L10: Budgeting and Cost Control

Instructor(s)
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Lecture 10

Oct. 11, 2012
System Project Management
ESD.36 Framework

Enterprise has chosen what product or system to develop

Next Project

Project Preparation
Project Planning
Project Adaptation
Project Monitoring
Project Control
Project Completion
Project Learning
Outline

- Tracking of Resource Consumption and Progress
  - Creating Measurable Plans
  - Schedule, Cost Tracking – “easy”
  - Scope/Progress Tracking – “hard”
  - Risk Tracking - how? (dedicated lecture to risk management)

- Industrial Practice
  - “Earned Value Management” (EVM)

- Role of Metrics in Project Management
  - Process-related metrics
  - Product-related metrics
Discussion Point

- What should we track on projects and why should we track it?
Project Tracking Challenges

- CPM/PERT, DSM, SD- our project planning tools are intended to help us establish a credible baseline for planned schedule, project and product cost- tracking should then be easy, right? But...
  - Timely data suited to direct use for project tracking is difficult to access
  - Competing agendas in project resource organizations make the already difficult task of technical progress assessment even harder
  - Fitting the data into the proper context for project assessment requires time and judgment
- The fidelity of tracking can be no better than the corresponding plan- detailed and realistic planning requires significant effort
Many following examples and methods draw upon DOD/aerospace practices

- Methods originated in industry
- Initial application found to be resource-intensive
- DOD applied due to project size and complexity

Commercial practices are converging with defense (movement in both directions) as IT infrastructure enables data acquisition and analyses

- Practices are coming full circle
- Stage-gate processes require tracking metrics

Tailoring for your organization and project is essential
Creating Measurable Plans

1. DEFINE THE WORK

2. SCHEDULE THE WORK

3. ALLOCATE BUDGETS

Planning Resolution & Timing

**Work Packages**
Detailed, short-span tasks, or material items, required to accomplish the objectives, typically in the near term (include costs & completion criteria)

**Planning Packages**
Future work that has not been detail planned as work packages. They are always scheduled to occur in the future.

Source: MCG [www.acq.osd.mil/evm](http://www.acq.osd.mil/evm)
Mapping Work to Resources

Source: public domain; MCG [www.acq.osd.mil/evm]
Project Planning & Control Context

Project management cycle

- Preparation
- Planning
- Execute/Monitor
- Adapt/Control
- Close out

Project/program manager tasks

- Develop a realistic plan of the work scope, the budget, and the schedule
- Organize the work and the teams
- Authorize work properly
- Control changes
- Performance reporting
- Understand variances
- Corrective actions
- Forecast of final cost and schedule
Data Sources for Project Tracking

- Project cost is usually tracked in development organization finance system
  - Data should be tracked on a ‘per task, per resource’ basis to be most useful
  - As outsourcing becomes a major strategy, similar costs must be gathered from suppliers
    - Reporting requirements need to be contractually specified
- Work completion is usually measured by milestone, but requires detailed planning and ‘costed’ tasks—this is often the most problematic measurement
  - ‘Percent complete’ measurements are notoriously unreliable
  - Milestone-based reporting is least ambiguous, but requires substantial planning effort
Earned Value Management

- Initially developed in industry (1970s)
- DOD adopted initially as “CSSR”, imposed on major contracts
  - CSSR = Cost, Schedule, Status Reporting
- Has converged into current Earned Value Management System (EVMS) in both commercial and DOD use
- If based on reasonable plan, excellent source of risk identification and project control metrics
Implementation Spectrum

Where

Commercial or Defense

<table>
<thead>
<tr>
<th>Small Companies</th>
<th>Larger Companies</th>
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<tbody>
<tr>
<td>as desired</td>
<td>corporate policy, “enterprise wide”</td>
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</table>

When

FFP contracts? DoD Non-Major Contracts (>12 months) DoD Major Contracts

<table>
<thead>
<tr>
<th>&lt;$6M*</th>
<th>&gt;$6M</th>
<th>&gt;$70M RDT&amp;E</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>&gt;$300M Prod</td>
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</table>

Reports

streamlined, no paper? tailored to needs C/SSR CPR

<table>
<thead>
<tr>
<th>DoD Non-Major Contracts (&gt;$12 months)</th>
<th>DoD Major Contracts (&gt;100M Prod)</th>
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<tbody>
<tr>
<td>C/SSR</td>
<td>CPR</td>
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</table>

Core EV Principles Tailored Applications ANSI/EIA-748-1998 (32 criteria)

Government Organic Foreign Countries

Major Defense Contractors

Small Companies Larger Companies as desired corporate policy, “enterprise wide” DoD Non-Major Contracts (>12 months) DoD Major Contracts (>100M Prod) C/SSR CPR

streamlined, no paper? tailored to needs

Commercial or Defense

Where

When

Reports

Core EV Principles Tailored Applications ANSI/EIA-748-1998 (32 criteria)
### 3+2=5 Key Elements

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>BCWS</td>
<td>Budgeted Cost of Work Scheduled</td>
</tr>
<tr>
<td>BCWP</td>
<td>Budgeted Cost of Work Performed</td>
</tr>
<tr>
<td>ACWP</td>
<td>Actual Cost of Work Performed</td>
</tr>
<tr>
<td>BAC</td>
<td>Budget at Completion</td>
</tr>
<tr>
<td>EAC</td>
<td>Estimate at Completion</td>
</tr>
</tbody>
</table>

**Planned Value**

**Earned Value**

**Actual Cost**
Schedule Variance

- **BC W$** of the work I scheduled to have done, how much did I budget for it to cost?
- **BC WP** of the work I actually performed, how much did I budget for it to cost?

**SCHEDULE VARIANCE** is the difference between work scheduled and work performed (expressed in terms of budget dollars)

**formula:** \( SV \$ = BCWP - BCWS \)

**example:**

\[
SV = BCWP - BCWS = \$1,000 - \$2,000 \\
SV = -$1,000 \text{ (negative = behind schedule)}
\]
Cost Variance

<table>
<thead>
<tr>
<th>BCWP</th>
<th>ACWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>of the work I actually performed, how much did I budget for it to cost?</td>
<td></td>
</tr>
<tr>
<td>of the work I actually performed, how much did it actually cost?</td>
<td></td>
</tr>
</tbody>
</table>

**COST VARIANCE** is the difference between budgeted cost and actual cost

**formula:** \[ CV \$ = BCWP - ACWP \]

**example:**
- \[ CV = BCWP - ACWP = \$1,000 - \$2,400 \]
- \[ CV = -$1,400 \] (negative = cost overrun)
Variance at Completion (VAC)

**BAC**
what the **total** job is **supposed** to cost

**EAC**
what the **total** job is **expected** to cost

**VARIANCE AT COMPLETION** is the difference between what the total job is supposed to cost and what the total job is now expected to cost.

**FORMULA:** \[ \text{VAC} = \text{BAC} - \text{EAC} \]

**Example:**
\[ \text{VAC} = $5,000 - $7,500 \]
\[ \text{VAC} = - $2,500 \quad (\text{negative} = \text{overrun}) \]
# 5 Basic Questions/Parameters

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>ANSWER</th>
<th>ACRONYM</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much work <strong>should</strong> be done?</td>
<td>Budgeted Cost for Work Scheduled</td>
<td>BCWS</td>
</tr>
<tr>
<td>How much work <strong>is</strong> done?</td>
<td>Budgeted Cost for Work Performed</td>
<td>BCWP</td>
</tr>
<tr>
<td>How much did the <strong>is done</strong> work cost?</td>
<td>Actual Cost of Work Performed</td>
<td>ACWP</td>
</tr>
<tr>
<td>What was the total job <strong>supposed to cost?</strong></td>
<td>Budget at Completion</td>
<td>BAC</td>
</tr>
<tr>
<td>What do we <strong>now expect</strong> the total job to cost?</td>
<td>Estimate at Completion</td>
<td>EAC</td>
</tr>
</tbody>
</table>
Concept Question 1

Which of these 5 quantities is most difficult to track? (and why?)

- BCWS
- BCWP
- ACWP
- BAC
- EAC
Earned Value Data Elements

Source: MCG www.acq.osd.mil/evm
- ESD.36J SPM

Massachusetts Institute of Technology
EV Data Elements- Variances

Source: MCG [www.acq.osd.mil/evm](http://www.acq.osd.mil/evm)
EV Data Elements- Projections

Source: MCG [www.acq.osd.mil/evm](http://www.acq.osd.mil/evm)
### Data Analysis Relationships

<table>
<thead>
<tr>
<th>Term</th>
<th>Symbol</th>
<th>Formula</th>
<th>Checklist Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Complete</td>
<td>% Done</td>
<td>BCWP / BAC</td>
<td>Ratio of work accomplished in terms of the total amount of work to do.</td>
</tr>
<tr>
<td>Cost Performance Index or</td>
<td>CPI</td>
<td>BCWP / ACWP</td>
<td>Ratio of work accomplished against money spent (Efficiency Rating: Work Done for Resources Expended)</td>
</tr>
<tr>
<td>Performance Factor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To Complete Performance Index</td>
<td>TCPI</td>
<td>BAC - BCWP</td>
<td>Ratio of work remaining against money remaining (Efficiency which must be achieved to complete the remaining work with the expected remaining money)</td>
</tr>
<tr>
<td>or Verification Factor</td>
<td>or VF</td>
<td>EAC - ACWP</td>
<td></td>
</tr>
<tr>
<td>Schedule Performance Index</td>
<td>SPI</td>
<td>BCWP / BCWS</td>
<td>Ratio of work accomplished against what should have been done (Efficiency Rating: Work done as compared to what should have been done)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimate At Completion</td>
<td>EAC</td>
<td>ETC + ACWP</td>
<td>Calculation of the estimate to complete plus the money spent</td>
</tr>
<tr>
<td>Estimate To Complete</td>
<td>ETC</td>
<td>BAC - BCWP</td>
<td>Calculation of the budgeted work remaining against the performance factor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CPI</td>
<td></td>
</tr>
</tbody>
</table>

Source: MCG [www.acq.osd.mil/evm](http://www.acq.osd.mil/evm)
Risk Indicators

EVM provides several metrics that can “flag” potential problems (risks) either as trends or thresholds.

- CPI: Good = ≥ 1.0
- SPI: Good = ≥ 1.0
Concept Question 2

- The ACWP of a project is $5.5M, the BCWS is $6.0M and the BCWP is $5M. The SPI and CPI are:
  - SPI=1.2, CPI=0.83
  - SPI=0.91, CPI=1.2
  - SPI=0.83, CPI=0.91
  - SPI=1.2, CPI=0.83
  - SPI=0.91, CPI=1.05
Email excerpt from one of my NASA sponsored projects:

....they passed on to us new EVM color coding guidelines from the Chief Engineer. We all frantically updated our charts. The failure to communicate was that I did not pass these new guideline to the PI's and COTR's before I left. In my defense, I only got a paper copy of the rules. So it was not straight forward to transfer. The main change is that being higher than 1.1 on your CPI or SPI is bad and colored that way. So you need to cover that in your comments. The new standards for CPI/SPI's are:

\[
0.9 \leq CPI/SPI \leq 1.1 \quad \text{GREEN}
0.8 \leq CPI/SPI < 0.9 \quad \text{YELLOW}
1.1 < CPI/SPI \leq 1.2 \quad \text{YELLOW}
\]

CPI/SPI < 0.8 or CPI/SPI > 1.2 \quad \text{RED}

We will use these for the next Monthly reports.

Question to the class:
  - What message does this send?
Planning ‘Granularity’

- To use EVMS with a reasonable amount of management resources, plan at the appropriate level of detail
- Avoid ‘% complete’ estimation
- Plan work packages with short duration, estimated package cost, and clear deliverable
- Assign ‘earned value’ at discrete levels, e.g.:
  - Zero value until work package start
  - 50% value while executing
  - Full value when deliverable is complete
Management Reserve

- Calculate total project management reserve required based on
  - statistical modeling
  - past experience
Project Control & Leverage

- Management reserve (cost and schedule) are important project management tools
  - Amounts based on statistical analyses, past experiences typically in the 10-30% range
  - Reserves should be planned and validated with the overall project plan

- The project manager **owns** management reserve and unallocated budget/schedule
  - Release of Management Reserve should be part of a formal, risk-driven process
  - Requests for reserve allocation should follow a quantitative template
Formulation of Project Metrics

- May be marginal, absolute, probabilistic
  - = X% improvement in __________
  - = X value of __________
  - = X value of __________ with 90% confidence
- Tradition is metric based on benefit/performance (with cost*, schedule and risk assessed later)
- Current practice is metric based on benefit/performance and cost
- “Ideal” would be metrics which include benefit/performance, schedule, cost and risk

* cost can include liens on resources in addition to $
Example:
F/A-18 E/F Gross Takeoff Weight (GTOW) Tracking
Problems with Metrics

- Identifying real and appropriate metrics is often one of the most difficult parts of engineering system design and projects
  - customer often does not vocalize real metric
  - often have several metrics (must treat independently or combine)
- Metrics don’t necessarily add linearly
  - mass does, cost doesn’t (can push cost to another element easily)
  - hard to flow metrics down
Earned Value Management ‘GOLD CARD’

- Please see https://acc.dau.mil/gc
Summary

- **Budgeting and Cost Control**
  - Need to monitor Schedule, Cost, Technical Progress vs Budget
  - Risk Identification and Tracking is crucial, but challenging (next week)
  - Formalized methods exist, e.g. EVM, but need to adapt to needs of particular projects
    - Large government project >$1B class
    - commercial product development $10M-100M class
    - small entrepreneurial firm <$10M