Outline

• Cost in Project Management
• Cost Management
  -- cost estimating
  -- cost budgeting
  -- cost control
• Sample Software
• Readings & web reference

Disclaimer: This is an overview module. We encourage learners to enroll in semester-long project management courses for a complete treatment of this topic.
Learning Objectives and Skills

**Students will**

- Be able to explain the Fundamentals of Project Costing
- Recognize and use Project Costing techniques
- Familiarize with Project Control mechanisms
  - Examining variances, project plan and human resource controls
  - Financial Controls, cumulative project variance, earned value approach
    - Calculating estimates to complete (ETC)
  - Financial considerations
    - Top-down and bottom up cost estimating, opportunity costs, TVM, DCF, IRR, capital budgeting techniques

**Skills developed**

- Content-specific skills
- Critical Thinking & Analytic skills
Project Cost Management Key Resources

- The Project Management Institute (PMI.org)

- The Project Management Body of Knowledge 3rd edition
  (All concepts in this module were based on discussions in Kerzner 2005.)
Project management is a process designed to manage or control company resources on a given activity, within time, within cost, and within scope. Time, cost, and scope are the constraints on the project.

Source: Project Management Planning & Control Techniques P131
Project Cost Management

Definition:

Project cost management includes the processes involved in planning, estimating, budgeting, and controlling costs so that the project can be completed within the approved budget.

----PMBOK

Source: Project Management Planning & Control Techniques P80
Cost Management Plan

- The cost management planning efforts occur early in project planning and set the framework for each of the cost management processes, so that performance of the processes will be efficient and coordinated.

- Cost management plan can establish, for example, the units of measure for a project; organizational procedures and processes; control thresholds; reporting formats, etc.

- The key cost management activities include:

  1. Cost Estimating
  2. Cost Budgeting
  3. Cost Control
Cost Estimating Process Overview

Cost Estimating - developing an approximation of the costs of the resources needed to complete project activities.

**Inputs**
1. Enterprise environment factors
2. Organizational process assets
3. Project scope statement
4. Work breakdown structure
5. WBS dictionary
6. Project management plan
   -- Schedule management plan
   -- Staffing management plan
   -- Risk register

**Tools & Techniques**
1. Types of estimates
2. Estimating methods
3. Project management software
6. Vendor bid analysis
7. Reserve analysis
8. Cost of quality

**Outputs**
1. Activity cost estimates
2. Activity cost estimate supporting detail
3. Requested change
4. Cost management plan

*Source: Adapted from The Project Management Body of Knowledge P162 and Kerzner, H. (2004)*
Techniques for Estimating Costs

The following techniques can be used for estimating costs:

High Low Method: Regression method: Scatter graph method: Engineering method

Illustration

The Kent Company provides you with the following activity levels and monthly costs for the first six months of 200X:

<table>
<thead>
<tr>
<th>Month</th>
<th>Units</th>
<th>Product Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>30</td>
<td>$370</td>
</tr>
<tr>
<td>February</td>
<td>35</td>
<td>$420</td>
</tr>
<tr>
<td>March</td>
<td>40</td>
<td>$460</td>
</tr>
<tr>
<td>April</td>
<td>45</td>
<td>$520</td>
</tr>
<tr>
<td>May</td>
<td>54</td>
<td>$620</td>
</tr>
<tr>
<td>June</td>
<td>60</td>
<td>$670</td>
</tr>
</tbody>
</table>

Required

1. Compute the fixed cost per month and the variable cost per unit using high low method and regression.

2. Compute the estimated costs for August if the company is expected to produce 38,000 units.

Source: Project Management: A Systems Approach to Planning, Scheduling, and Controlling P542
Life-Cycle Costing (LLC)

LLC requires that decisions made during the R&D process be evaluated against the total life-cycle cost of the system.

Life-cycle costs are the total cost to the organization for the ownership and acquisition of the product over its full life.

This includes the cost of:

- R&D cost
- Production cost
- Construction cost
- Operation and maintenance cost
- Product retirement and phase-out cost (also called disposal cost)

“At the end of the validation phase 85% of the decision affecting the total life-cycle cost will have been made, and the cost reduction opportunity is limited to a maximum 22%.”

Source: Project Management: A Systems Approach to Planning, Scheduling, and Controlling P579
Project costs

A project estimate can be sub-divided into a number of different costs, consider the following:

-- Direct product costs
-- Indirect product costs
-- Period costs
-- Variable costs
-- Fixed costs
-- Semi variable costs
-- Relevant (incremental costs)
-- Sunk costs
-- Opportunity costs
Cost Budgeting Process Overview

Cost Budgeting - aggregating the estimated costs of individual activities or work packages to establish a cost baseline.

**Inputs**
1. Project scope statement
2. Work breakdown structure
3. WBS dictionary
4. Activity cost estimates
5. Activity cost estimate supporting detail
6. Project schedule
7. Resource calendars
8. Contract
9. Cost management plan

**Tools & Techniques**
1. Cost aggregation
2. Reserve analysis
3. Parametric estimating
4. Funding limit reconciliation
5. Capital budgeting

**Outputs**
1. Cost baseline
2. Project funding requirements
3. Cost management plan
4. Requested changes

Source: The Project Management Body of Knowledge P167
Cost budget

A COST BUDGET is a financial plan that sets forth the resources necessary to carry out activities and meet financial goals for a future period of time.

A MASTER BUDGET presents a company’s overall financial plan for the coming year or other planning period.

The OPERATING BUDGET summarizes the firm’s operating plans for the period.

The CASH BUDGET is a summary of projected cash balances based on expected cash receipts from operations and cash payments for operations, and cash receipts and payments from financing and investing activities.

A CAPITAL BUDGET details plans for the acquisition and replacement of major portions of property, plant and equipment.
The QQQ Manufacturing Company prepared a budget for manufacturing overhead for the month of January 200X. The budget is shown right:

At the end of the month it was determined that only 80,000 units were produced.

**Required:**

**Question 1**

Prepare a static budget showing the variances between actual and budgeted numbers.

<table>
<thead>
<tr>
<th>Production in units</th>
<th>90,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Overhead:</td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>$2,700</td>
</tr>
<tr>
<td>Repairs</td>
<td>4,500</td>
</tr>
<tr>
<td>Payroll</td>
<td>63,000</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>9,000</td>
</tr>
<tr>
<td><strong>Total Variable Overhead</strong></td>
<td><strong>79,200</strong></td>
</tr>
<tr>
<td>Fixed Overhead</td>
<td></td>
</tr>
<tr>
<td>Superintendence</td>
<td>$8,000</td>
</tr>
<tr>
<td>Factory rent</td>
<td>10,000</td>
</tr>
<tr>
<td>Maintenance</td>
<td>3,000</td>
</tr>
<tr>
<td>Indirect labor</td>
<td>5,000</td>
</tr>
<tr>
<td>Depreciation of equipment</td>
<td>12,000</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>4,000</td>
</tr>
<tr>
<td><strong>Total Fixed Overhead</strong></td>
<td><strong>42,000</strong></td>
</tr>
<tr>
<td><strong>TOTAL OVERHEAD</strong></td>
<td><strong>$121,200</strong></td>
</tr>
</tbody>
</table>
Selecting Projects

• Economic project selection criteria

  Project manager are often called upon to be active participants during the cost-benefit analysis of project selection. It is highly unlikely that companies will approve a project where the costs exceed the benefits.

  The process of identifying the financial benefits is called capital budgeting, which maybe defined as the decision making process.

  Sophisticated capital budgeting techniques take into consideration depreciation schedules, tax information, and cash flow. Now we only discuss four basic principles:

  -- Payback Period: *is the exact length of time needed for a firm to recover its initial investment as calculated from cash inflows. It is the least precious of all capital budgeting methods because the calculations are not adjusted for the time value of money. So it is often used as a supplemental tool accompany other methods.*

  -- Discounted Cash Flow (DCF)

  -- Net Present Value (NPV)

  -- Internal Rate of Return (IRR)
The time value of money

Everyone knows that a dollar today is worth more than a dollar a year from now. The reason for this is because of the time value of money.

Let us look at the equation:

$$ FV = PV (1+k)^n $$

where $FV = \text{Future value of an investment}$

$PV = \text{Present value}$

$k = \text{Investment interest rate (or cost of capital)}$

$n = \text{Number of years}$

Example: You have a choice between two investments. A will generate $100,000 two years from now and B will generate $110,000 three years from now. If the cost of capital is 15%, which investment will better?

Using the formula for discounted cash flow

$$ PVA = \$75,614 $$

$$ PV_B = \$72,327 $$

The answer is: the return of A is worth more than the return of B.
Net Present Value (NPV)

The Net Present Value (NPV) equates the discounted cash flows against the initial investment. Mathematically,

\[ NPV = \sum_{t=1}^{n} \left( \frac{FV_t}{(1+k)^t} \right) - \Pi \]

where FV is the future value of the cash inflows, \( \Pi \) represents the initial investment, and k is the discount rate equal to the firm’s cost of capital.

example:

<table>
<thead>
<tr>
<th>year</th>
<th>Cash Inflows</th>
<th>Present Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$1000</td>
<td>$909</td>
</tr>
<tr>
<td>2</td>
<td>2000</td>
<td>1653</td>
</tr>
<tr>
<td>3</td>
<td>2000</td>
<td>1503</td>
</tr>
<tr>
<td>4</td>
<td>5000</td>
<td>3415</td>
</tr>
<tr>
<td>5</td>
<td>2000</td>
<td>1242</td>
</tr>
</tbody>
</table>

PV of cash inflows less investment

<table>
<thead>
<tr>
<th>year</th>
<th>Cash Inflows</th>
<th>Present Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>8722</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10000</td>
</tr>
</tbody>
</table>

(1278)

This indicates that the cash inflows discounted to the present will not recover the initial investment.

The decision-making criteria are as follow:

-- If NPV ≥ 0, accept the project
-- If NPV < 0, reject the project

A positive value of NPV indicates that the firm will earn a return ≥ its cost of capital.

Source: Project Management: A Systems Approach to Planning, Scheduling, and Controlling P584
Internal Rate of Return

The Internal Rate of Return (IRR) is the discount rate where the present value of cash inflows exact equals the initial investment. In other words, IRR is the discount rate when NPV = 0. Mathematically

\[
\sum_{t=1}^{n} \left[ \frac{FV_t}{(1 + IRR)^t} \right] - \Pi = 0
\]

The solution to problems involving IRR is basically a trial-and-error solution. The table below shows that with the cash inflows provided and with a $5000 initial investment, an IRR of 10% yielded a value of $3722 for NPV. It implies that the cash inflows are equivalent to a 31% return on investment. Therefore, if the cost of capital were 10%, this would be an excellent investment. Also, this project is probably superior to other projects with a lower value of IRR.

Source: Project Management: A Systems Approach to Planning, Scheduling, and Controlling P585
Case Study

Question
Robots R Us estimates to invest the following in a project to make sophisticated robotic toys for children

<table>
<thead>
<tr>
<th>Design</th>
<th>$90 million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td>$110 million</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$200 million</td>
</tr>
</tbody>
</table>

The total cost of the project is $200 million of which $40 million is invested by the company in cash and the balance $160 million is obtained through a bank loan. It is agreed that the loan principal will be repaid by 5 equal end of year payments of $32 million. The interest on the loan is 10 percent per annum and will be paid at the end of the year based on the remaining balance of the loan.

The company estimates that its sales will be 100,000 robotic toys per year. The anticipated selling price is $700 per robotic toy and sales are expected to grow at 20,000 robots per year. The anticipated operating and maintenance costs are $50 million the first year and, due to production efficiencies, it is expected to decrease by $3 million per year. The effective tax rate is 40%. The design and engineering costs are capitalized and the depreciation of the equipment manufactured to produce the robotic toys is based on MACRS.

For tax purposes, under MACRS, the equipment is depreciated over six calendar years and the percentages are as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20.00</td>
</tr>
<tr>
<td>2</td>
<td>32.00</td>
</tr>
<tr>
<td>3</td>
<td>19.20</td>
</tr>
<tr>
<td>4</td>
<td>11.52</td>
</tr>
<tr>
<td>5</td>
<td>11.52</td>
</tr>
<tr>
<td>6</td>
<td>5.76</td>
</tr>
</tbody>
</table>

Required:
1. Prepare a statement showing the cash flows for the business
2. Compute the net present value and determine if the project is feasible
3. Compute the internal rate of return (IRR) of the project
4. What additional factors may have to be taken into account in deciding whether to go ahead with the project?
**Cost Control Process Overview**

**Cost Control** - influencing the factors that create additional costs and controlling changes to the project budget.

**Inputs**
1. Cost baseline
2. Project funding requirements
3. Performance reports
4. Work performance information
5. Approved change requests
6. Project management plan

**Tools & Techniques**
1. Cost change control system
2. Performance measurement analysis
3. Forecasting
4. Project performance reviews
5. Project management software
6. Variance management

**Outputs**
1. Cost estimate
2. Cost baseline
3. Performance measurements
4. Forecasted completion
5. Requested changes
6. Recommended corrective actions
7. Organizational process assets
8. Project management plan

*Source: The Project Management Body of Knowledge P171*
3. Cost control achieving project success

Project success depends to a great extent upon management’s abilities to cost control. Maintaining cost control requires a well-designed and implemented project cost control system. A sound project cost control system performs four basic functions:

1. Establishes baseline cost.
2. Collects actual cost data.
3. Reports and evaluates (including earned value).
4. Takes corrective action.

This figure provides an illustration of the elements involved in a project cost control system and their interrelationship.

Source: The AMA Handbook of Project Management P67
Performance Measurement Analysis

Performance measurement techniques help to assess the magnitude of any variances that will invariably occur.

An important part of cost control is to determine the cause and magnitude of a variance and to decide if the variance requires corrective action.

**Earned value analysis (EVM)** compares the value of the budgeted cost of work earned at the original allocated budget amount to both the budgeted cost of work planned and to the actual cost for completed work. It involves developing these key values for each activity:

1. **Planned Value (PV)** is the budgeted cost for the work scheduled to be completed on an activity or WBS component.
2. **Actual Cost (AC)** is the total cost incurred in accomplishing work on the schedule activity or WBS component. AC must correspond in definition and coverage to whatever was budgeted for the PV and the EV.
3. **Earned Value (EV)** is the budgeted amount for the work actually completed on the schedule activity or WBS component.
4. **Estimate to Complete (ETC)** is the cost estimate for work remaining and is used in forecasting the project cost at completion.

   \[ \text{ETC} = (\text{total PV} - \text{EV to date}) \]
   \[ \text{ETC} = (\text{remaining PV} \times \text{CPI}) \]
Variance

The PV, EV and AC values are used in combination to provide performance measures of whether or not work is being accomplished as planned at any given point in time. The most common used measures are cost variance (CV) and schedule variance (SV). The amount of variance of the CV and SV values tend to decrease as the project reaches completion due to the compensating effect of more work being accomplished.

- **Cost Variance (CV)** = EV-AC, CV at the end of the project will be the difference between the budget at completion and the actual amount spend.

- **Schedule Variance (SV)** = EV-PV, SV will ultimately equal 0 when the project is completed because all of the planned values will have been earned.

CV and SV can be converted to efficiency indicators to reflect the cost and schedule performance.

- **Cost Performance Index (CPI)**, CPI = EV/AC, CIP < 1 means costs overrun the estimates, CIP > 1 means costs underrun the estimates.

- **Schedule Performance Index (SPI)**, SPI = EV/PV, SIP is used to predict the completion data and is sometimes used in conjunction with the CPI to forecast the project completion estimates.

Source: The Project Management Body of Knowledge P174
3. Cost Control

### Variance Control

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Budget at Completion (BAC)</strong></td>
<td>$1,230</td>
<td>$1,230</td>
<td>$1,230</td>
<td>$1,230</td>
<td>$1,400</td>
<td>$1,400</td>
<td>$1,400</td>
</tr>
<tr>
<td><strong>Earned Value (EV)</strong></td>
<td>$100</td>
<td>$200</td>
<td>$300</td>
<td>$450</td>
<td>$750</td>
<td>$800</td>
<td>$1,125</td>
</tr>
<tr>
<td><strong>Actual Cost (AC)</strong></td>
<td>$100</td>
<td>$205</td>
<td>$315</td>
<td>$600</td>
<td>$800</td>
<td>$1,000</td>
<td>$1,200</td>
</tr>
<tr>
<td><strong>Planned Value (PV)</strong></td>
<td>$100</td>
<td>$220</td>
<td>$325</td>
<td>$550</td>
<td>$725</td>
<td>$925</td>
<td>$1,175</td>
</tr>
<tr>
<td><strong>Cost Variance (CV)</strong></td>
<td>$0</td>
<td>($5)</td>
<td>($15)</td>
<td>($150)</td>
<td>($50)</td>
<td>($200)</td>
<td>($75)</td>
</tr>
<tr>
<td><strong>Schedule Variance (SV)</strong></td>
<td>$0</td>
<td>($20)</td>
<td>($25)</td>
<td>($100)</td>
<td>$25</td>
<td>($125)</td>
<td>($50)</td>
</tr>
<tr>
<td><strong>Cost Performance Index (CPI)</strong></td>
<td>1.00</td>
<td>0.98</td>
<td>0.95</td>
<td>0.75</td>
<td>0.94</td>
<td>0.80</td>
<td>0.94</td>
</tr>
<tr>
<td><strong>Schedule Performance Index (SPI)</strong></td>
<td>1.00</td>
<td>0.91</td>
<td>0.92</td>
<td>0.82</td>
<td>1.03</td>
<td>0.86</td>
<td>0.96</td>
</tr>
<tr>
<td><strong>Estimate to Completion (ETC)</strong></td>
<td>$1,130</td>
<td>$1,056</td>
<td>$977</td>
<td>$1,040</td>
<td>$693</td>
<td>$750</td>
<td>$293</td>
</tr>
<tr>
<td><strong>Estimate at Completion (EAC)</strong></td>
<td>$1,230</td>
<td>$1,261</td>
<td>$1,292</td>
<td>$1,640</td>
<td>$1,493</td>
<td>$1,750</td>
<td>$1,493</td>
</tr>
<tr>
<td><strong>Variance at Completion (VAC)</strong></td>
<td>$0</td>
<td>($31)</td>
<td>($62)</td>
<td>($410)</td>
<td>($93)</td>
<td>($350)</td>
<td>($93)</td>
</tr>
</tbody>
</table>

#### Status based on Average Performance Index

- **GREEN**
- **YELLOW**
- **RED**

#### Comments
- New baseline set

### Variance Analysis

**Source:** Microsoft Templates
Case Study on Variance Analysis

The Mercer Company manufactures redwood window boxes. Each box requires the following direct materials and direct labor.

<table>
<thead>
<tr>
<th>Material</th>
<th>Standard Price</th>
<th>Standard Quantity (rate)</th>
<th>Standard Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1” clear redwood 5 feet</td>
<td>$1.50 per foot</td>
<td>6.0</td>
<td>$6.0</td>
</tr>
<tr>
<td>Direct labor</td>
<td>0.5 hr</td>
<td>$9.0 per hour</td>
<td>$4.5</td>
</tr>
</tbody>
</table>

During March 200X, the following was determined:
1. Purchases of lumber amounted to $37,700. The price paid was $1.45 per foot.
2. The direct labor cost was $21,840. The hourly rate of pay was $9.10.
3. 5,000 boxes were manufactured.

Required

Compute the total cost variance. Breakdown the cost variance into different components and explain who you would hold responsible and how you would conduct the investigation.
Forecasting

Forecasts are generated, updated, and reissued based on work performance and any information that could impact the project in the future.

The **earned value technique** parameters of Budget At Completion (BAC), AC to date, and the CPI efficiency indicator are used to calculate ETC and EAC. BAC = total PV at completion.

Forecasting techniques help to assess the cost or amount of work to completes schedule activities, called EAC. They also help to determine the ETC, which is the estimate for completing the remaining work for a schedule activities.

ETC forecasting technique based upon the performing organization providing the Estimate To Complete is:

-- ETC based on new estimate.

Alternatively, following tow formulas is used to calculate ETC using earned value data:

-- ETC based on atypical variances. ETC = (BAC-EV)
-- ETC based on typical variances. ETC = (BAC-EV)/ CPI

ETC forecasting technique based upon the performing organization providing the Estimate At Complete is:

-- EAC using a new estimate. EAC = AC+ETC

Alternatively, following tow formulas is used to calculate EAC using earned value data:

-- EAC using remaining budget. EAC = AC+BAC-EV
-- EAC using CPI. EAC = AC+ [(BAC- EV)/CPI]
Cost Baseline & Justifying Cost

Once the project is initiated, the cost or financial baseline need to be established against which status will be reported and variances will be measured. Figure below represents a cost baseline. Each block represents a cost account or work package element. The summation of all the work packages would equal the time-phased budget.

Project pricing is often based upon best guesses rather than concrete estimates.

Every company has its own evaluation criteria cost summery approval process. Typical elements that must be justified or supported by hard data include:

-- Labor Rates
-- Overtime
-- Scrap Factors
-- Risks
-- Hidden Cost

Other often hidden cost

Source: Project Management: A Systems Approach to Planning, Scheduling, and Controlling P634

Source: Project Management: A Systems Approach to Planning, Scheduling, and Controlling P637
Sample Software: Construction Estimating Software--Corecon

http://www.corecon.com/Features/Estimating.aspx?gclid=COSkhvq82JECFSGWGnodR1vDZg
Readings & References

- Construction Estimating Software
  Corecon
  http://www.corecon.com/Features/Estimating.aspx?gclid=COSkhvq82JECFSGWGgodR1vDZg
  SuccessEstimator
  http://www.uscost.com/successestimator.asp