastery and in-depth understanding of the basic EVM metrics system, and is also a major factor of management "buy-in".

Quality of Planning

Another very important benefit of using EVM is the "pressure" that this method exerts on having proper project plans, integrating scope, cost and time. If a project plan has inconsistent data (often entered accidentally), then the EVM indicators will tend to produce results that will easily identify these inconsistencies and their likely causes.

One typical example is physical progress and resource consumption being reported in a task which has a start date in the future. If this happens, most likely the EVM model of most scheduling tools will not report the actual cost and/or the Earned Value for this task. This will lead to an obvious inconsistency in the calculation of the aggregate physical progress and/or CPI indicators.

There are several inconsistencies that often occur in schedule models that integrate scope, cost and time. The use of EVM will make these inconsistencies more visible and easier to diagnose. In this way, EVM exerts a healthy "pressure" to ensure the project plan has the required level of quality in its data. Furthermore, the whole structuring of the project plan will tend to improve when EVM is being use because, once again, "structural defects" (e.g. excessive long duration parallel tasks) will tend to make EVM calculations more difficult.

Accountability and Team Performance Assessment

In our experience, another major benefit of using EVM is the increased level of accountability over the project work by all stakeholders. This is stimulated in two ways:

- Reporting physical completion on the work packages requires the periodical evaluation and acceptance of scope accomplishment;
- EVM performance indicators can be used as an input to the performance appraisal of team members that perform the work packages.

Project team leaders accountable for the performance of work packages will tend to lead and pressure their team members and stakeholders to accomplish the work within acceptable levels of cost and time performance.

Extension to the Basic EVM Model

We have found that the EVM basic model has a number of weaknesses and in fact it is an incomplete model, as some metrics need to be improved and others created in order to correctly report the project status.

The extensions to the basic EVM model that we have developed include, among others, the following elements:

- Corrections to existing indicators:
  - Correction to CPI value in extreme conditions (e.g. EV>0, AC=0)
  - Correction to SPI value in extreme conditions, namely:
    - Task finishes earlier than planned in the baseline;
    - Task finishes later than planned in the baseline;
    - Task starts earlier than planned in the baseline;
- Feasibility indicators:
  - Use of To Complete SPI (TSPI);
- Forecasting indicators:
  - Forecasted duration and completion date based on the expected future SPI;
- Several "what-if" analysis models trading cost, scope, time and resources. For example:
  - % scope that can be accomplished within the baseline completion date or within the available budget;
  - Estimated completion date in face of available resources.

These extensions have proven extremely important to ensure that the overall model is consistent: stakeholders will significantly reduce their level of trust in the EVM system if some indicators are reported as "not always valid" (especially time performance indicators).

Additionally, the use of specialized metrics for "what-if" analysis models allows for the EVM system to answer key questions at the aggregate level where top-management perceives the project and is willing to make decisions. We often see some unnecessary confusion being made between the aggregate analysis provided by EVM indicators, and the detailed scheduling analysis based on the critical path method and other bottom-up approaches. Understanding the aggregate top-down nature of the EVM indicators and metrics is essential to make an effective use of the EVM system.

Data Quality System

As already mentioned, the use of EVM is tightly couple with the quality of planning and controlling data. Ensuring that the data in the EVM system is consistent is therefore essential to build trust in the performance metrics and to ensure that these do not provide misleading information.

With project plans often having hundreds, if not thousands of work packages and tasks, it may become virtually impossible to ensure that all data in the plan is consistent. Detecting inconsistent data accidentally can only severely reduce trust in the model and jeopardize stakeholders "buy-in".

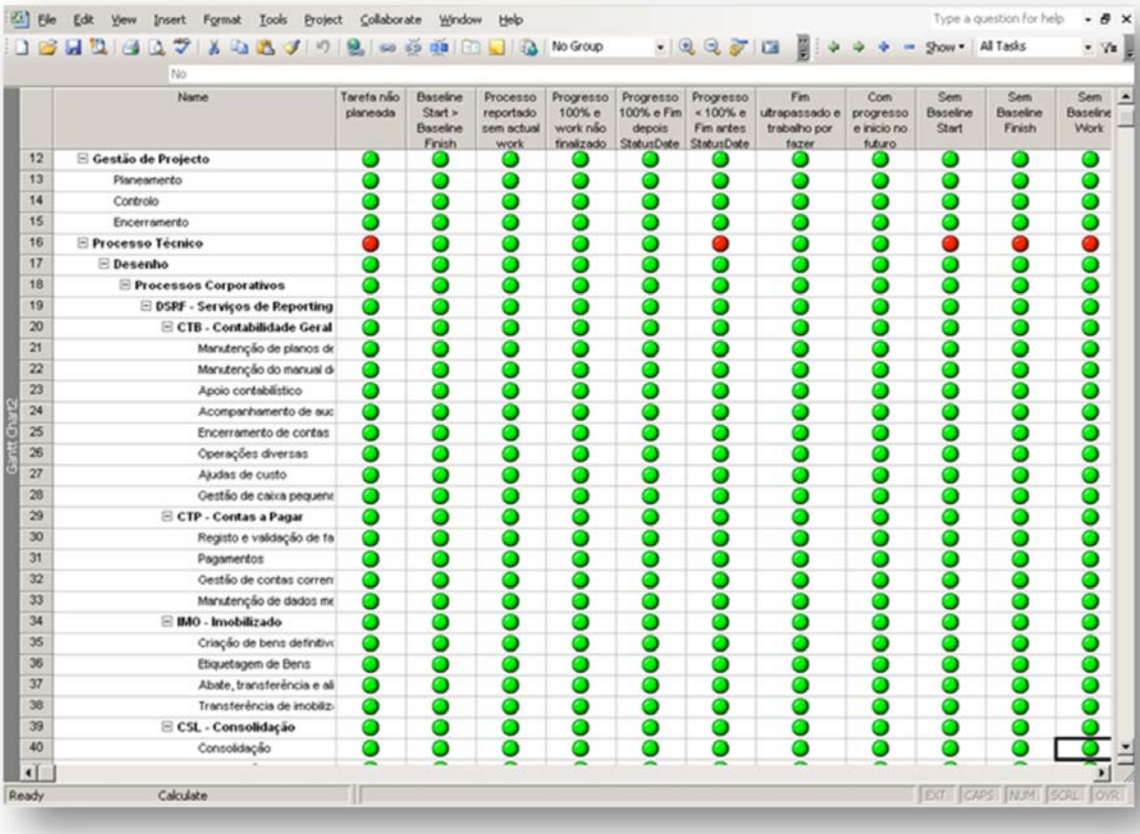
Our experience has shown that data quality assessment and control must be achieved through a systematic and predictable process, as opposed to a "ad hoc" process. We achieved this by developing data quality systems tailored to the specific planning methodologies, which always included the following elements:

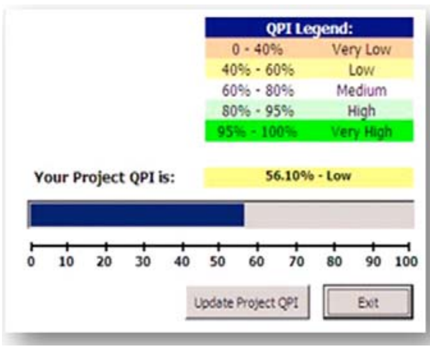
- "Red traffic light" indicators identifying inconsistencies that must be corrected:
    - Example 1: physical progress reported in tasks that are in the future;
    - Example 2: remaining budget in tasks that are in the past (finish date);

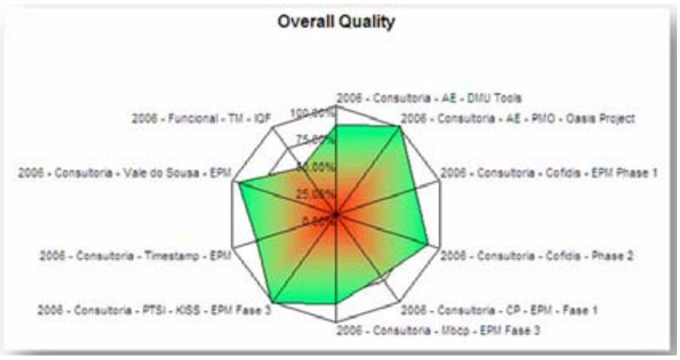
- "Yellow traffic light" indicators identifying potential inconsistencies that should be checked:
    - Example 1: task with a very long duration about to be initiated (i.e. needing to be "rolling waved"?);
    - Example 2: task with a few days remaining to complete and with a very large remaining budget and/or remaining physical completion (i.e. unrealistic completion date?);

- Overall score for data quality as a weighted score of all inconsistencies detected in the plan. In multi-project environments, projects are often ranked by this overall quality indicator.

The pictures below show examples of a practical implementation of this type of system.





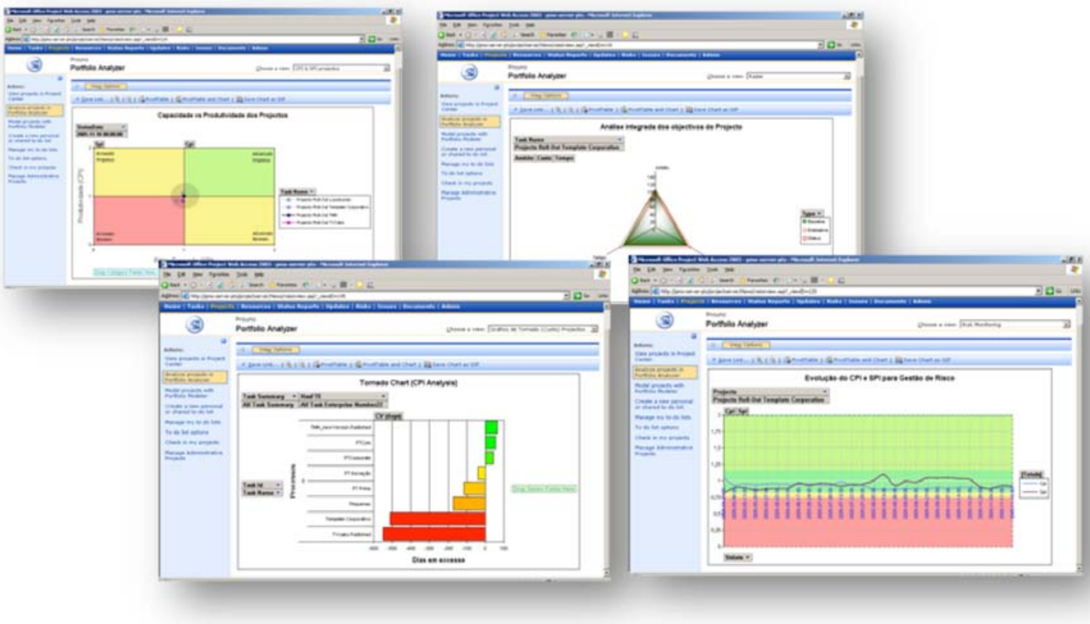


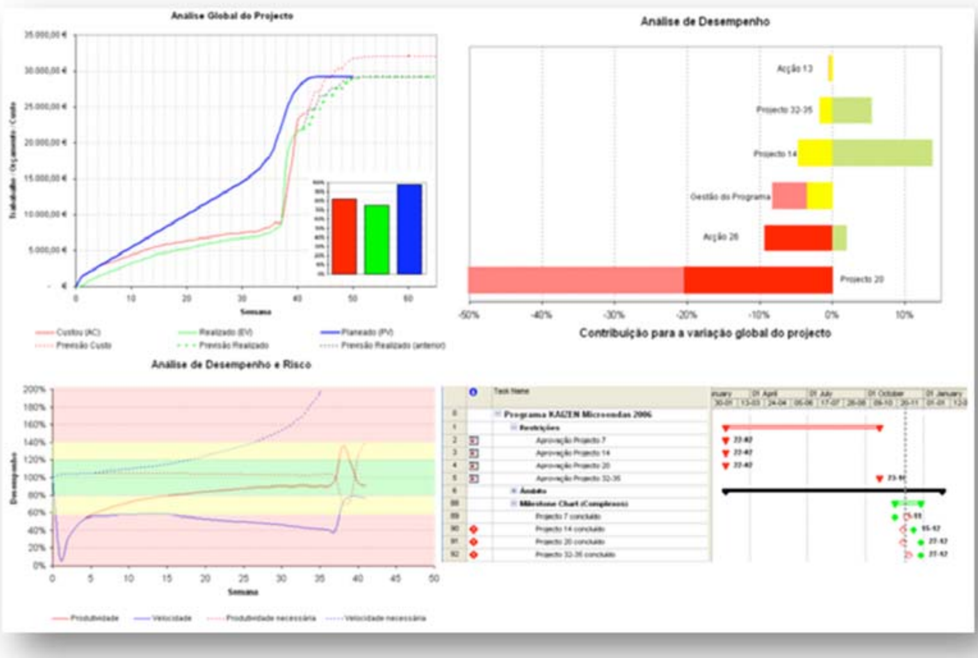
Communication to Stakeholders

Another major aspect of an EVM system is its potential use as an effective tool to communicate a clear, common picture of the project status to stakeholders. We have found that, if properly tailored, an EVM system can work as a very powerful communication tool providing stakeholders with a common language and a means to develop an objective common understanding about the project status and performance.

Our experience has demonstrated that there is large a variety of ways in which EVM data can be graphically represented, and which can greatly enhance understanding. The specific representations that we have developed responded primarily to stakeholders' priorities regarding project objectives (e.g. time vs. cost), as well as to the specific dynamics of the project environment which are the primary cause of performance (i.e. where is the project, and *why*).

The pictures below show some alternative representations we developed for different clients, based on Microsoft's EPM system.





If properly used, this type of representations can be very effectively as the primary basis for on-going reporting to the stakeholders throughout the project life-cycle.

Cross Industry Trends

Over the last ten years we have been experiencing the use of Earned Value Management as the primary method for project monitoring and controlling, across various industries.

In Portugal, Earned Value was first use to support the management of the Lisbon world fare back in 1998. Later, it was used to support the monitoring of the Euro204 program, comprised of several infra-structure and civil construction projects.

Despite its apparent success and adequacy in the heavy construction industry, we have been using Earned Value in other rather different environments, like:

- Large telecommunications infra-structure projects (e.g. at Motorola);
- Software development and IT projects (in banking and telecommunications);
- Consulting projects (process improvement initiatives);
- Engineering projects in significantly different production environments;
- Automotive industry (engineering and IT infra-structure projects);
- Research and Development projects for the textile industry;
- Pharmaceutical industry (fine chemicals);
- Railway infra-structure projects;
- Defense acquisition and defense Research and Development projects (e.g. at NATO).

Our experience in this wide range of industrial and business settings suggests that the fundamental and core usefulness of Earned Value Management – to measure project performance in an objective manner, to provide an aggregate top-down analysis of the project future, and communicate to stakeholders – remains valid in all cases. We further conclude that EVM also provides an effective common language to senior management and other stakeholders, especially to those that are not specialists about the project scope. We have found that by looking at the EVM metrics, one can easily interpret the project status and gain valid insight into the potential causes of performance without having to "drill-down" into the technical details of the project. The use of simple language like: "Amount of Work that should have been done" and "Work done", instead of BCWS and BCWP, makes this much easier. Graphical representations are also very powerful to enhance understanding.

The challenges of data collection, time and cost accounting, and assessing physical progress, may vary from industry to industry. However, once the right mechanisms are in place, EVM is immediately applicable. Proper project planning is a requirement for EVM, as it is for Project Management in general. Data quality systems can greatly reduce the amount of effort required to develop and maintain healthy plans.

We foresee an increasingly growing demand for the implementation of EVM systems across all business sectors, as EVM becomes the *de facto* standard and common language for controlling projects, programs and portfolios in a continuously fast changing business environment.

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