Basics of Cost and Schedule Monitoring

Nathaniel Osgood

4/5/2004
Announcements

- **Tuesday field trip**
  - Leave at 4pm
  - At existing platform 4:15pm

- Problem set grading: ps1 ongoing, ps2 end of this week

- TP3 out today

- Questions on problem set?
Topics

- Monitoring and Scheduling: The Big Picture
- Monitoring
  - Links to previous topics
  - Key components in realizing effective monitoring
  - Measurement: Basics of cost and schedule tracking
    - Components of Measurability
    - Collecting information
  - Performance Metrics
  - Forecasting
  - Quality monitoring
Monitoring and Control: Two Parts of a Feedback System

- Goal is to *detect* and *correct* deviation from desired
  - Budget
  - Schedule
  - Quality

- Detection: Monitoring
- Correction: Control
  - Much harder than monitoring!
  - Bring project performance back in line with plans
  - Typical: Bring plans in line with performance
Growing Expenditures, Declining Control
Definitions

Monitoring: Project Monitoring is the set of procedures and management practices used to collect information about the performance achieved or forecasted in a project and the developing organization, based on a set of performance metrics.

Performance Analysis: The process of determining performance variances based on monitored or forecasted performance.
Project Control: The purpose of project control is to adjust the project to meet its goals by assessing the performance of the project, analyzing the causes of performance problems, designing changes to address problems that are determined to need attentions, and implementing those changes through control actions. Project control is distinguished from project planning in two important ways: 1) project control yields a set of designs, decisions, and actions, whereas project planning yields a design, and 2) project control is a real time process during the implementation, not before the implementation begins.
Critical Role of a Feedback System

- Totally static planning is a (useful!) *fiction*
- Many factors make deviations *standard e.g.*
  - Physical: Weather, diff. geotechnical conditions,…
  - Early or late delivery of procured items
  - Changes in owner needs
  - Differences in productivity
  - Community opposition/Concerns abutting buildings
  - Mistakes in planning
- Even within slack, have resource constraints
- Morale often dependent on good planning
<table>
<thead>
<tr>
<th>Rank</th>
<th>Challenge</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coping with end-date-driven schedules</td>
<td>85%</td>
</tr>
<tr>
<td>2</td>
<td>Coping with resource limitations</td>
<td>83%</td>
</tr>
<tr>
<td>3</td>
<td>Communicating effectively among task groups</td>
<td>80%</td>
</tr>
<tr>
<td>4</td>
<td>Gaining commitment from team members</td>
<td>74%</td>
</tr>
<tr>
<td>5</td>
<td>Establishing measurable milestones</td>
<td>70%</td>
</tr>
<tr>
<td>6</td>
<td>Coping with changes</td>
<td>60%</td>
</tr>
<tr>
<td>7</td>
<td>Working out project plan agreement with team</td>
<td>57%</td>
</tr>
<tr>
<td>8</td>
<td>Gaining commitment from management</td>
<td>45%</td>
</tr>
<tr>
<td>9</td>
<td>Dealing with conflict</td>
<td>42%</td>
</tr>
<tr>
<td>10</td>
<td>Managing vendors and subcontractors</td>
<td>38%</td>
</tr>
<tr>
<td>11</td>
<td>Other challenges</td>
<td>35%</td>
</tr>
</tbody>
</table>
# Problems Ranked by General and Engineering Managers

<table>
<thead>
<tr>
<th>Rank by</th>
<th>General Managers</th>
<th>Engineering Managers</th>
<th>Reason or Problem</th>
<th>Frequency of Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rarely</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td></td>
<td>Insufficient Front-End Planning</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td></td>
<td>Unrealistic Project Plan</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td></td>
<td>Project Scope Underestimated</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td></td>
<td>Customer/Management Changes</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>13</td>
<td></td>
<td>Insufficient Contingency Planning</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td></td>
<td>Inability to Track Progress</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td></td>
<td>Inability to Detect Problems Early</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td></td>
<td>Insufficient Number of Checkpoints</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td></td>
<td>Staffing Problems</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td></td>
<td>Technical Complexities</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>6</td>
<td></td>
<td>Priority Shifts</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>10</td>
<td></td>
<td>No Commitment by Personnel to Plan</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>7</td>
<td></td>
<td>Sinking Team Spirit</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>14</td>
<td></td>
<td>Unqualified Project Personnel</td>
<td></td>
</tr>
</tbody>
</table>

Directly observed reasons for schedule slips and budget overruns. Solid bar, engineering managers' ranking; twisted bar, general managers' ranking.
Topics

- Monitoring and Scheduling: The Big Picture

  - Monitoring

    - Links to previous topics
    - Key components in realizing effective monitoring
    - Measurement: Basics of cost and schedule tracking
      - Components of Measurability
      - Collecting information
    - Performance Metrics
    - Forecasting
    - Quality monitoring
Links to Earlier Topics: Scheduling

- Scheduling provides us with a yardstick to help us understand what to expect over time
  - Work Progress
  - Expenditures
  - Without some scheduling, we would have nothing against which to compare progress!

- Monitoring ⇒ Scheduling: Must reformulate schedule to reflect discrepancies!
Schedule Updates from Monitoring

- New estimates for activity
  - Costs
  - Durations
  - Resource availability

- Must compute new critical path
  - May lead to changed monitoring priorities

- NB: A schedule that does not get updated to reflect in-field conditions is
  - Unlikely to be used
  - Dangerous if used
Project Plan is the Foundation of Effective Monitoring

- Plan Ahead
- Involve Project Team Members during the Planning
- Define Specific Task Responsibility
- Obtain Commitment
- Assure Measurability
Cost Estimation helps us understand cost implications of activities

- Often this is folded into the schedule
- Without estimation, we also would have nothing against which to compare progress!

Often used to prepare initial budget

- Problems
  - Different level of granularity
  - Estimate oriented towards outside reporting
Topics

✓ Monitoring and Scheduling: The Big Picture

■ Monitoring
  ✔ Links to previous topics
  ■ Key components in realizing effective monitoring
  ■ Measurement: Basics of cost and schedule tracking
    ■ Components of Measurability
    ■ Collecting information
  ■ Performance Metrics
  ■ Forecasting
  ■ Quality monitoring
Components of Effective Monitoring

- **Representative Performance Metrics** (established at planning phase)
- **Cost & Schedule Milestones** should be well-defined and clearly approved/rejected.
- **Reporting Schedule** (perhaps of variable $\Delta t$’s)
  - Financial importance of activity
  - Activity criticality
  - Rate of work
  - Difficulty of work
- **Management Scheme** organized for honestly and accurately identifying and reporting performance
- **Involvement** of responsible and knowledgeable people in the reporting scheme
- **Project Reviews** (walkthrough’s & inspections)
- **Project Audits**
### Characteristics of Effective Management Cost Control Systems

#### BUDGETS
- Budgets are broken into cost elements, such as activities broken into time phases, showing expenditure profiles.
- They are estimated by responsible individuals.
- Budgets are associated with known risk factors and uncertainties.
- Budgets are agreed on between a responsible manager and upper management.
- Budgets are made in constant dollars, hence providing for adjustment for inflation or overhead changes.

#### ACTIVITIES
- Activities are part of a clear and systematic cost model (e.g., the WBS).
- They are clearly defined in terms of the work to be performed, results, timing, and individual responsibilities.
- Activities are agreed on by the individual responsible regarding the work, timing, and budget.
- They are measurable milestones and deliverables.
- Activities are associated with a singular controlling authority, responsible for results.
- Activities are visible throughout the project and the organization, and there is senior management involvement.
- Activities are reflective of overall project objectives.
- Activities are regularly reviewed by management.
- Activities are monitored to detect early problems regarding task accomplishment and integration.
Topics

✓ Monitoring and Scheduling: The Big Picture

■ Monitoring
  ✓ Links to previous topics
  ✓ Key components in realizing effective monitoring

■ Measurement: Basics of cost and schedule tracking
  ■ Components of Measurability
  ■ Collecting information

■ Performance Metrics

■ Forecasting

■ Quality monitoring
Measurement of Project Progress

- Traditional measures of project “progress” are based on resources consumed
  - Time spent
  - Money spent
- What is the problem with this?
Effective Measurement

- Most effective progress measurements are carried out not on project *inputs* (\$, labor, time, etc.) but on project *outputs*
  - Goal: Measure *progress towards completion*
- Inputs are easy to measure; how do we measure *outputs*?
  - Where possible, divide activities into stages
  - Define clear-cut milestones
  - Keep track of costs, labor, time on per-activity basis
Characteristics of Well Defined Milestone

- Clearly Defined Entity
- Verifiable Parameters for Each Delivery Item
- Clear Relationship to Program Management Plan
- Well Defined Responsible Organization or Individual
# Steps for Establishing Measurable Milestones

## Steps in Establishing Measurable Milestones

<table>
<thead>
<tr>
<th>Planning Activity and Responsible Organization or Individual</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Start with customer and/or sponsor requirement and develop program management plan. (Customer and program office responsible)</td>
<td>Project/system specifications, statement of work, work breakdown structure, project management subplans, budget, schedule, project team roster</td>
</tr>
<tr>
<td>2 Define key milestones throughout the life cycle of the project. (Program office or engineering manager responsible)</td>
<td>Milestone schedule, dates for design review, tests, prototypes, installations, documentation, training</td>
</tr>
<tr>
<td>3 Define deliverable items for each milestone. (Engineering manager and task leader responsible)</td>
<td>List of deliverables (for example, milestone for design review: diagrams, tradeoff analysis, make-buy decisions, system specifications, bill of material, safety plan, test plans)</td>
</tr>
<tr>
<td>4 Define specific parameters for each deliverable item. (Task leader responsible)</td>
<td>Statement of work, task authorization, specifications, vendor test, sign-off, report, method</td>
</tr>
<tr>
<td>5 Establish modular cost budgets for each key milestone; try to establish cost accounts for each deliverable item. (Engineering manager and task leader responsible)</td>
<td>Budgets, elements of cost task budgets such as: Tasks A-D: deliverable 1, $12,000. Tasks E-K: deliverable 2, $50,000. Tasks L-P: deliverable 3, $8,000.</td>
</tr>
</tbody>
</table>
Measuring Progress w/i Activity

- **Units completed (units task specific)**
  - ft Rebar laid, # columns placed, yd$^3$ earth moved, panels mounted, ft$^2$ drywall placed, ft piping installed

- **Incremental sub-task milestones**
  - Each associated with agreed-upon fraction of work
  - May be weighted if going on simultaneously

- **Supervisor subjective opinion**

- **Binary start-finish**

- **Input measure: $ incurred/estimated total $**
Key Component: Linking Activities and Count Accounts

- **Recording granularity critical** – limits what can be understood with the data
- **Many-to-many mapping between**
  - Cost categories
  - Activities
- **Traditional operational accounting would just have cost code with type of item being charged**
- **Ways of addressing**
  - More detailed cost code (incorporating activity)
  - Apportioning of ambiguous costs according to non-ambiguous
Tradeoffs in Cost Granularity

- **More detailed advantages**
  - Preserves option of finer investigation
  - Can allow for quicker
    - Response to deviations
    - Determination if control strategies helping

- **Less detailed advantages**
  - Less work for staff
  - Faster recording
  - Lower likelihood of error/compliance failure
Means of Collecting Data

- Foremen note progress on timesheets
  - (Implicit): Team
  - Cost category for item
  - Square footage for progress estimate (if lucky…)
- Payroll clerk enters timesheets in office
- Additional managerial attention can be applied for important activities
Review: Cost Breakdown Structure

- Canonical way of accounting for costs in the project
- Assigns accounts for different types of expenditures
- Should permits tracking expenditure by activity (work item)
- Often includes WBS-based characterization (e.g. CSI Masterformat)
Managerial vs. Financial Accounting

- **Managerial (“Cost”) Accounting**
  - Reporting to managers for strategic planning
  - Operational use

- **Financial accounting**
  - Typically for outside parties (owners, taxes, regulators, …)
  - Trans. in general ledger (double-entry bookkeeping)
  - Familiar income and balance-sheets
  - Many “accounting fictions” to systematically account for flows
Recall: Cost Code

- Mirrored by cost hierarchy
- Commonly include standardized and project components
  - Project id (often has useful info to avoid lookup)
    - Often omitted from internal project references
  - Area-facility code (geographically distributed projects, or areas of a facility unique to project)
  - Work-type code: WBS May be standard code (e.g. CSI Masterformat) if uniform across projects
  - Distribution code: Cost type associated with work
    - (e.g. Materials, Equipment, Labor, Subcontract, etc.)
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>201</td>
<td>Clearing and preparing site</td>
</tr>
<tr>
<td>202</td>
<td>Substructure</td>
</tr>
<tr>
<td>202.1</td>
<td>Excavation and shoring</td>
</tr>
<tr>
<td>202.2</td>
<td>Piling</td>
</tr>
<tr>
<td>202.3</td>
<td>Concrete masonry</td>
</tr>
<tr>
<td>202.31</td>
<td>Mixing and placing</td>
</tr>
<tr>
<td>202.32</td>
<td>Formwork</td>
</tr>
<tr>
<td>202.33</td>
<td>Reinforcing</td>
</tr>
<tr>
<td>203</td>
<td>Outside utilities (water, gas, sewer, etc.)</td>
</tr>
<tr>
<td>204</td>
<td>Superstructure</td>
</tr>
<tr>
<td>204.1</td>
<td>Masonry Construction</td>
</tr>
<tr>
<td>204.2</td>
<td>Structural steel</td>
</tr>
<tr>
<td>204.3</td>
<td>Wood framing, partitions, etc.</td>
</tr>
<tr>
<td>204.4</td>
<td>Exterior finishes (brickwork, terra cotta, cut stone, etc.)</td>
</tr>
<tr>
<td>204.5</td>
<td>Roofing, drains, gutters, flashing, etc.</td>
</tr>
<tr>
<td>204.6</td>
<td>Interior finish and trim</td>
</tr>
<tr>
<td>204.61</td>
<td>Finish flooring, stairs, doors, trim</td>
</tr>
<tr>
<td>204.62</td>
<td>Glass, windows, glazing</td>
</tr>
<tr>
<td>204.63</td>
<td>Marble, tile, terrazo</td>
</tr>
<tr>
<td>204.64</td>
<td>Lathing and plastering</td>
</tr>
<tr>
<td>204.65</td>
<td>Soundproofing and insulation</td>
</tr>
<tr>
<td>204.66</td>
<td>Finish hardware</td>
</tr>
<tr>
<td>204.67</td>
<td>Painting and decorating</td>
</tr>
<tr>
<td>204.68</td>
<td>Waterproofing</td>
</tr>
<tr>
<td>204.69</td>
<td>Sprinklers and fire protection</td>
</tr>
<tr>
<td>204.7</td>
<td>Service work</td>
</tr>
<tr>
<td>204.71</td>
<td>Electrical work</td>
</tr>
<tr>
<td>204.72</td>
<td>Heating and ventilating</td>
</tr>
<tr>
<td>204.73</td>
<td>Plumbing and sewage</td>
</tr>
<tr>
<td>204.74</td>
<td>Air conditioning</td>
</tr>
<tr>
<td>204.75</td>
<td>Fire alarm, telephone, security, miscellaneous</td>
</tr>
<tr>
<td>205</td>
<td>Paving, curbs, walks</td>
</tr>
<tr>
<td>206</td>
<td>Installed equipment (elevators, revolving doors, mail chutes, etc.)</td>
</tr>
<tr>
<td>207</td>
<td>Fencing</td>
</tr>
</tbody>
</table>
Cost Code Illustration

Developing Project Code from Standard Code

- Recognize & Categorize Physical & Geographical Features in Project
- Delete Unnecessary Items Modify or Expand Important Parts

- Standard Cost Code
- Project Number
- Area-Facility Code
- Work-Type Code
- Distribution Code

0 = Total
1 = Labor
2 = Material
3 = Equipment
4 = Subcontract, etc.
Example Project Code

- **Project Code**: 88NB04
- **Floor**: 11th
- **Work Type Code**: 03320
- **Distribution Code**: 2
- **Material Cost**: [Lightweight Aggregate]
- **Other Codes**:
  - 88 = Job Start 1988
  - N = Negotiated Contract
  - B = Building
  - 04 = 4th Building this year
Reporting

- Often delayed (minimizing delay critical in effectiveness of feedback systems)
- Selective reporting widely used: Report only problematic items
- Frequent reporting for
  - Important (e.g. high cost)
  - Uncertainty (Unfamiliar procedure, …)
  - Critical
  - Scope
<table>
<thead>
<tr>
<th>Factor</th>
<th>(1) Budgeted Cost</th>
<th>(2) Estimated Total Cost</th>
<th>(3) Cost Committed</th>
<th>(4) Cost Exposure</th>
<th>(5) Cost to Date</th>
<th>(6) Over or (Under)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>$99,406</td>
<td>$102,342</td>
<td>$49,596</td>
<td>—</td>
<td>$52,746</td>
<td>$2,936</td>
</tr>
<tr>
<td>Material</td>
<td>88,499</td>
<td>88,499</td>
<td>42,506</td>
<td>45,993</td>
<td>—</td>
<td>0</td>
</tr>
<tr>
<td>Subcontracts</td>
<td>198,458</td>
<td>196,323</td>
<td>83,352</td>
<td>97,832</td>
<td>15,139</td>
<td>(2,135)</td>
</tr>
<tr>
<td>Equipment</td>
<td>37,543</td>
<td>37,543</td>
<td>23,623</td>
<td>—</td>
<td>13,920</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>72,693</td>
<td>81,432</td>
<td>49,356</td>
<td>—</td>
<td>32,076</td>
<td>8,739</td>
</tr>
<tr>
<td>Total</td>
<td>496,599</td>
<td>506,139</td>
<td>248,433</td>
<td>143,825</td>
<td>113,881</td>
<td>9,540</td>
</tr>
</tbody>
</table>
# Reporting: Example 2

## A Cash Flow Status Report ($)

<table>
<thead>
<tr>
<th></th>
<th>Charges</th>
<th>Estimated</th>
<th>% Complete</th>
<th>Projected</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs 7/02</td>
<td>8,754,516</td>
<td>65,863,092</td>
<td>13.292</td>
<td>66,545,263</td>
<td>682,171</td>
</tr>
<tr>
<td>Billings 7/01</td>
<td>67,511,602</td>
<td>9,276,621</td>
<td>13.741</td>
<td>966,339</td>
<td></td>
</tr>
<tr>
<td>Payables 7/01</td>
<td>6,719,103</td>
<td>1,300,089</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receivables 7/02</td>
<td>8,761,673</td>
<td>7,209,344</td>
<td>391,671</td>
<td>343,653</td>
<td></td>
</tr>
<tr>
<td>Cash Position</td>
<td>7,062,756</td>
<td>7,209,344</td>
<td>146,588</td>
<td>2,067,277</td>
<td></td>
</tr>
</tbody>
</table>

**Total:** 8,754,516
Integrated S-Curve

[Diagram showing an integrated cost/schedule system with labels for contracted costs, actuals, target cost (BCWS), cost overrun to date (against the budget), management reserve, scheduled performance, and schedule slippage-to-date.]
Exploratory Breakdown

- Business intelligence software
- Dynamic breakdown by category
- Popular for high-level managers
- Common examples (EXCEL): PivotTable, PivotChart
Schedule vs Cost Monitoring

- **Schedule estimates: Aggregate measures suspect**
  - Remember that some activities much more important than others!
    - May want to track particular activities
  - Falling behind on non-critical activities may shift critical path

- **Cost estimates: All sources of cost can lead to cost overruns**
  - In general, impact of absolute cost overrun from one activity similar to other activities
Topics

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  - Performance Metrics
  - Forecasting
  - Quality monitoring
Main categories of performance metrics:

- scope
- time
- money
- quality
- productivity
- safety

Performance Metrics typically are defined in preparation for project monitoring before project control.

Must facilitate the project control process as well as the reporting functions of project monitoring.
# Main Performance Metrics

<table>
<thead>
<tr>
<th>Categories</th>
<th>Performance measurements</th>
<th>Targets</th>
<th>Units of measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scope</strong></td>
<td>Amount of work accomplished</td>
<td>Amount of work to be accomplished</td>
<td>M, M², M³, Tons, $</td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td>Completion dates</td>
<td>Milestones, Deadline</td>
<td>Day, Week, Month</td>
</tr>
<tr>
<td><strong>Money</strong></td>
<td>Cost, Cash flow</td>
<td>Budget, Profit, Cash flow</td>
<td>$, Net Present Value (NPV)</td>
</tr>
<tr>
<td><strong>Quality</strong></td>
<td>Quality achieved (Appearance, Durability, Strength, Suitability)</td>
<td>Target quality level (Appearance, Durability, Strength, Suitability)</td>
<td>Number of defects, Value of defects, Number of change orders</td>
</tr>
<tr>
<td><strong>Safety</strong></td>
<td>Actual accidents and injuries, delays and economic damages occurred</td>
<td>Goaled accidents and injuries level</td>
<td>Person, $, Day, Week, Month</td>
</tr>
<tr>
<td><strong>Productivity</strong></td>
<td>Actual productivity</td>
<td>Planned productivity</td>
<td>Work unit/worker/time</td>
</tr>
</tbody>
</table>
Earned Value Approach - Definitions

Integrating cost, schedule, and work performed by ascribing monetary values to each.

- **Budgeted Cost of Work Scheduled (BCWS, $)**: the value of work scheduled to be accomplished in a given period of time.
- **Actual Cost of Work Performed (ACWP, $)**: the costs actually incurred in accomplishing the work performed within the control time.
- **Budgeted Cost of Work Performed (BCWP, $)**: the monetary value of the work actually performed within the control time (= Earned Value).
- **Actual Time of Work Performed (ATWP, time)**
- **Schedule Time of Work Performed (STWP, time)**
Earned Value Chart

Cost Schedule Plan (Baseline)

Actual Cost

BCWS
Schedule Variance

BCWP

Value Completed

Spending Variance or Cost Overrun (Quantity and Price)

Time Variance (10 day delay)

Month

Dollars

Earned Value Chart
Cost Variance

- **Is project spending more or less money than anticipated for the work that I did?**

- **Cost Variance** \( (CV = BCWP - ACWP) \)
  - + (Underrun); - (Overrun); 0 (On Budget)

- **Cost Index** \( (CI = BCWP/ACWP) \)
  - > 1 (Underrun); < 1 (Overrun); 1 (On Budget)
Schedule Variance

- One metric for judging if project making is “progressing” faster or slower than expected
  - More precisely: “How does the value of the work I have actually performed compare to the work I anticipated performing during this time?”
  - “Progress” here is measured in value of the work ($)
- Calculated in $ -- but here this is a proxy for value
- Schedule Variance \( SV = BCWP - BCWS \)
  - + (Ahead); - (Behind); 0 (On Schedule)
  - Even if just slightly ahead/behind in time, may be large if working on very expensive component of project
- Schedule Index \( SI = \frac{BCWP}{BCWS} \)
  - > 1 (Ahead); < 1 (Behind); 1 (On Schedule)
Time Variance

- Is project spending more or less time than anticipated for the work that I did?
- Measured in units of time
- May be very close even if big difference in the resource spending

- Time Variance \( (TV = STWP - ATWP) \)
  - + (Ahead); - (Delay); 0 (On Schedule)

- Time Index \( (TI = STWP / ATWP) \)
  - > 1 (Ahead); < 1 (Delay); 1 (On Schedule)
Resource Flow Variance

- *Compares* how much expecting to **spend** during this timeframe with what actually spent – regardless of how much work got done.

- **Warning:** Doesn’t indicate bad or good. e.g. = if
  - Going faster but more cheaply than expected
  - Going slower but more expensively than expected

- **Resource Flow Variance** \((RV = BCWS - ACWP)\)
  - + (Underrun); - (Overrun); 0 (On Target)

- **Resource Flow Index** \((RI = BCWS / ACWP)\)
  - > 1 (Underrun); < 1 (Overrun); 1 (On Target)
Control Limits

![Graph showing control limits and budget costs over weeks.](image-url)
Example: Gantt Chart Schedule

ACTIVITY

A
B
C
D
E
F
G

WEEKS

0  5  10  15  20  25

Non Critical Path Activity
Critical Path Activity
## Example: Traditional Reporting

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>A</th>
<th>B</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>DURATION (WEEKS)</td>
<td>5</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>COST (IN $)</td>
<td>1,500</td>
<td>3,000</td>
<td>5,700</td>
</tr>
<tr>
<td>COST PER WEEK (IN $)</td>
<td>300</td>
<td>1,000</td>
<td>814</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>WEEK 1</th>
<th>WEEK 2</th>
<th>WEEK 3</th>
<th>WEEK 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ACTIVITY STATUS</td>
<td>ACTUAL COST</td>
<td>ACTIVITY STATUS</td>
<td>ACTUAL COST</td>
</tr>
<tr>
<td>A</td>
<td>STARTED</td>
<td>$ 500</td>
<td>IN PROCESS</td>
<td>$ 1,000</td>
</tr>
<tr>
<td>B</td>
<td>STARTED</td>
<td>1,000</td>
<td>IN PROCESS</td>
<td>2,000</td>
</tr>
<tr>
<td>E</td>
<td>STARTED</td>
<td>814</td>
<td>IN PROCESS</td>
<td>1,500</td>
</tr>
</tbody>
</table>
Example: Earned Value Reporting

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>A</th>
<th>B</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTUAL COST (IN $)</td>
<td>1,500</td>
<td>3,000</td>
<td>2,900</td>
</tr>
<tr>
<td>BUDGETED COST (IN $)</td>
<td>300 × 4 = 1,200</td>
<td>3,000</td>
<td>814 × 4 = 3,256</td>
</tr>
<tr>
<td>WORK PERFORMED AS % OF WORK CONTENT</td>
<td>100</td>
<td>100</td>
<td>2/7 = 28.6</td>
</tr>
</tbody>
</table>
Example: Activity Analysis

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>BCWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$1,500</td>
</tr>
<tr>
<td>B</td>
<td>$3,000</td>
</tr>
<tr>
<td>E</td>
<td>$1,628</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>ACWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$1,500</td>
</tr>
<tr>
<td>B</td>
<td>$3,000</td>
</tr>
<tr>
<td>E</td>
<td>$2,900</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>BCWS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$300 \times 4 = $1,200</td>
</tr>
<tr>
<td>B</td>
<td>$3,000</td>
</tr>
<tr>
<td>E</td>
<td>$814 \times 4 = 3,256</td>
</tr>
</tbody>
</table>
**Example: Variances**

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>BCWP - ACWP = CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$1,500 - $1,500 = $0</td>
</tr>
<tr>
<td>B</td>
<td>$3,000 - $3,000 = $0</td>
</tr>
<tr>
<td>E</td>
<td>$1,628 - $2,900 = -$1,272</td>
</tr>
<tr>
<td></td>
<td><strong>CUMULATIVE VARIANCE = -$1,272</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>BCWP - BCWS = SV</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$1,500 - $1,200 = $300</td>
</tr>
<tr>
<td>B</td>
<td>$3,000 - $3,000 = $0</td>
</tr>
<tr>
<td>E</td>
<td>$1,628 - $3,256 = -$1,628</td>
</tr>
<tr>
<td></td>
<td><strong>CUMULATIVE VARIANCE = -$1,328</strong></td>
</tr>
</tbody>
</table>
## Example: Activity Indexes

<table>
<thead>
<tr>
<th>Activity</th>
<th>BCWP/BCWS</th>
<th>SI</th>
<th>BCWP/ACWP</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1,500/1,200</td>
<td>1.25</td>
<td>1,500/1,500</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>3,000/3,000</td>
<td>1</td>
<td>3,000/3,000</td>
<td>1</td>
</tr>
<tr>
<td>E</td>
<td>1,628/3,256</td>
<td>0.5</td>
<td>1,628/2,900</td>
<td>0.56</td>
</tr>
</tbody>
</table>
Example: Project Indexes

The Aggregate Cost Index is:

\[
SI = \frac{1,500 + 3,000 + 1,628}{1,200 + 3,000 + 3,256} = 0.82
\]

\[
CI = \frac{1,500 + 3,000 + 1,628}{1,500 + 3,000 + 2,900} = 0.83
\]
### Example: Earned Value Reporting

Values (in Dollars) of BCWS, BCWP, and ACWP for Weeks 1-4

<table>
<thead>
<tr>
<th>Activity</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BCWS</td>
<td>BCWP</td>
<td>ACWP</td>
<td>BCWS</td>
</tr>
<tr>
<td>A</td>
<td>300</td>
<td>500</td>
<td>500</td>
<td>300</td>
</tr>
<tr>
<td>B</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>E</td>
<td>814</td>
<td>300</td>
<td>814</td>
<td>814</td>
</tr>
<tr>
<td></td>
<td>2,114</td>
<td>1,800</td>
<td>2,314</td>
<td>2,114</td>
</tr>
</tbody>
</table>
Example: Earned Value Analysis

Values of SI and CI for Weeks 1-4

<table>
<thead>
<tr>
<th>Week</th>
<th>BCWS ($)</th>
<th>BCWP ($)</th>
<th>ACWP ($)</th>
<th>CI = ( \frac{BCWP}{ACWP} )</th>
<th>SI = ( \frac{BCWP}{BCWS} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2,114</td>
<td>1,800</td>
<td>2,314</td>
<td>0.78</td>
<td>0.85</td>
</tr>
<tr>
<td>2</td>
<td>4,228</td>
<td>3,700</td>
<td>4,500</td>
<td>0.82</td>
<td>0.88</td>
</tr>
<tr>
<td>3</td>
<td>6,342</td>
<td>5,000</td>
<td>6,300</td>
<td>0.79</td>
<td>0.79</td>
</tr>
<tr>
<td>4</td>
<td>7,456</td>
<td>6,128</td>
<td>7,400</td>
<td>0.83</td>
<td>0.82</td>
</tr>
</tbody>
</table>
Example: Schedule and Cost Index

Schedule Index for the Project

Cost Index for the Project
Example: Integrating CI and SI

Integrating CI and SI

- Schedule problems
- Budget OK
- Project on schedule and on budget
- Schedule and budget problems
- Budget problems
- Schedule OK

Week 1 (0.85, 0.78)
Week 2 (0.88, 0.82)
Week 3 (0.79, 0.79)
Week 4 (0.82, 0.83)