Project Cost Management

Introduction
Course Objectives

- Upon completing today’s activities you will be knowledgeable of tools and techniques to:
  - Allocate overall costs to WBS work packages
  - Develop a project estimate and budget
  - Use Earned Value Analysis to control budget
  - Immediately apply PM principles on the job
Your Objectives

☐ What do you want to get out of the course?

■ 1
■ 2
■ 3
■ 4
■ 5
■ 6
## Tentative Agenda

<table>
<thead>
<tr>
<th>Hour</th>
<th>Topic/Activity</th>
<th>Slide #</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Estimating</td>
<td></td>
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<tr>
<td>3</td>
<td>Budgets &amp; Cost Control</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Earned Value Analysis</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Accounting Issues</td>
<td></td>
</tr>
</tbody>
</table>
Worried About Budget Cuts?

Source: http://californiamondioring.org/images/budgetcut.jpg
Controlling Project Costs

- What is the most difficult aspect of controlling project costs?
  - Predicting labor costs
  - Cost accounting process
  - Establishing overhead costs
  - Scope creep

August 2004 PM Network Magazine member survey
Which Project Control Functions Need the Most Improvement?

- Documenting Project Status: 4%
- Managing Issue, Risk, & Change: 21%
- Tracking/Analyzing Project Costs: 9%
- Estimating Project Costs: 21%
- Managing Critical Path: 9%
- Developing Schedule & WBS: 13%
- Facilitating Planning/Control Sessions: 2%
- Educating Project Team: 21%

Cost Management Components (PMBOK)

- Cost Estimating
  - Costs for each resource

- Cost Budget
  - Allocating overall cost estimates to individual work activities to establish cost baseline

- Cost Control
  - Controlling changes to project budget
  - Earned Value and variance analysis
Estimating Basics – 1 (PMBOK)

- Time treated separately by PMBOK, obvious inter-connection between time and cost.
- On small projects resource planning, estimating, and budgeting may be same activity!
- If project cost performance linked to incentives/rewards, then separate controllable and uncontrollable costs.
Estimating Basics - 2

☐ To improve accuracy:
  ■ Base cost on WBS
  ■ Estimate developed by the person doing the work

☐ Baseline estimate should only be updated for “approved” changes.

☐ PM needs to determine costs, even if budget is set by senior mgmt AND reconcile any differences.
Budget Estimates – Is their Common Ground?

- Assuming that ALL parties are reasonably honest:
  - Jobs looks easier, faster, & cheaper to mgmt than to person doing the work.
  - Mgmt is optimistic and not prone to admitting errors or omissions.
  - Subordinates are naturally pessimistic & want to build in cost/time protection.

*Mantel et al. (2001). Core Concepts in PM*
Estimate Politics - Construction

- Vast majority of construction mega-projects over past 70 yrs had significant cost overruns.
  - Sydney Opera House – 1,400%
  - Boston – Big Dig/CAT – Can’t count that high!

- Formula deciding which projects get built:
  
  Project approval equals underestimated cost, plus overestimated revenue, plus undervalued environmental impact, plus overvalued economic development effect.”

Source - Viewpoint: Misrepresentation Drives Projects, p. 87 ENR, 1/5/04.
Major PM Outputs To Date

- Project Charter
- Scope Statement
- WBS
- Activity List
- Network Diagram
- Activity Duration Estimates
- Schedule
Questions/Notes
## Resource Planning

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Tools &amp; Techniques</th>
<th>Outputs</th>
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</thead>
<tbody>
<tr>
<td>Enterprise Environ Factors</td>
<td>Expert Judgment</td>
<td>Resource Req</td>
</tr>
<tr>
<td>Org Process Assets</td>
<td>Alternative Analysis</td>
<td>Activity Attrib UP</td>
</tr>
<tr>
<td>Activity List</td>
<td>Published Est Data</td>
<td>Resource Breakdown Struct</td>
</tr>
<tr>
<td>Activity Attributes</td>
<td>PM Software</td>
<td>Resource Calendar UP</td>
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<tr>
<td>Resources</td>
<td>Bottom-up Estimate</td>
<td>Requested Changes</td>
</tr>
<tr>
<td>Availability</td>
<td></td>
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<tr>
<td>PM Plan</td>
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</tbody>
</table>

Resource Planning Concerns 1

- Organizations internal & external resource pool, capacity, & demand?
- Where can necessary availability of knowledge and skills be found?
- Type and capacity needed for project?
- Are most knowledgeable and skilled resources working on most strategic initiatives?
Resource Planning Concerns 2

- What is the availability of a given resource for a specific period of time?
- How are resources performing on a given project, program, or business area?
- What are resource utilizations, realization, and profitability?
Resource Factors

- Labor
- Material
- Supplies
- Equipment
- Contingency & Escalation
Resource Breakdown Structure

- Application Development
  - Design
    - Business Analyst
    - DB Architect
    - Systems Analyst
  - Program
    - Associate Pgmr
    - Programmer
    - Senior Pgmr
  - Test
    - Test Designer
    - Test Supv
    - Test Technician
Resource Leveling

- Any form of network analysis in which scheduling decisions are driven by resource management concerns.
  - Limited resource availability
  - Difficult to manage changes in resource levels
- Rescheduling activities so the requirement for resources on the project does not exceed resource limits.

(Source: Max Wideman’s PM Glossary)
Resource Leveling Example

Red = Critical Path
Green = Activities with float
Blue = Available float

Would it be useful to level the resources?
Time Scaled Dependencies

Resource Leveling Activity

- See hand out
- Enter critical resources first
- How can float be applied to balance worker loading?
## 7.1 Cost Estimating

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Tools &amp; Techniques</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterprise Envir Factors</td>
<td>□ Analogous Est</td>
<td>□ Activity cost estimate</td>
</tr>
<tr>
<td>Org Proc Assets</td>
<td>□ Resource costs</td>
<td>□ Supporting detail</td>
</tr>
<tr>
<td>Scope Statement</td>
<td>□ Parametric Est.</td>
<td>□ Requested changes</td>
</tr>
<tr>
<td>WBS &amp; Dictionary</td>
<td>□ Bottom-up Est.</td>
<td>□ Cost mgmt plan UP</td>
</tr>
<tr>
<td>PM Plan</td>
<td>□ PM Software</td>
<td></td>
</tr>
<tr>
<td>- Schedule plan</td>
<td>□ Vendor bids</td>
<td></td>
</tr>
<tr>
<td>- Staff plan</td>
<td>□ Reserve analysis</td>
<td></td>
</tr>
<tr>
<td>- Risk register</td>
<td>□ Cost of quality</td>
<td></td>
</tr>
</tbody>
</table>
Cost Estimating Process

WBS

Resource Requirements

Resource Rates

Estimate Method

- Historical
- Analogous
- Parametric
- Weighted
- Bottom-Up
- Vendor Bid

Estimate
Estimate

☐ Estimate vs. Pricing

- Estimate is an “Approximation” of resources needed to complete the project (quantification)
- Pricing is a business decision with estimate just one input. Other factors:
  - Supply & Demand, Risk, etc.

☐ Budget – Planned allocation of resources, based on estimate.
Methods of Estimating

- **Top-Down (Analogous)**
  - Collective judgment based on previous similar projects: Used when limited detail exists, Less costly, but less accurate

- **Parametric**
  - Mathematical models (linear regression, learning curves) to predict project costs – e.g. cost per line of code, cost per linear foot, and cost per installation.

- **Bottom-Up**
  - Based on WBS – Resource requirements estimated by those responsible for execution
Analogous Estimate - NASA

- **RFQ And Historical Data**
  - PDQ Inc., has received an RFQ for 84 XYZ Systems to be built and delivered in 2005. A 120-lot of this same system was delivered in 2001.
  - How will the proposed 84-lot be different from the historical (baseline) of 120-lot?
    - Plant now at full capacity
    - Shortage of skilled workers
    - New manufacturing processes reduced cycle time to 100 hours.
    - Inflation adjustment, etc.

*Source: http://www.jsc.nasa.gov/bu2/PCEHHTML/pceh.htm*
Analogues Estimate Example: Tunnel Costs for Chunnel Project

- Consulting engineers hired by Banks concluded tunneling estimates 20% too high.
  - Based on 50 German railroad tunnels ranging from 400m to 11K
  - Cost range of £55 to £140 per Cu M

- What was different about the Chunnel that might justify higher costs
PERT or Weighted Average $\$

- $E = \frac{(O + 4m + P)}{6} = \text{Expected Cost}$
- $O = \text{Optimistic time}$
  - Expected duration in only 1 of 20 repetitions
- $m = \text{Most likely}$
- $P = \text{Pessimistic time}$
  - Expected duration in only 1 of 20 repetitions
- Note: Assumes “Normal” distribution
Support Details for Estimate

- WBS Dictionary/Description
- How estimate was developed?
- Assumptions
- Cost range, e.g. $20,000 +/- $2,000
  - Level of confidence
- Audit trail of estimate development
Direct Costs

- Costs that are specifically attributable to an activity or group of activities without apportionment.
- Costs such as labor, material, equipment, travel that can be consistently related to work performed on a particular project.
- Direct costs are best contrasted with indirect costs that cannot be identified to a specific project.

*Source: Max Wideman’s PM Glossary*
Indirect Costs

- Also known as Overhead, General & Administrative (G&A), or Burden.
- Resources expended which are not directly identified to a specific contract, project, product, service, or activity.
  - e.g. taxes, accounting, HR
- Costs may be allocated to projects on a prorated basis.

Source: Max Wideman’s PM Glossary
Fixed Costs

 Costs that do not vary with the volume of work such as set-up, rental fees, accommodation, insurance, depreciation, security and utilities.
Variable Cost

- Cost that changes with the production quantity or the performance of services.
- Cost that changes over time, such as an hourly rate for resources that rises as the resource continues to work.
- Materials, supplies, wages
**Estimating Activity**

- For one activity or work package, identify and estimate the cost of:

<table>
<thead>
<tr>
<th>Direct Costs</th>
<th>Indirect Costs</th>
<th>Fixed Costs</th>
<th>Variable Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.</td>
<td></td>
<td>4. Utilities</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
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</tr>
</tbody>
</table>
Accuracy of Estimates

- Rough Order of Magnitude Estimate
  - Guestimate range at project initiation
    - -50% to +100% from actual

- Budget Estimate
  - Developed during planning phase
    - -10% to +25% from actual

- Definitive Estimate
  - Developed during planning
    - -5% to +10% from actual
Estimate Activity Cost $10,000

- Rough Order of Magnitude Estimate
  - SWAG 50% to +100% from actual
  - Range: $5,000 to $20,000

- At planning phase -10% to +25%
  - Range: $9,000 - $12,500

- Finalized Estimate -5% to +10%
  - Range: $9,500 - $11,000
## Variation in Cost & Schedule Estimates by Phase

<table>
<thead>
<tr>
<th>Phase</th>
<th>Effort and Size</th>
<th>Schedule</th>
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<tbody>
<tr>
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<td>Optimistic</td>
<td>Pessimistic</td>
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<tr>
<td>Initial concept</td>
<td>0.25</td>
<td>4.0</td>
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<tr>
<td></td>
<td>0.60</td>
<td>1.60</td>
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<tr>
<td>Approved concept</td>
<td>0.50</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>0.80</td>
<td>1.25</td>
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<tr>
<td>Req. Specs</td>
<td>0.67</td>
<td>1.5</td>
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<tr>
<td></td>
<td>0.85</td>
<td>1.15</td>
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<tr>
<td>Product specs.</td>
<td>0.80</td>
<td>1.25</td>
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<tr>
<td></td>
<td>0.90</td>
<td>1.10</td>
</tr>
<tr>
<td>Detailed specs.</td>
<td>0.90</td>
<td>1.10</td>
</tr>
<tr>
<td></td>
<td>0.95</td>
<td>1.05</td>
</tr>
</tbody>
</table>

Source: Barry Boehm, www.learningsolutions.com
Phase Gate Criteria

Source: New Product Development
http://www.npd-solutions.com/reviews.html
Phase Gates in Development Life Cycle

Gates
Executives evaluate the proposed cost, schedule, scope & risk.

Discovery Remaining

Requirements  Design  Construction  Operate

Source: www.learningsolutions.com/WhitePapers/ProjectManagement-Phase_Gate.html
Issues in Budget Types

- **Top-Down**
  - Accurate overall
  - Variance in details
  - Most common

- **Bottoms-Up**
  - More accurate
  - Creates buy-in
  - Rare in true form

- Upper-level managers reluctant to let workers set budget
- Fear natural tendency to overstate costs
- Budget is mgmt’s primary tool for project control
- Reluctant to let other set control limits

*Mantel et al. (2001). Core Concepts in PM*
Types of Estimating Errors

- Random errors cancel out – often called compensating error
- Bias – consistent high or low costing
Potential Estimating Problems

- Misinterpretation of **scope** - poorly defined requirements.
- Inaccurate **WBS**
- Failure to account for **risks**
- Poorly defined or overly optimistic **schedule**
- Shortage of qualified **resources**
- Failure to account for cost escalation and inflation
- Failure to use the correct **estimating techniques**
- **Inaccurate pricing** rates for overhead, general and administrative, and indirect costs
- Inexperienced **project managers**
Costing Alternatives

- **Life Cycle Costing**
  - Project cost alternatives include acquisition, operating, and disposal.
  - Total costs to organization for ownership and acquisition of the product over its full life.
Costing Alternatives

Value Engineering

Organized effort to analyze the functions of systems, equipment, facilities, services, and supplies for the purpose of achieving the essential functions at the lowest life cycle cost consistent with required performance, reliability, quality, and safety. (Max Wideman’s PM Glossary)
Lifecycle Cost Elements

- **R & D Costs**: The cost of feasibility studies; cost-benefit analysis; system analysis; design detail and development; fabrication, assembly; testing of engineering models; and associated documentation.

- **Production Costs**: The cost of fabrication, assembly and testing of production models; operation and maintenance of the production capability; and associated logistical support requirements.

- **Construction Costs**: The cost of new manufacturing facilities or upgrading of existing structures to accommodate production and operation of support requirements.

- **Operation and Maintenance Costs**: The cost of sustaining operational personnel and maintenance support. Examples include: spare/repair parts, test and support equipment, transportation and handling, facilities modifications, and technical data changes.

- **Product retirement and phase-out costs**: The cost of phasing the product out of inventory due to obsolescence or wear out, and subsequent equipment item recycling and reclamation as appropriate.
Learning Curve Impact on Estimate

- Help!
- Have a go
- Hit and miss
- "Sound"
- Relative Mastery
- Second Nature
Learning Curve Steps

- Unconscious incompetence
- Conscious incompetence
- Conscious competence
- Unconscious competence

Typically, unit performance improves by a fixed \% each time total production quantity doubles.

Learning Curve Example

A firm wins a contract to supply 30 units of a complex electronic device. The firm is competent to produce the device, but has never produced one this complex.

Learning Curve in Action
Typical manufacturing learning curve = 80%
• First unit estimated to take 10 hours to produce.
• Second unit would require: 0.80 x 10 = 8 hours
• Fourth unit: 0.80 x 8 = 6.4 hours
• Eighth unit: 0.80 x 6.4 = 5.12 hours
Eventually time levels out and no further gains accrued.
Review Questions

1. What are the pros & cons of top-down and bottoms-up budgeting?
2. How can the learning curve be applied to the time/cost estimate?
3. What is the expected range of accuracy of Definitive estimates?
4. Provide an example of fixed costs? Variable costs?
5. Explain the difference between and analogous and parametric estimate?
6. What is the purpose of value engineering?
Project Cost Management
Budgeting

Project Management Training Group
Illinois State University
Richard Boser
Cost Budgeting

Total cost baseline for measuring project performance
Traffic Enforcement Budget?

Source: http://www.lacp.org/Graphics/PoliceBike.jpg
## 7.2 Cost Budgeting

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Tools &amp; Techniques</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope</td>
<td>Cost aggregates</td>
<td>Cost baseline</td>
</tr>
<tr>
<td>□ WBS</td>
<td>□ Reserve analysis</td>
<td>□ Funding req.</td>
</tr>
<tr>
<td>□ WBS Dictionary</td>
<td>□ Parametric Est.</td>
<td>(Progress Pay)</td>
</tr>
<tr>
<td>□ Cost Estimate &amp;</td>
<td>□ Fund limiting reconciliation</td>
<td>□ Cost Mgmt Plan UP</td>
</tr>
<tr>
<td>Supporting detail</td>
<td>(Cost leveling)</td>
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<tr>
<td>□ Schedule</td>
<td></td>
<td>□ Req. changes</td>
</tr>
<tr>
<td>□ Res. Calendars</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Contracts</td>
<td></td>
<td></td>
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<tr>
<td>□ Cost Mgmt Plan</td>
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</tr>
</tbody>
</table>
What Elements Do Estimate & Budget Have in Common?

- Direct Costs of Resources
- Indirect Costs
  - Project Overhead
  - General & Administrative
- Contingency and Escalation
- Profit (Market factors)
- Above sums into baseline budget
Contingency & Escalation

- **Contingency:**
  - Specific provision(s) to mitigate random or unknown project risks from causing project failure or frequent baseline changes.
  - Reserves (2 Types): Provision in project plan to mitigate cost and/or schedule risk.

- **Escalation (Inflation)**
  - Anticipated rise in uncommitted costs of resources (labor, material, equipment) over duration of project.

Adapted from Max Wideman’s PM Glossary
Reserves – Known Unknowns

- Cost Estimating Tool
  - Contingency allowance
  - Discretion of PM
  - Anticipated but not certain events
  - Potentially overstates costs
  - Part of project scope and baseline
  - e.g. weather, productivity...
Reserves – Unknown Unknowns

- Budgeting Tool - Mgmt Contingency
  - Unplanned but potentially required changes to scope & baseline
  - Approval needed for PM to spend
  - May result from risk register
  - NOT part of project baseline
  - NOT part of EVA
    - e.g. risks, approved changes...
Cumulative Cost, Time & Uncertainty

Cumulative Project Cost

Contingency

Estimate

Time

Actual Cost/Time

Design Complete

Analysis Complete

Project Initiation

### Estimate Worksheet - Software Interface Project

1. **Project Phase (From WBS)**
   - Total staff hours Phase 1: 120
   - Total staff hours Phase 2: 92
   - Total staff hours Phase 3: 52
   - Total staff hours Phase 4: 166
   - Total staff hours Phase 5: 80
   - Total staff hours Phase 6: 20
   - Total staff hours Phase 7: 440
   - Total staff hours Phase 8: 40
   - Total staff hours Phase 9: 80
   - Total staff hours Phase 10: 60
   - **Total staff hours:** 1150

2. **Total staff hours @ $50/hr**
   - **$ 50.00**
   - **Total Personnel Costs:** $ 57,500

3. **Misc. Costs**
   - a. Materials/Furniture/Office Supplies: 16,000
   - b. Equipment: 46,500
   - c. Facilities: 32,000
   - d. Technology: 18,500
   - e. Information: n/a
   - f. External Vendors: 53,000
   - g. Other:
     - Training & Development: 12,000
   - **Total Misc. Resource Costs:** $ 178,000

4. **Sub-Total Project Costs:** $ 235,500

5. **Contingency (Mgmt Reserve)**
   - 15% on Sub-Total: 15%
   - **$ 35,325**

6. **TOTAL PROJECT COST:** $ 270,825
Budget Output - Cost Baseline

- Time-phased, used to measure & monitor cost performance.
- Cumulative costs typically result in S-curve.

PMBOK Fig. 7.2
# Budget Aggregation

<table>
<thead>
<tr>
<th>Cost Budget</th>
<th>$2,150</th>
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</thead>
<tbody>
<tr>
<td>Mgmt Reserve</td>
<td>$280 (e.g. 15%)</td>
</tr>
<tr>
<td>Cost Baseline</td>
<td>$1,870</td>
</tr>
<tr>
<td>Contingency Reserve</td>
<td>$170 (e.g. 10%)</td>
</tr>
<tr>
<td>Project</td>
<td>$1,700</td>
</tr>
<tr>
<td>Control Account</td>
<td>$1,000</td>
</tr>
<tr>
<td>Work Packages</td>
<td>$300 $700</td>
</tr>
<tr>
<td>Activities</td>
<td>$100 + $100 + $100</td>
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Questions & Notes
# 7.3 Cost Control

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<tr>
<th>Inputs</th>
<th>Tools &amp; Techniques</th>
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</thead>
<tbody>
<tr>
<td>Cost baseline</td>
<td>Cost change control system</td>
<td>Cost estimate UP</td>
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<tr>
<td>Funding require</td>
<td>Performance measurements</td>
<td>Baseline UP</td>
</tr>
<tr>
<td>Performance</td>
<td>Forecasting</td>
<td>Perform measure</td>
</tr>
<tr>
<td>reports</td>
<td>Proj perform review</td>
<td>Forecast complete</td>
</tr>
<tr>
<td>Work perform</td>
<td>PM software</td>
<td>Req changes</td>
</tr>
<tr>
<td>info</td>
<td>Variance mgmt</td>
<td>Corrective action</td>
</tr>
<tr>
<td>Change requests</td>
<td></td>
<td>Org Proc Asset UP (Lessons learned)</td>
</tr>
<tr>
<td>PM plan</td>
<td></td>
<td>PM plan UP</td>
</tr>
</tbody>
</table>
Cost Control (PMBOK)

- Monitor and document cost performance to detect and understand variance
- Ensure appropriate changes are recorded accurately on the cost baseline
- Prevent incorrect/unauthorized changes from being included on the cost baseline
- Inform stakeholders of authorized changes
- Acting to bring expected costs within acceptable limits
Change Requests
CHANGE ORDER
AIA Document G701

Distribution to:
Owner
Architect
Contractor
Field
Other

Project:
(name, address)

Change Order Number:

Initiation Date:

To (Contractor):

Architect's Project No:

Contract For:

Contract Date:

You are directed to make the following changes in this Contract:

The original Contract Sum or Guaranteed Maximum cost was $ 
Net change by previously authorized Change Orders: $ 
The Contract Sum or Guaranteed Maximum prior to this Change Order was $ 
The Contract Sum or Guaranteed Maximum will be (increased) (decreased) (unchanged) by this Change Order $ 
The new Contract Sum or Guaranteed Maximum including this Change Order will be $ 
The Contract Time will be (increased) (decreased) (unchanged) by Days 
The Date of Substantial Completion as of the date of this Change Order therefore is

Authorized:

ARCHITECT
Address

CONTRACTOR
Address

OWNER
Address

By
Date

By
Date

By
Date
Types of Progress Reporting

- Physical progress - % Complete
- 50/50 Rule -- A task is 50% complete once it is started and 100% complete only when finished
- 20/80 Rule -- A task is 20% complete once it is started and 100% complete only when finished
- 0/100 Rule -- A task does not get credit for partial completion it is 100% complete only when finished
Earned Value Management

- Is the project ahead/behind schedule?
- Is the project over/under budget?
- How efficiently is the project team using resources (time/money)?
- When is the project likely to be completed?
- What is the likely cost at completion?
Earned Value: Purpose

Management team can readily compare how much work has actually been completed against the amount of work planned to be accomplished. Planned work constitutes a cost and schedule measurement baseline.

Source: http://evm.nasa.gov/definition1b.html
EVA – 3 Key Values

- **Planned Value (PV)**
  - Physical work scheduled to be performed and the estimated value of work
  - (old – BCWS - Budgeted Cost of Work Scheduled)

- **Earned Value (EV) – Measured Progress**
  - Physical work actually accomplished including value of work
  - (old – BCWP - Budgeted Cost of Work Performed)

- **Actual Cost (AC)**
  - Cost incurred to accomplish the Earned Value
  - (old – ACWP – Actual Cost of Work Performed)

*Note: Values can be cost or time!*
EVA – Key Values Examples

- **Planned Value**: Total planned budget for a 5-day task is $1000 and it starts on Monday. If status date is the following Wednesday (end of day 3), the PV is $600.

- **Actual Cost**: If task actually incurs a total cost of $150 during each of the first 3 days, then AC is $450.

- **Earned Value**: If after 3 days 50% percent of the work on a task has been completed, then EV is $500.
Earned Value Ex. #1

Earned Value Graphic Report

Source: Adapted from PMBOK 2000 Fig. 10-2
Schedule Variance

Work performed is "earned" on the same basis it was planned, i.e. dollars, work hours, or other quantifiable units. Planned value (PV) compared with earned value (EV) measures work planned vs. work accomplished. Any difference is called schedule variance.

\[ SV = EV - PV \]

Source: Earned Value Mgmt @ http://evm.nasa.gov/definition1b.html
Cost Variance

**Earned Value** for work performed compared with **actual cost incurred** for work performed (from accounting systems), provides objective measure of **cost efficiency**. Any difference is **cost variance**.

\[ CV = EV - AC \]

Source: Earned Value Mgmt @ http://evm.nasa.gov/definition1b.html
Variance Calculations

\[ CV = EV - AC = 50K - 80K = -30K = \text{Cost Overrun} \]

\[ SV = EV - PV = 50K - 100K = -50K = \text{Behind Schedule} \]

\[ SPI = \frac{EV}{PV} = \frac{50K}{100K} = .50 \quad - \text{Progress at } 50\% \text{ planned rate.} \]

\[ CPI = \frac{EV}{AC} = \frac{50K}{80K} = .625 - \text{Earning } 62 \text{ cents on the $}. \]

Source: Earned Value Mgmt @ http://evm.nasa.gov/definition1b.html
Earned Value Ex. #2

A contractor agrees to build a 4 sided fence. The work is scheduled for ONE day per side (four consecutive days) at a cost of $1,000 per side (total $4,000). At the end of Three days work, the contractor has completed two sides of the fence and spent $2,500.

Perform an EVM analysis at this point in the project.

- **PV** = $3,000  
  Planned Value (PV) – Value of work scheduled to date
- **EV** = $2,000  
  Earned Value (EV) – Value of work actually accomplished
- **AC** = $2,500  
  Actual Cost (AC) - Cost incurred to accomplish work

Source: Rita Malcahy PMP Exam Prep
EVM Performance Measures

- Schedule Variance (SV) = EV – PV
  - Behind schedule, + Ahead of schedule
- Schedule Performance Index (SPI) = EV / PV
  - I am progressing at ___% of the planned rate.
- Cost Variance (CV) = EV – AC
  - Over budget, + Under budget
- Cost Performance Index (CPI) = EV / AC
  - I am getting $ ____ out of every $1.00 budgeted.

PC – Planned Value
EV – Earned Value
AC – Actual Cost of work performed
EVM Performance Measures

- **SV = EV − PV = $2,000 − $3,000 = (- $1,000)**
  - (Behind schedule)
    - “I am progressing at 67% of the planned rate.”

- **SPI = EV / PV = $2,000/$3,000 = 0.667**
  - (Behind schedule)

- **CV = EV − AC = $2,000 − $2,500 = (-$500)**
  - (Over budget)

- **CPI = EV / AC = $2,000/$2,500 = 0.800**
  - “I am getting $0.80 out of every $1.00 budgeted.”

- **PV = $3,000, EV = $2,000, AC = $2,500**
- **Schedule Variance (SV) = EV − PV**
- **Schedule Performance Index (SPI) = EV / PV**
- **Cost Variance (CV) = EV − AC**
- **Cost Performance Index (CPI) = EV / AC**
Costs at Completion

- **BAC** = Budget at Completion
  - How much was the total project budget?

- **ETC** = Estimate To Completion
  - From this point forward, how much MORE will it cost to finish the project?
  - \( \text{ETC} = \frac{(\text{BAC} - \text{EV})}{\text{CPI}} \)  -- or = \( \text{EAC} - \text{AC} \)

- **VAC** = Variance at Completion
  - How much over or under budget do we expect to be a completion of the project?
  - \( \text{VAC} = \text{BAC} - \text{EAC} \)
**Estimate at Completion (EAC)**

- EAC is the forecast of the most likely project costs based on performance reports and risk quantification (PMBOK).
- EAC = BAC / CPI
- May be in a cost range of high to low.
EAC - Ways to Calculate

1. EAC = BAC / CPI (Most common method)
   - Assumes current variance will continue

2. EAC = AC + ETC
   - Original estimate flawed or changing conditions make it irrelevant.

3. EAC = AC + (BAC – EV)
   - Use if project experienced atypical variance that is not expected to continue.

4. EAC = AC + (BAC – EV) / CPI
   - Similar to #2 only modified by Cost Performance Index

- BAC = Budget at Completion
- ETC = Estimate at Completion
- VAC = Variance at Completion
- PC = Planned Value
- EV = Earned Value
- AC = Actual Cost of work
EAC – Calculation Example

Which is most likely to yield realistic answer?

1. EAC = BAC / CPI = $4,000 / 0.80 = $5,000
2. EAC = AC + ETC
3. EAC = AC + (BAC – EV)
   = $2,500 + ($4,000 - $2,000) = $4,500
4. EAC = AC + (BAC – EV) / CPI
   = $2,500 + ($4,000 - $2,000) / 0.80 = $5,000

• PV = $3,000, EV = $2,000, AC = $2,500, CPI = 0.80
• BAC = Budget at Completion = $4,000
• ETC = Estimate at Completion
• VAC = Variance at Completion
• PC – Planned Value
• EV – Earned Value
• AC – Actual Cost of work
Summary of EVA Formulas

- PV
- AC
- EV
- CV = EV – AC
- CPI = EV / AC
- SV = EV – PV
- SPI = EV / PV
- BAC = Baseline $

- EAC = BAC / CPI
  = AC + ETC
  = AC + BAC – EV
  = AC + (BAC – EV)/CPI
- ETC = EAC – AC
  = (BAC – EV) / CPI
- VAC = BAC - EAC
Earned Value Activity

- The Pentagon agrees to build a 5 sided fence. The work is scheduled for ONE month per side at a cost of $1,000 per side (total $5,000). At the end of 3 months work, the contractor has completed 2 sides of the fence and spent $4,000 (and seeking change orders to recoup costs).

- Perform an EVM analysis at this point in the project.

  \[
  \begin{align*}
  PV &= \underline{} \\
  AC &= \underline{} \\
  EV &= \underline{} \\
  CV &= \underline{} \\
  CPI &= \underline{} \\
  BAC &= \underline{} \\
  SV &= \underline{} \\
  SPI &= \underline{} \\
  EAC &= \underline{} \\
  ETC &= \underline{} \\
  VAC &= \underline{} 
  \end{align*}
  \]

Adapted From Rita Malcahy PMP Exam Prep
## EVA Ex. #3 Worksheet

<table>
<thead>
<tr>
<th>EVA Item</th>
<th>Value</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BAC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EAC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ETC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VAC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Cost Management Plan

☐ How will you handle cost variance?
☐ EVA indicates cost and schedule overruns! What now?
☐ Identify 4-6 corrective actions you would take.
## EVA Performance Report
(PMBOK)

<table>
<thead>
<tr>
<th>#</th>
<th>WBS Element</th>
<th>Budget Planned Value $ (PV)</th>
<th>Earned Value $ (EV)</th>
<th>Cost Actual Value $ (AC)</th>
<th>Cost Variance CV=EV-AC</th>
<th>% CV / EV</th>
<th>Schedule Variance SV=EV-PV</th>
<th>% SV / PV</th>
<th>Performance Index EV / AC</th>
<th>Schedule SPI EV / PV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Pre-Pilot Plan</td>
<td>63,000</td>
<td>58,000</td>
<td>62,500</td>
<td>(4,500)</td>
<td>-7.8%</td>
<td>(5,000)</td>
<td>-7.9%</td>
<td>0.93</td>
<td>0.92</td>
</tr>
<tr>
<td>2.0</td>
<td>Checklists</td>
<td>64,000</td>
<td>48,000</td>
<td>46,800</td>
<td>1,200</td>
<td>2.5%</td>
<td>(16,000)</td>
<td>-25.0%</td>
<td>1.03</td>
<td>0.75</td>
</tr>
<tr>
<td>3.0</td>
<td>Curriculum</td>
<td>23,000</td>
<td>20,000</td>
<td>23,500</td>
<td>(3,500)</td>
<td>-17.5%</td>
<td>(3,000)</td>
<td>-13.0%</td>
<td>0.85</td>
<td>0.87</td>
</tr>
<tr>
<td>4.0</td>
<td>Midterm Eval</td>
<td>68,000</td>
<td>68,000</td>
<td>72,500</td>
<td>(4,500)</td>
<td>-6.6%</td>
<td>-</td>
<td>0.0%</td>
<td>0.94</td>
<td>1.00</td>
</tr>
<tr>
<td>5.0</td>
<td>Implementation Support</td>
<td>12,000</td>
<td>10,000</td>
<td>10,000</td>
<td>-</td>
<td>0.0%</td>
<td>(2,000)</td>
<td>-16.7%</td>
<td>1.00</td>
<td>0.83</td>
</tr>
<tr>
<td>6.0</td>
<td>Manual of Practice</td>
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<td>6,000</td>
<td>200</td>
<td>3.2%</td>
<td>(800)</td>
<td>-11.4%</td>
<td>1.03</td>
<td>0.89</td>
</tr>
<tr>
<td>7.0</td>
<td>Roll-Out Plan</td>
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<td>13,500</td>
<td>18,100</td>
<td>(4,600)</td>
<td>-34.1%</td>
<td>(6,500)</td>
<td>-32.5%</td>
<td>0.75</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td><strong>Totals</strong></td>
<td><strong>257,000</strong></td>
<td><strong>223,700</strong></td>
<td><strong>239,400</strong></td>
<td><strong>(15,700)</strong></td>
<td><strong>-7.0%</strong></td>
<td><strong>(33,300)</strong></td>
<td><strong>-13.0%</strong></td>
<td><strong>0.93</strong></td>
<td><strong>0.87</strong></td>
</tr>
</tbody>
</table>

Source: PMBOK 2000 Fig 10-3
Earned Value Ex. #4

<table>
<thead>
<tr>
<th>#</th>
<th>WBS Element</th>
<th>Budgeted</th>
<th>Planned</th>
<th>Earned Value $ (EV)</th>
<th>Budgeted at Completion BAC</th>
<th>Planned (PV)</th>
<th>Earned Value $ (EV)</th>
<th>Earned Value Analysis Activity - Determine each of the EV values for the Project Report below</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>A</td>
<td>94,000</td>
<td>94,000</td>
<td>94,000</td>
<td>95,000</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>B</td>
<td>36,000</td>
<td>36,000</td>
<td>36,000</td>
<td>36,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>C</td>
<td>44,000</td>
<td>34,000</td>
<td>30,000</td>
<td>27,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.0</td>
<td>D</td>
<td>56,000</td>
<td>40,000</td>
<td>32,000</td>
<td>34,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>E</td>
<td>42,000</td>
<td>8,000</td>
<td>6,600</td>
<td>7,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td>F</td>
<td>64,000</td>
<td>24,000</td>
<td>21,000</td>
<td>22,500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td>336,000</td>
<td>236,000</td>
<td>219,600</td>
<td>221,000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Review Questions

1. What is the purpose of earned value analysis?
2. What does the earned value number tell you?
3. The CPI and SPI are both > 1.0. Is this good or bad for your project?
4. What does a CPI of 0.82 mean to your project?
5. What is the difference between ETC and EAC?
Association for the Advancement of Cost Engineering (AACE) References

- Cost Estimate Classification System

- COST ENGINEERING TERMINOLOGY
## Answers to EVA Activity

<table>
<thead>
<tr>
<th>EVA Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV</td>
<td>3,000</td>
</tr>
<tr>
<td>EV</td>
<td>2,000</td>
</tr>
<tr>
<td>AC</td>
<td>4,000</td>
</tr>
<tr>
<td>BAC</td>
<td>5,000</td>
</tr>
<tr>
<td>CV</td>
<td>(2,000)</td>
</tr>
<tr>
<td>CPI</td>
<td>50%</td>
</tr>
<tr>
<td>SV</td>
<td>(1,000)</td>
</tr>
<tr>
<td>SPI</td>
<td>67%</td>
</tr>
<tr>
<td>EAC</td>
<td>10,000</td>
</tr>
<tr>
<td>ETC</td>
<td>6,000</td>
</tr>
<tr>
<td>VAC</td>
<td>(5,000)</td>
</tr>
</tbody>
</table>

The Pentagon agrees to build a 5 sided fence. The work is scheduled for ONE month per side at a cost of $1,000 per side (total $5,000). At the end of 3 months work, the contractor has completed 2 sides of the fence and spent $4,000 (and seeking change orders to recoup costs).
Depreciation

- Large assets (such as equipment, buildings) have a loss of value over their useful life. Funds must be set aside to replace obsolete and worn out equipment.

- Types:
  - Straight-Line Depreciation
  - Accelerated Depreciation
    - Double Declining Balance
    - Sum of the Year Digits

- Ask your account for appropriate recovery costs as overhead charges.
Straight-Line Example

- A $5,000 computer with a $200 salvage value and an estimated useful life of three years would be depreciated by $1,600 annually.
- $5,000 - $200 = $4,800/3 = $1,600
Sum of the Years Digits

- Take expected life of an asset (in years) count back to one and add the figures together.
- Example: 10 years useful life = 10 + 9 + 8 + 7 + 6 + 5 + 4 + 3 + 2 + 1 - Sum of years = 55
- First year asset depreciated 10/55 in value [the fraction 10/55 is equal to 18.18%], second year 9/55 [16.36%], etc.
Opportunity Cost

- The opportunity given up by selecting one project over another. No calculations required. Example: Project D has an NPV of $100,000 and Project H has an NPV of $180,000. What is the opportunity cost of selecting Project H?
- Answer: $100,000 – you gave up Project D
Sunk Cost

- Expended costs.
- According to accounting standards, sunk costs most considered when decided to continue with a troubled project.
- Would you throw good money after bad?
Methods of Project Selection

- Payback Period
- Present Value
- Net Present Value
- Internal Rate of Return
- Benefit Cost Ratio
Pay-Back Period

- Period over which the total cash flow receipts from a project equal the original investment, without discounting.
- Project cost $10,000 and is expected to save company $5,000/yr. Payback = ____?
- Your firm has 2 project alternatives to choose from. Which is most favorable?
  - Project A has payback = 10 months
  - Project B has payback = 18 months
- Answer: Project A – Investment recovered faster
### Present Value (Not for Cash Flows)

PV = \( FV/(1+r)^n \)

- **FV** = future value
- **r** = interest rate
- **n** = # of time periods

Present value of $700,000 received 4-years from now if expect interest rate is 6% is:

\[
\text{ANSWER} = \frac{700,000}{(1 + .06)^4} \\
= \frac{700,000}{1.262477} \\
= 554,465.50
\]
Net Present Value (NPV) Discounted Cash Flows

- You have two projects to choose from. Project A will take 3 years to complete and has a NPV of US $1,200,000. Project B will take 4 years to complete and has a NPV of US $1,500,000. Which Project would you prefer?

- Answer: Project B – the number of years was already taken into account when calculating the NPV
**Internal Rate of Return (IRR)**

- Interest rate at which inflows = outflows
- Return earned on the capital invested in the project
  - Discount rate which gives an NPV of zero.
  - Equivalent to the yield on the investment.
- You have two Projects to choose from. Project A with an IRR of 23% or Project B with an IRR of 45%. Which one would you prefer?
  - Answer: Project B (Bigger is better!)
Benefit Cost Ratio (BCR)

- If BCR > 1 then benefits greater than cost
- If BCR < 1 then benefits are less than cost

- A BCR of 1.5 means that
  A. Costs are greater than benefits
  B. Payback is 1.5 times cost
  C. Profit is 1.5 times cost
  D. Costs are 1.5 times profit

  - Answer: B - BCR focuses on revenue
Review Questions

1. What financial tools can be used to aid in project selection?

2. What do you need to know about depreciation?

3. Project cost $10,000 and is expected to save company $10,000/yr. Payback = ____?

4. How do sunk costs differ from opportunity costs?
Project Cost Management

The End!

Project Management Training Group
Illinois State University
Richard Boser