COST MANAGEMENT

NWCCC MEETING
April 28, 1999
SHERATON PORTLAND, OREGON

M. STEVEN FRANKLIN, CCE
HARRIS GROUP, INC.
PORTLAND, OREGON
503-228-7200
PURPOSE: To acquaint you with various cost management terms and techniques, to assist you in implementing them on your jobs.

FRAMEWORK: Cost management during various phases of a project (see "Phases of a project" chart).
ABILITY TO INFLUENCE FINAL COST OVER PROJECT LIFE

ABILITY TO INFLUENCE COST

CONCEPTUAL

DETAILED ENGINEERING

PROCUREMENT

CONSTRUCTION

COST EXPENDITURE

COST INFLUENCE

START DATE

TIME

NEED DATE

STARTUP
<table>
<thead>
<tr>
<th>PHASES OF A PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROJECT IDENTIFICATION</td>
</tr>
<tr>
<td>- FEASIBILITY ESTIMATE</td>
</tr>
<tr>
<td>- PROJECT PLAN</td>
</tr>
<tr>
<td>PROJECT PLANNING</td>
</tr>
<tr>
<td>- PRELIM CONTROL ESTIMATE</td>
</tr>
<tr>
<td>- MILESTONE SCHEDULE</td>
</tr>
<tr>
<td>PROJECT DEFINITION</td>
</tr>
<tr>
<td>- SCOPE &amp; ESTIMATE</td>
</tr>
<tr>
<td>- FRONT-END SCHEDULE</td>
</tr>
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</tr>
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</tr>
<tr>
<td>DETL ENG + PROC SCHED'S</td>
</tr>
<tr>
<td>CONSTRUCTION</td>
</tr>
<tr>
<td>- FINAL CONTROL ESTIMATE</td>
</tr>
<tr>
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</tr>
<tr>
<td>STARTUP</td>
</tr>
<tr>
<td>- FINAL COSTS</td>
</tr>
<tr>
<td><em>AS BUILT</em> SCHEDULES</td>
</tr>
</tbody>
</table>

Harris Group Inc.
PROJECT IDENTIFICATION PHASE
Order of magnitude estimating

End-Product Units

Scale of Operations

Ratio or Factor Methods
  - Multiple of Equipment Cost
  - Hand Factors

Physical Dimensions Method

Parametric Estimates

Cost Indices
Order of magnitude estimating

End-Product Units

Project A $100mm for 100 widgets
Project B 50 widgets => $50mm

Scale of Operations

Ratio or Factor Methods
- Multiple of Equipment Cost
- Hand Factors

Physical Dimensions Method

Parametric Estimates

Cost Indices
Order of magnitude estimating

End-Product Units

**Scale of Operations**  
$100\text{mm} \times (50/100)^6 = 66\text{mm}$

Ratio or Factor Methods  
- Multiple of Equipment Cost
- Hand Factors

Physical Dimensions Method

Parametric Estimates

Cost Indices
Order of magnitude estimating

End-Product Units

Scale of Operations

Ratio or Factor Methods
- Multiple of Equipment Cost
  1.5 * EQ$ self-contained
  6.0 * EQ$ small parts
- Hand Factors

Physical Dimensions Method

Parametric Estimates

Cost Indices
Order of magnitude estimating

End-Product Units

Scale of Operations

Ratio or Factor Methods
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Physical Dimensions Method
Historical costs per area, volume, length, etc.

Parametric Estimates

Cost Indices
Order of magnitude estimating

End-Product Units

Scale of Operations

Ratio or Factor Methods
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- Hand Factors

Physical Dimensions Method

Parametric Estimates
  "End-product" parameters
    Key Physical Quantities
    Unit hours & costs
  Total

Cost Indices
Order of magnitude estimating

End-Product Units

Scale of Operations

Ratio or Factor Methods
  - Multiple of Equipment Cost
  - Hand Factors

Physical Dimensions Method

Parametric Estimates

Cost Indices

Cost @ one time & place

"Watchouts": technology, cycles, location, lag, averages
Document how to use
Order of magnitude estimating

Good results if:
- Defined process
- Skilled user

End-Product Units

Scale of Operations

Ratio or Factor Methods
- Multiple of Equipment Cost
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Physical Dimensions Method

Parametric Estimates

Cost Indices
### PRELIMINARY PRODUCTION COST ESTIMATING FORM

**Location:** 

**Product(s):** 

**Capital Investment:** 

<table>
<thead>
<tr>
<th>Total</th>
<th>Nelson Index:</th>
<th>CE Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less working capital</td>
<td>M&amp;S Index</td>
<td>Annual Operating</td>
</tr>
<tr>
<td>Less salvage value</td>
<td>ENR Index:</td>
<td>Days:</td>
</tr>
<tr>
<td>Depreciable investment</td>
<td>Annual production:</td>
<td></td>
</tr>
</tbody>
</table>

**Raw materials**

<table>
<thead>
<tr>
<th>Raw materials</th>
<th>Annual quantity</th>
<th>Unit cost</th>
<th>$/year</th>
<th>$/</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Gross raw material cost (sum of lines 1 to 4): 

**Misc. credits and debits**

<table>
<thead>
<tr>
<th>Misc. credits and debits</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(6)</td>
<td></td>
</tr>
<tr>
<td>(7)</td>
<td></td>
</tr>
<tr>
<td>(8)</td>
<td></td>
</tr>
<tr>
<td>(9)</td>
<td>Total debit (credit) (sum of lines 6 to 8):</td>
</tr>
<tr>
<td>(10)</td>
<td>Net raw material cost (lines 5 + line 9):</td>
</tr>
</tbody>
</table>

**Direct expense**

<table>
<thead>
<tr>
<th>Direct expense</th>
<th>Unit</th>
<th>Quantity</th>
<th>Unit cost</th>
<th>$/year</th>
<th>$/</th>
</tr>
</thead>
<tbody>
<tr>
<td>(11) Steam</td>
<td>M lb</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(12) Water ( )</td>
<td>M gal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(13) Water ( )</td>
<td>M gal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(14) Electricity</td>
<td>kW-hr</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(15) Fuel ( )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(16) Fuel ( )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(17) Labor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(18) Supervision</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(19) Maintenance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(20) Factory supplies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(21) Indirect overhead</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(22) Payroll overhead</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(23) Laboratory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(24) Contingencies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(25)</td>
<td>Total direct conversion cost (sum of lines 11 to 24):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Indirect expense**

<table>
<thead>
<tr>
<th>Indirect expense</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(26) Depreciation</td>
<td></td>
</tr>
<tr>
<td>(27) Real estate taxes &amp; insurance</td>
<td></td>
</tr>
<tr>
<td>(28) Depletion allowances</td>
<td></td>
</tr>
<tr>
<td>(29) Amortization</td>
<td></td>
</tr>
<tr>
<td>(30)</td>
<td>Total indirect conversion cost (sum of lines 26 to 29):</td>
</tr>
<tr>
<td>(31) Total conversion cost (line 25 + line 30):</td>
<td></td>
</tr>
<tr>
<td>(32) Total operating cost (line 31 + line 10):</td>
<td></td>
</tr>
<tr>
<td>(33) Packing &amp; shipping expense</td>
<td></td>
</tr>
<tr>
<td>(34) TOTAL COST FOR PLANT (line 32 + line 33):</td>
<td></td>
</tr>
</tbody>
</table>

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NEW PRODUCT EVALUATION

Given: New product in the electronic industry

Investment: 70 units
5-year life
Straight Line Depreciation

Sales Potential: 7 times the investment or approximately 500 units
Cost (variable): 45% to 55% to sales
Income Taxes: 50%
Cost of Capital: 20%

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>50.0</td>
<td>71.3</td>
<td>90.0</td>
<td>127.5</td>
<td>160.00</td>
<td>498.8</td>
<td></td>
</tr>
<tr>
<td>Variable Expense</td>
<td>27.5</td>
<td>39.2</td>
<td>49.5</td>
<td>58.7</td>
<td>73.6</td>
<td>248.5</td>
<td></td>
</tr>
<tr>
<td>Fixed Expense</td>
<td>14.0</td>
<td>14.0</td>
<td>14.0</td>
<td>14.0</td>
<td>14.0</td>
<td>70.0</td>
<td></td>
</tr>
<tr>
<td>Total Expense</td>
<td>41.5</td>
<td>53.2</td>
<td>63.5</td>
<td>72.7</td>
<td>87.6</td>
<td>318.5</td>
<td></td>
</tr>
<tr>
<td>Taxable Balance</td>
<td>8.5</td>
<td>18.1</td>
<td>26.5</td>
<td>54.8</td>
<td>72.4</td>
<td>180.3</td>
<td></td>
</tr>
<tr>
<td>Tax at 50%</td>
<td>4.3</td>
<td>9.0</td>
<td>13.3</td>
<td>27.4</td>
<td>36.2</td>
<td>90.2</td>
<td></td>
</tr>
<tr>
<td>Balance A.T.</td>
<td>4.2</td>
<td>9.1</td>
<td>13.2</td>
<td>27.4</td>
<td>36.2</td>
<td>90.1</td>
<td></td>
</tr>
<tr>
<td>Plus: Depreciation</td>
<td>14.0</td>
<td>14.0</td>
<td>14.0</td>
<td>14.0</td>
<td>14.0</td>
<td>70.0</td>
<td></td>
</tr>
<tr>
<td>Less: Investment</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(70.0)</td>
<td></td>
</tr>
<tr>
<td>Cash Flow</td>
<td>(70)</td>
<td>18.2</td>
<td>23.1</td>
<td>27.2</td>
<td>41.4</td>
<td>50.2</td>
<td>90.1</td>
</tr>
</tbody>
</table>

Return on Investment = 29%
Net present value at 20% cost of capital = 17.1

Notes:
PHASES OF A PROJECT
PROJECT PLANNING PHASE
PARAMETER ESTIMATE

"END-PRODUCT" PARAMETERS

KEY QUANTITIES

APPROPRIATE UNIT RATES

TOTAL COST
PHASES OF A PROJECT

PROJECT IDENTIFICATION
- FEASIBILITY ESTIMATE
- PROJECT PLAN

PROJECT PLANNING
- PRELIM CONTROL ESTIMATE
- MILESTONE SCHEDULE

PROJECT DEFINITION
- SCOPE & ESTIMATE
- FRONT-END SCHEDULE

DETAIL ENGINEERING
- BUDGET ESTIMATE
- DETL. ENG/RG + PROC SCHEDS

CONSTRUCTION
- FINAL CONTROL ESTIMATE
- DETAIL CONSTRUCTION

STARTUP
- FINAL COSTS
- "AS BUILT" SCHEDULES

Harris Group Inc.
PROJECT DEFINITION/ENGINEERING
### TOTAL PROJECT COST BREAKDOWN STRUCTURE AND WORK BREAKDOWN STRUCTURE RELATIONSHIP

<table>
<thead>
<tr>
<th>PHASES</th>
<th>INDIRECTS (1)</th>
<th>DIRECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Labor</td>
</tr>
<tr>
<td>Conceptual Engineering</td>
<td>$</td>
<td>WH</td>
</tr>
<tr>
<td>Detailed Engineering</td>
<td>$</td>
<td>WH</td>
</tr>
<tr>
<td>Procurement</td>
<td>$</td>
<td>WH</td>
</tr>
<tr>
<td>Construction</td>
<td>$</td>
<td>WH</td>
</tr>
<tr>
<td>Startup</td>
<td>$</td>
<td>WH</td>
</tr>
<tr>
<td>Other (2)</td>
<td>$</td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**
- The COST BREAKDOWN STRUCTURE (CBS) is composed of all elements in the matrix for which dollars ($) are budgeted. The total dollar value of all of these elements equals the project budget.
- The WORK BREAKDOWN STRUCTURE (WBS) is composed of those direct labor elements in the matrix for which work-hours (WH) are budgeted and lend themselves to work progress measurement.

**Footnotes:**
1. Supervision above first level, staff, facilities, supplies and services, travel, etc.
2. Home office overhead, contingency reserve, profit, etc.
INTEGRATED PROJECT CONTROL SYSTEMS

WBS
SCHEDULE ACTIVITIES

CBS
COST ACCOUNTS

ESTIMATE
<table>
<thead>
<tr>
<th>COST</th>
<th>FINANCIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pareto's law</td>
<td>Receipts</td>
</tr>
<tr>
<td>Labor cost</td>
<td>Expenditures</td>
</tr>
<tr>
<td>Productivity</td>
<td>Payments</td>
</tr>
<tr>
<td>Worker hours</td>
<td>Taxes</td>
</tr>
<tr>
<td>Quantity control</td>
<td>Capitalization</td>
</tr>
<tr>
<td>Commitments</td>
<td></td>
</tr>
</tbody>
</table>
Constructability is …..

"the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives"

maximize concurrent construction
minimize rework
increase productivity
decrease construction equipment costs
design for less costly materials & less waste
startup & construction drive engineering & procurement
emphasize standardization & repetition
use off-the-shelf materials & equipment
simplify
promote accessibility
realistic specifications
minimize unscheduled activities
incorporate flexibility for field managers
work when & where it is most efficient
proactive attention, NOT just "review"
team effort by owner, engineer, constructor & operator
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increase productivity
decrease construction equipment costs
design for less costly materials & less waste
startup & construction drive engineering & procurement
emphasize standardization & repetition
use off-the-shelf materials & equipment
simplify
promote accessibility
realistic specifications
minimize unscheduled activities
incorporate flexibility for field managers
work when & where it is most efficient

**proactive attention, NOT just "review"**
team effort by owner, engineer, constructor & operator
Constructability is …

"the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives"

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**team effort by owner, engineer, constructor & operator**
Definitive Estimate

Review the documents
Prepare the summary
Prepare bid file
Prepare for takeoffs (forms, wage rates,..)
Site visit
Quantity takeoff of work items "in sequence"
Costing - hours, $
Sources
Construction equipment
Subcontracts
Indirects - General Conditions, Overhead
Alternates
Allowances
Markups - Contingency, Profit
Tabulate
Check & Review
Cuts/Adds
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Forecasting during Design

Purchases

"Best guess" quantities
CONSTRUCTION PHASE
Work Measurement

Based on WBS

Methods:
Units completed
Milestones
Start / finish
Opinion
Cost ratio
Weighted value equivalent units
# Monthly Quantity Report

## Service Water Piping

<table>
<thead>
<tr>
<th>Weight</th>
<th>Activity</th>
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Field Engineer
Control Account for Service Water Piping

Service Water Piping

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Cumulative

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Cost & Schedule Performance

You have summarized all control accounts in area A of a project to the end of the reporting period. You note that you had scheduled 28,000 work hours, had earned 26,000 work hours and actually paid for 25,000 work hours. Analyze the cost and schedule status in area A at the end of the reporting period.
Cost & Schedule Performance

You have summarized all control accounts in area A of a project to the end of the reporting period. You note that you had scheduled 28,000 work hours, had earned 26,000 work hours and actually paid for 25,000 work hours. Analyze the cost and schedule status in area A at the end of the reporting period.

BCWS
BCWP
ACWP
Cost & Schedule Performance

You have summarized all control accounts in area A of a project to the end of the reporting period. You note that you had scheduled 28,000 work hours, had earned 26,000 work hours and actually paid for 25,000 work hours.

Analyze the cost and schedule status in area A at the end of the reporting period.

<p>| | |</p>
<table>
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Cost & Schedule Performance

You have summarized all control accounts in area A of a project to the end of the reporting period. You note that you had scheduled 28,000 work hours, had earned 26,000 work hours and actually paid for 25,000 work hours.

Analyze the cost and schedule status in area A at the end of the reporting period.

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<td>SV = BCWP - BCWS</td>
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<tr>
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<td>SPI = BCWP / BCWS</td>
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<tr>
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**Cost & Schedule Performance**

You have summarized all control accounts in area A of a project to the end of the reporting period. You note that you had scheduled 28,000 work hours, had earned 26,000 work hours and actually paid for 25,000 work hours. Analyze the cost and schedule status in area A at the end of the reporting period.

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Productivity

In planning and budgeting a fixed price project, a given work package was estimated to include 200 units of work. Estimators further utilized a unit rate of 4 work hours per unit of work so budgeted for 800 work hours in this account. In the field, it was subsequently determined that there were really 240 units of work to be performed. This was strictly an estimating error and, with no contingency fund available, the budget remained at 800 work hours. At the end of the latest reporting period, work was 50% complete (120 units) and 432 work hours had been paid for. Is this package overrunning or underrunning cost? Is productivity better or worse than planned?
Productivity

In planning and budgeting a fixed price project, a given work package was estimated to include 200 units of work. Estimators further utilized a unit rate of 4 work hours per unit of work so budgeted for 800 work hours in this account. In the field, it was subsequently determined that there were really 240 units of work to be performed. This was strictly an estimating error and, with no contingency fund available, the budget remained at 800 work hours. At the end of the latest reporting period, work was 50% complete (120 units) and 432 work hours had been paid for. **Is this package overrunning or underrunning cost?**

Is productivity better or worse than planned?

<table>
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<tr>
<th>Budget</th>
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<th>Total</th>
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<tbody>
<tr>
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<td>W-H</td>
<td>W-H/unit</td>
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Productivity

In planning and budgeting a fixed price project, a given work package was estimated to include 200 units of work. Estimators further utilized a unit rate of 4 work hours per unit of work so budgeted for 800 work hours in this account. In the field, it was subsequently determined that there were really 240 units of work to be performed. This was strictly an estimating error and, with no contingency fund available, the budget remained at 800 work hours. At the end of the latest reporting period, work was 50% complete (120 units) and 432 work hours had been paid for. **Is this package overrunning or underrunning cost?**

Is productivity better or worse than planned?

<table>
<thead>
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<th>To-go</th>
<th>Total</th>
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Productivity

In planning and budgeting a fixed price project, a given work package was estimated to include 200 units of work. Estimators further utilized a unit rate of 4 work hours per unit of work so budgeted for 800 work hours in this account. In the field, it was subsequently determined that there were really 240 units of work to be performed. This was strictly an estimating error and, with no contingency fund available, the budget remained at 800 work hours. At the end of the latest reporting period, work was 50% complete (120 units) and 432 work hours had been paid for. **Is this package overrunning or underrunning cost?**

Is productivity better or worse than planned?

**Option #1 - remainder at budget**

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<tr>
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Productivity

In planning and budgeting a fixed price project, a given work package was estimated to include 200 units of work. Estimators further utilized a unit rate of 4 work hours per unit of work so budgeted for 800 work hours in this account. In the field, it was subsequently determined that there were really 240 units of work to be performed. This was strictly an estimating error and, with no contingency fund available, the budget remained at 800 work hours. At the end of the latest reporting period, work was 50% complete (120 units) and 432 work hours had been paid for. Is this package overrunning or underrunning cost? Is productivity better or worse than planned?

**Option #2 - remainder at to-date**

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<td>W-H</td>
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Productivity

In planning and budgeting a fixed price project, a given work package was estimated to include 200 units of work. Estimators further utilized a unit rate of 4 work hours per unit of work so budgeted for 800 work hours in this account. In the field, it was subsequently determined that there were really 240 units of work to be performed. This was strictly an estimating error and, with no contingency fund available, the budget remained at 800 work hours. At the end of the latest reporting period, work was 50% complete (120 units) and 432 work hours had been paid for. Is this package overrunning or underrunning cost?
Is productivity better or worse than planned?

Option #3 - curve fit

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Productivity

In planning and budgeting a fixed price project, a given work package was estimated to include 200 units of work. Estimators further utilized a unit rate of 4 work hours per unit of work so budgeted for 800 work hours in this account. In the field, it was subsequently determined that there were really 240 units of work to be performed. This was strictly an estimating error and, with no contingency fund available, the budget remained at 800 work hours. At the end of the latest reporting period, work was 50% complete (120 units) and 432 work hours had been paid for. Is this package overrunning or underrunning cost? Is productivity better or worse than planned?

CWH (credit work hours) = budget rate * units completed

PI (Performance Index) = CWH / AWH
Productivity

In planning and budgeting a fixed price project, a given work package was estimated to include 200 units of work. Estimators further utilized a unit rate of 4 work hours per unit of work so budgeted for 800 work hours in this account. In the field, it was subsequently determined that there were really 240 units of work to be performed. This was strictly an estimating error and, with no contingency fund available, the budget remained at 800 work hours. At the end of the latest reporting period, work was 50% complete (120 units) and 432 work hours had been paid for. Is this package overrunning or underrunning cost?

**Is productivity better or worse than planned?**

CWH (credit work hours) = budget rate * units completed

\[ = 4 \times 120 = 480 \]

PI (Performance Index) = CWH / AWH

\[ = \frac{480}{432} = 1.11 \]
# FIXED versus VARIABLE BUDGETING

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<td>Directly evaluate cost performance</td>
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<tr>
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</tr>
<tr>
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FIXED versus VARIABLE BUDGETING

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<thead>
<tr>
<th>Work Hours</th>
<th>2-1</th>
<th>3-1</th>
<th>4-1</th>
<th>5-1</th>
<th>6-1</th>
<th>7-1</th>
<th>8-1</th>
<th>9-1</th>
<th>10-1</th>
<th>11-1</th>
<th>12-1</th>
<th>1-1</th>
<th>2-1</th>
<th>3-1</th>
<th>4-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potable Water</td>
<td>502</td>
<td>0.8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steam &amp; Condensate</td>
<td>19085</td>
<td>29.7%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air &amp; Vacuum</td>
<td>2407</td>
<td>3.9%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Process Liquids</td>
<td>6567</td>
<td>10.2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Desalted B.F.W.</td>
<td>2995</td>
<td>4.7%</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Oil, Chemicals, Vents, Millwater &amp; Misc.</td>
<td>25330</td>
<td>39.4%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Contingency</td>
<td>7362</td>
<td>11.4%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>84288</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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**Legend**
- Planned
- Actual
Cost and Schedule Performance Graph

SV = Schedule Variance
CV = Cost Variance
ΔT = Time Variance
Productivity Profile

Productivity Index

Projected

Actual

Physical Completion (%)
Workhour Productivity Trend Chart

- Actual Cumulative
- Actual Period
- Plan for Period
- Estimated Workhour(s)
- Cumulative Plan

Workhour(s)/% Complete vs. Percent Complete
Building Structural Steel Erection

Unit Rates and Progress

Cumulative Period

% Progress Based on Quantity Installed

Estimated 30.0
Unit Wage Rate

$ 7.00

Actual

Planned

JUL  AUG  SEP  OCT  NOV  DEC  JAN  FEB  MAR  APR  MAY
1986  1987

Figure 8
Suggested References:

The following is a list of reference books related to the topics of Cost Estimating:

1. *Cost Engineer's Notebook*, Association for the Advancement of Cost Engineering

   The preceding pages are excerpted primarily from reference document #20 above.
Estimating Aids - Reference Materials

The following is an abbreviated list of reference materials which are available to the estimator:

10. *Index of the Cost of Industrial Building*, Aberthaw Co.
17. Societies and Organizations:

   American Concrete Institute (ACI)
   American Institute of Architects (AIA)
   American Institute of Steel Construction (AISC)
   American National Standards Institute (ANSI)
   American Nuclear Society (ANS)
   American Society of Testing and Materials (ASTM)
   American Society of Mechanical Engineers (ASME)
   American Welding Society (AWS)
   Associated Builders and Contractors (ABC)
   Associated General Contractors of America (AGC)
   Construction Specifications Institute (CSI)
   National Constructors Association (NCA)
   National Electrical Contractors Association (NECA)
   Power Crane and Shovel Association (PCSA)