

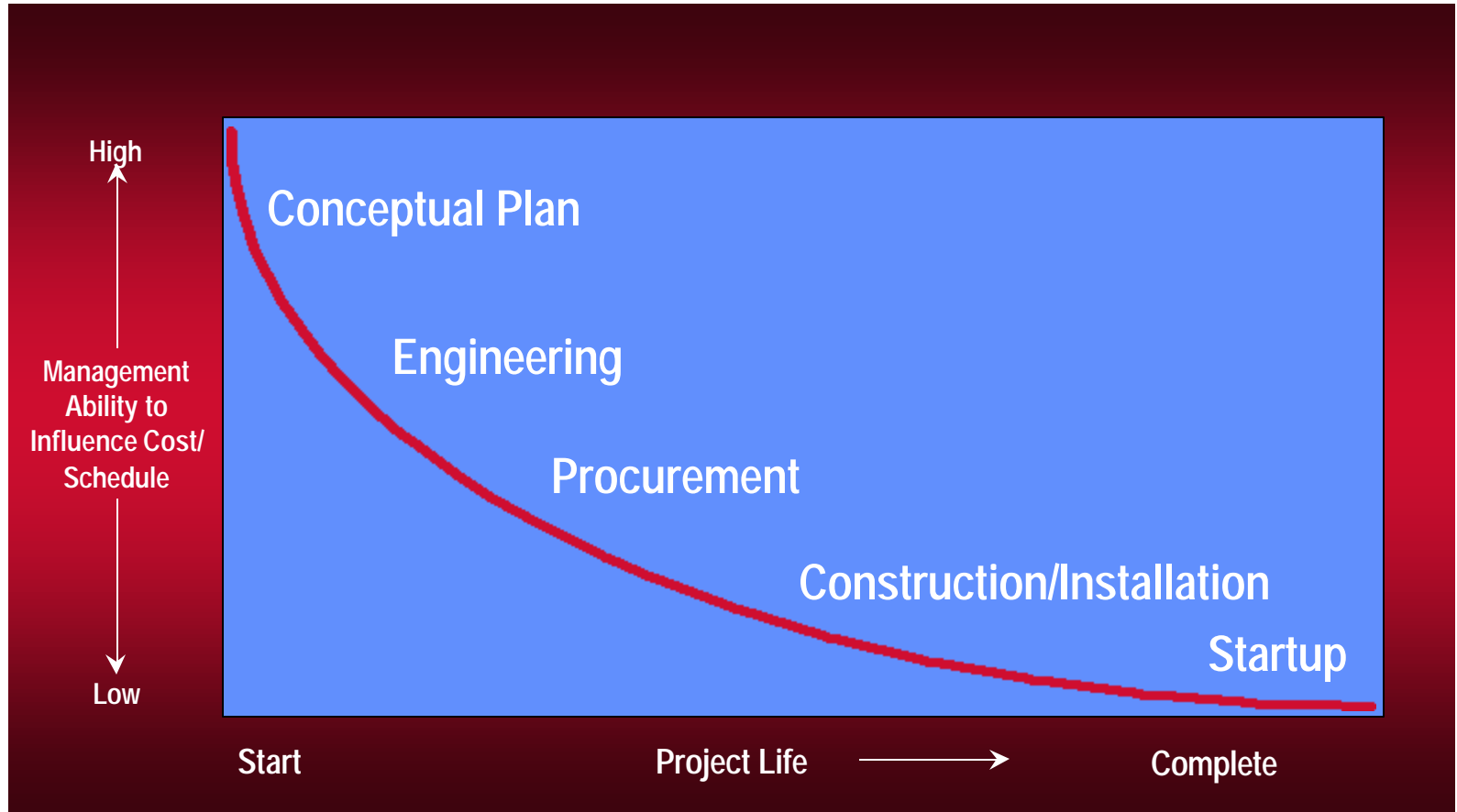
Performance Management in the Construction Industry

Ralph Kay

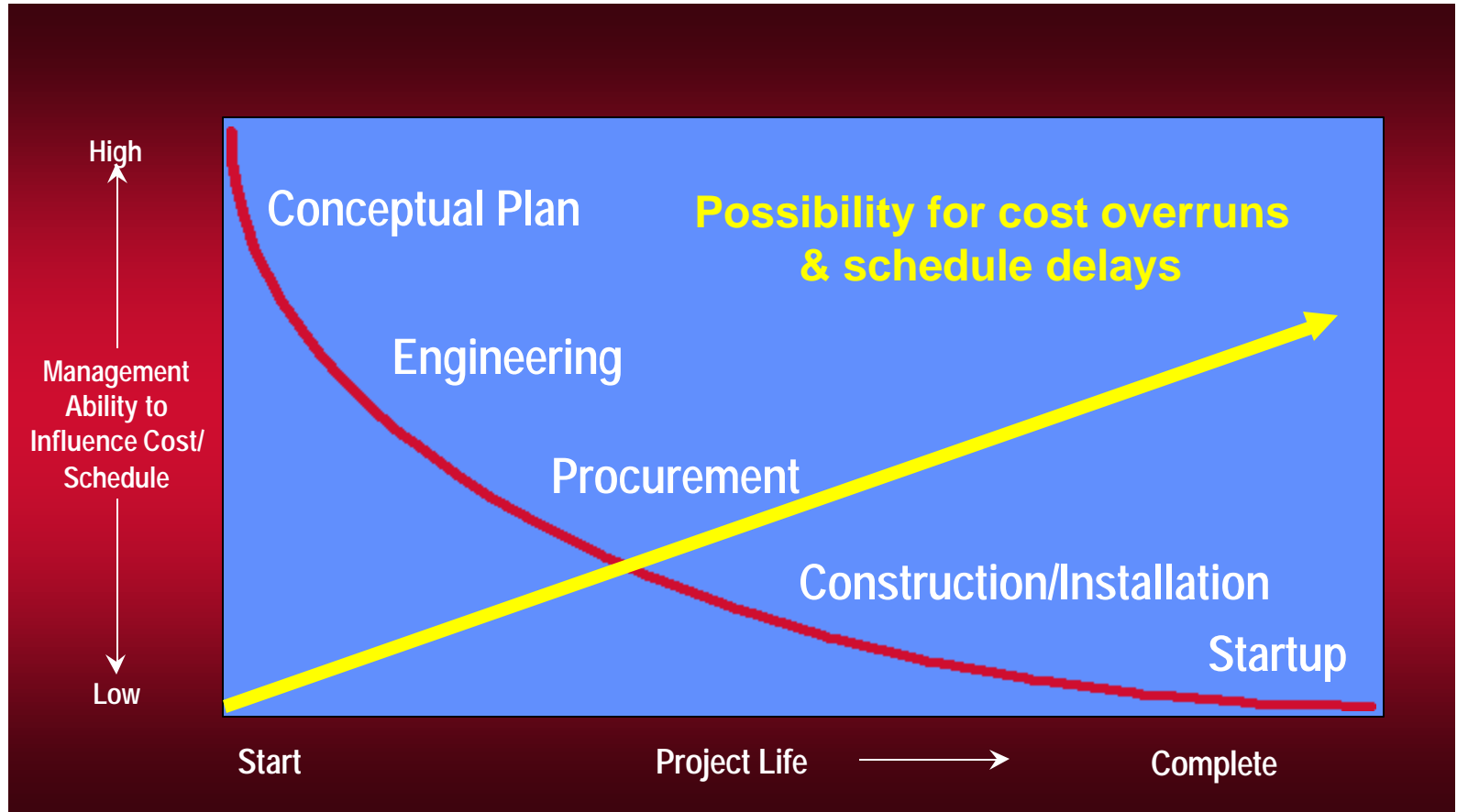
Bechtel Savannah River



Management Influence on Project Cost and Schedule



Management Influence on Project Cost and Schedule

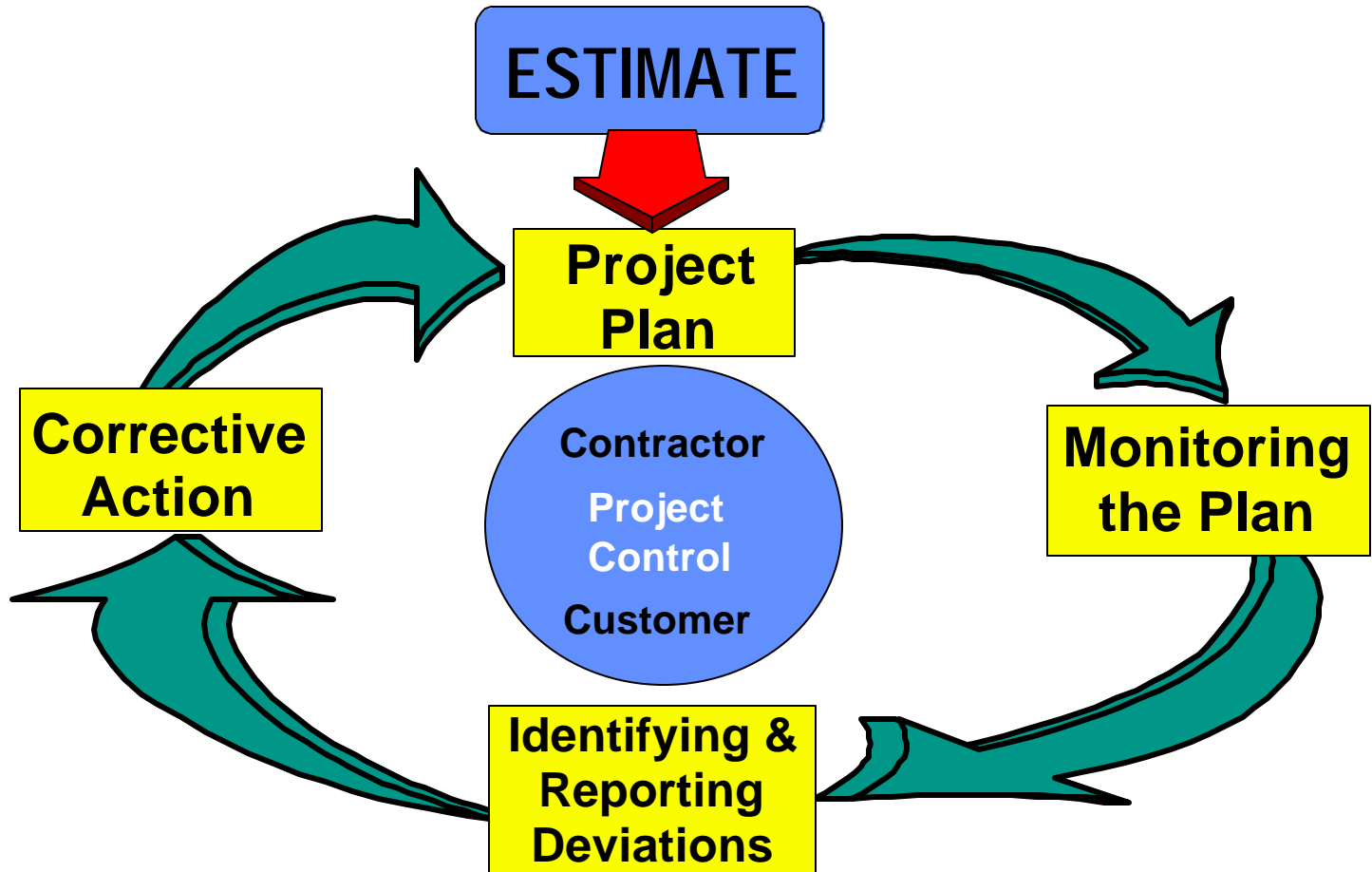


Objectives

- **Address critical project control tools and their use on construction projects**
 - **Estimating**
 - **Planning & Scheduling**
 - **Performance Analysis**
 - **Progress Reporting**
 - **Baseline Control / Trending**
 - **Forecasting**



The Control Cycle



Project Controls Process

Scope and Organization

- Scope of Work
- Design and Other Criteria
- Work Breakdown Structure
- Organizational Breakdown Structure
- Code of Accounts

Planning

- Estimates
- Project Schedules
- Time Phased Budgets
- Risk Analysis

Monitoring

- Physical Progress
- Expenditures and Commitments
- Cost and Schedule Trends
- Project Changes

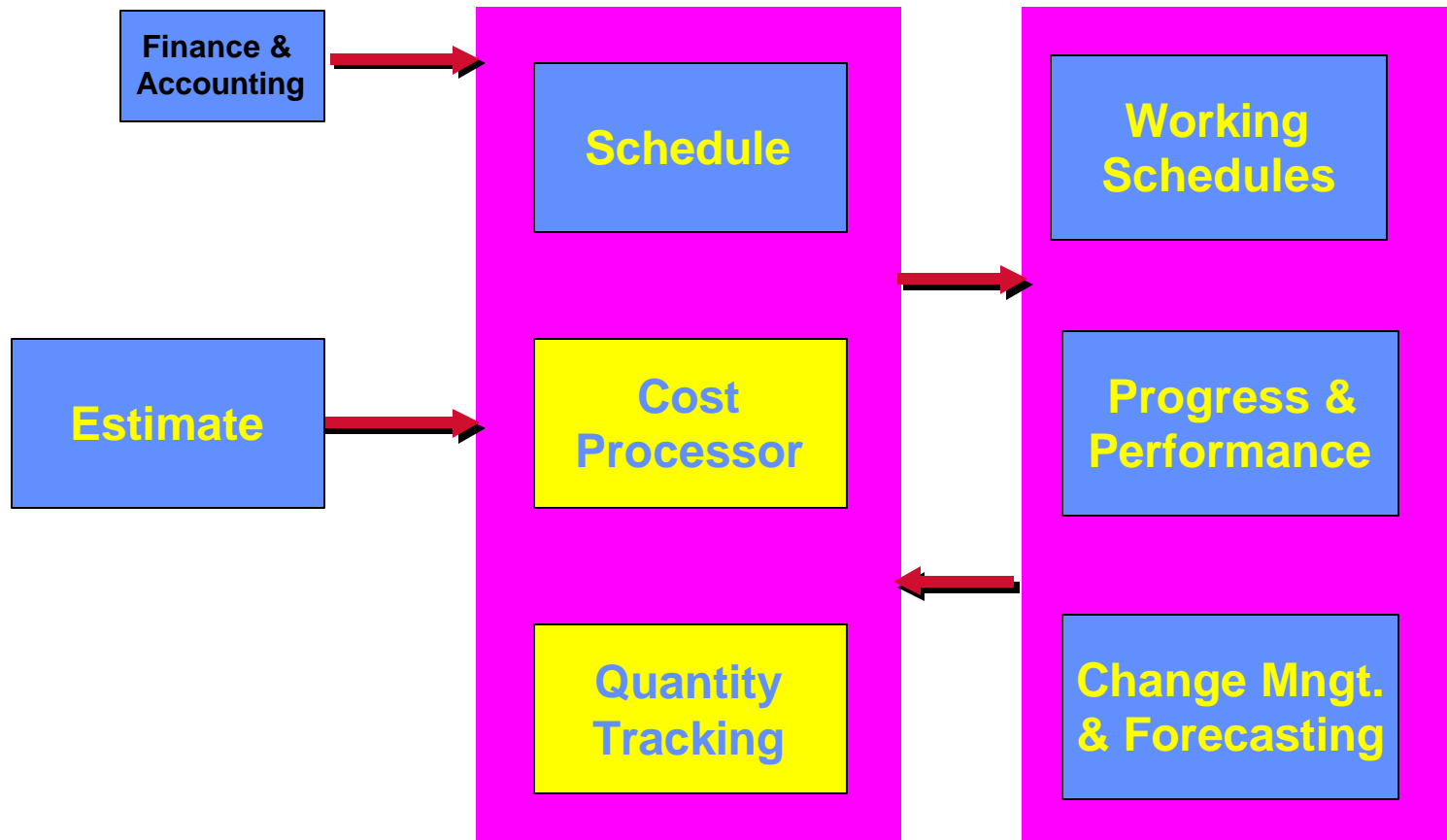
Analysis

- Critical Items
- Planned vs. Actual Performance & Productivity
- Schedule Updates
- Forecasts
- Funding and Cash Flows

Reporting

- Accomplishments and Milestones Achieved
- Actions for Critical Items
- Cost and Schedule Performance
- Plan Forward

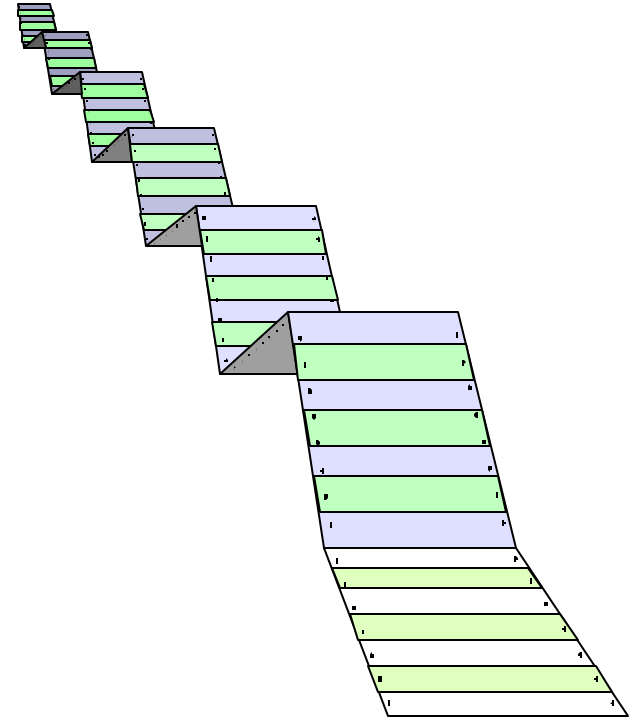
Construction Controls System



Scope Planning Execution Monitoring Analysis Reporting

Types of Estimates

- **Conceptual (Order of Magnitude)**
- **Preliminary**
- **Definitive**
- **Others:**
 - **Alternatives/"What-if's"**
 - **Field estimates (change orders & trends)**



Estimate Type Comparison

Order of Magnitude

+/- 30% accuracy

Engr 0% - 10%

**Plant cost/
capacity**

Ratio method

Similar work

Preliminary

**+/- 25%
accuracy**

Engr >10% cpt

Site specific

Major equip

known

Bulks factored

Definitive

**+/- 10 to 25%
accuracy**

Engr >40% cpt

Major equip qty

Qty takeoffs

**Site specific
labor**

**Detailed Constr.
Plan**

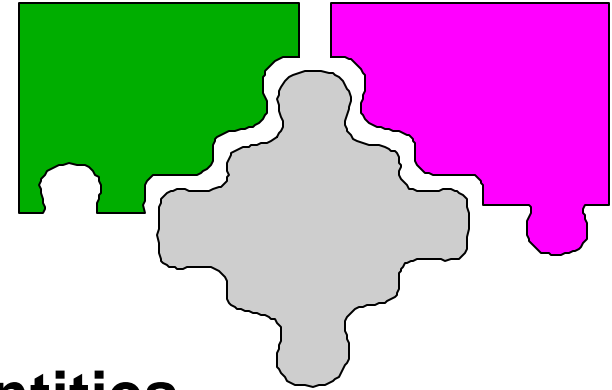
Definitive Estimate Methodology

- **Major equipment pricing based on committed cost or firm quotations**
- **Materials and Subcontracts based on detail quantity take-offs; firm unit cost or fixed price quotes or current billing costs**
- **Labor estimated from man-hour unit rates per quantity incorporating crew and craft mix**
- **Construction indirects detailed by major account and non-manual staffing plan**
- **Home office support costs based on man-hour by department or function**

Definitive Estimate General Requirements

- **Complete Process Design**
- **Mechanical Equipment List and Data Sheets**
- **P & ID's**
- **Critical Instrument Schedule and Data Sheets**
- **Electrical Single Lines**
- **Project Execution Plan**
- **Project Intermediate Schedule**

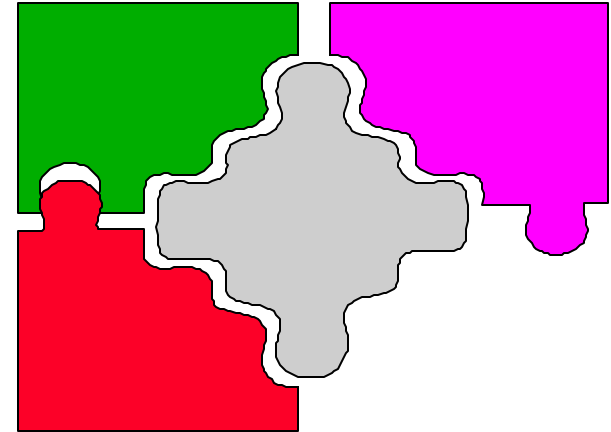
Quantification



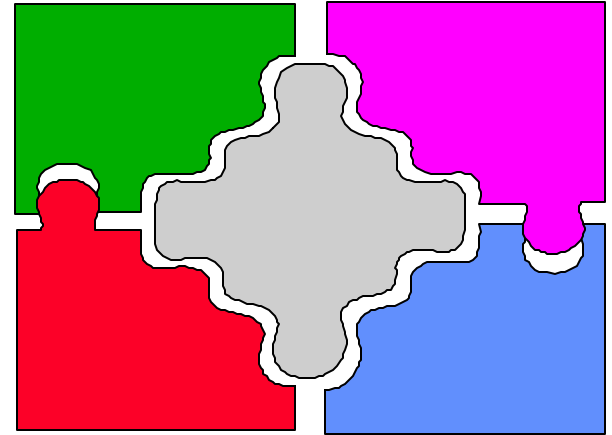
- **Driver of an Estimate**
- **Means of Developing Quantities**
 - actual
 - takeoffs
 - estimates from P&IDs, single lines, etc.
 - estimates to go
 - allowances
 - reference projects
- **Basis of Quantities Reflect the Estimate Level of Confidence**

Materials and Subcontracts - Pricing

- **Bid Evaluation**
- **Phone Quotes**
- **Previous Projects**
- **Industry Sources**



Manual Labor



■ Unit Rates

- Based on corporate and / or industry standards

■ Productivity Factors

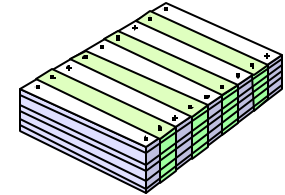
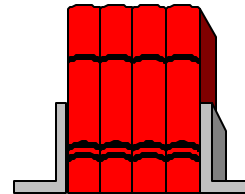
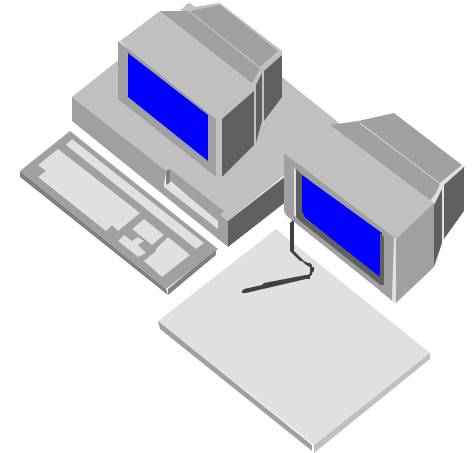
- Developed by construction/estimating and using reference projects or regional standards

■ Wage Rates

- Buildup of wage (payroll costs plus fringes, additives by craft)
- Craft mix (mix of craft workers per work operation)

Estimating Resources

- **Historical**
- **Reference Standards**
- **Reference Project/Plant**
- **Industry Data**
 - Means
 - Richardson's
- **Budgetary Quotes**
- **Trade Journals**
- **Who are the Guru's???**



Planning & Scheduling

- **A Plan** is a logical sequence of events
 - Identifies the Project GOALS
 - Encompasses the Scope of Work
 - Defines the Project Execution Plan
 - Identifies the required resources

Planning & Scheduling

- A **Schedule** incorporates durations and dates into the sequence of events necessary to accomplish the Plan
 - Used to establish project baseline
 - Prime tool to communicate project status
 - Serves as the basis for resources
 - Used to monitor and analyze progress
 - Must have proper level of detail

Types of Schedules

- **Bar Chart / Graph** - Only provides a pictorial representation of the project
 - Used for simple projects or for presentation purposes on complex projects
- **Critical Path Method (CPM)** - Provides a true picture of the schedule for the project. It provides the critical path and allows various analyses to be done. The schedule is **logically driven**.

CPM Scheduling

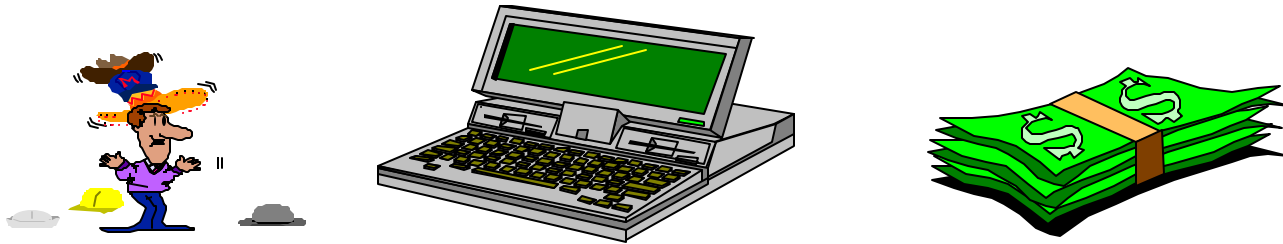
- **Critical Path Method** - the calculation of the earliest and latest start and finish dates of activities based on their durations and relationships to other activities
- **Critical Path** - one or more continuous chains of zero or negative float activities running from the start event to the finish event in the schedule. Normally the longest path in the schedule
- **Critical Activity** - any activity on the critical path

CPM Calculation

- **The determination of the earliest start and finish dates, and the latest start and finish dates of every activity in the network**
- **Early dates indicate the earliest start and finish dates when an activity can be performed if all preceding activities have been completed**
- **Late start and finish dates are the latest dates an activity can be performed without delaying the project**
- **A computer is best suited to handle the numerous calculations of a forward pass and backward pass**

Resource Scheduling

- People, equipment, costs, space, bulks...



- It defines which resources should be utilized on specific tasks - between which dates
- Good resource scheduling is the basis for maximizing the productivity of people and equipment while minimizing their cost

Why use Resource Scheduling?

- **Optimizes resource use**
 - Analyze staffing requirements
 - Evaluate effects of limited staffing
 - Avoid wide fluctuations in daily need for various resources
- **Analytically manage and use schedule float**
- **Produce more realistic schedules**
- **Produce progress & performance curves**
- **Comply with client requirements**

Common Scheduling Failures

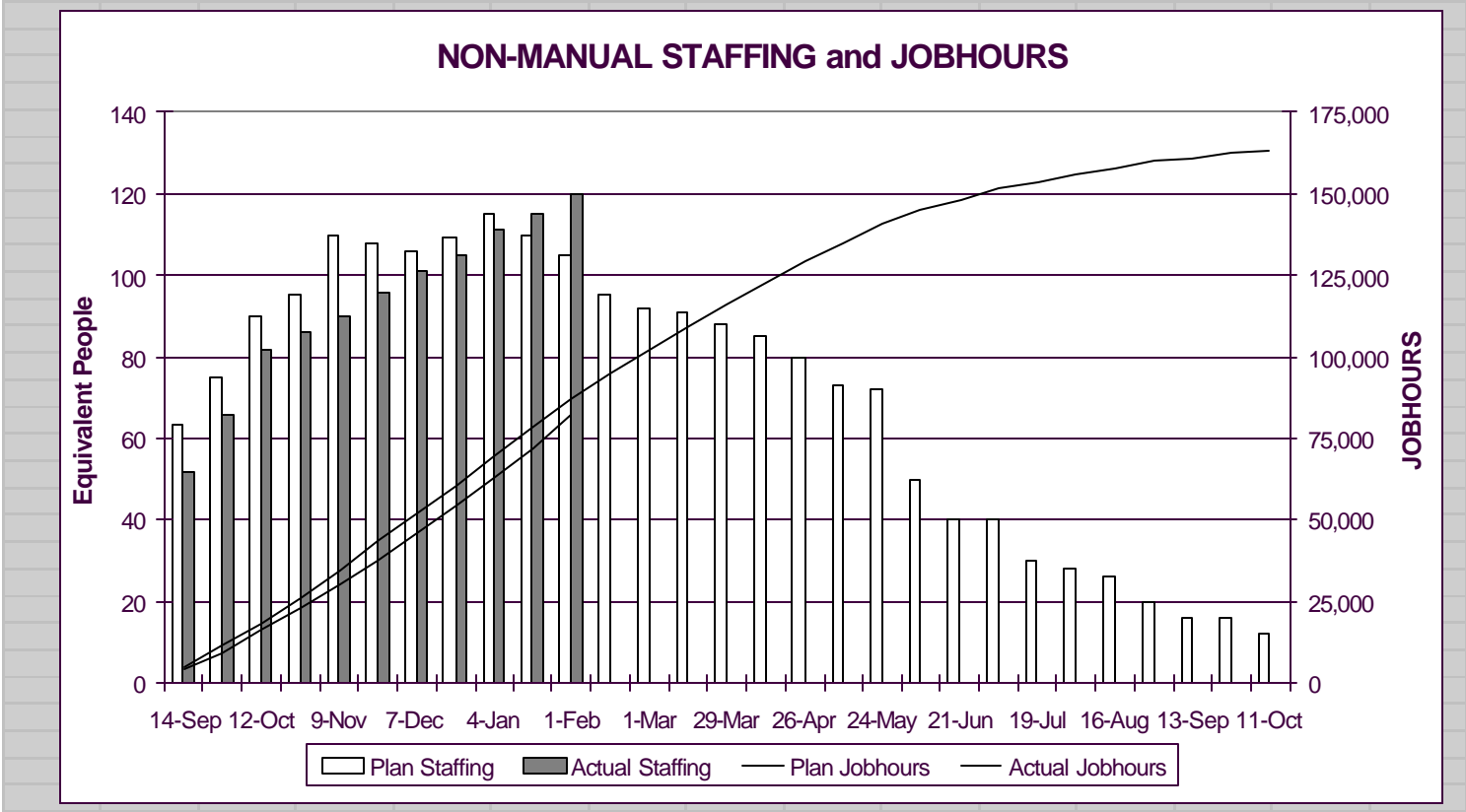
- **Lack of buy-in by all project team members**
- **Lack of PLANNING**
- **Poorly defined activities**
- **Inappropriate scheduling detail**
- **Inadequate logic ties**
- **Poor estimating of durations**
- **Failure to effectively manage float**
- **Failure to disseminate the proper information to all parties**

Primavera Schedule

ACTIVITY ID	ACTIVITY DESCRIPTION	DWC DMR	DAYS																									
			2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Z0P02-100	PE-FIRE PROTECTION/ENGINEERING SUMMARY	100																										
Z0P02-500	PE-01-FIRE HYDRANTS & PWS - PROP SPEC	20																										
Z0P02-100	PE-DESIGN & ISSUE PWD REV'D	20																										
Z0P02-100	PE-01-PIPE DESIGN	20																										
Z0P02-500	SC-002-01/G-FIRE PIPE PROTECTION - PROP'S	20																										
Z0P02-100	PE-01-HANGER DESIGN	20																										
Z0P02-250	PE-ROUTE CABLE (SET/ROUTE)	30																										
Z0P02-100	PE-CABLE DESIGN	20																										
Z0P02-450	PE-TERMINATION DESIGN (SET/ROUTE)	15																										
Z0P02C-500	PE-01-FIRE HYDRANTS & PWS - BEA	30																										
Z0P02C-500	SC-002-01/G-FIRE PIPE PROTECTION - BEA	20																										
Z0Z50-100	PE-A/C-FIRE PIPE PROTECTION - INSTALL	60																										
Z0Z054-500	PE-01-FIRE HYDRANTS & PWS - INSTALL	60																										
Z0Z054-500	SC-002-01/G-FIRE PIPE PROTECTION - INSTALL	60																										
Z0P040-100	PE-FIRE PROTECTION - WALKDOWN & PUNCHLIST	15																										
Z0P045-100	PE-FIRE PROTECTION - CHECKOUT	15																										

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Staffing and Jobhour Curve



Field Non-Manual Staffing Plan

FIELD NON-MANUAL STAFFING PLAN

Job No. XXXXX-XXX

Data Date

Position		1994												1995												Jobhours			
		M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	Plan	To-Date	To-go	Forecast			
Site Manager	Plan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3,612						
	Actual/Fcst	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1,376	2,064	3,440			
Site Superintendant	Plan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3,440						
	Actual/Fcst	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1,204	1,892	3,096			
Mechanical Sup't	Plan			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				2,666						
	Actual/Fcst			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1						860	1,548	2,408			
Piping Sup't	Plan				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2,924						
	Actual/Fcst				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		860	1,892	2,752			
Civil/Structural Sup't	Plan		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1					2,580						
	Actual/Fcst		0.5	1	1	1	1	1	1	1	1	1	1	1	1	0.5								1,118	1,290	2,408			
Electrical/Instr Sup't	Plan				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2,924						
	Actual/Fcst				0.5	1	1	1	1	1	1	1	1	1	1	1	1	1						774	1,720	2,494			
Secretary	Plan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3,612						
	Actual/Fcst	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1,376	2,064	3,440			
S/T	Plan	2	4	5	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	5	5	3	21,758						
	Actual/Fcst	2	4	4	7	7	7	7	7	7	7	7	7	7	7	7	6	5	4	2	0			7,568	12,470	20,038			
Field Engineering Sup'v	Plan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3,612						
	Actual/Fcst	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1,290	2,064	3,354			
Mechanical Field Engr	Plan				1	1	1	1	1	1	1	1	1	1	1	1	1	1					2,752						
	Actual/Fcst				1	1	1	1	1	1	1	1	1	1	1	1	1							860	1,720	2,580			
Piping Field Engr	Plan				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3,096						
	Actual/Fcst				0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		946	1,892	2,838			
Civil/Struct Field Engr	Plan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1							2,752						
	Actual/Fcst	0.5	1	1	1	1	1	1	1	1	1	1	1	1										1,290	1,204	2,494			
Elect/Instr Field Engr	Plan				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3,268						
	Actual/Fcst				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1,032	2,064	3,096			
S/T	Plan	2	2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	3	3	2	15,480						
	Actual/Fcst	1	2	4	5	5	5	5	5	5	5	5	5	5	5	4	4	4	3	2	0			5,418	8,944	14,362			

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Manual Labor Wage Rate Report

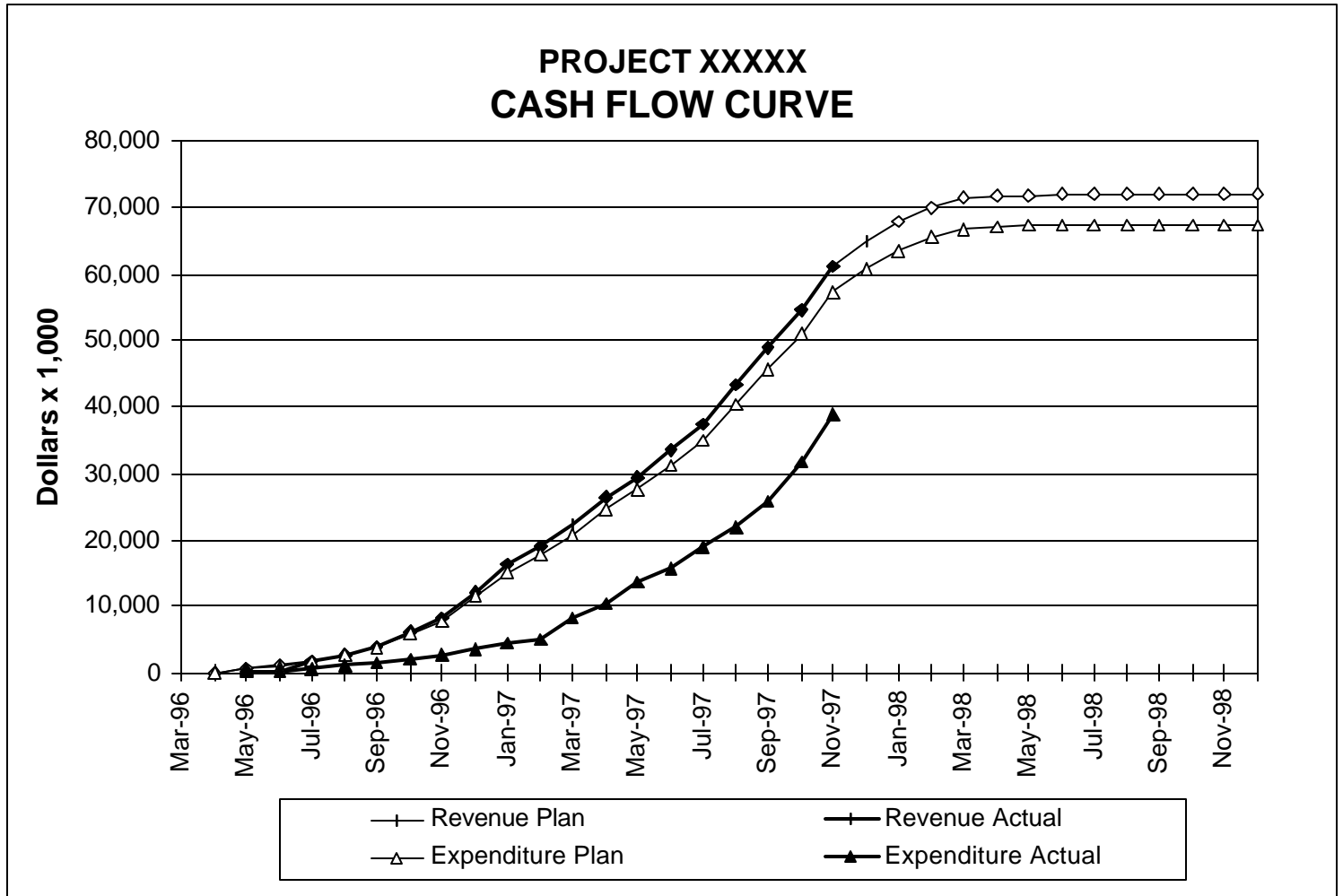
MANUAL LABOR WAGE RATE and CRAFT MIX

Job No. XXXXX

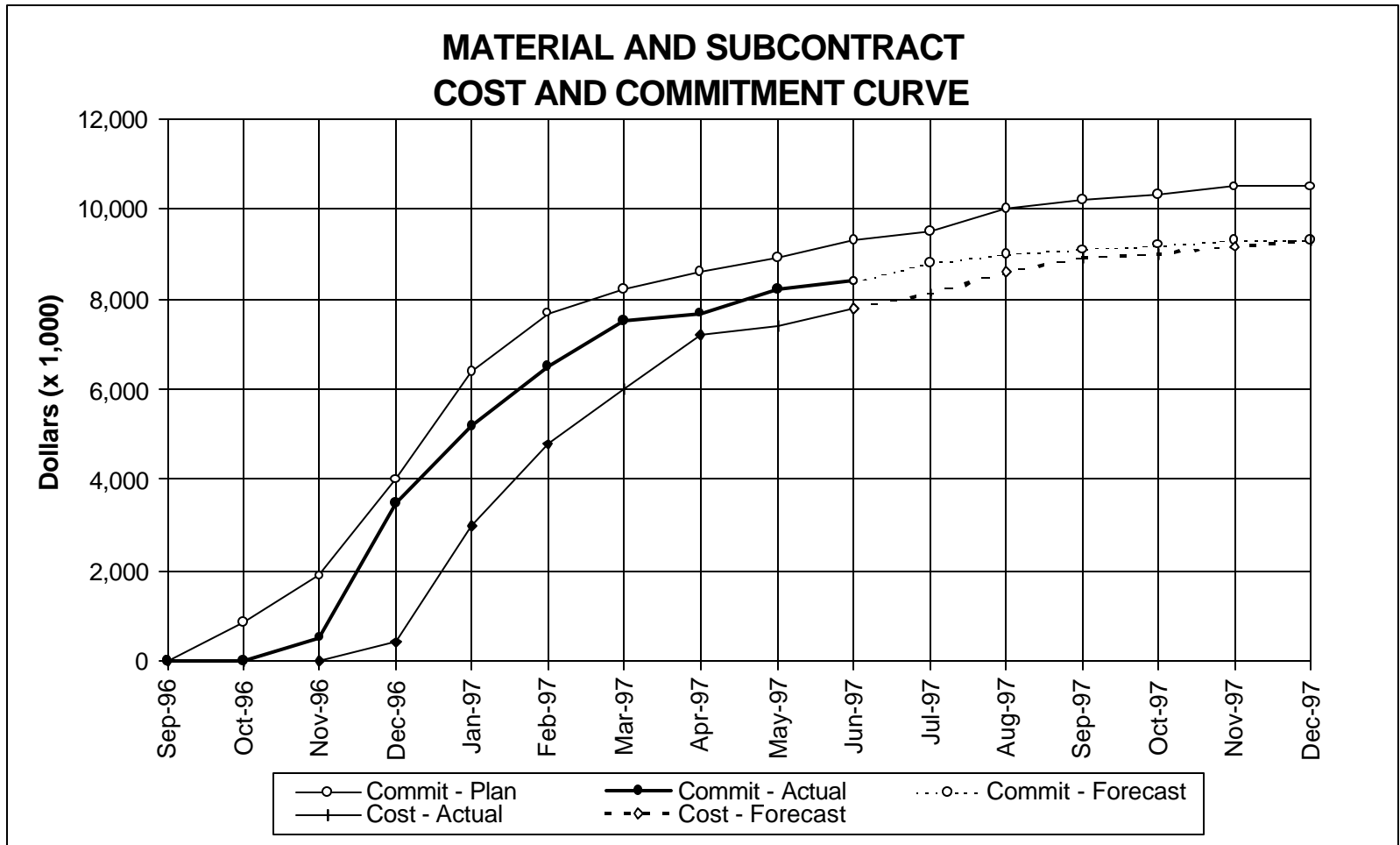
Period Ending: 12-Oct-96

Craft ID	Description	Jobhours			Dollars			Wage Rate			Craft Mix		
		Budget	To-Date	This Wk	Budget	To-Date	This Wk	Budget	To-Date	This Wk	Budget	To-Date	This Wk
BM	Boilermaker	5,743	3,245	327	179,986	96,571	9,336	31.34	29.76	28.55	6.8%	9.2%	10.2%
CP	Carpenter	6,588	4,876	434	160,286	128,873	12,386	24.33	26.43	28.54	7.7%	13.8%	13.6%
EL	Electrician	18,756	5,678	387	685,907	213,777	14,485	36.57	37.65	37.43	22.1%	16.1%	12.1%
IN	Insulator	1,322	0	0	32,164	0	0	24.33	0.00	0.00	1.6%	0.0%	0.0%
IW	Ironworker	5,676	4,976	466	169,599	141,517	13,477	29.88	28.44	28.92	6.7%	14.1%	14.6%
LB	Laborer	8,457	5,548	512	114,677	70,737	6,477	13.56	12.75	12.65	9.9%	15.7%	16.0%
MW	Millwright	4,345	2,854	287	141,864	87,561	8,966	32.65	30.68	31.24	5.1%	8.1%	9.0%
PF	Pipefitter	26,345	5,633	445	988,991	223,348	17,853	37.54	39.65	40.12	31.0%	15.9%	13.9%
PL	Plumber	4,335	978	175	148,387	34,680	5,877	34.23	35.46	33.58	5.1%	2.8%	5.5%
TD	Teamster	3,445	1,543	166	78,029	34,316	3,665	22.65	22.24	22.08	4.1%	4.4%	5.2%
	TOTAL	85,012	35,331	3,199	2,699,890	1,031,380	92,522	31.76	29.19	28.92	100.0%	100.0%	100.0%

Cash Flow Curve



Cost and Commitment Curve



Progress and Performance Objectives

- **Compare Actual Project Progress against Planned Progress**
- **Measure the Performance of Work being Executed**
- **Identify Deviations to the Plan (Trends)**
- **Implement Corrective Actions (Mitigate)**
- **Forecasting Tool**

Physical Progress

- ***Physical Progress*** is represented by **Percent Complete**
- ***Percent Complete*** is based on **Earned Value**
- ***Earned Value*** (EV) is a direct measurement of quantity of work completed expressed in terms of the budget assigned to the work
 - EV should be quantity based whenever possible (minimize LOE)
 - EV is a value added tool, but it should be used in conjunction with the other control tools

Construction Performance Measurement

- **Calculations:**

$$\begin{array}{l} \text{Detail level} \\ \% \text{ Complete} \end{array} = \frac{\text{Installed Quantity}}{\text{Forecast Quantity}}$$

$$\begin{array}{l} \text{Summary level} \\ \% \text{ Complete} \end{array} = \frac{\text{Earned Man-hours}}{\text{Forecast Man-hours}}$$

$$\text{Earned Man-hours} = (\text{Quantity Installed}) \times (\text{Budget Unit Rate})$$

$$\text{Man-hour PF} = \frac{\text{Earned Man-hours}}{\text{Actual Man-hours}}$$

Progress and Performance Reporting Tools

- **Quantity Unit Rate Reports**
- **Progress and Performance Reports**
- **Progress and Performance Curves**
- **Material & S/C Cost & Commitment Curves**
- **Quantity Installation Curves**

Quantity Unit Rate Reports

- **A Quantity Unit Rate Report is an integral part of a construction control system to monitor and control direct hire labor performance**
- **The QURR also provides:**
 - **Early indication of problem areas that need corrective action**
 - **Comparison between actual, budget and forecast labor performance**

QURR Report

Run Date: 2/26/02 08:43:12 am
 Data Date: 02/17/02 Selection Criteria
 Mgmt. Co.: E529
 Exec. Co. %
 Project %
 Activity Code %
 User Code %
 TWC %
 Archived Records: NO



Projects
WEEKLY Quantity and Unit Rate Report
 Sort: COST CODE - PROJECT: Projects and WADs



N:\PCUSG\SITS\QURRRPTS\QUR1R2A.RPP

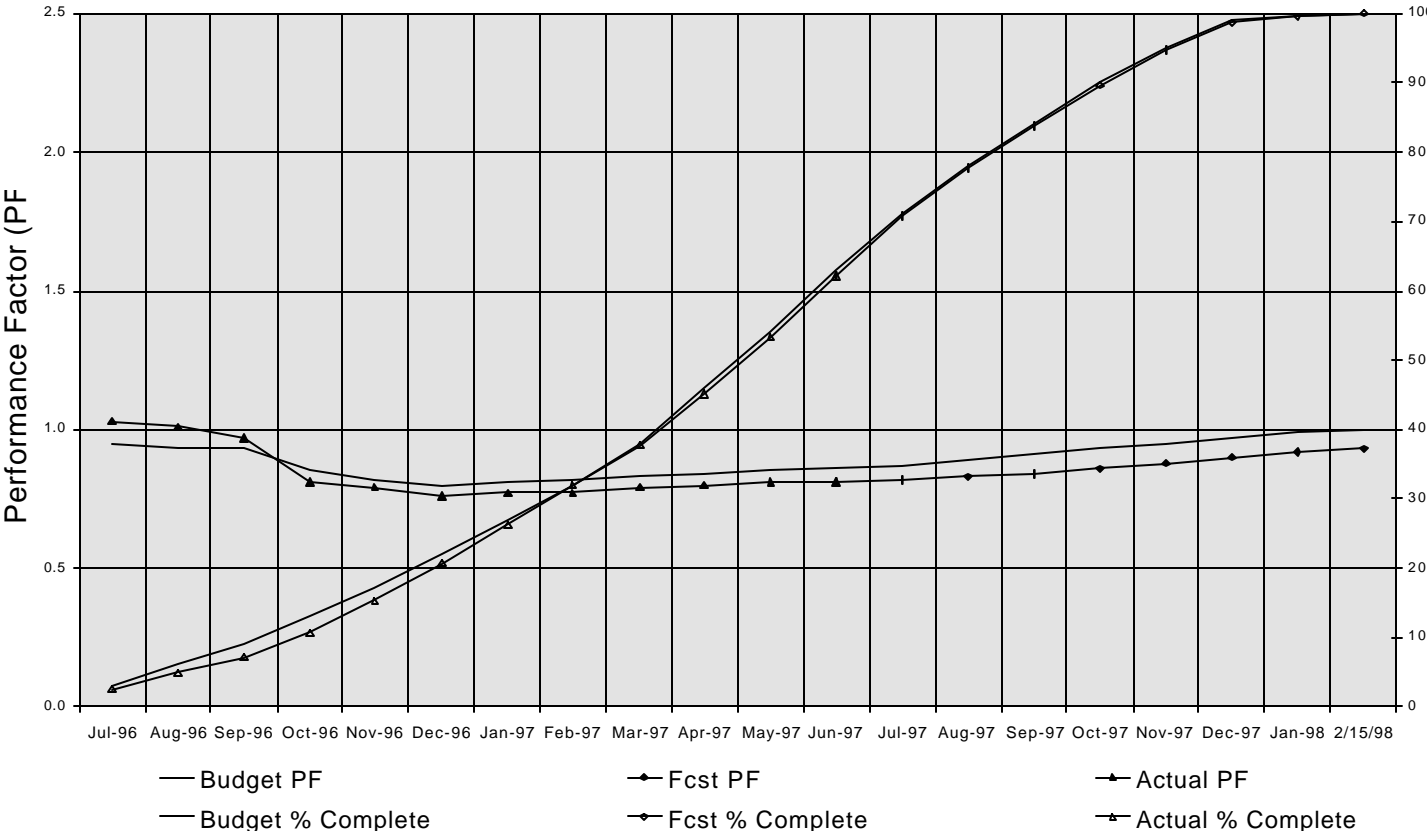
Calculation Base: BUDGET

TWC	TWC DESCRIPTION	UOM	QUANTITIES				MANHOURS						TOTAL SCOPE	←UNIT RATE→		PHYS % CMLPT	PERFORMANCE		TREND FCST
			CUR BGT	CUR FCST	TO DATE	THIS PER	CUR BGT	CUR FCST	TO DATE	THIS PER	←EARNED→	TO DATE		THIS PER	FCST BGT		DATE	TO DATE	
2200	Transformers	EA	2	2	0	0.0	105	105	0	0	0	105	52.50	0.00	0.00	0.00	0.00		
2500	Install New 60A Fuse Disconnect Switch	EA	12	12	4	4.0	249	249	75	0	93	0	249	19.86	8.33	37.35	1.24	0.00	108
2530	Low Voltage Equipment	EA	3	3	3	3.0	12	12	11	0	12	0	12	4.00	3.67	100.00	1.09	0.00	13
2930	Replace LL6 Welders	PC	100	100	100	0.0	1000	1000	918	0	1000	0	1000	10.00	9.19	100.00	1.09	0.00	1089
6000	(25) Transformer, Canyon Interocks	PC	100	100	52	0.0	53664	81549	72041	41	42225	0	52652	23.93	38.71	80.87	0.59	0.00	35418
6100	Cable Tray and Wireway	LF	70	70	70	70.0	86	86	35	0	86	0	86	1.23	0.50	100.00	2.48	0.00	211
6200	Conduit	LF	25483	22210	6227	6227.0	31841	25978	3732	0	4891	0	26900	1.12	0.39	15.04	1.31	0.00	6848
6220	Intermediate Metal Conduit (IMC)	LF	1255	1255	0	0.0	1091	1091	25	25	0	0	1091	0.87	0.00	0.00	0.00	0.00	1091
6270	Engineered Conduit Supports	EA	75	75	0	0.0	9708	9708	0	0	0	0	9708	124.08	0.00	0.00	0.00	0.00	
6300	Wire and Cable	LF	79074	126786	94752	94752.0	9381	13158	5789	0	7064	0	13021	0.14	0.03	56.06	1.22	0.00	8871
6310	Power and Control Cable Pulling 600V & Less	LF	3020	3020	0	0.0	266	266	0	0	0	0	266	0.09	0.00	0.00	0.00	0.00	
6343	Optical Cable Pulling	LF	15800	14100	0	0.0	3336	2840	0	0	0	0	2840	0.19	0.00	0.00	0.00	0.00	
6344	Heat Trace for Safety Shower	LF	3835	3771	40	40.0	844	824	8	0	28	0	832	0.41	0.07	0.97	3.50	0.00	98
6350	Other Unscheduled Cable & Connections	LF	1810	1810	0	0.0	242	242	0	0	0	0	242	0.13	0.00	0.00	0.00	0.00	
6400	Connections	EA	603	686	565	565.0	2766	3349	1958	0	4318	0	5473	229.23	3.77	65.51	2.21	0.00	28731
6410	Power and Control Connections 600V & Less	EA	327	327	0	0.0	165	165	0	0	0	0	165	0.52	0.00	0.00	0.00	0.00	
6440	Special Connections	EA	292	321	321	321.0	3437	3823	3823	0	3778	0	3778	11.77	11.91	100.00	0.99	0.00	3734
6610	Grounding Cable	PC	100	100	67	0.0	905	905	543	2	602	0	905	4.30	3.62	66.52	1.11	0.00	889
6700	Boxes, Fixtures and Devices	EA	23	23	1	1.0	503	503	24	0	15	0	503	18.99	12.00	2.98	0.63	0.00	9
6710	Metal Boxes - (Greater than 12" x 12")	EA	7	7	0	0.0	26	26	0	0	0	0	26	3.71	0.00	0.00	0.00	0.00	
6720	Fixtures and Devices	EA	13	13	1	1.0	211	211	142	0	107	0	211	57.84	71.00	50.71	0.75	0.00	81
6900	Thermo Jumper	PC	100	100	104	0.0	1196	1146	983	0	1196	0	1196	3.99	2.46	100.00	1.22	0.00	2358
6910	Testing	PC	100	100	69	0.0	499	425	122	0	204	0	499	0.83	0.33	51.76	2.42	0.00	2495
6920	Re-Label Control Panels A&B	PC	100	100	36	0.0	270	754	749	0	270	0	270	2.70	3.75	100.00	0.38	0.00	488
6930	Miscellaneous Electrical Bulk Operations	PC	100	100	70	0.0	6021	7542	5036	0	5308	0	6021	6.02	4.78	86.57	1.05	0.00	6109
6940	Dismantle (D&R)	PC	100	100	72	5.9	2820	2681	1722	10	1926	158	2820	2.82	2.36	66.65	1.12	16.63	3662
6950	Lock, Tag & Try	PC	100	100	46	11.9	241	201	48	20	92	24	241	0.80	0.55	25.87	1.90	1.17	325
7200	Mechanical Instrumentation	EA	89	89	49	49.0	769	519	60	0	489	0	769	8.63	0.72	46.05	8.15	0.00	952
7220	Instruments	EA	33	42	42	42.0	184	234	35	0	234	0	234	5.58	0.83	100.00	6.69	0.00	1564
7300	Electrical Instrumentation	PCT	100	100	92	0.0	2812	2998	2111	0	2768	0	2812	7.03	5.29	98.53	1.31	0.00	3789
GRAND TOTAL:							134650	162590	99971	98	76796	182	134927			60.94	0.77	1.87	108925

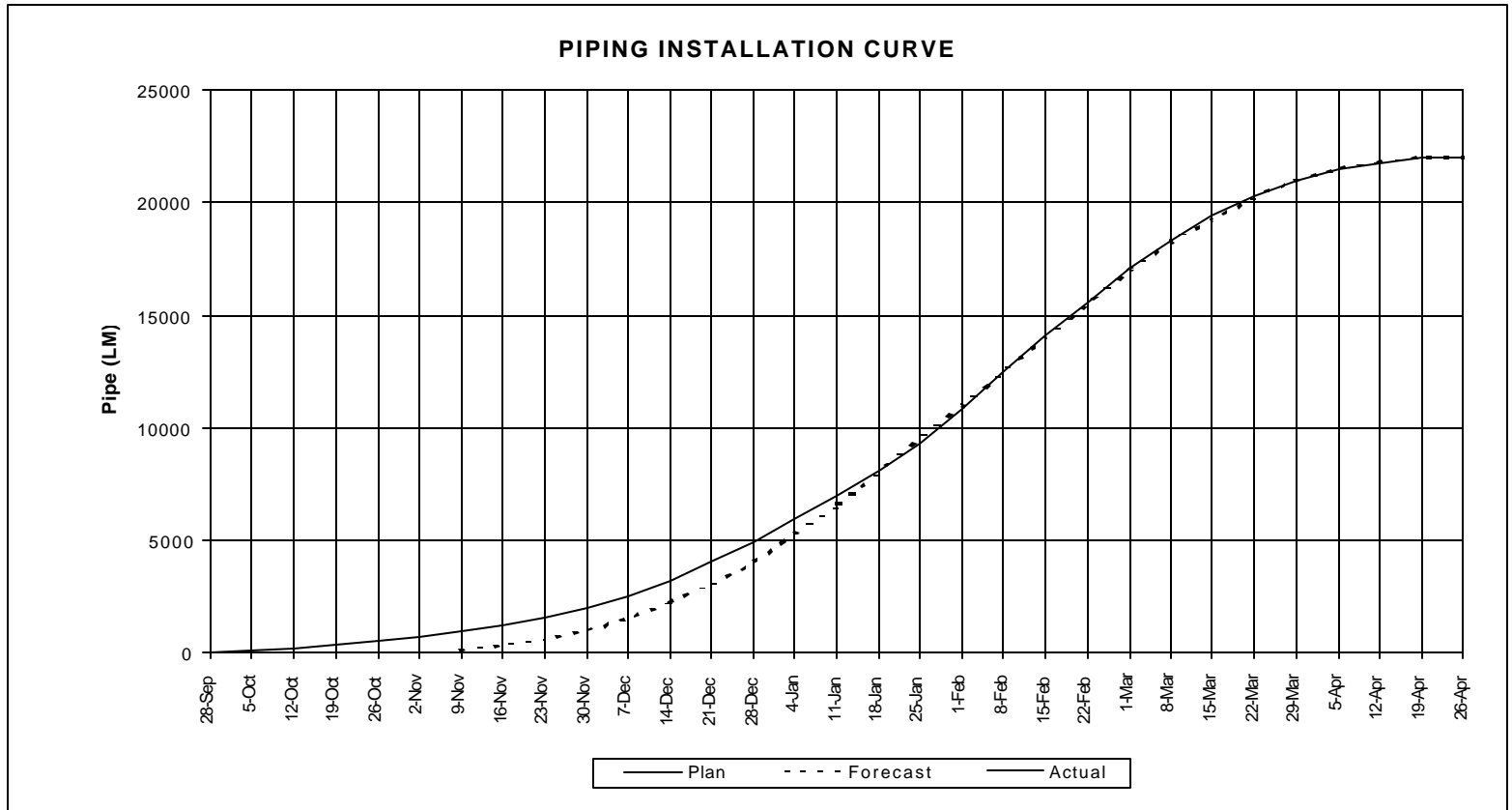
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Construction Direct Hire Progress and Performance Curve

Progress & Performance Curves
Total Manual Construction



Quantity Installation Curve



Trending and Change Control

- **Change Control** - formal process of modifying the project cost & schedule baseline and/or contract
- **Trend Program** - a precursor to the formal change control process that identifies the potential for change to occur to the scope, cost and/or schedule baseline

Trend Definitions

■ Scope Change Trend

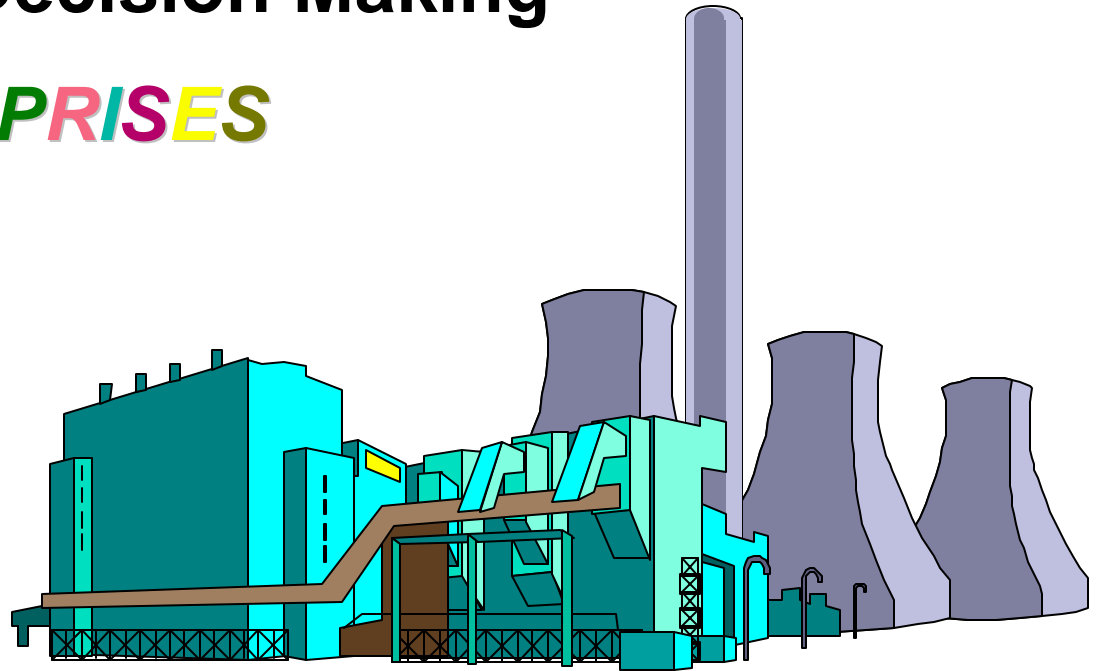
- An item of change to the project scope, schedule, or plant quality requested by the Client, recommended by the contractor or required by Regulatory Agencies

■ Other Trends

- Items that cannot be classified as scope changes, but are attributable to project evolution, such as: pricing, quantity fluctuations, design changes, productivity

Key Trend Program Attributes

- **Early Identification**
- **Informed Decision Making**
- **Timely Decision Making**
- **NO SURPRISES**



Trend Impact Assessment

- **Why do we need to change?**
- **Who or what is impacted by the change?**
 - Project functions
 - Cost elements
 - Schedule
- **The objective is?**
 - Only change for the better
- **The Action is?**
 - If you can't avoid it... minimize or work around it

Forecast Objectives

- **Evaluate current status of project cost and schedule**
- **Determine critical items for management review and action**
- **Provide a sound basis for future project control**

Forecast Elements

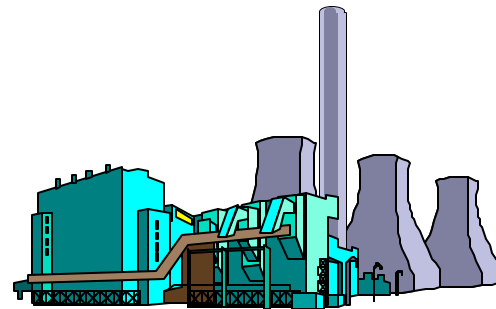
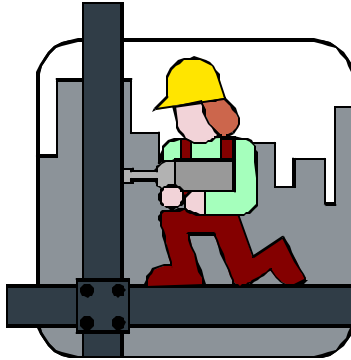
- **Quantity Development & Review**
- **Material & Subcontract Pricing Review**
- **Manual Labor Productivity Analysis**
- **Manual Labor Pricing Analysis**
- **Construction Indirect Cost Analysis**
- **Home Office Cost Analysis**
- **Schedule Analysis**
- **Escalation Analysis**
- **Contingency Analysis**

Forecast Elements

- **Quantity Development & Review**
 - **To-Date Installed Quantities**
 - **Total Forecast Quantities**
 - **Budget Quantities**
 - **Detailed Take-offs**
 - **Scope Growth Allowance**

Summary

- These are just some of the tools that can be used to manage construction projects
- Utilize the “graded approach” based on project complexity, size and risk



- If/when a construction project gets into trouble, **DON'T eliminate your controls tools to try to save money**