COST MANAGEMENT

NWCCC MEETING
April 28, 1999
SHERATON PORTLAND, OREGON

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PORTLAND, OREGON
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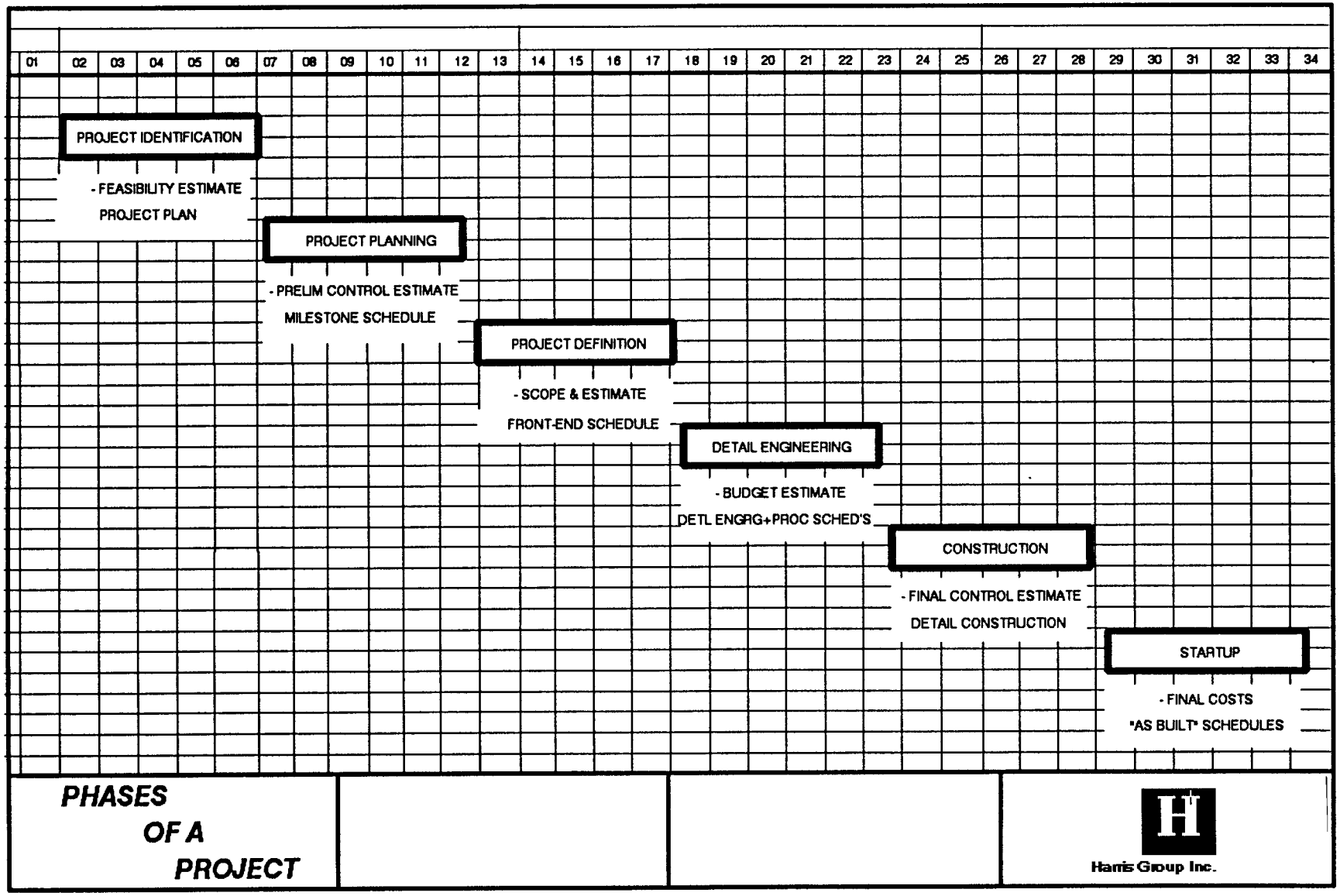
PURPOSE: To acquaint you with various cost management terms and techniques, to assist you in implementing them on your jobs.

FRAMEWORK: Cost management during various phases of a project (see "Phases of a project" chart).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DETAIL CONSTRUCTION
STARTUP
- FINAL COSTS
"AS BUILT" SCHEDULES
PHASES
OF A
PROJECT
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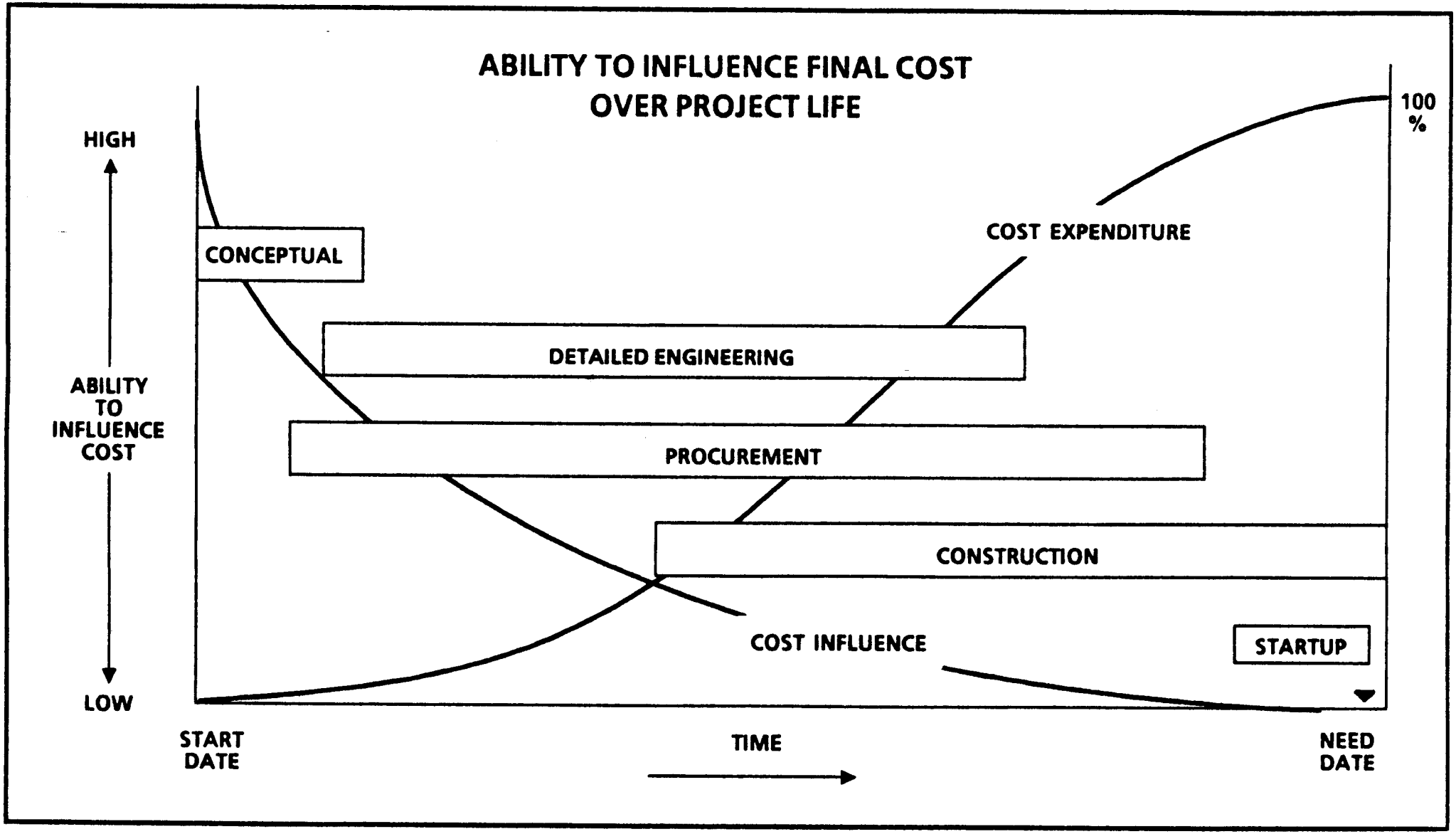
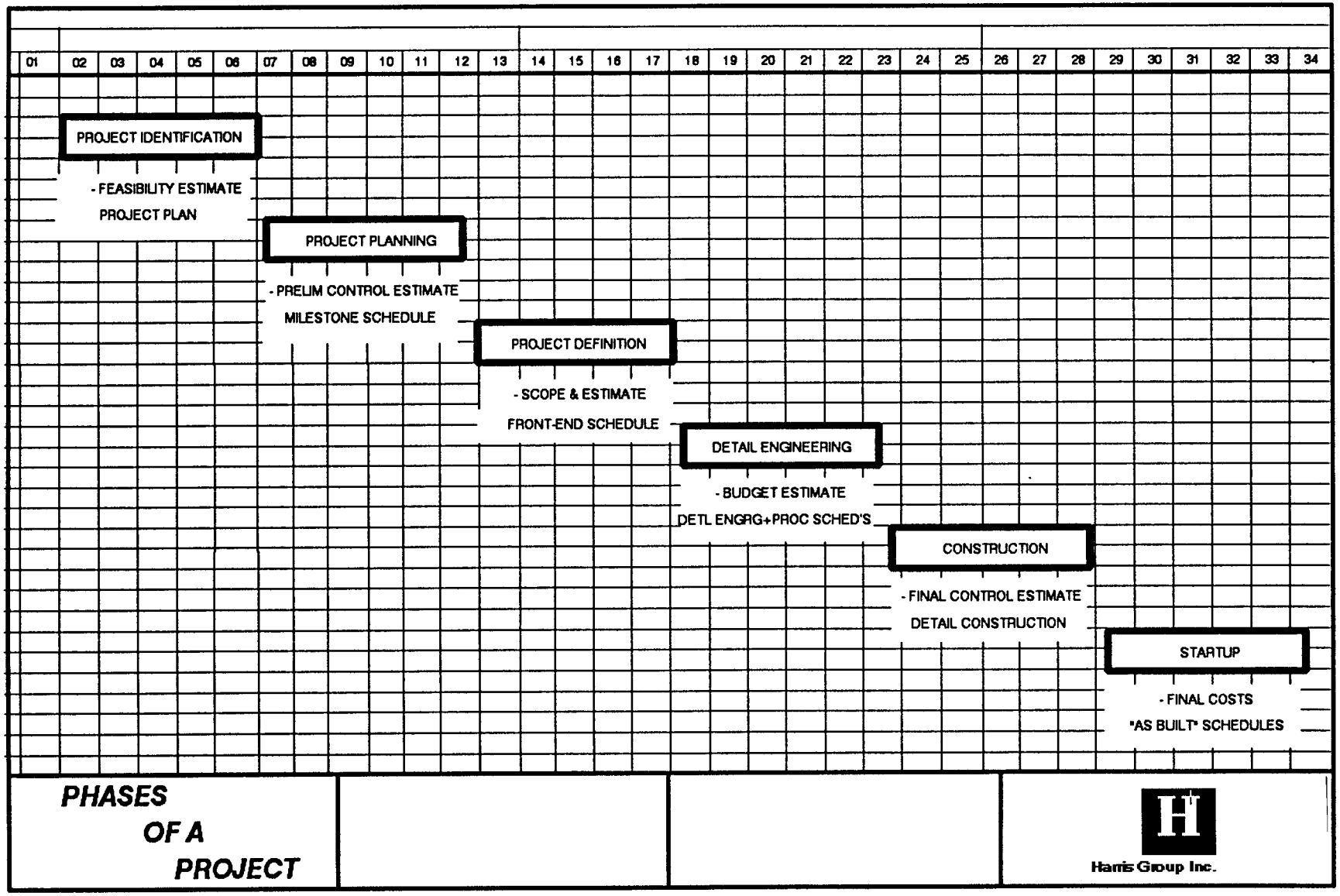

ABILITY TO INFLUENCE FINAL COST
OVER PROJECT LIFE
HIGH
ABILITY
TO
INFLUENCE
COST
LOW
100
%
COST EXPENDITURE
CONCEPTUAL
DETAILED ENGINEERING
PROCUREMENT
CONSTRUCTION
COST INFLUENCE
STARTUP
START
DATE
TIME
NEED
DATE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PROJECT IDENTIFICATION PHASE

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 **$100mm * (50/100)$^{.6}$ = $66mm**

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

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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
- Multiple of Equipment Cost

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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

- Hand Factors

Physical Dimensions Method

Parametric Estimates

Cost Indices

Date _____

By _____

PRELIMINARY PRODUCTION COST ESTIMATING FORM

Location: _____ Product(s): _____

Capital Investment: Process: _____

Total _____ Nelson Index: _____ CE Index _____

Less working capital _____ M&S Index _____ Annual Operating

Less salvage value _____ ENR Index: _____ Days: _____

Depreciable investment _____ Annual production: _____

	Raw materials	Annual quantity	Unit cost	$/year	$/
(1)					
(2)					
(3)					
(4)					
(5)	Gross raw material cost (sum of lines 1 to 4):				
	Misc. credits and debits				
(6)					
(7)					
(8)					
(9)	Total debit (credit) (sum of lines 6 to 8):				
(10)	Net raw material cost (lines 5 + line 9):				

	Direct expense	Unit	Quantity	Unit cost	$/year	$/
(11)	Steam	M lb				
(12)	Water ( )	M gal				
(13)	Water ( )	M gal				
(14)	Electricity	kW-hr				
(15)	Fuel ( )					
(16)	Fuel ( )					
(17)	Labor					
(18)	Supervision					
(19)	Maintenance					
(20)	Factory supplies					
(21)	Indirect overhead					
(22)	Payroll overhead					
(23)	Laboratory					
(24)	Contingencies					
(25)	Total direct conversion cost (sum of lines 11 to 24):					
	Indirect expense					
(26)	Depreciation					
(27)	Real estate taxes & insurance					
(28)	Depletion allowances					
(29)	Amortization					
(30)	Total indirect conversion cost (sum of lines 26 to 29):					
(31)	Total conversion cost (line 25 + line 30):					
(32)	Total operating cost (line 31 + line 10):					
(33)	Packing & shipping expense					
(34)	TOTAL COST FOR PLANT (line 32 + line 33):					

NEW PRODUCT EVALUATION

Given: New product in the electronic industry

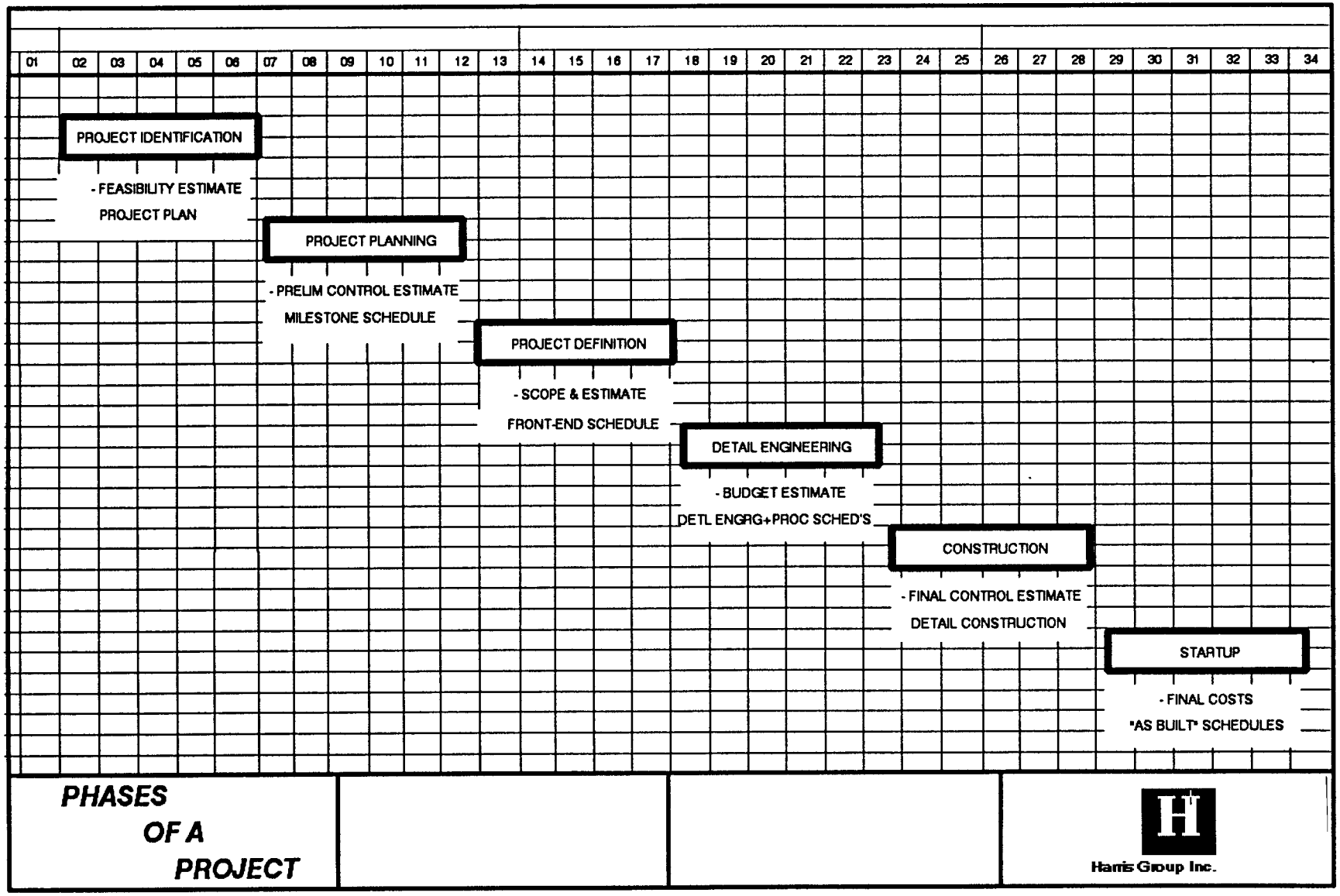
Investment:	70 units
	5-year life
	Straight Line Depreciation
Sales Potential:	7 times the investment or approximately 500 units
Cost (variable):	45% to 55% to sales
Income Taxes:	50%
Cost of Capital:	20%

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

Return on Investment = 29%

Net present value at 20% cost of capital = 17.1

Notes: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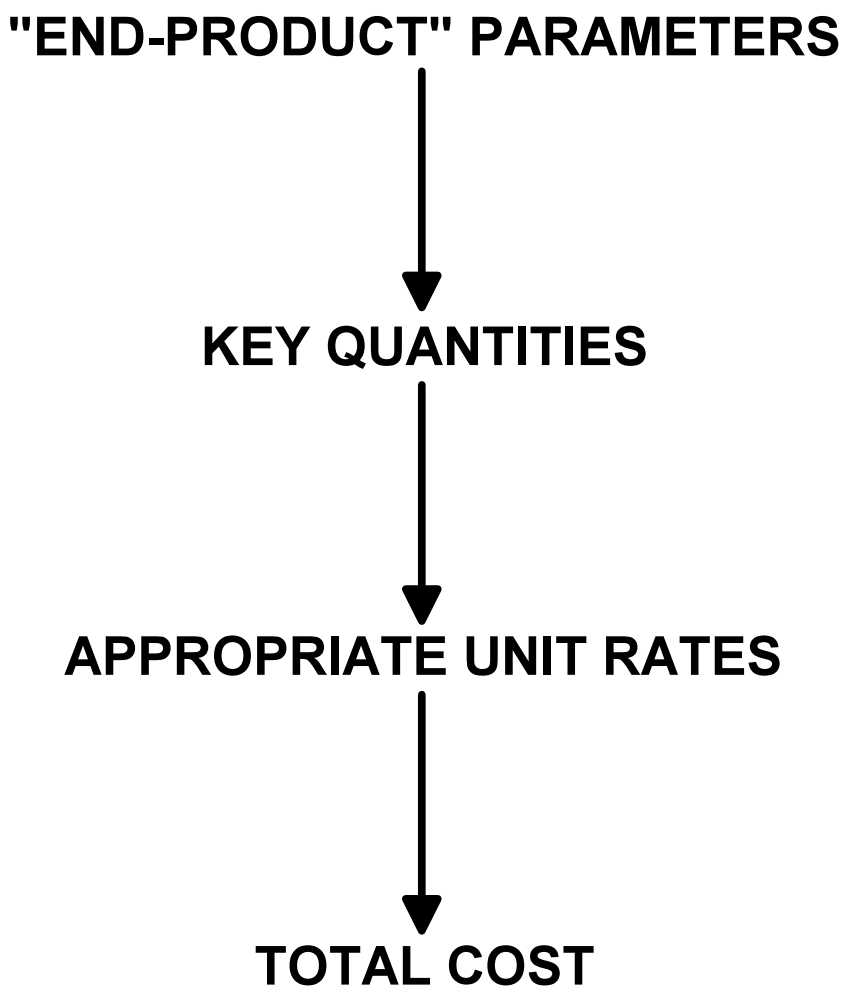
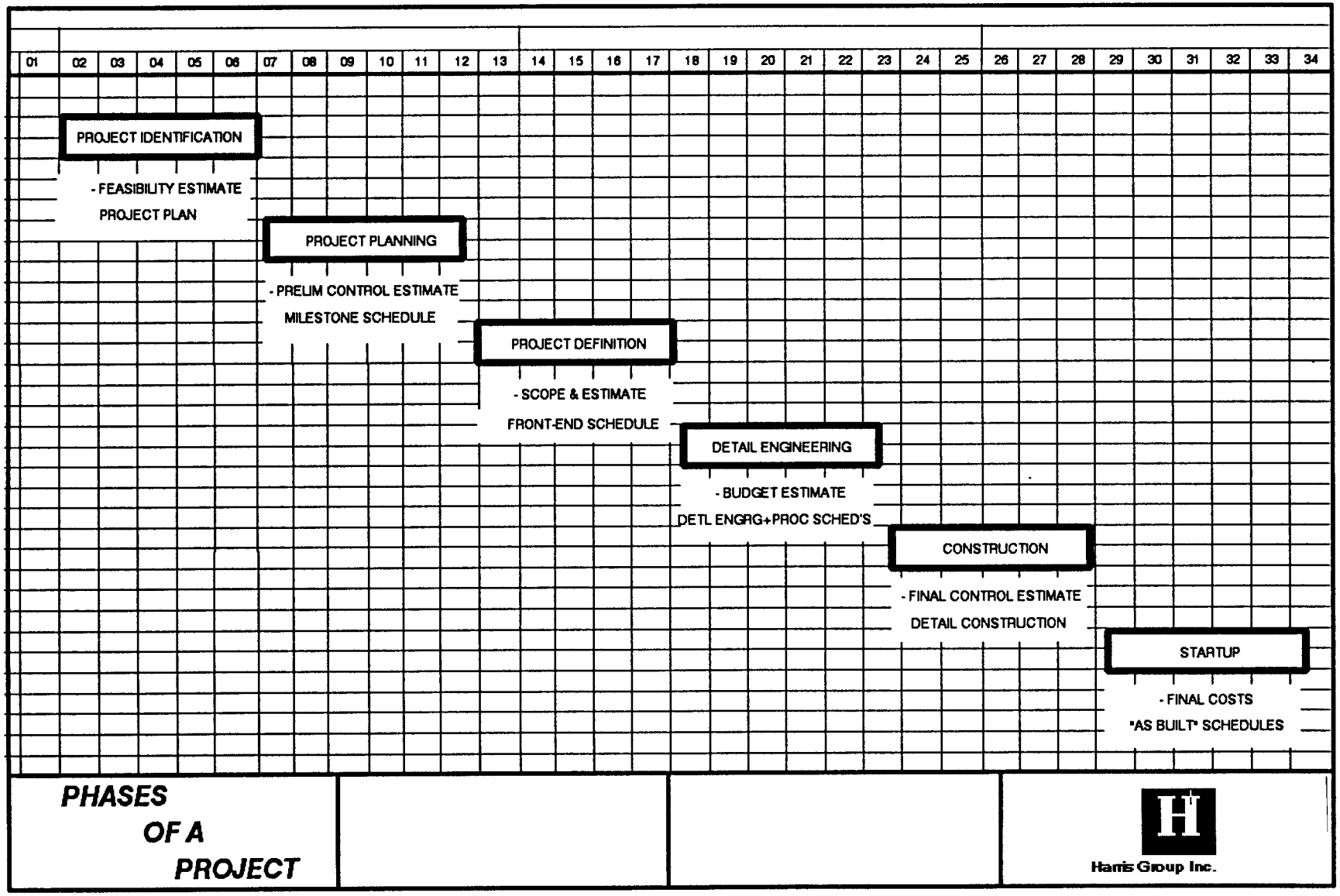
PROJECT PLANNING PHASE

PARAMETER ESTIMATE

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PROJECT DEFINITION/ENGINEERING

TOTAL PROJECT
COST BREAKDOWN STRUCTURE
AND
WORK BREAKDOWN STRUCTURE
RELATIONSHIP

PHASES	INDIRECTS (1)	DIRECTS		
		Labor	Material	Equipment
Conceptual Engineering	$	WH $	$	$
Detailed Engineering	$	WH $	$	$
Procurement	$	WH $	$	$
Construction	$	WH $	$	$
Startup	$	WH $	$	$
Other (2)	$			

Legend:

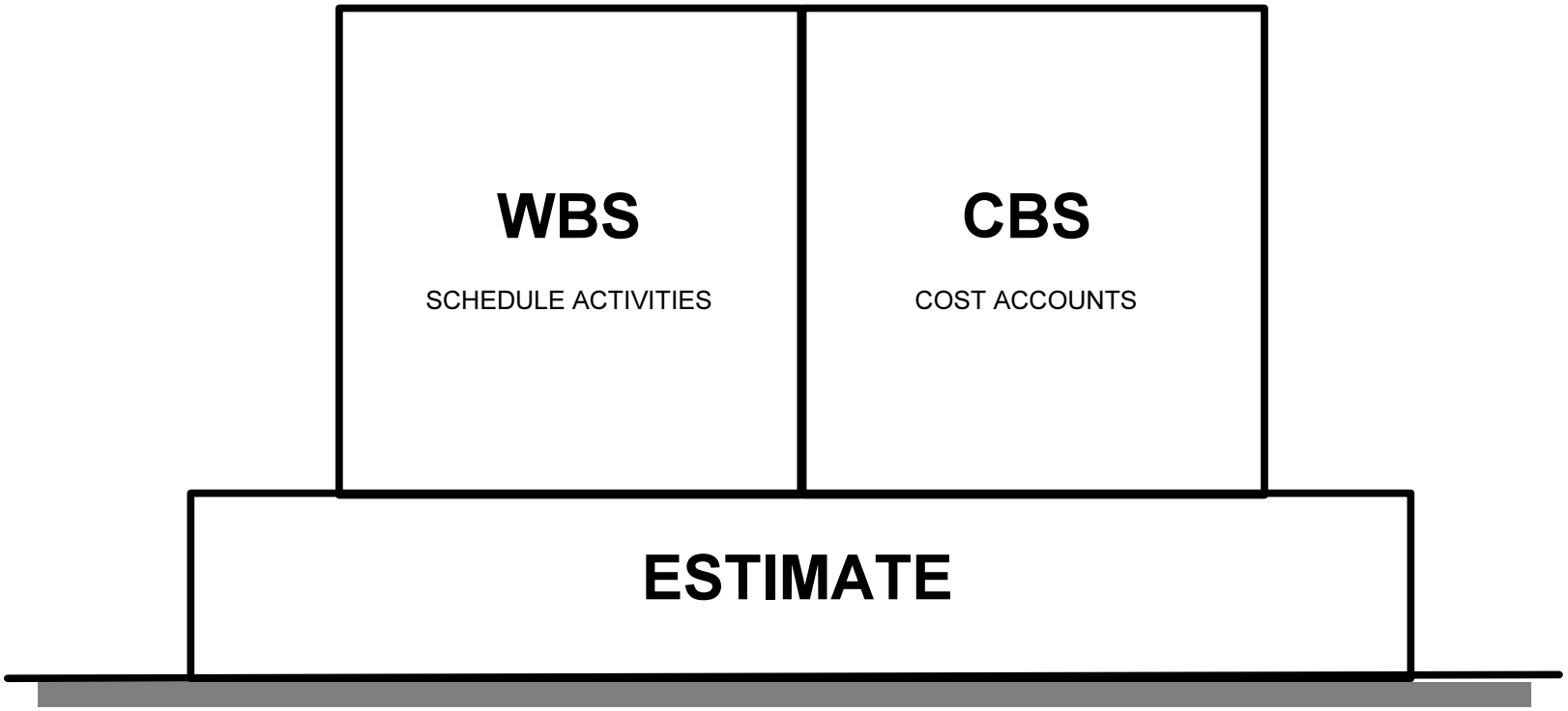
The COST BREAKDOWN STRUCTURE (CBS) is composed of all elements in the matrix for which dollars ($) are budgeted. The total dollar value of all of these elements equals the project budget.

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



COST	FINANCIAL
Pareto's law	Receipts
Labor cost	Expenditures
Productivity	Payments
Worker hours	Taxes
Quantity control	Capitalization
Commitments	

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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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

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Alternates

Allowances

Markups - Contingency, Profit

Tabulate

Check & Review

Cuts/Adds

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

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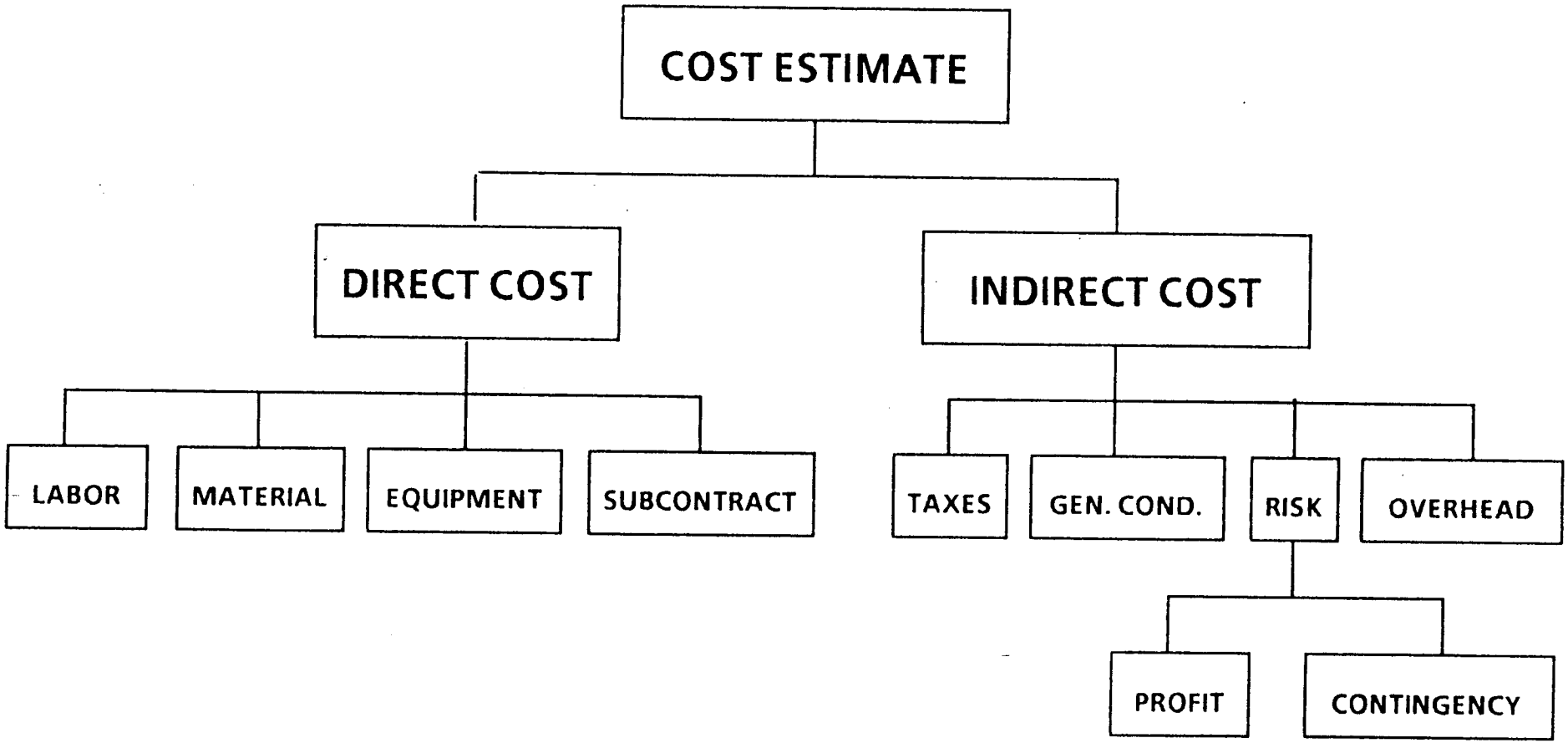
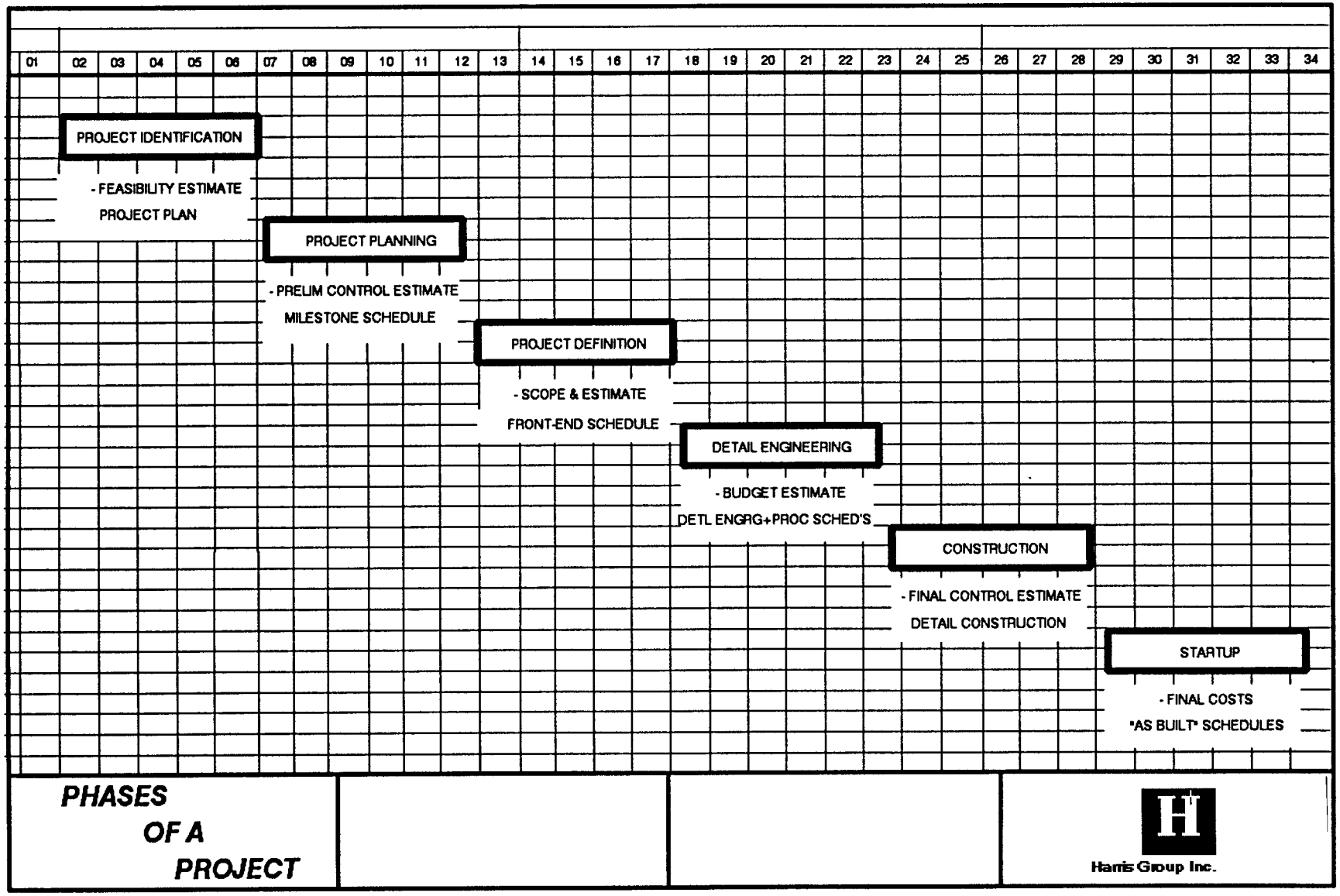

COST ESTIMATE
DIRECT COST
INDIRECT COST
LABOR
MATERIAL
EQUIPMENT
SUBCONTRACT
TAXES
GEN. COND.
RISK
OVERHEAD
PROFIT
CONTINGENCY

Forecasting during Design

Purchases

"Best guess" quantities


01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
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 ENGRG+PROC SCHED'S
CONSTRUCTION
- FINAL CONTROL ESTIMATE
DETAIL CONSTRUCTION
STARTUP
- FINAL COSTS
"AS BUILT" SCHEDULES
PHASES
OF A
PROJECT
Harris Group Inc.

CONSTRUCTION PHASE

Work Measurement

Based on WBS

<u>Methods:</u>
Units completed
Milestones
Start / finish
Opinion
Cost ratio
Weighted value equivalent units

Monthly Quantity Report

Control Account Baseline

Project _____ _____ Date _____ Rev. _____

Account Code	Description	This Period / To Date
SWP000	**Service Water Piping**	

Weight	Activity	U/M	Latest Estimate	Week Ending 1/6	1/13	1/20	1/27			
0.25	Large Hangers	EA	100	5 / 5	15 / 20	15 / 35	15 / 50			
0.30	Large Pipe	LF	2000				50 / 50			
0.10	Large Valves	EA	10							
0.15	Large Pipe Weld	EA	150							
0.20	Small Pipe	LF	1500							
Total Control 1.00	Control Item Large Pipe	U/M LF	Control Quantity 2000	25 / 25	75 / 100	75 / 175	90 / 265			

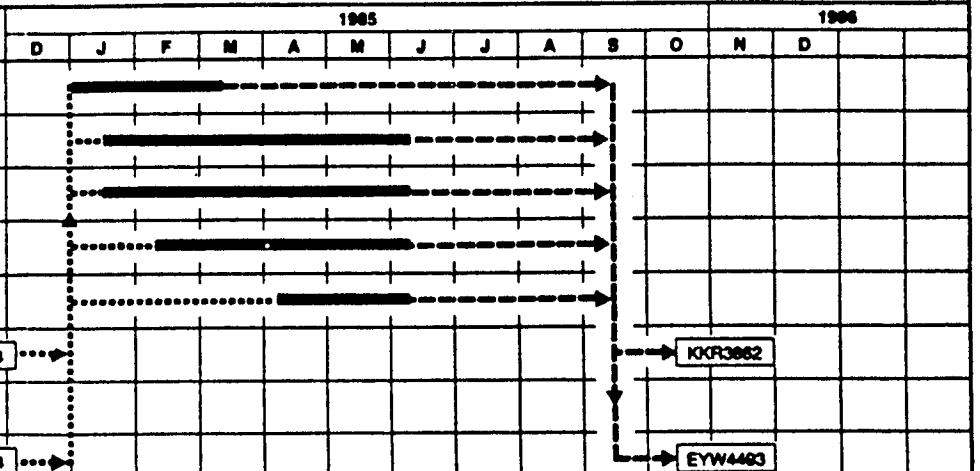
Field Engineer

Control Account for Service Water Piping

Control Account Baseline Project _____ Date _____ Rev. ____

Account Code	Description	Total Control
SWP000	Service Water Piping	W-H 3000

Weight	Activity	U/M	Latest Estimate
0.25	Large Hangers	EA	100
0.30	Large Pipe	LF	2000
0.10	Large Valves	EA	10
0.15	Large Pipe Weld	EA	150
0.20	Small Pipe	LF	1500
			ABC1234
			EFG7234



Total Control	Control Item	U/M	Qty.												
1.00	Large Pipe	LF	2000	W-H		380	660	510	560	660	230	Total					
				W-H		380	1040	1550	2110	2770	3000	Cumulative					
				%		13	35	52	70	92	100	Cumulative					

Earned Value

Code	Accounts	U/M	Total quantity	Quantity To-Date	Budget W-H	Earned W-H
0811	Forms	SM	500	500	5000	
0812	Resteel	CWT	10	9	1000	
0813	Place & finish	CM	1000	750	10000	
0810	SLABS @ GRADE	xxx	xxx	xxx		
0821	Forms	SM	550	55	6000	
0822	Resteel	CWT	10	2	1000	
0823	Place & finish	CM	2500	0	15000	
0820	ELEVATED SLABS	xxx	xxx	xxx		
0800	CONCRETE	xxx	xxx	xxx		

Earned Value

Code	Accounts	U/M	Total quantity	Quantity To-Date	Budget W-H	Earned W-H
0811	**Forms**	**SM**	**500**	**500**	**5000**	**5000**
0812	Resteel	CWT	10	9	1000	
0813	Place & finish	CM	1000	750	10000	
0810	SLABS @ GRADE	xxx	xxx	xxx		
0821	Forms	SM	550	55	6000	
0822	Resteel	CWT	10	2	1000	
0823	Place & finish	CM	2500	0	15000	
0820	ELEVATED SLABS	xxx	xxx	xxx		
0800	CONCRETE	xxx	xxx	xxx		

Earned Value

Code	Accounts	U/M	Total quantity	Quantity To-Date	Budget W-H	Earned W-H
0811	Forms	SM	500	500	5000	5000
0812	**Resteel**	**CWT**	**10**	**9**	**1000**	**900**
0813	Place & finish	CM	1000	750	10000	
0810	SLABS @ GRADE	xxx	xxx	xxx		
0821	Forms	SM	550	55	6000	
0822	Resteel	CWT	10	2	1000	
0823	Place & finish	CM	2500	0	15000	
0820	ELEVATED SLABS	xxx	xxx	xxx		
0800	CONCRETE	xxx	xxx	xxx		

Earned Value

Code	Accounts	U/M	Total quantity	Quantity To-Date	Budget W-H	Earned W-H
0811	Forms	SM	500	500	5000	5000
0812	Resteel	CWT	10	9	1000	900
0813	**Place & finish**	**CM**	**1000**	**750**	**10000**	**7500**
0810	SLABS @ GRADE	xxx	xxx	xxx		
0821	Forms	SM	550	55	6000	
0822	Resteel	CWT	10	2	1000	
0823	Place & finish	CM	2500	0	15000	
0820	ELEVATED SLABS	xxx	xxx	xxx		
0800	CONCRETE	xxx	xxx	xxx		

Earned Value

Code	Accounts	U/M	Total quantity	Quantity To-Date	Budget W-H	Earned W-H
0811	Forms	SM	500	500	5000	5000
0812	Resteel	CWT	10	9	1000	900
0813	Place & finish	CM	1000	750	10000	7500
0810	**SLABS @ GRADE**	**xxx**	**xxx**	**xxx**		**13400**
0821	Forms	SM	550	55	6000	
0822	Resteel	CWT	10	2	1000	
0823	Place & finish	CM	2500	0	15000	
0820	ELEVATED SLABS	xxx	xxx	xxx		
0800	CONCRETE	xxx	xxx	xxx		

Earned Value

Code	Accounts	U/M	Total quantity	Quantity To-Date	Budget W-H	Earned W-H
0811	Forms	SM	500	500	5000	5000
0812	Resteel	CWT	10	9	1000	900
0813	Place & finish	CM	1000	750	10000	7500
0810	SLABS @ GRADE	xxx	xxx	xxx		13400
0821	**Forms**	**SM**	**550**	**55**	**6000**	**600**
0822	Resteel	CWT	10	2	1000	
0823	Place & finish	CM	2500	0	15000	
0820	ELEVATED SLABS	xxx	xxx	xxx		
0800	CONCRETE	xxx	xxx	xxx		

Earned Value

Code	Accounts	U/M	Total quantity	Quantity To-Date	Budget W-H	Earned W-H
0811	Forms	SM	500	500	5000	5000
0812	Resteel	CWT	10	9	1000	900
0813	Place & finish	CM	1000	750	10000	7500
0810	SLABS @ GRADE	xxx	xxx	xxx		13400
0821	Forms	SM	550	55	6000	600
0822	**Resteel**	**CWT**	**10**	**2**	**1000**	**200**
0823	Place & finish	CM	2500	0	15000	
0820	ELEVATED SLABS	xxx	xxx	xxx		
0800	CONCRETE	xxx	xxx	xxx		

Earned Value

Code	Accounts	U/M	Total quantity	Quantity To-Date	Budget W-H	Earned W-H
0811	Forms	SM	500	500	5000	5000
0812	Resteel	CWT	10	9	1000	900
0813	Place & finish	CM	1000	750	10000	7500
0810	SLABS @ GRADE	xxx	xxx	xxx		13400
0821	Forms	SM	550	55	6000	600
0822	Resteel	CWT	10	2	1000	200
0823	**Place & finish**	**CM**	**2500**	**0**	**15000**	**0**
0820	ELEVATED SLABS	xxx	xxx	xxx		
0800	CONCRETE	xxx	xxx	xxx		

Earned Value

Code	Accounts	U/M	Total quantity	Quantity To-Date	Budget W-H	Earned W-H
0811	Forms	SM	500	500	5000	5000
0812	Resteel	CWT	10	9	1000	900
0813	Place & finish	CM	1000	750	10000	7500
0810	SLABS @ GRADE	xxx	xxx	xxx		13400
0821	Forms	SM	550	55	6000	600
0822	Resteel	CWT	10	2	1000	200
0823	Place & finish	CM	2500	0	15000	0
0820	**ELEVATED SLABS**	**xxx**	**xxx**	**xxx**		**800**
0800	CONCRETE	xxx	xxx	xxx		

Earned Value

Code	Accounts	U/M	Total quantity	Quantity To-Date	Budget W-H	Earned W-H
0811	Forms	SM	500	500	5000	5000
0812	Resteel	CWT	10	9	1000	900
0813	Place & finish	CM	1000	750	10000	7500
0810	SLABS @ GRADE	xxx	xxx	xxx		13400
0821	Forms	SM	550	55	6000	600
0822	Resteel	CWT	10	2	1000	200
0823	Place & finish	CM	2500	0	15000	0
0820	ELEVATED SLABS	xxx	xxx	xxx		800
0800	**CONCRETE**	**xxx**	**xxx**	**xxx**		**14200**

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.

BCWS	**28000**
BCWP	**26000**
ACWP	**25000**

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	28000	**SV = BCWP-BCWS**
BCWP	26000	**SPI = BCWP/BCWS**
ACWP	25000	**CV = BCWP-ACWP**
		CPI = 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.

BCWS	28000	**SV = BCWP-BCWS**	**-2000**
BCWP	26000	**SPI = BCWP/BCWS**	**0.93**
ACWP	25000	**CV = BCWP-ACWP**	**1000**
		CPI = BCWP/ACWP	**1.04**

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?

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Is productivity better or worse than planned?

	Budget	**To-date**	**To-go**	**Total**
Units				
W-H				
W-H/unit				

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	Budget	To-date	To-go	Total
Units	**200**	**120**	**120**	**240**
W-H	**800**	**432**		
W-H/unit	**4**	**3.6**	**0**	**0**

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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

	Budget	To-date	To-go	Total
Units	200	120	120	240
W-H	800	432	**480**	**912**
W-H/unit	4	3.6	**4**	**3.8**

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

	Budget	To-date	To-go	Total
Units	200	120	120	240
W-H	800	432	**432**	**864**
W-H/unit	4	3.6	**3.6**	**3.6**

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

	Budget	To-date	To-go	Total
Units	200	120	120	240
W-H	800	432	**368**	**800**
W-H/unit	4	3.6	**3.067**	**3.33**

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 * 120 = 480
PI (Performance Index) = CWH / AWH
= 480 / 432 = 1.11

FIXED versus VARIABLE BUDGETING

VARIABLE

Directly evaluate productivity
More database management
Varies directly with quantities
Real budgets are unit rates
No budget constraint incentive
Earned value changes with budget
Rework hours shown separately
Budget must be kept current

FIXED

Directly evaluate cost performance
Simplified bookkeeping
Constant target
Performance data may be distorted
Incentives to work smarter
Earned value cumulative

HYBRID SYSTEM

Original budget	Approved transfers	Approved changes	Current budget	Period actuals	To-date actuals	To-go	Forecast

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Budget must be kept current	

HYBRID SYSTEM

Original budget	Approved transfers	Approved changes	Current budget	Period actuals	To-date actuals	To-go	Forecast

FIXED versus VARIABLE BUDGETING

VARIABLE	FIXED
Directly evaluate productivity	Directly evaluate cost performance
More database management	Simplified bookkeeping
Varies directly with quantities	Constant target
Real budgets are unit rates	Performance data may be distorted
No budget constraint incentive	Incentives to work smarter
Earned value changes with budget	Earned value cumulative
Rework hours shown separately	
Budget must be kept current	

HYBRID SYSTEM

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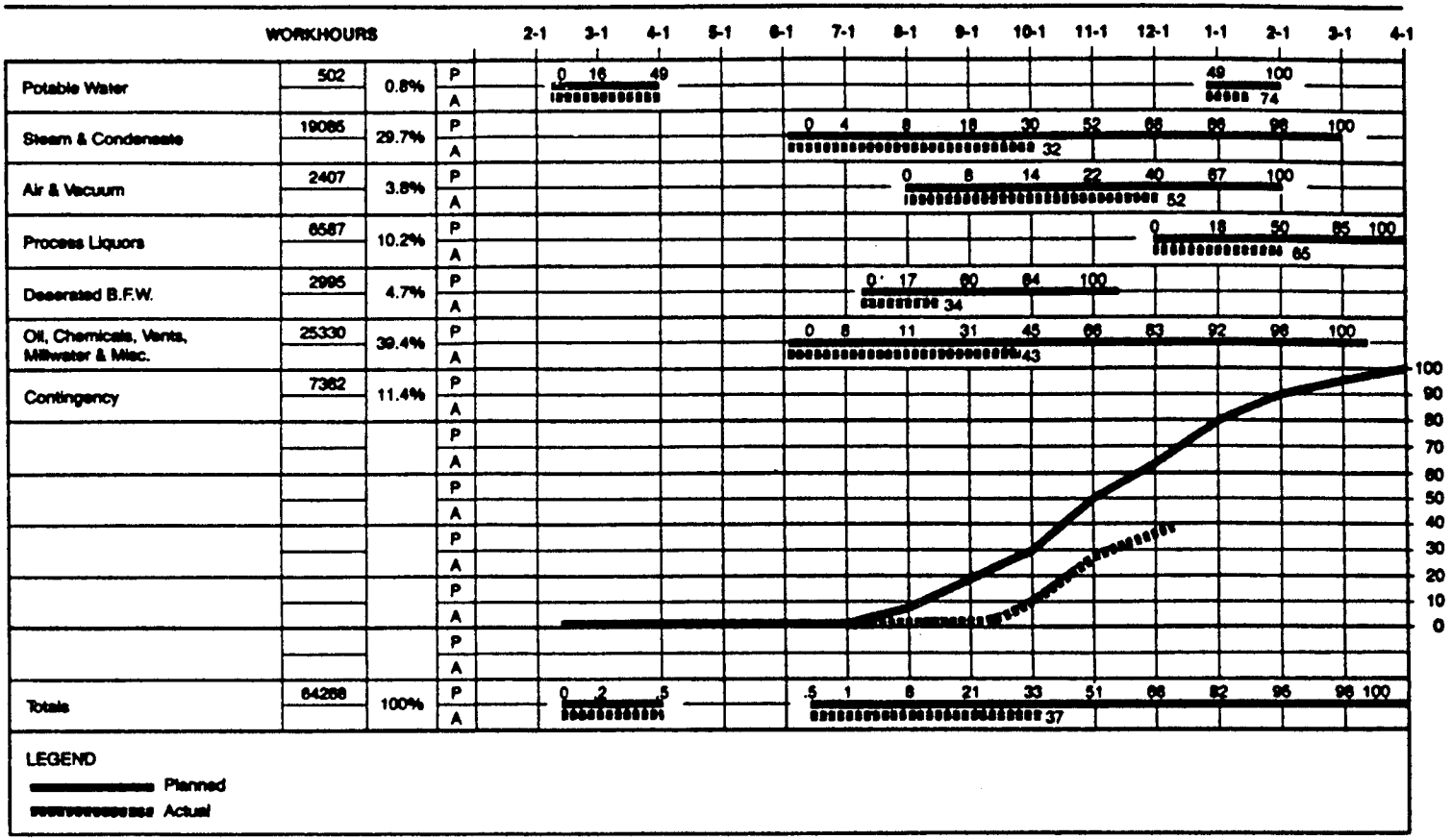
HYBRID SYSTEM

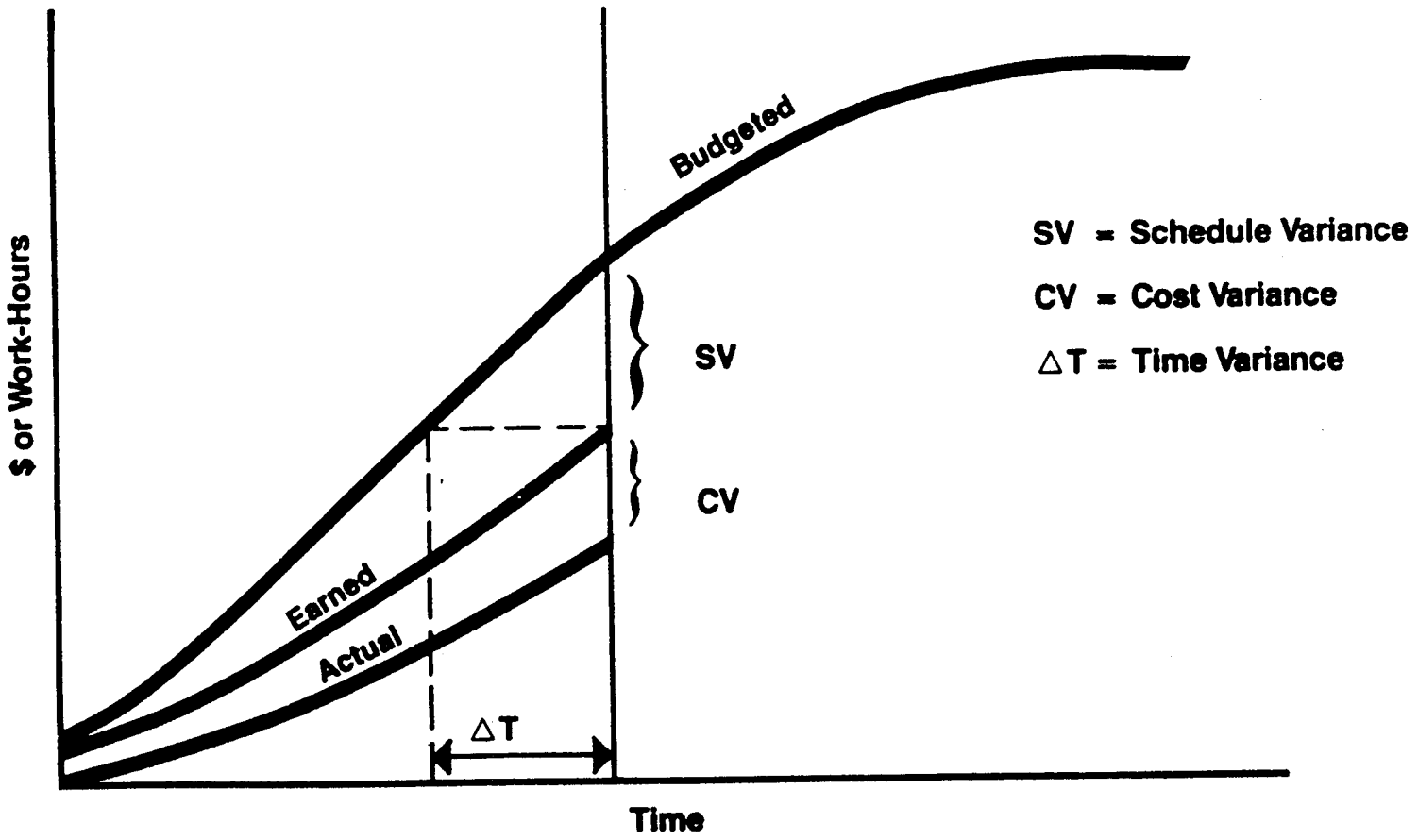
Original budget	Approved transfers	Approved changes	Current budget	Period actuals	To-date actuals	To-go	Forecast

REPORTING

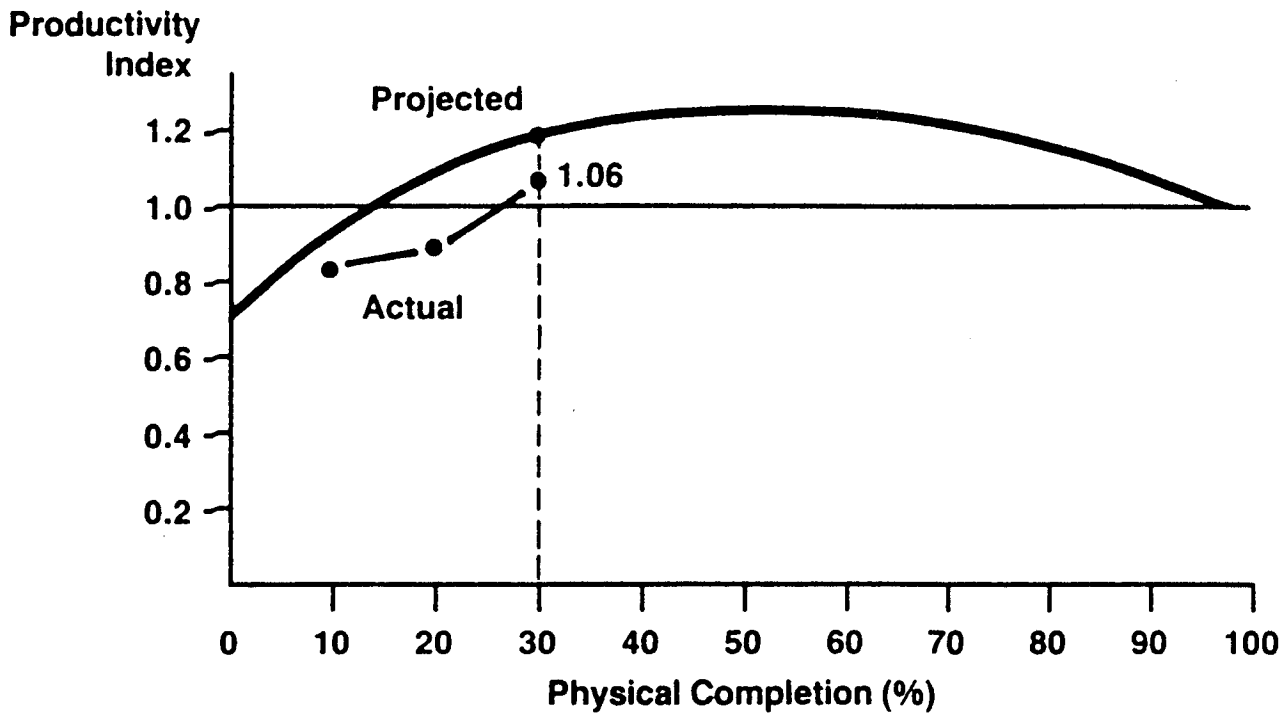
Monitoring Schedule



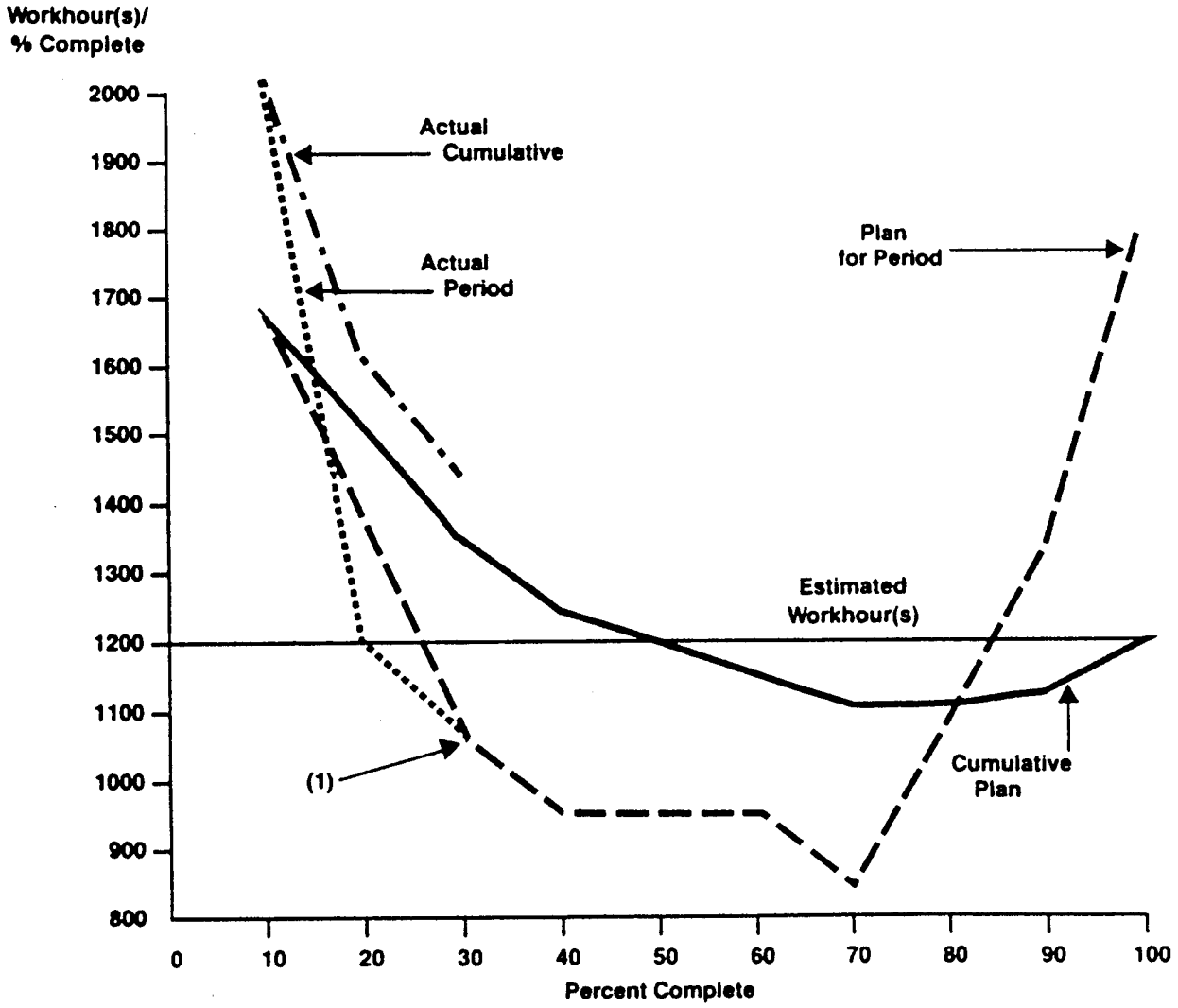
Cost and Schedule Performance Graph



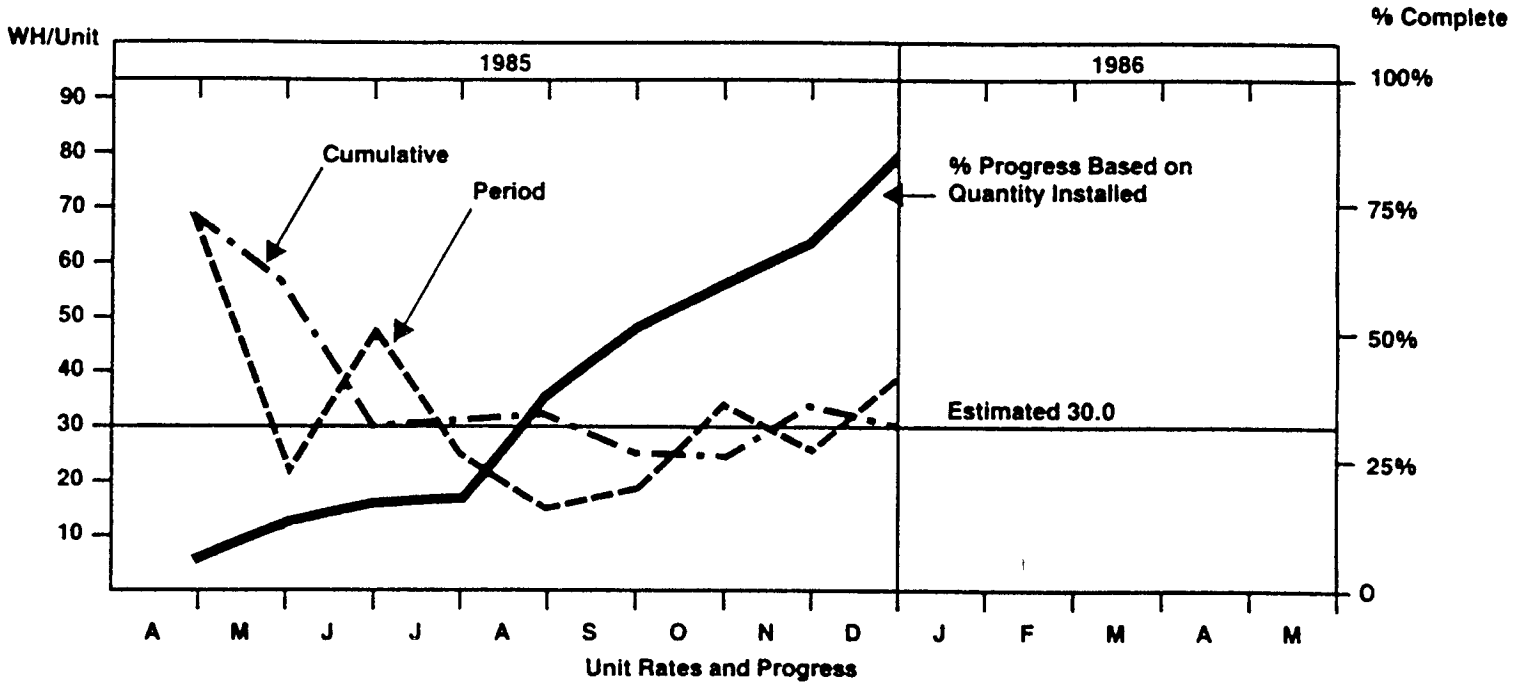
Productivity Profile



Workhour Productivity Trend Chart



Building Structural Steel Erection



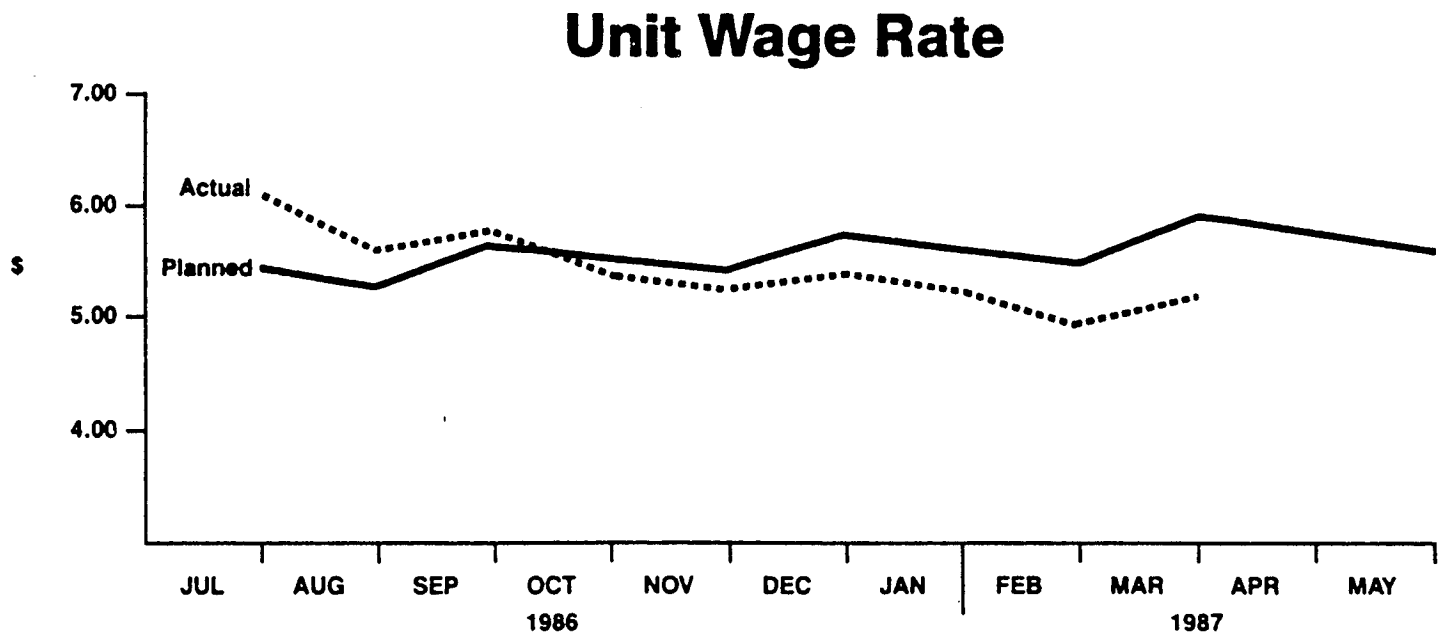
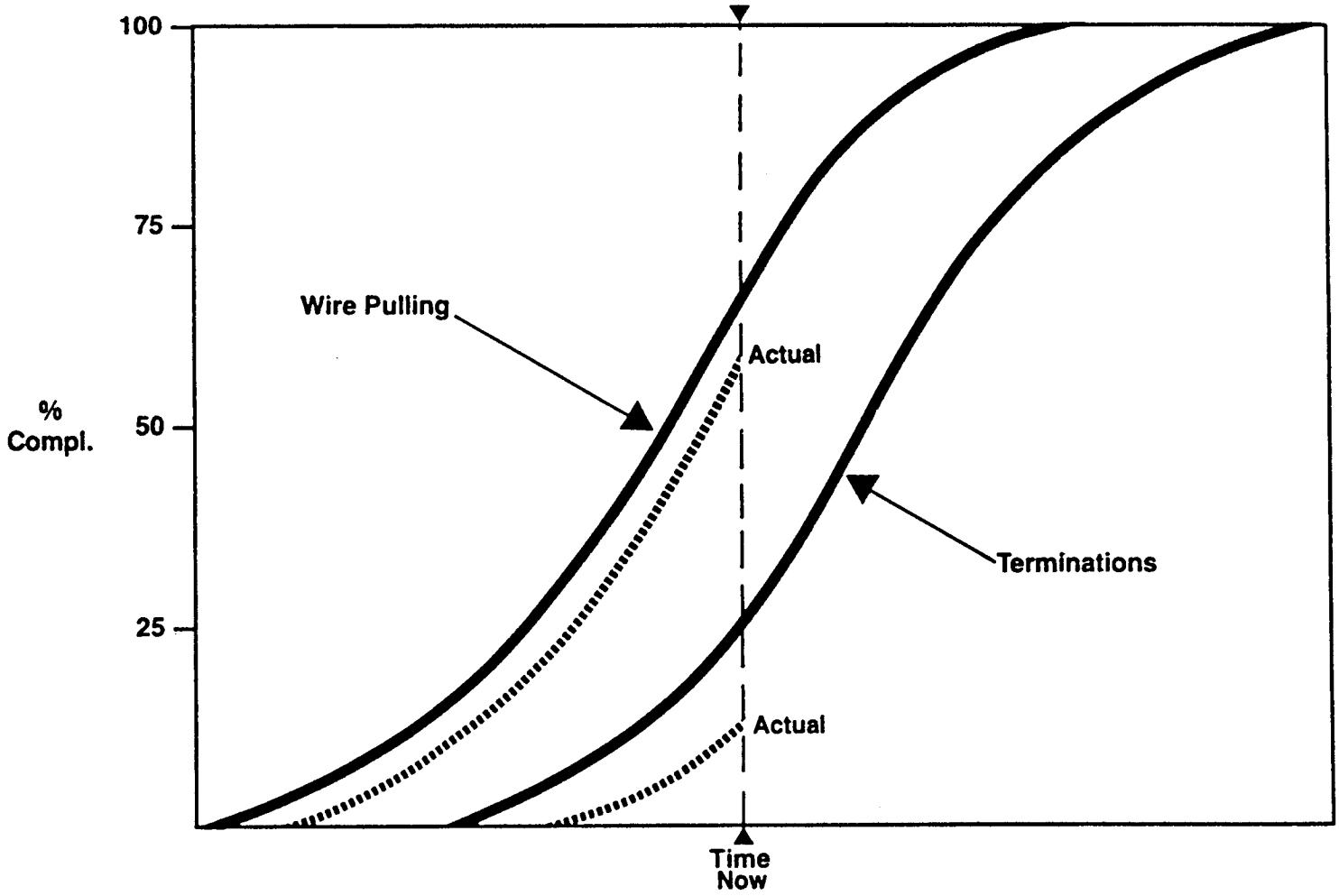

Unit Wage Rate
7.00
6.00
5.00
4.00
$
Actual
Planned
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
1986
1987

Figure 8

Bulk Quantity Curves



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
2. Neil, *Construction Cost Estimating for Project Control*, Prentice-Hall, Inc.
3. Jelen and Black, *Cost and Optimization Engineering*, McGraw-Hill Book Co.
4. Humphreys, ed., *Project and Cost Engineers' Handbook*, Marcel Dekker, Inc.
5. Vernon, *Realistic Cost Estimating for Manufacturing*, Society of Manufacturing Engineers.
6. Ostwald, *Cost Estimating for Engineering and Management*, Prentice-Hall, Inc.
7. Guthrie, *Process Plant Estimating, Evaluation & Control*, Craftsman Book Co.
8. Lorensoni and Clark, *Applied Cost Engineering*, Marcel Dekker, Inc.
9. Humphreys and Katell, *Basic Cost Engineering*, Marcel Dekker, Inc.
10. Bent, *Applied Cost and Schedule Control*, Marcel Dekker, Inc.
11. Bauman, *Fundamentals of Cost Engineering in the Chemical Industry*, Reinhold Publishing Co.
12. *The Building Estimator's Reference Book*, Frank R. Walker CO.
13. Page, *Cost Estimating for Pipelines and Marine Structures*, Gulf Publishing Co.
14. Popper, *Modern Cost Engineering Techniques*, McGraw-Hill Book Co.
15. Land, Simplified Approach to Preliminary Cost Estimates, CHEMICAL ENGINEERING, June 1948
16. Hand, Estimating Capital Costs from Process Flow Sheets, AACE Cost Engineers Notebook.
17. From Flow Sheet to Cost Estimate, PETROLEUM REFINER, September 1958
18. US Parameter Costs, ENGINEERING NEWS-RECORD, December 17, 1987
19. Project Control for Construction, Report 6.5, Construction Industry Institute, September 1987
20. *Skills & Knowledge of Cost Engineering*, 2nd Edition, 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:

1. *Process Plant Construction Estimating Standards*, Richardson Engineering Services, Inc.
2. *Contractors' Equipment Cost Guide*, Dataquest - The Associated General Contractors of America (AGC)
3. *The Building Estimator's Reference Book*, Frank R. Walker, Co.
4. *Means Building Construction Cost Data*, R. S. Means Co.
5. *Estimating Earthwork Quantities*, Norseman Publishing Co.
6. *Caterpillar Performance Handbook*, Caterpillar, Inc.
7. *Means Man-Hour Standards*, R. S. Means Co.
8. *Rental Rates & Specifications*, Associate Equipment Distributors.
9. *Rental Rate Blue Book*, Dataquest - The Dun & Bradstreet Corporation.
10. *Index of the Cost of Industrial Building*, Aberthaw Co.
11. *Dow Historical Local Cost Indexes*, F. W. Dodge Co.
12. *Engineering News Record*, McGraw-Hill Co.
13. *U.S. Army Engineer's Contract Unit Price Index*, U.S. Army Corps of Engineers.
14. *Chemical Engineering Plant Cost Index*, McGraw-Hill Co.
15. *Bureau of Labor Statistics*, U.S. Department of Labor.
16. *Dodge Guide to Public Works and Heavy Construction Costs*, F. W. Dodge 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 Specification Institute (CSI)
National Constructors Association (NCA)
National Electrical Constructors Association (NEC
Power Crane and Shovel Association (PCSA)