Project Cost management for Project Managers based on PMBOK

By Dr. T D Jainendrakumar

The Cost Management includes the processes involved in estimating, budgeting, and controlling costs so that the project can be completed within the approved budget. Project managers must make sure that their projects are well defined, have accurate time and cost estimates, and have a realistic budget that they were involved in approving. Costs are usually measured in monetary units like dollars.

Before going to this knowledge area we need to familiar with some of the definitions or terms used in Cost management.

Definitions

- Profit = Revenue – Costs
- Profit Margin = Profit / Revenue
- Cash flow refers to the movement of cash into or out of the project.
- Direct costs are costs that can be directly related to producing the deliverable of the project: Salaries, cost of hardware & software purchased specifically for the project
- Indirect costs are costs that are not directly related to the deliverable of the project, but are indirectly related to performing the project, e.g. cost of electricity, Internet, rent and office supplies.
- Reserves are dollars included in a cost estimate to mitigate cost risk by allowing for future situations that are difficult to predict
- Sunk cost is money that has been spent in the past; when deciding what projects to invest in or continue, you should not include sunk costs in the project budget.
  - To continue funding a failed project because a great deal of money has already been spent on it and it is not a valid way to include that money to the revised project budget to make a failed project successful, sunk costs should be forgotten
- Variable Costs: change with the amount of production (cost of material).
- Fixed Costs: do not change with production (rent, setup costs, etc.)
- Net present value: the total present value (PV) of a time series of cash flows. It is a standard method for using the time value of money to appraise long-term projects. Higher the NPV is better.

- Discount rate: Minimum acceptable rate of return on an investment.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Discount rate</td>
<td>10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>3</td>
<td>PROJECT 1</td>
<td>YEAR 1</td>
<td>YEAR 2</td>
<td>YEAR 3</td>
<td>YEAR 4</td>
<td>YEAR 5</td>
<td>TOTAL</td>
</tr>
<tr>
<td>4</td>
<td>Benefits</td>
<td>$0</td>
<td>$2,000</td>
<td>$3,000</td>
<td>$4,000</td>
<td>$5,000</td>
<td>$14,000</td>
</tr>
<tr>
<td>5</td>
<td>Costs</td>
<td>$5,000</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$9,000</td>
</tr>
<tr>
<td>6</td>
<td>Cash flow</td>
<td>($5,000)</td>
<td>$1,000</td>
<td>$2,000</td>
<td>$3,000</td>
<td>$4,000</td>
<td>$5,000</td>
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<tr>
<td>7</td>
<td>NPV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$2,316</td>
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<td>8</td>
<td>Formula</td>
<td>=npv(b1,b6:f6)</td>
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</table>

Note that cash flow totals are equal, but NPVs are not because of the time value of money. (In Project 1 invested $5000 but 4th year it is crossing the break even with a margin of $1000. In project 2 in the 4th year it is crossing the breakeven point with higher margin that is $3000. Time value of money is more here, and NPV is higher).

- Internal Rate of Return: interest rate received for an investment consisting of payments and income that occur at regular periods (How fast the money come back to you after the investment).

- Technically speaking IRR is the discount rate when the present value of the cash inflows equals the original investment.

- IRR is the discount rate when NPV equals zero

- You invest $100 and getting back $3 per annum every year, your IRR is 3%.

- But you invest $100 and you get back $60 first year and again $60 Next Year and stops, what is the IRR?

- You have to find the value of ‘r’ from the formula for finding NPV by equating with the RHS=0 (sum the discounted cost as negative number and discounted benefits as positive numbers)
-100(1+r)^0 + 60(1+r)^1 + 60(1+r)^2 = 0 here you have to find out the value of ‘r’ by trial and error method (trial at 0.14 value -1.2#0 Trial at 0.12 value 1.4#0 and trial at 0.13 value 0.09 almost equal to 0 therefore IRR is 13%.

Return on investment (ROI) is calculated by subtracting the project costs from the benefits and then dividing by the costs.

ROI = (total discounted benefits - total discounted costs) / discounted costs (It is the income divided by the investment) The higher the ROI, the better the project. Many organizations have a **required rate of return** or minimum acceptable rate of return on investment for project

Opportunity Cost: The cost given up by selecting one project over another.

Payback Period: The time it takes to recover your investment in the project before you start accumulating profit.

**Earned Value Management**

EVM is a project performance measurement technique that integrates scope, time, & cost data

Given a baseline, you can determine how well the project is meeting its goals

You must enter actual information periodically to use EVM.

**Planned Value (PV)**, formerly called the budgeted cost of work scheduled (BCWS), also called the budget, is that portion of the approved total cost estimate planned to be spent on an activity during a given period

**Actual Cost (AC)**, formerly called actual cost of work performed (ACWP), is the total of direct & indirect costs incurred in accomplishing work on an activity during a given period

**Earned Value (EV)**, formerly called the budgeted cost of work performed (BCWP), is the percentage of work actually completed multiplied by the actual cost. If the percentage of work is 100% then the earned value will be equal to planned value.

Let us consider an example with the 5 work packages, PV & AC & % of work performed are given in the table below and each work packages has to be completed in a month’s time. This means total duration of the project is 5 months and the values are given in dollars; let us do the performance measurement and see how to find Earned value performance measurements.
<table>
<thead>
<tr>
<th>Work package</th>
<th>Planned Value (PV)</th>
<th>Actual Cost (AC)</th>
<th>% of work performed (WP)</th>
<th>Earned Value (EV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>100000</td>
<td>110000</td>
<td>100%</td>
<td>100000</td>
</tr>
<tr>
<td>2.</td>
<td>100000</td>
<td>90000</td>
<td>80%</td>
<td>72000</td>
</tr>
<tr>
<td>3.</td>
<td>100000</td>
<td>70000</td>
<td>50%</td>
<td>35000</td>
</tr>
<tr>
<td>4.</td>
<td>100000</td>
<td>Not done</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>100000</td>
<td>Not done</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- In the above table Total Planned value (PV) for the work packages 1 to 3 that is in 3 months is 300000 (add columns under PV up to work package 3)

- Similarly Total Actual Cost (AC) for the work packages 1 to 3 is 270000

- Total Earned Value (EV) up to this stage is 207000 means that, in this project, to complete work package from 1 to 3, they have spent 270000 but the actual worth of the work completed is only 207000 that is earned value (means over spend).

Now let us find out the Performance measurements like Cost Variance (CV), Schedule Variance (SV), Cost Performance Index (CPI) and schedule performance index (SPI)

- Cost Variance (CV) = EV – AC (207000 – 270000) = -63000 (over spend) 63000

- Schedule Variance(SV) = EV – PV (207000-300000) = -93000 means the work supposed to be planned to finish in 3 months in 300000 could not be achieved and actually spend 270000 in 3 months, but actual worth (EV) of the work completed is 207000 means the remaining work worth of 93000 is lagging behind schedule.

- Cost Performance Index (CPI)=EV/AC (207000/270000)=0.77 (Any value under 1.0 shows bad that is over budget, if the value is 1.0 shows exactly as per plan (within budget) and if the value is above 1.0 shows under budget)

- Schedule Performance Index(SPI)=EV/PV (207000/300000) = 0.69 (Any value under 1.0 shows bad that is behind the schedule, if the value is 1.0 shows it is on time and if the value is above 1.0 shows ahead of schedule)

Next we are going to do the Forecasting from the above example

**Forecasting**

**Estimate at Completion EAC**

- The management’s assessment of the cost of the project at completion
- After variance analysis, the estimated cost at completion is determined
- Can use calculated indices or use management judgment.
(Our BAC for the entire project = 500000 (five months) and EV=207000, AC=270000, PV=300000, CPI=0.77, SPI=0.69

If the **Past performance is continuing** means performance is continuing at the CPI of 0.77

1. EAC = (BAC / CPI)= 500,000 / 0.77 = 649350 means if the project is continuing as per the past performance at the CPI of 0.77 then the project will be completed at the cost of 649350

**Past performance will not continue in future** (Initially some delay has occurred but in future project will be moving as per plan)

   1. EAC=AC+ (BAC-EV) = 270000+ (500000-207000) =563000 Due to some problems initially some delay has occurred, but from the 4th month onwards project is assumed to be as per the plan that is the CPI=1 in that case we will take the Actual Cost up to that stage, because past is past nothing can be done on that and add AC with the remaining work that is BAC-EV.

   2. Suppose at the third month you see that the estimation was entirely wrong in that case EAC= (AC+ Re-estimate (use bottom up estimation)), let us say the bottom up ETC is 300000, then EAC=270000+300000=570000.

   3. In rare cases when SPI & CPI are having huge variation like CPI is 1 and SPI= 0.60 to get the more accurate EAC we have to consider the value of CPI and SPI in that case we use the formula EAC=(AC+(BAC-EV/CPI*SPI)) in our case EAC=270000+(500000-207000)/(0.77*0.60))=821478, this is not realistic our CPI and SPI have no huge difference, therefore this value of EAC is not applicable in this example and we have to use the assumption wisely.

**Estimate to Complete**

**Past performance will not continue in future**

1. ETC= BAC-EV (500000-207000) =293000, here estimate to complete is 293000(will continue as CPI=1

2. ETC=Complete re-estimate and find out bottom-up ETC

3. We can find ETC with EAC, take any of the above assumptions of EAC and subtract Actual Cost that is ETC=EAC-AC. ETC=649350-270000=379350 (assumption from the past performance is continuing).

**Variance at Completion**

VAC=BAC-EAC (500000-649350) =-149350 (EAC past performance will continue in future)
This shows that the total variance by the time we complete the project will be 149350.
To-Complete Performance Index

How well do we have to perform to get back on track

The calculated project of cost performance that must be achieved on the remaining work to meet a specified goal (BAC or EAC).

I. \( \text{TCPI} = \frac{\text{Work Remaining} (\text{BAC-EV})}{\text{Funds Remaining} (\text{BAC-AC})} \)

**Assumption 1** (That is \( \text{TCPI} = \frac{\text{BAC-EV}}{\text{BAC-AC}} = \frac{(500000-207000)}{(500000-270000)} = 1.27 \))

This means that if you continue the work at CPI = 1.27 you will be able to finish the work with in 500000.

Or

II. \( \text{TCPI} = \frac{\text{Work Remaining} (\text{BAC-EV})}{\text{Funds Remaining} (\text{EAC-AC})} \)

**Assumption 2** (TCPI = \( \frac{\text{BAC-EV}}{\text{EAC-AC}} = \frac{(500000-270000)}{(649350-270000)} = 0.77 \))

Means in this case if you continue the work with a CPI of 0.77 then you will be able to finish the work with a total cost of 649350.

Plan Cost Management

This is the first process in the project cost management knowledge area which comes in planning process group to establish the policies, procedures, & documentation for planning, managing, expending, and controlling project costs. It describes in detail how the project costs will be managed or how the rest of the process in this knowledge area will be carried out.

Plan Cost Management: Inputs

1. Project Management Plan, contains but not limited to:
   - Scope Baseline
   - Schedule Baseline
   - Other Information (risks, communication, etc.)

2. Project Charter (provides summary budget)

3. Enterprise Environmental Factors (organizational culture, structure, market conditions etc.)

4. Organizational Process Assets(Financial control procedures, Historical Information’s lessons learned, budgeting related policies, procedures and guidelines etc.)

Plan Cost Management: T & T

1. Expert Judgment (Expertise based on application area appropriate for the activities)
2. Analytical Techniques (to understand the fund raising options)
3. Meetings (Planning meeting with stakeholders)
Plan Cost Management: Output

1. Cost Management Plan, can include but not limited to
   - Units of Measure (centimeter, meter etc.)
   - Level of Precision (rounded after two decimal points etc)
   - Level of Accuracy (+ or – 10%) or (+ or – 30%)
   - Control Accounts (Aggregated up to control of accounts level)
   - Control Thresholds (How much CV & SV can vary)
   - Rules for Performance Measurement
   - Reporting Formats
   - Process Description
   - Additional Details

Estimate Costs

This is the second Process in this knowledge area which comes in planning process group for developing an approximation (estimate) for the cost of the resources necessary to complete the project activities. It is also important to develop a cost management plan that describes how cost variances will be managed on the project and assessing pricing, how much the organization will charge for the product or service.

Estimate Costs: Inputs

1. Cost Management Plan (output from the previous process)

2. Human Resource Management Plan (project staffing details like personal rates etc.)

3. Scope Baselines
   - Scope Statement
   - WBS
   - WBS Dictionary

4. Project Schedule (Planned start date, end date, duration etc.)

5. Risk Register (to consider Risk mitigation costs)

6. Enterprise Environmental Factors
   - Market Conditions
   - Published Commercial Data

7. Organizational Process Assets
   - Cost Estimating Policies
   - Cost Estimating Templates
   - Historical Information
   - Lessons Learned
Estimate Costs: T & T

1. Expert Judgment
2. Analogous Estimating (Top down or Take Historical data for estimation))
3. Parametric Estimating (Apply historical data with statistical data for estimation)
4. Bottom-up estimating (Estimate from activity levels to WBS Level and to Control of Accounts level and finally estimate the total cost of the project)
5. Three-point Estimating (Triangular & Beta Distribution)
   a. Triangular Distribution \( Te = \frac{(To+Tm+Tp)}{3} \)
   b. Beta Distribution (PERT) \( Te = \frac{(To+4Tm+Tp)}{6} \)
      (Where \( Te \) = Total estimate, \( To \) = Total optimistic, \( Tm \) =Total most likely and \( Tp \) = Total Pessimistic)
6. Reserve Analysis (Contingency reserve to manage known risk)
7. Cost of Quality (Cost of appraisal or conformance & Cost of failure or non-conformance)
8. Project Management Software (like primavera, MS-Project etc)
9. Vendor Bid analysis (Vendor bid analysis to find out the cost of procurement of each items used for the project activities)
10. Group Decision Making Techniques (brainstorming, Delphi, nominal group Technique)

Estimate Costs: Output

1. Activity Cost Estimates (Direct and Indirect cost required to complete the project)

2. Basis of Estimates (supporting document includes :)
   ▪ How it was developed
   ▪ Estimation Assumptions
   ▪ Constraints
   ▪ Range of possible estimates (e.g., -5% to +10 % in case of bottom up estimation or -25 % to +75% in case of Rough Order of Magnitude estimation or triangular estimation)
   ▪ Confidence Level of the estimate )

3. Project Document Updates (Cost related documents and risk register)

Determine Budget

This is the third process in this knowledge area which comes under planning process group for aggregating the cost estimates of individual activities of work package to establish an authorized cost baseline.
An important goal of cost baseline is to have:

- A time-phased budget that project managers use to measure and monitor cost performance
- Estimating costs for each major project activity over a time period provides management with a foundation for project cost control
- Providing information for project funding requirements –at what point(s) in time how much money will be needed

**Determine Budget: Inputs**

1. Cost Management Plan (information regarding how the project cost will be managed and controlled)
2. Scope Baseline (Scope statement, WBS and WBS dictionary)
3. Activity Costs Estimates (Output from the previous process for aggregation up to work packages)
4. Basis of Estimates (Supporting details of the estimated cost)
5. Project Schedule
6. Resource Calendars (When a particular resource will be used in the project)
7. Risk Register (How to aggregate risk response costs)
8. Agreements (Cost related items in the agreements)
9. Organizational Process Assets (cost estimating tools, formats, policies and procedures etc.)

**Determine Budget: T & T**

1. Cost Aggregation (aggregating cost estimates to work package levels and further to control of accounts level to find the cost base line)
2. Reserve Analysis (Both contingency reserve and management reserve is created)
3. Expert Judgment (Expert opinions from other units or stakeholders)
4. Historical Relationships (To consider the analogous estimation or parametric estimation)
5. Funding Limit Reconciliation (At a particular point of time how much fund is required if the project is running over budget or how much excess fund is available if the project is under budget again if the project is going as per the plan, how much fund is required for completing the next phase etc., identified)

**Determine Budget: Outputs**

1. Cost Performance Baseline: Cost base line is the total project cost minus the management reserve for dealing the unknown risk. (Costs are aggregated activity level including contingency to WBS level and again aggregate all the WBS level including the contingency reserve will get the control of accounts and the sum of all the control of accounts will get the cost baseline, when we add management reserve for dealing with unknown risk to the aggregated control of accounts will give the total project cost. That
is if we minus management reserve from total project cost we will get the cost baseline. Cost base line is the time phased project budget excluding the management reserve.

Cumulative cost values are given in the Y axis and if the project is progressing with time as per the plan the funding requirements at the different point of time is shown in the graph. If the project is not progressed as per the plan then the S curve will vary accordingly and funding requirements also will vary. At a particular point of time how much fund is required if the project is running over budget or how much excess fund is available if the project is under budget again if the project is going as per the plan, how much fund is required for completing the next phase etc.,

2. Project Funding Requirements (Management provide some amount by expecting that the project will run for a certain period and after reaching that again management will release the fund, but the project manager should ask the management for the required fund as per the performance measurement reports to carry out the project without any delay.

3. Project Document Updates: Performance reports, risk register, issue logs, milestone list etc.,

Control Costs

This is the fourth process of this knowledge area which comes under monitoring and control process group for monitoring the status of the project costs and managing the changes to the cost baseline, includes:

- Influencing the factors that create changes to the authorized baseline
- Monitoring cost performance to detect variances from the plan
- Ensuring that all appropriate changes are recorded
- Preventing incorrect, inappropriate, or unauthorized changes
- Informing the appropriate stakeholders of authorized changes
- Analyzing positive and negative variances and how it affects the other control processes
Control Costs: Inputs

1. Project Management Plan:
   - Cost Baseline
   - Cost Management Plan
   - Project Funding Requirements

2. Work Performance Indicators (activities that have been started and cost as per the schedule etc. has to be monitored)

3. Organizational Process Assets (procedures for cost control etc.)

Control Costs: T & T

1. Earned Value Management (discussed)
2. Forecasting (discussed)
3. To-Complete Performance Index (discussed)
4. Performance Reviews (are based on performance measurement and forecasting data)
   - Variance Analysis
   - Trend Analysis
   - Earned Value Performance
5. Reserve Analysis (status of the contingency and management reserve are monitored)
6. Project Management Software (like primavera, MS-Project etc)

Control Costs: Outputs

1. Work Performance Measurements compared with planned and documented as work performance information.

2. Budget Forecasts

3. Change Requests (Changes in the plan has to get approved from change control board through perform integrated change control process)

4. Project Management Plan Updates
   1. Cost Baseline
   2. Cost Management Plan

5. Organizational Process Assets Updates (Causes of variance, organizational procedures, standards regarding cost monitoring and control)

6. Project Document Updates (Cost estimates and basis of cost estimates are updated)
References:

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4. https://www.google.co.in/search?q=project+funding+s+curve+diagram%5C&es_sm=93&biw=1280&bih=699&tbm=isch&imgil=B7foVxgM19UOM%253A%253B_L_qw_NH6T0NBM%253Bhttp%25252F%25252Fwww.slideshare.net%25252FNASAPMC%25252Fstephenbook&source=iu&pf=m&fir=B7foVxgM19UOM%253A%253B_L_qw_NH6T0NBM%253B&usg=__Z_s2E1stO4GW05icRT0UZJ9bNc%3D&ved=0CC8Qyjc&ei=17u3VJiKldKPuAS9miCABQ#imgdii= &imgrc=yF0Y63zastUfuM%253A%253B Jvx-34MVlpv4rM%253Bhttp%253A%252F%252Fwww.pm-primer.com%252Fwp-content%252Fuploads%252F2012%252F04%252Fscurve1.jpg%3Bhttp%253A%252F%252Fwww.pm-primer.com%252Fdetermine-budget%3B493%3B395
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