Application of Earned Value Management (EVM) for Effective Project Control

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Introduction

One of the main preconditions of a successful Project is to follow an approved Project Plan which is mainly includes the following components:

- Budget
- Schedule
- Scope

This project plan is called a Project Baseline .The most important of the Project Manager's responsibilities on the project is to keep all its parameters inside the boundaries defined by the baseline. To ensure that at any point in time the Project is moving in the right direction to be completed below budget, ahead of time with the scope fully implemented, the Project Manager should use Project Control, which represents monitoring of actual project performance to define deviations from the project plan and choose corrective actions if needed.

Project Control

Project control is critical for the success of the Project and should start as early in the Project life cycle as possible. Uncontrolled or poorly controlled projects usually fail. Project Control is supposed to provide continuous monitoring of the Project's path to completion and correcting it if necessary. The Project should be controlled from the very beginning, because the more time a Project Manager has to work on corrective actions and implement them if needed, the more chances the Project has to hit the target.

Project Control is a complex process which includes the following main components:

- Monitoring of performance
- Developing and analyzing progress reports for cost, scope, schedule
- Identifying variances, their causes and impacts
- Evaluating options for corrective actions
- Selecting the most appropriate actions and implementing them
- Controlling project changes
- Initiating baseline changes as needed

Because of this complexity, a Project Manager has to have Project Control personnel helping him with this extremely important function, which requires a lot of effort, but brings undeniable benefits as follows:

- Better Project performance:
    - On time and within budget
    - According to specifications and expectations
- Effective communication of project status to stakeholders
- Having early warnings for problems
- Learning from experience

Performance Measurement

One of the most important tasks of Project Control is to obtain an accurate data on Project performance, because this information is a basis for Project status analysis, which in turn determines if the Project is proceeding as planned or corrective actions are needed.

For every Project it is recommended to obtain the following performance data on a regular basis:

- Progress Data – What has been accomplished as of today?
- Effort Data – How much resource time has been spent to achieve this progress?
- Change Data – Type of change, cause and impact
- Expense Data – Costs of human resources, facilities, equipment, etc.

To collect this data, the following main types of reports are used:

- Status
- Progress
- Forecast

These reports should include the following data:

- Task completions (full or percent complete)
- Actual effort
- Cost data and issues

How often these reports should be collected depends on length and phase of the specific Project. Frequency of reporting may be weekly, bi-weekly, monthly, quarterly etc. For troubled projects even daily reports may be needed.

Earned Value Analysis (EVA)

Now, when we have Project performance data, the next question is how to analyze it. It is not enough, for example, to find out only how much money is already spent on the Project. What is more important is to understand what was accomplished. For example, just knowing from a cost report that 50% of Project Budget is spent at the certain moment does not give us any idea how well or badly the Project is performing. If we completed 50% of all the work, we are doing fine. If only 30% of the work is done, the Project needs a significant improvement to avoid failure.

One of the most effective techniques to analyze Project performance is Earned Value Analysis (EVA), which instead of just answering the question “What performance results are we currently getting?” it will allow us to understand if we got our money’s worth for these performance results.

The United States Government started using EVA for Project Control in the 1960s and from that time the technique remained practically unchanged. Right now, it is accepted world-wide because of its effectiveness and relative simplicity.

EVA uses three main metrics, which are listed below. For each metric, the following information is included:

- Definition
- Question that each metric is answering
- Real life example to show how a specific metric is determined

The first metric, which is very important but hard to obtain because it is based on performance measurement, is

Earned Value (EV) or Budgeted Cost of Work Performed (BCWP):
"The sum of budgets for fully and partially completed work packages"[1]

Question: "How much was budgeted for the amount of work done?"

Example: A hotel Owner hired a Contractor to install 20,000 sq. ft. of carpet in 20 days with a budget of $100,000.

After 5 days, 4,000 sq. ft. of carpet were installed. What is EV?
Solution: EV = ($100,000/20,000) x 4,000 = $20,000

The second metric, which is much easier to obtain because it is based on project schedule and cash flow which always should be available, is:

Planned Value (PV) or Budgeted Cost of Work Scheduled (BCWS):
"The sum of the budgets for all work packages, planning packages etc. scheduled to be accomplished (including in-process work packages)" [1]

Question: "How much work should be done by certain date? How much did we plan to spend as of certain date?"

Example: A hotel Owner hired a Contractor to install 20,000 sq. ft. of carpet in 20 days with a budget of $100,000.

What is PV after 5 days of work?
Solution: PV = ($100,000/20) x 5 = $25,000

And the third metric, which is easily obtainable because it is based on actual invoices, is:

Actual Cost (AC) or Actual Cost of Work Performed (ACWP)":
"The costs actually incurred and recorded in accomplishing the work performed within a given time period"[1]

[1] URL: evm.nasa.gov/glossary.html

Question: "How much money have we actually spent?"

Example: After 5 days of work on the carpet installation, the Contractor submitted the invoice for $30,000. What is AC?

Solution: AC = $30,000

Using main EVA metrics, we may obtain several derived ones. The most important ones are shown below, including their meaning for the Project status.

- Schedule Variance SV = EV – PV
  - SV =0 – on schedule
  - SV > 0 -- ahead of schedule
  - SV < 0 – behind schedule

- Schedule Performance Index SPI = EV/PV
  - SPI = 1 – on schedule
  - SPI > 1 -- ahead of schedule
  - SPI < 1 – behind schedule

Using main EVA metrics from the previous example, the corresponding derived metrics may be calculated as follows:

- From the previous example, EV = $20,000; PV = $25,000;
  - SV = $20,000 - $25,000 = - $5,000 – Behind Schedule
  - SPI = $20,000/$25,000 = 0.8 – Behind Schedule

- Cost Variance CV = EV – AC
  - CV =0 – on budget
  - CV > 0 -- under budget
  - CV < 0 – over budget

- Cost Performance Index CPI = EV/AC
  - CPI =0 – on budget
  - CPI > 1 -- under budget
  - CPI < 1 – over budget

Again, based on main EVA metrics from the previous example, the derived metrics may be calculated as follows:

- From the previous example, EV = $20,000; AC = $30,000
  - CV = $20,000 - $30,000 = - $10,000 – Over Budget
  - CPI = $20,000/$30,000 = 0.67 – Over Budget

Forecasting at Completion

Besides understanding of current Project status, it is even more important for a Project Manager to envision how Project baseline values will look like at its completion. In order to have this information, the Project Manager needs to prepare a forecast at completion, which may be done using the following principal approaches:

- Extrapolation based on statistical analysis of the work performed using EVA:
  - How will we end the Project if things go the same way as before?

- Re-estimating, including the following activities:
  - Look at what has occurred
  - Determine the cause
  - Analyze if the cause will lead to similar variances in future
  - Reassess staffing, methods, estimates, technology etc. to compensate for negative variances to date
  - Forecast the outcome and update the Project plan

We'll concentrate on the extrapolation approach, which is the most popular out of the two, because it may be done as often as we have an updated project performance information available and, respectively, can calculate updated EVA metrics, which enables us to react swiftly on detected problems and develop corrective actions. Re-estimating requires much more time and effort and may be done only a couple of times during the course of the Project.

With that said, let's start with the following main definitions related to cost and time forecasting at completion using EVA:

- Main definitions for cost forecasting process:

  - BAC – Budget at Completion. "The total planned budget"[2] for the Project
  - EAC – Estimate at Completion. "The estimated total cost for all authorized work"[2]: EAC = BAC/CPI
  - CVAC = BAC – EAC – Cost Variance at Completion, forecasted final cost variance

  For carpet installation example:

  - BAC = $100,000.
  - EAC = $100,000/0.67= $149,253
  - CVAC = $100,000 - $149,253 = - $49,253

  So the Project will cost $49,253 more than budgeted

[2]URL: evm.nasa.gov/glossary.html

- Main definitions for time forecasting process:

    - SAC – Schedule at Completion. - Planned duration of the Project
    - ESAC – Estimated Schedule at Completion: ESAC = SAC/SPI
    - SVAC = SAC – ESAC - Schedule Variance at Completion, forecasted final schedule variance

    For carpet installation example:

    - SAC = 20 days. ESAC = 20/0.8 = 25 days
    - SVAC =20 – 25 = - 5 days

    So the Project will be completed 5 days later than scheduled

Corrective Actions

Now, after forecasting at completion is done, the Project Manager needs to decide if a projected outcome of the Project requires corrective actions, which may be defined as a documented plan for executing the future project work to bring expected project outcome in line with the project management plan. The main goal of corrective action is to eliminate the cause or the impact of schedule or budget slippage through:

- Identification of slippage
- Determination of its cause
- Evaluation of alternatives (accept, change the baseline values: budget, schedule, scope, etc., take action to reduce or eliminate)
- Acting

The following corrective actions may be suggested:

- For schedule slippage:

    - Crash – Add resources, work overtime, etc.
    - Fast track – Change the sequence of tasks (perform tasks in parallel, for example)
    - Maximize the use of the most effective resources
    - Use progressive technology
    - Expedite certain intermediate deliverables and approvals
    - Reduce the scope by putting off some features or functions of the product, getting corresponding approval from the stakeholders

- For budget overruns:

    - Use cheaper supplies
    - Explore trade-off possibilities (with client approval):
        - Scope reduction
        - Delaying of Project completion date

- Improve productivity

Let's develop corrective actions for considered earlier carpet installation example. First of all, we need to recap the parameters of Earned Value Analysis performed after 5 days from the start of the Project:

- Cost Analysis:
  - Earned Value EV = $20,000
  - Actual Cost AC = $30,000
  - Cost Variance CV = - $10,000 – Over Budget
  - Cost Performance Index CPI = 0.67 – Over Budget
  - Budget at Completion BAC = $100,000
  - Estimate at Completion EAC = $149,253
  - Cost Variance at Completion CVAC = - $49,253

Conclusion: Installation of carpet will cost $49,253 more than planned (budgeted).

- Schedule Analysis:
  - Planned Value PV = $25,000
  - Schedule Variance SV = - $5,000 – Behind Schedule
  - Schedule Performance Index SPI = 0.8 – Behind Schedule
  - Schedule at Completion SAC = 20 days.
  - Estimated Schedule at Completion ESAC = 25 days
  - Schedule Variance at Completion SVAC = - 5 days

Conclusion: The Project will be completed 5 days later than scheduled.

Obviously, the situation with the Project is very worrisome. The good thing is that we had this analysis done after only 25% of allocated time passed. The earlier you discover the problem, the better chances you have to fix it. Now there are two questions to answer:

- What needs to be done for the Project to be ultimately successful?
- Who should perform these corrective actions?

Let's start with the second question. Who is responsible for correcting the Project depends on the type of a Contract between the hotel's Owner and the Contractor. There are two most popular types of contracts that may be used in our example:

- **Lump Sum**. Main principle: the Contractor provides specified services for a fixed price to be paid by the Owner upon completion of work (or there are partial payments made at certain points of the Project).

  In our example it means that the Hotel's Owner hired the Contractor to install 20,000 sq. ft. of carpet in 20 days for a fixed price of $100,000. And now the Contractor is responsible

to deliver as promised. There may be penalties built into the Contract for work finished in longer than 20 days, low quality of work (if there are specific quality requirements spelled out in the Contract) etc. But ultimately, with a Lump Sum Contract, the Contractor has to bring the Project back to the originally planned path. So, in this case, the Contractor has to act as the Project Manager.

- **Time and Materials**. Main principle: the Contractor is paid for actual labor and material expenses based on predetermined rates. Payment may be either done after completion of work, or partial payments may be made at certain points of the Project.

  In our example, it means that the Owner has to act as the Project Manager, closely monitoring the work performed by the Contractor and taking necessary steps to ensure that the full amount of work (20,000 sq. ft. of carpet installed) is performed in no longer than 20 days and for no more than $100,000.

Each of these types of Contract has pros and cons, but this topic is outside of the scope of our EVA course.

Now, let's get back to our troubled Project and try to find a remedy for all the problems that EVA helped us to uncover.

1. Schedule Slippage

So far, 4,000 sq. ft. of carpet were installed in 5 days, which means that productivity of work was 4,000 sq. ft. / 5 days = 800 sq. ft. / day. In order to finish the Project on time, the remaining 16,000 sq. ft. of carpet needs to be installed in 15 days, which means that a required productivity of work should be 16,000 sq. ft. / 15 days = 1,067 sq. ft. / day for the rest of the Project.

2. Cost overruns.

So far, 4,000 sq. ft. of carpet were installed at the cost of $30,000, which means that the unit cost is $30,000 / 4,000 sq. ft. = $7.50 / sq. ft. To finish the Project on budget, the remaining 16,000 sq. ft. of carpet should be installed at the cost of $70,000, which means that the unit price for the rest of the Project should be reduced to: $70,000 / 16,000 sq. ft. = $4.375 / sq. ft.

As we see, there are some significant challenges that should be overcome to make the Project successful. Naturally, it would be much easier for the Project Manager to deal with just one issue (either schedule slippage or cost overrun):

- You are running late, but have extra money, so bring more carpet installers, start working overtime etc.
- You overspent so far, but are ahead of schedule, so slow down, move workers to another Project etc.

With two out of three Project constraints (the third one is usually a scope) in jeopardy, the Project Manager has real problems to deal with. One of the options is to consider delaying of a Project

completion date (trade time for money). Maybe there is no real criticality in the installation of all 20,000 sq. ft. of carpet in 20 days, maybe even 25 days are acceptable. This option may work if the Owner is acting as the Project Manager. If the Contractor is the Project Manager, postponing the completion date may lead to penalties to be paid by the Contractor.

Another venue to consider is bringing in more productive workers. It should help with a schedule slippage but may increase a cost overrun even more because more productive workers are usually more expensive. However, if increase in productivity is significant, maybe it will allow to speed up the Project so much that in the future some workers may be moved to another projects ultimately reducing costs, but still making the Project completion date. This option needs to be evaluated by estimating its expected positive impact on the Project parameters. If decision is made to implement it, performance data should be collected and EVA repeated in a couple of days to see if situation is improving and the Project is back on track.

Another possibility is to use a less expensive carpet (if it is acceptable). Doing that may help not only with a cost overrun but provide extra funds to correct a schedule slippage. Again, if after evaluation, this option is chosen, a performance data should be collected and EVA repeated in a couple of days to evaluate the impact of chosen corrective measures.

So, there are still a few possible ways to cure a failing Project which need to be evaluated by the Project Manager to select the most promising one, implement it and use EVA after some time passed to see if a chosen remedy works.

Earned Value Management (EVM)

Earned Value Management is a Project Control process based on monitoring of EVA metrics during the course of the Project. Doing that allows Project personnel to measure Project performance, compare what was planned and achieved, forecast Project outcome and identify corrective measures, if needed. The following steps need to be taken by any organization to be successful in the application of EVM for its Projects:

- Project Control personnel should be trained in EVA technique
- The organization needs to establish internal Standards and Procedures governing the application of EVM for specific types of Projects and Contracts that the organization is dealing with.
- Templates need to be created to simplify the use of EVM for typical Projects
- “Lessons learned” sessions should be conducted after completion of every Project to identify what did and did not go well with all project management activities including EVM.
- Application of appropriate EVA software needs to be considered to increase effectiveness of the EVM process.

Conclusion

This course presented an overview of modern practices in effective Project Control through the application of Earned Value Management to enable you to:

- Define project baseline
- List main components of project control
- Define performance data that should be obtained for every Project
- List the main metrics of Earned Value Analysis and describe how to calculate them
- Forecast Project outcome
- Describe corrective actions that may be considered for schedule slippage and cost overrun
- Understand how to make EVM successful