Ch. 9 - PROJECT CONTROL
- Monitoring
- Evaluating
- Updating

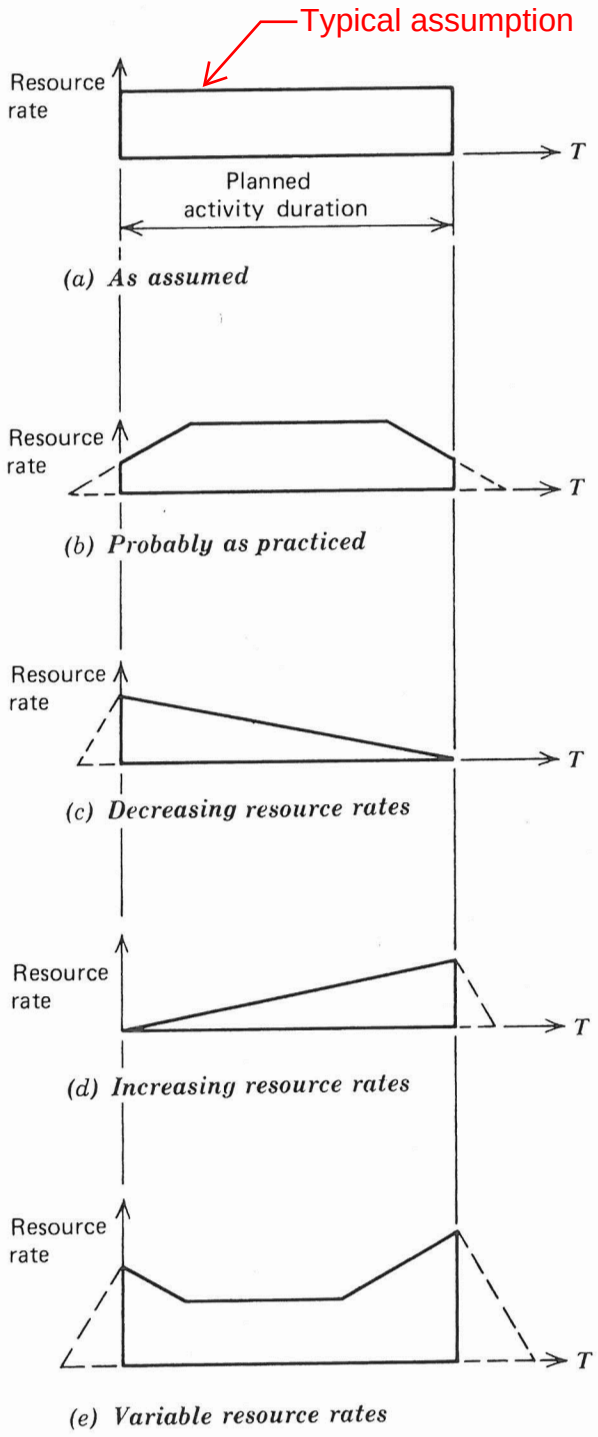


Figure 9.1 Target activity durations.

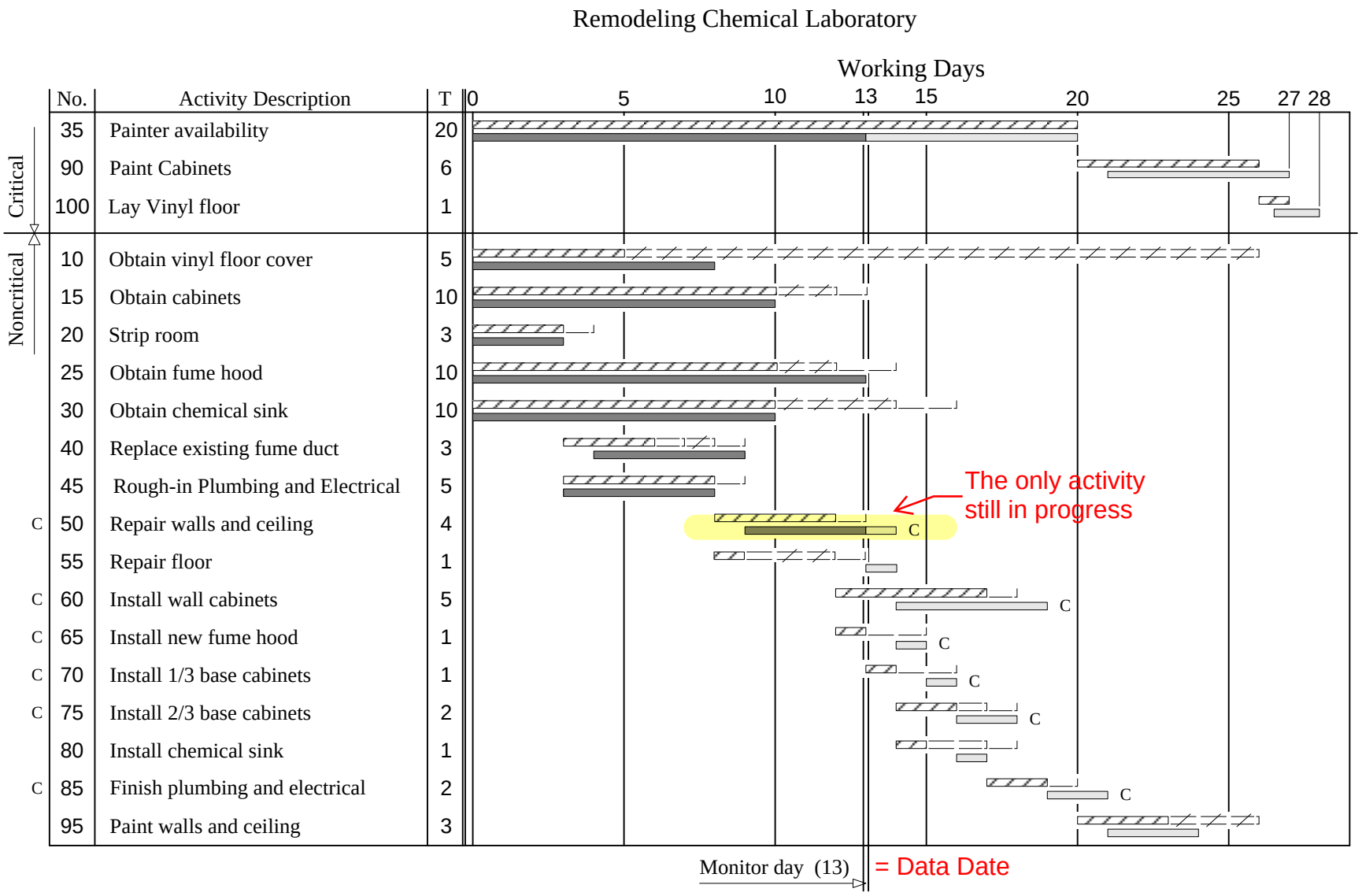
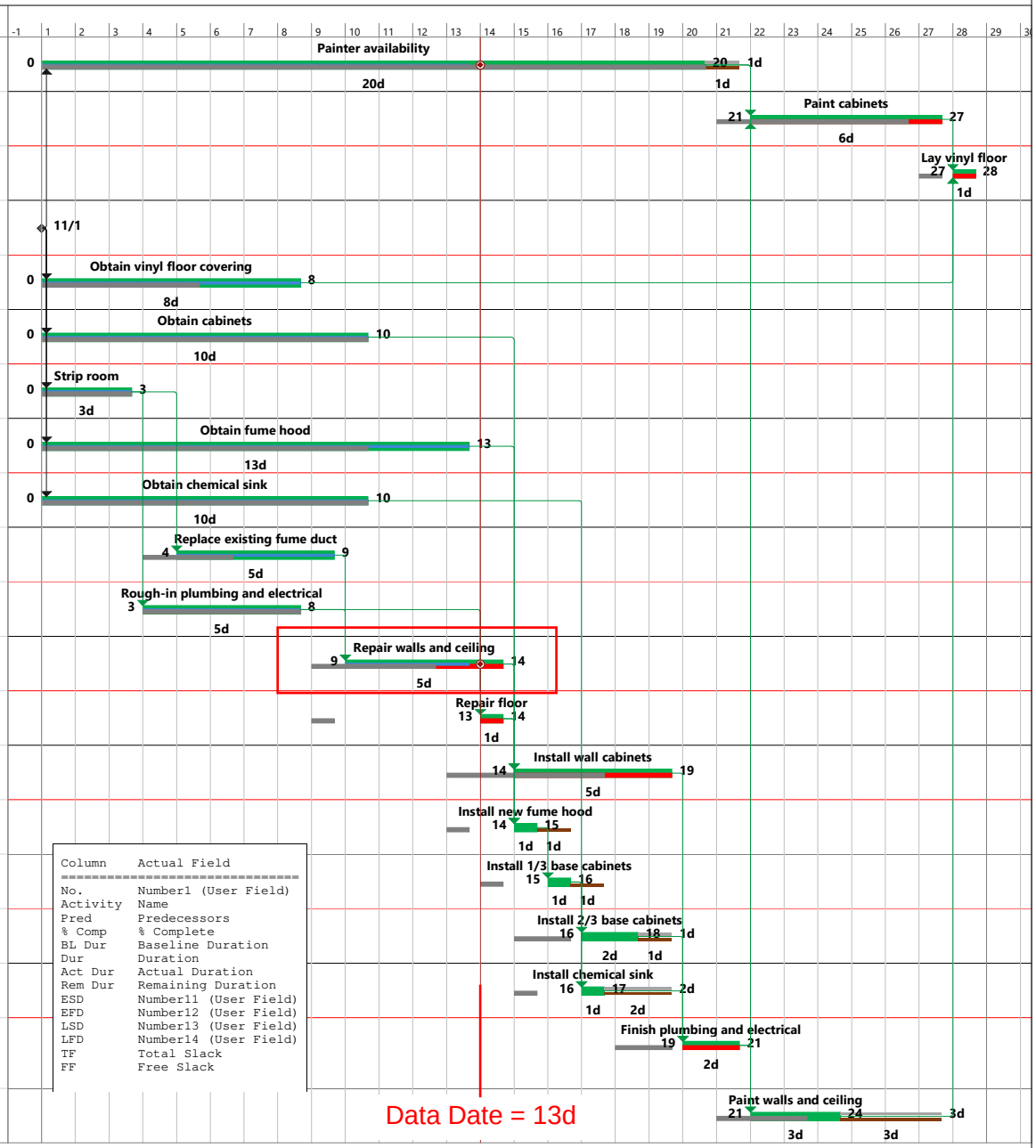


Figure 9.1 Bar Chart from Precedence Network Computations at Monitoring Day 13.

ID	No.	Activity	Pred	% Comp	BL Dur	Dur	Act Dur	Rem Dur	Actual Start	Actual Finish	ESD	EFD	LSD	LFD	TF	FF
7	35	Painter availability	1	65%	20d	20d	13d	7d	11/1/24	NA	0	20	0	21	1d	1d
18	90	Paint cabinets	7,17	0%	6d	6d	0d	6d	NA	NA	21	27	21	27	0d	0d
20	100	Lay vinyl floor	18,19,2	0%	1d	1d	0d	1d	NA	NA	27	28	27	28	0d	0d
1	5	Contract award		100%	0d	0d	0d	0d	11/1/24	11/1/24	0	0	0	0	0d	0d
2	10	Obtain vinyl floor covering	1	100%	5d	8d	8d	0d	11/1/24	11/8/24	0	8	0	8	0d	0d
3	15	Obtain cabinets	1	100%	10d	10d	10d	0d	11/1/24	11/10/24	0	10	0	10	0d	0d
4	20	Strip room	1	100%	3d	3d	3d	0d	11/1/24	11/3/24	0	3	0	3	0d	0d
5	25	Obtain fume hood	1	100%	10d	13d	13d	0d	11/1/24	11/13/24	0	13	0	13	0d	0d
6	30	Obtain chemical sink	1	100%	10d	10d	10d	0d	11/1/24	11/10/24	0	10	0	10	0d	0d
8	40	Replace existing fume duct	4	100%	3d	5d	5d	0d	11/5/24	11/9/24	4	9	4	9	0d	0d
9	45	Rough-in plumbing and	4	100%	5d	5d	5d	0d	11/4/24	11/8/24	3	8	3	8	0d	0d
10	50	Repair walls and ceiling	8,9	80%	4d	5d	4d	1d	11/10/24	NA	9	14	9	14	0d	0d
11	55	Repair floor	9	0%	1d	1d	0d	1d	11/14/24	NA	13	14	13	14	0d	0d
12	60	Install wall cabinets	10,3,11	0%	5d	5d	0d	5d	NA	NA	14	19	14	19	0d	0d
13	65	Install new fume hood	10,5,11	0%	1d	1d	0d	1d	NA	NA	14	15	15	16	1d	0d
14	70	Install 1/3 base cabinets	13	0%	1d	1d	0d	1d	NA	NA	15	16	16	17	1d	0d
15	75	Install 2/3 base cabinets	14	0%	2d	2d	0d	2d	NA	NA	16	18	17	19	1d	1d
16	80	Install chemical sink	6,14	0%	1d	1d	0d	1d	NA	NA	16	17	18	19	2d	2d
17	85	Finish plumbing and electrical	12,15,16	0%	2d	2d	0d	2d	NA	NA	19	21	19	21	0d	0d
19	95	Paint walls and ceiling	7,17	0%	3d	3d	0d	3d	NA	NA	21	24	24	27	3d	3d



Typical S-curve shape --- Rule of thumb

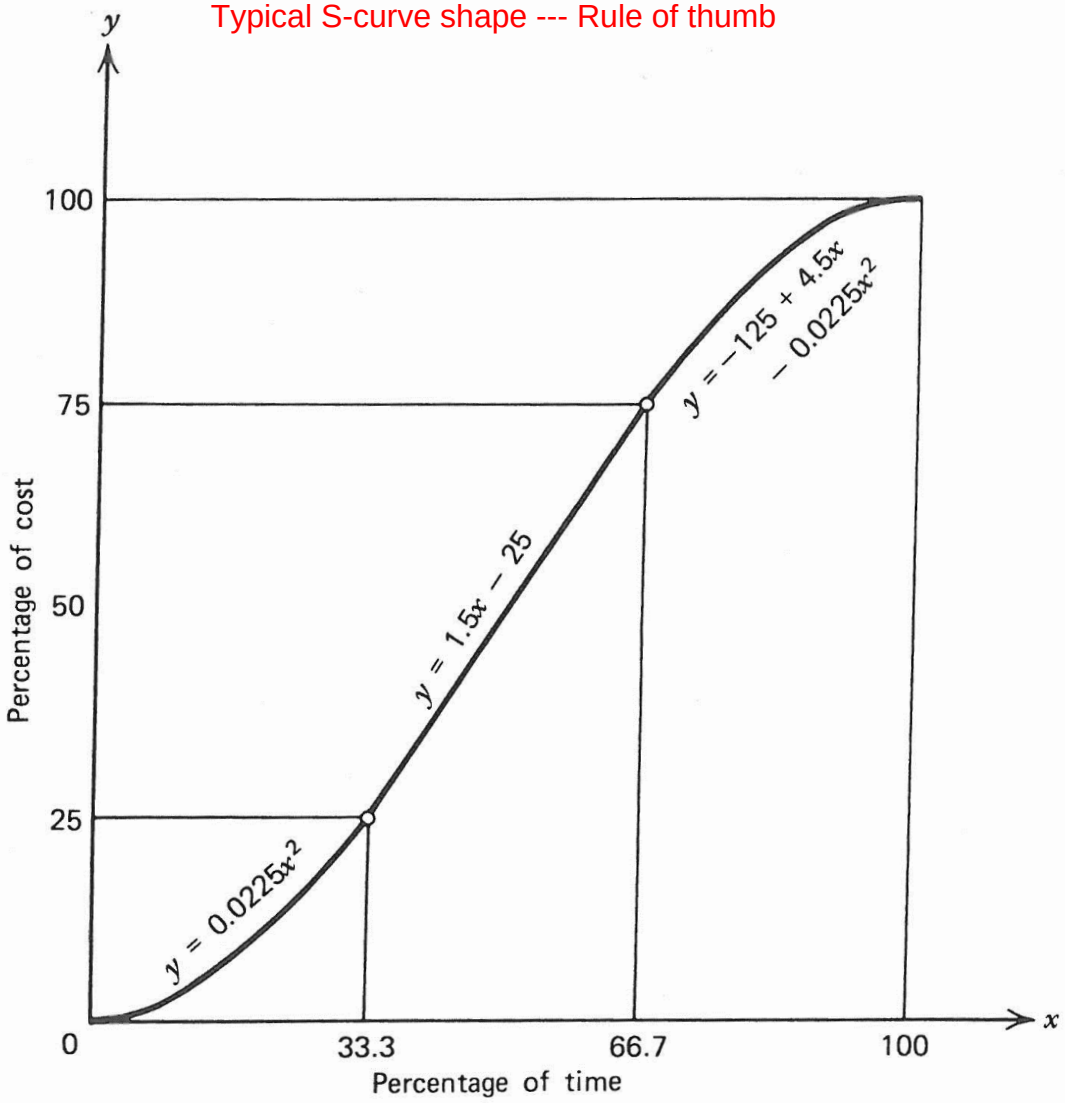


Figure 9.3 Anticipated target S-curve.

Constructed from scheduling & cost computations (example follows)

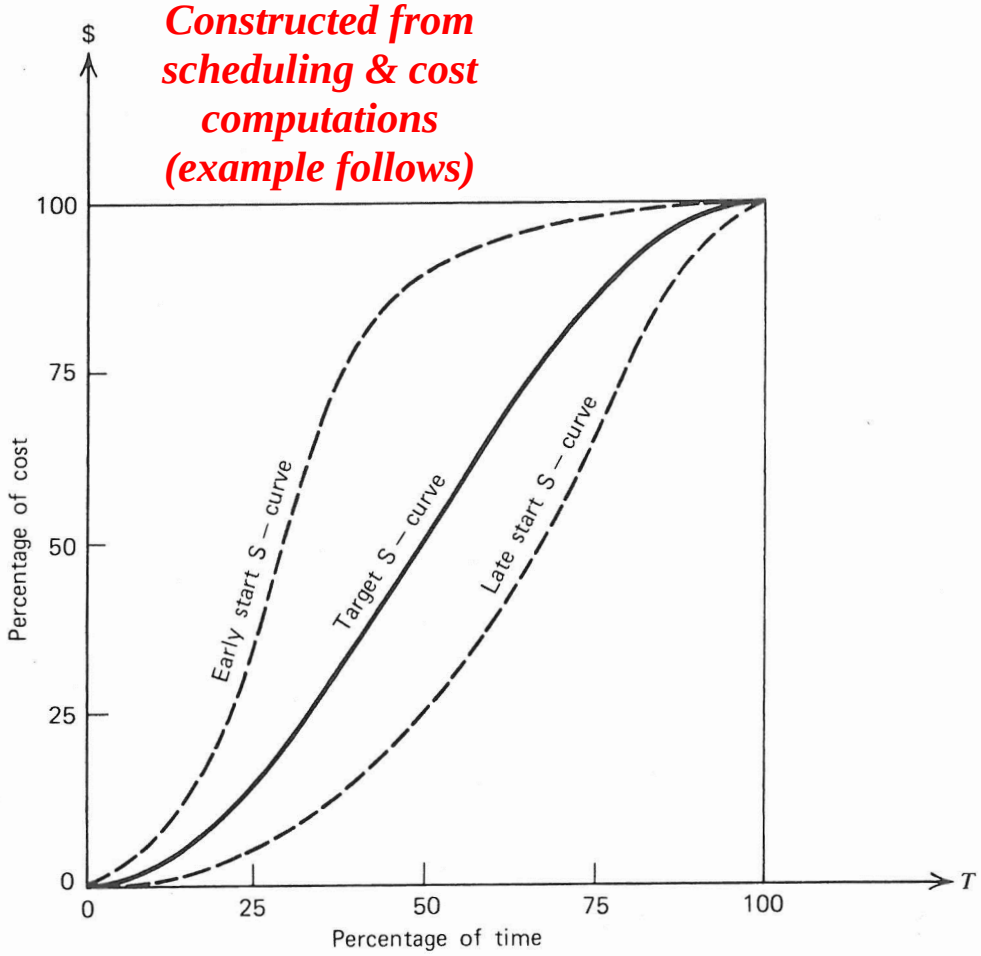


Figure 9.4 The S-curve field (envelope)

TABLE 9.1

Sample Project Cost Data

Activity	Duration (Days)	Cost Rate ($/Day)	Total Cost ($)
A	2	500	1,000
B	17	200	3,400
C	3	3,000	9,000
D	5	1,000	5,000
E	6	2,000	12,000
F	2	500	1,000
G	1	1,000	1,000

TABLE 9.1

Sample Project Cost Data

Activity	Duration (Days)	Cost Rate ($/Day)	Total Cost ($)
A	2	500	1,000
B	17	200	3,400
C	3	3,000	9,000
D	5	1,000	5,000
E	6	2,000	12,000
F	2	500	1,000
G	1	1,000	1,000

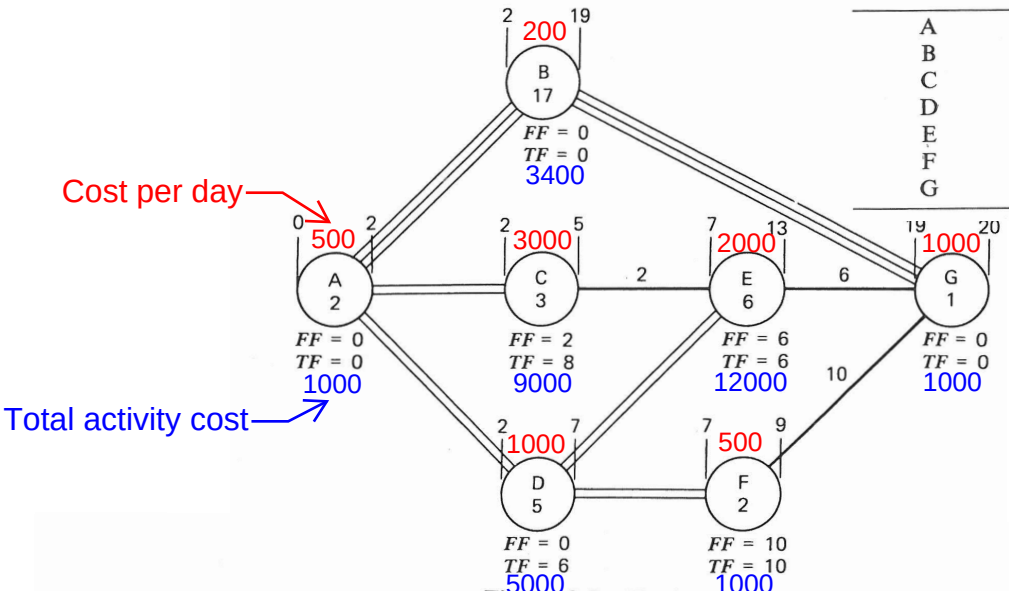


Figure 9.5 Early start tree.

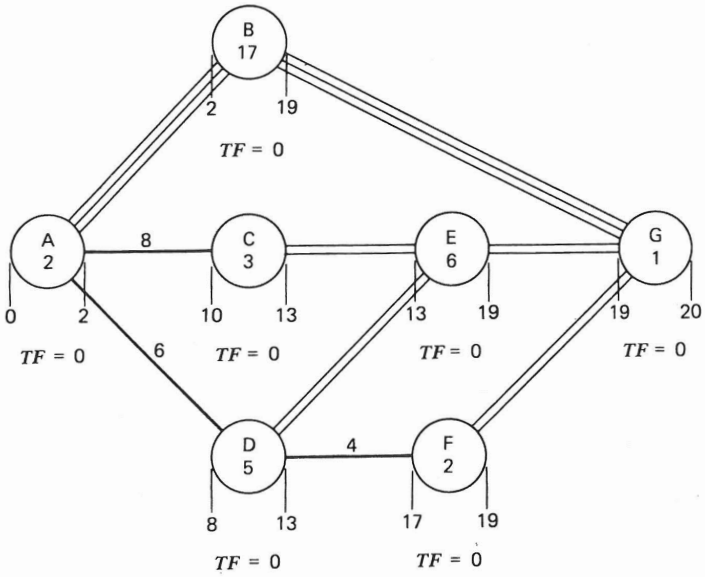


Figure 9.6 Late start tree.

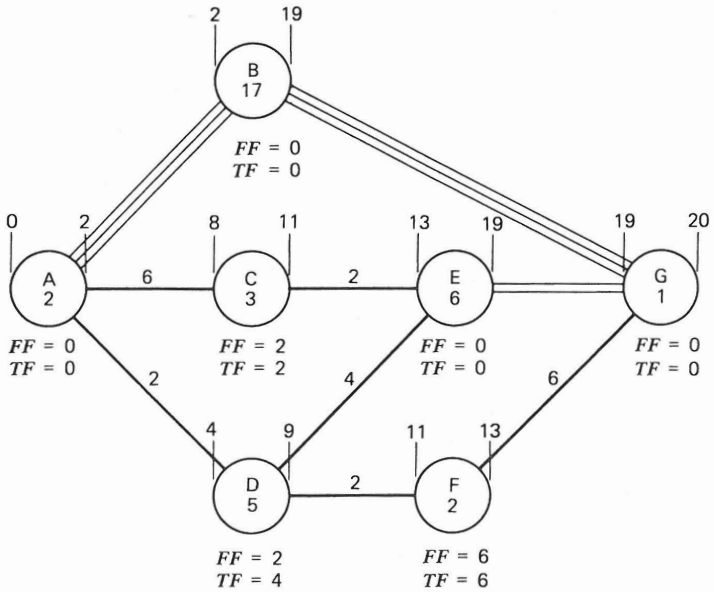
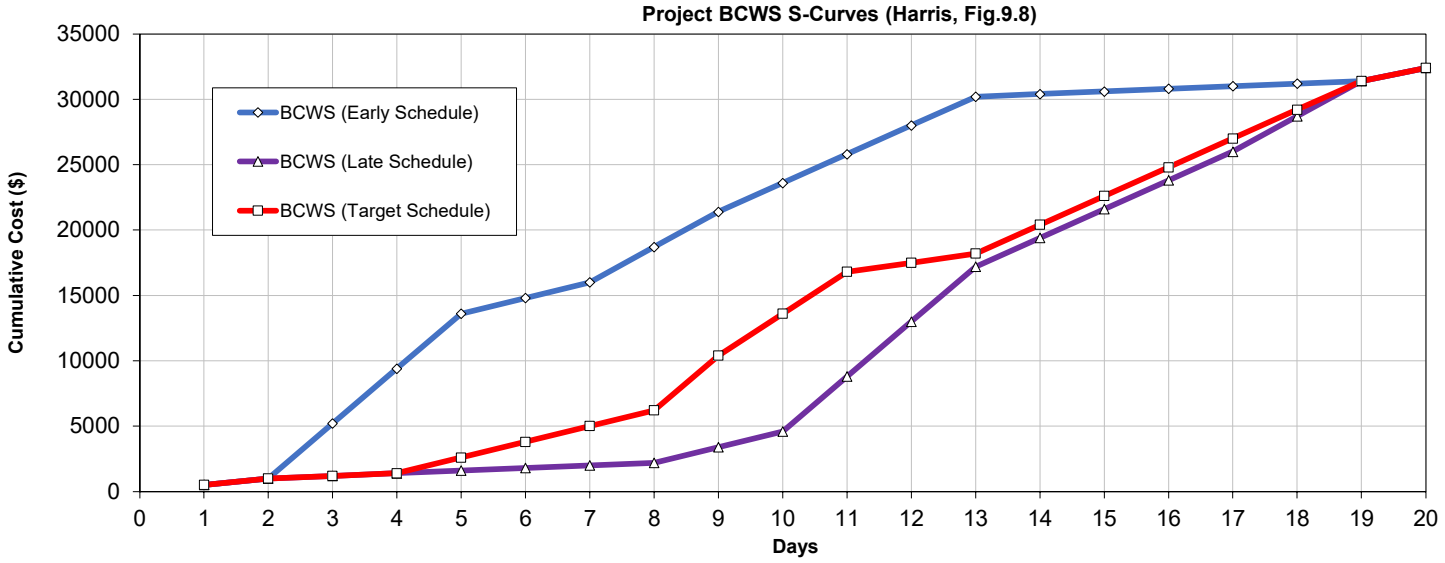


Figure 9.7 Target network.



Act	Dur days	Total Cost $	Rate $/day	ESD	EFD	Early Schedule 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	2	1000	500	0	2		500	500																		
B	17	3400	200	2	19				200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	
C	3	9000	3000	2	5				3000	3000	3000															
D	5	5000	1000	2	7				1000	1000	1000	1000	1000													
E	6	12000	2000	7	13									2000	2000	2000	2000	2000	2000							
F	2	1000	500	7	9									500	500											
G	1	1000	1000	19	20																					1000
		32400			Daily Costs ($)	0	500	500	4200	4200	4200	1200	1200	2700	2700	2200	2200	2200	2200	200	200	200	200	200	200	1000
					Cumulative Cost ($)	0	500	1000	5200	9400	13600	14800	16000	18700	21400	23600	25800	28000	30200	30400	30600	30800	31000	31200	31400	32400

Act	Dur days	Total Cost $	Rate $/day	LSD	LFD	Late Schedule 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	2	1000	500	0	2		500	500																		
B	17	3400	200	2	19				200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	
C	3	9000	3000	10	13												3000	3000	3000							
D	5	5000	1000	8	13										1000	1000	1000	1000	1000							
E	6	12000	2000	13	19															2000	2000	2000	2000	2000	2000	
F	2	1000	500	17	19																			500	500	
G	1	1000	1000	19	20																					1000
		32400			Daily Costs ($)	0	500	500	200	200	200	200	200	200	1200	1200	4200	4200	4200	2200	2200	2200	2200	2700	2700	1000
					Cumulative Cost ($)	0	500	1000	1200	1400	1600	1800	2000	2200	3400	4600	8800	13000	17200	19400	21600	23800	26000	28700	31400	32400

Act	Dur days	Total Cost $	Rate $/day	TSD	TFD	Target Schedule 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	2	1000	500	0	2		500	500																		
B	17	3400	200	2	19				200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	
C	3	9000	3000	8	11										3000	3000	3000									
D	5	5000	1000	4	9						1000	1000	1000	1000	1000											
E	6	12000	2000	13	19															2000	2000	2000	2000	2000	2000	
F	2	1000	500	11	13													500	500							
G	1	1000	1000	19	20																					1000
		32400			Daily Costs ($)	0	500	500	200	200	1200	1200	1200	1200	4200	3200	3200	700	700	2200	2200	2200	2200	2200	2200	1000
					Cumulative Cost ($)	0	500	1000	1200	1400	2600	3800	5000	6200	10400	13600	16800	17500	18200	20400	22600	24800	27000	29200	31400	32400

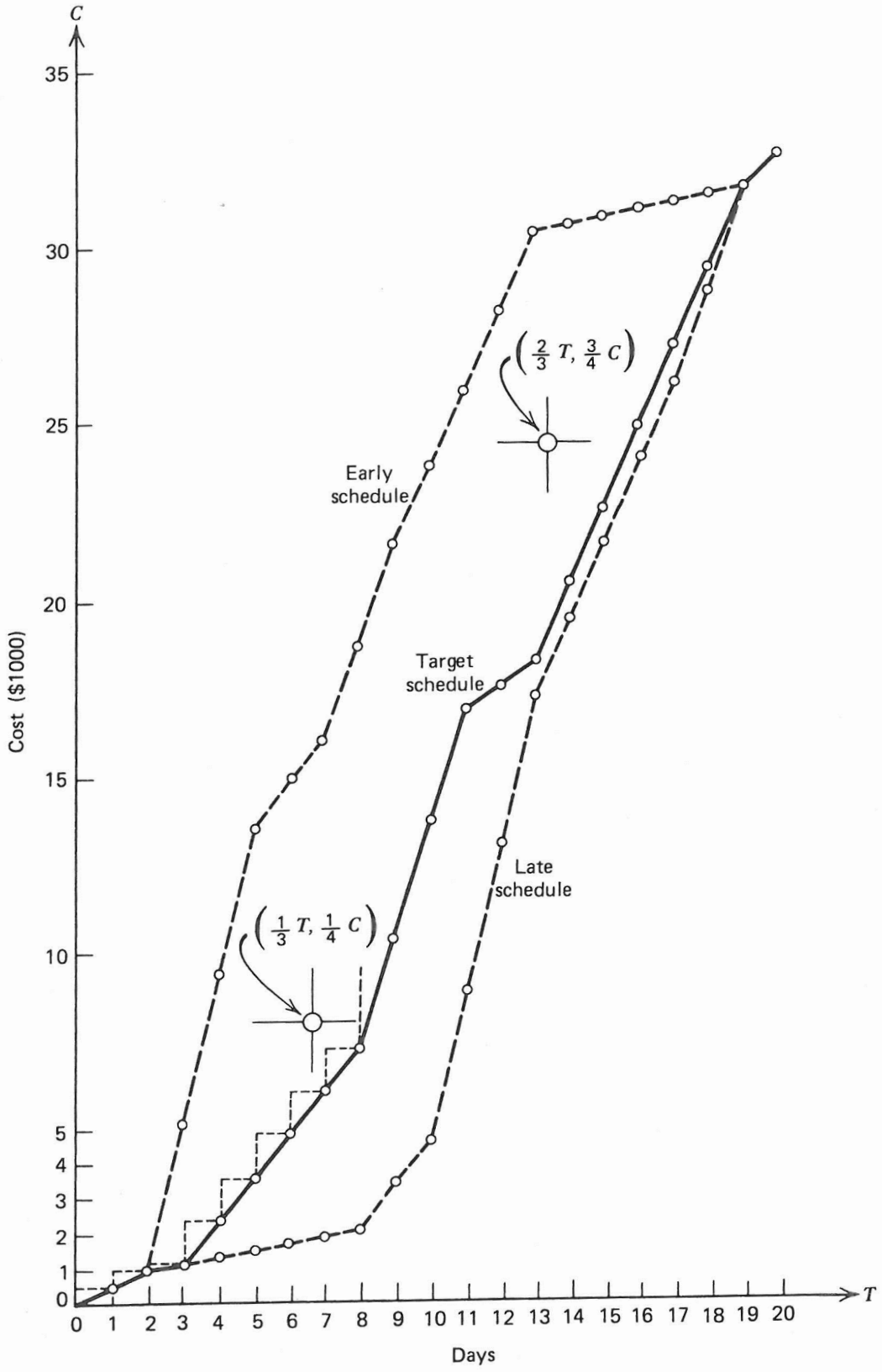


Figure 9.8 Project S-curves.

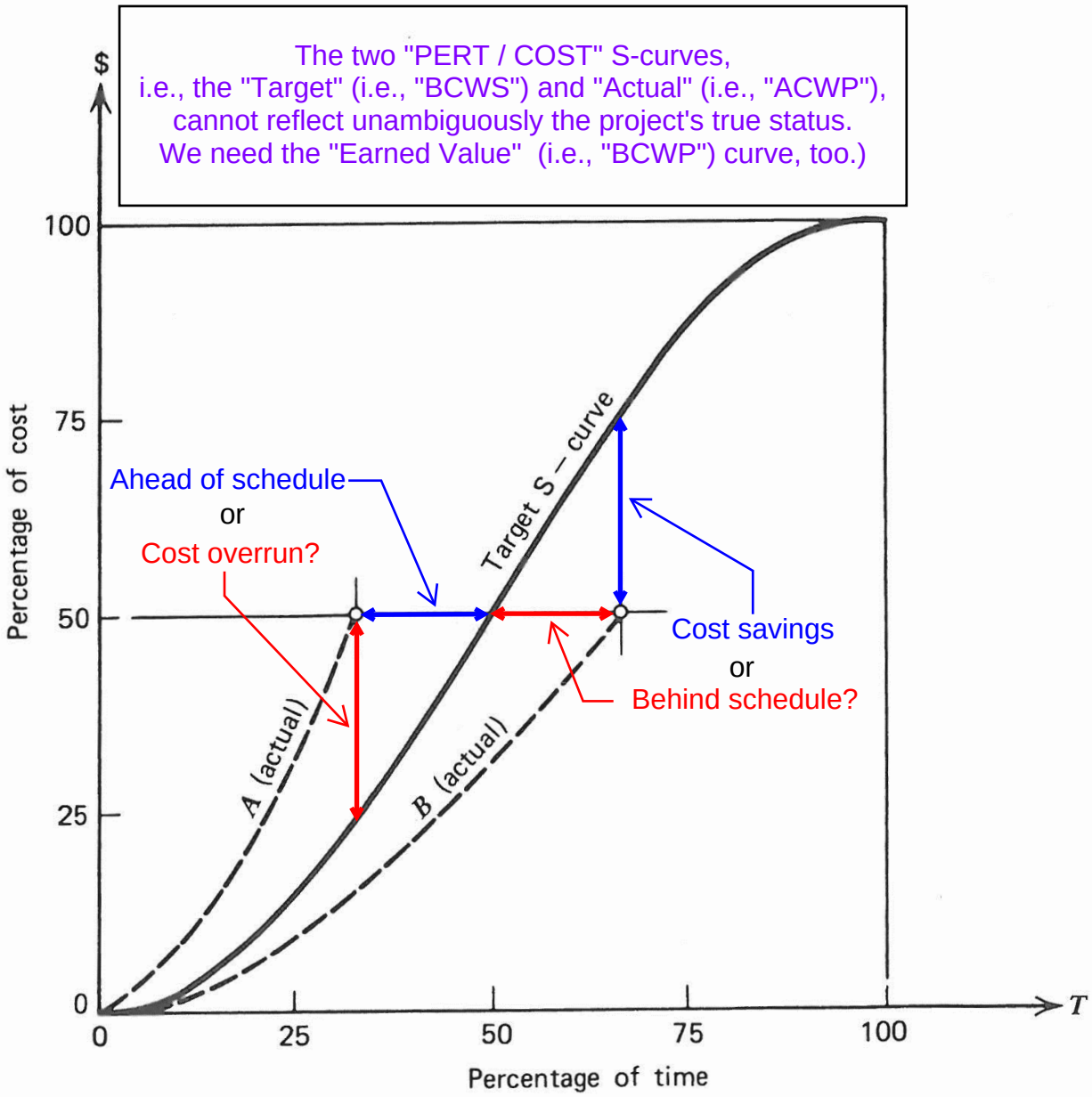


Figure 9.9 Actual versus target S-curves.

This a "better" graph in that the two "ACWP" curves A and B show the two possible status alternatives for the same Data Date.

Still, however, the two "PERT / COST" S-curves, i.e., the "Target" (i.e., "BCWS") and "Actual" (i.e., "ACWP"), cannot reflect unambiguously the project's true status. We need the "Earned Value" (i.e., "BCWP") curve, too.)

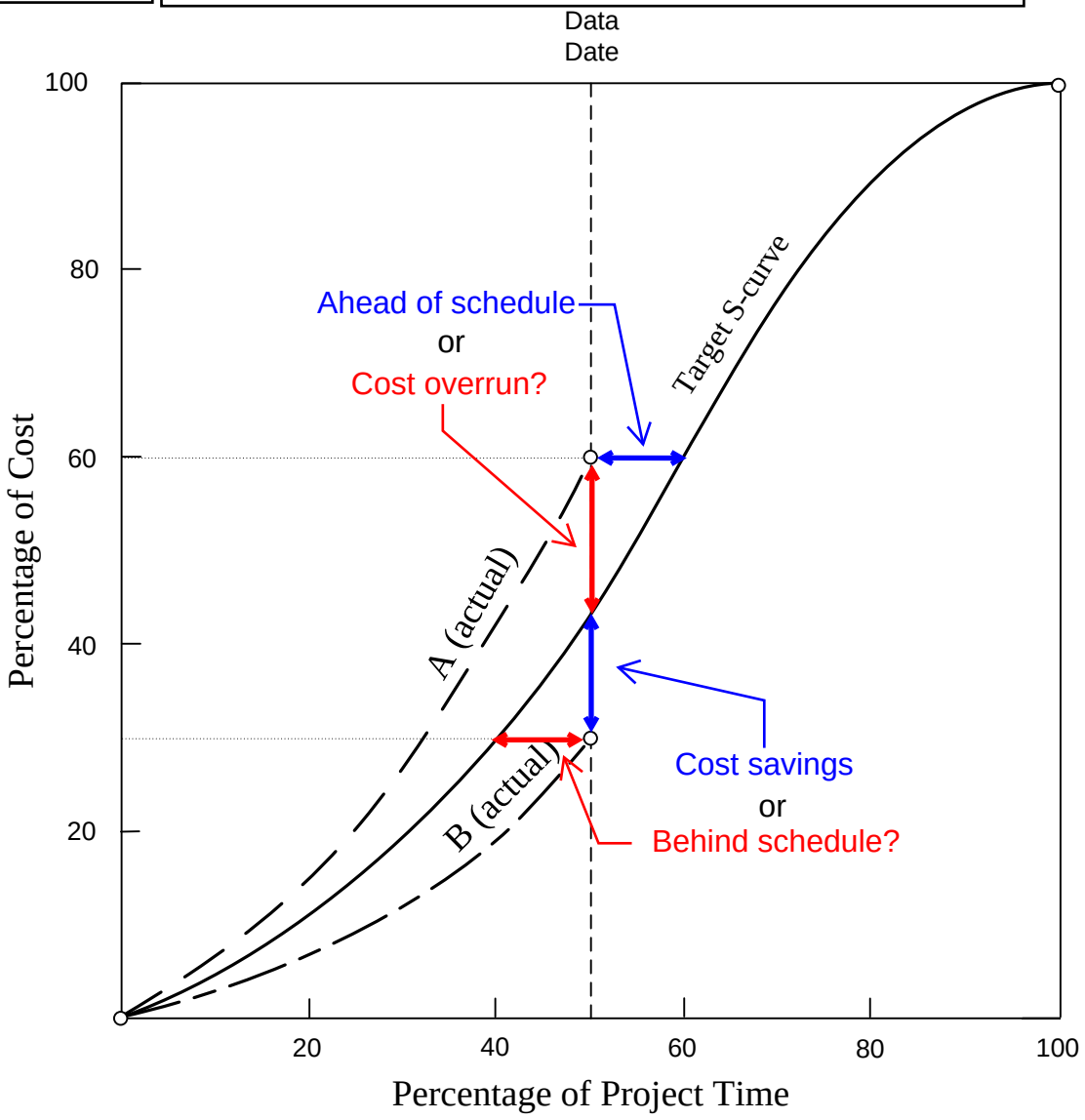
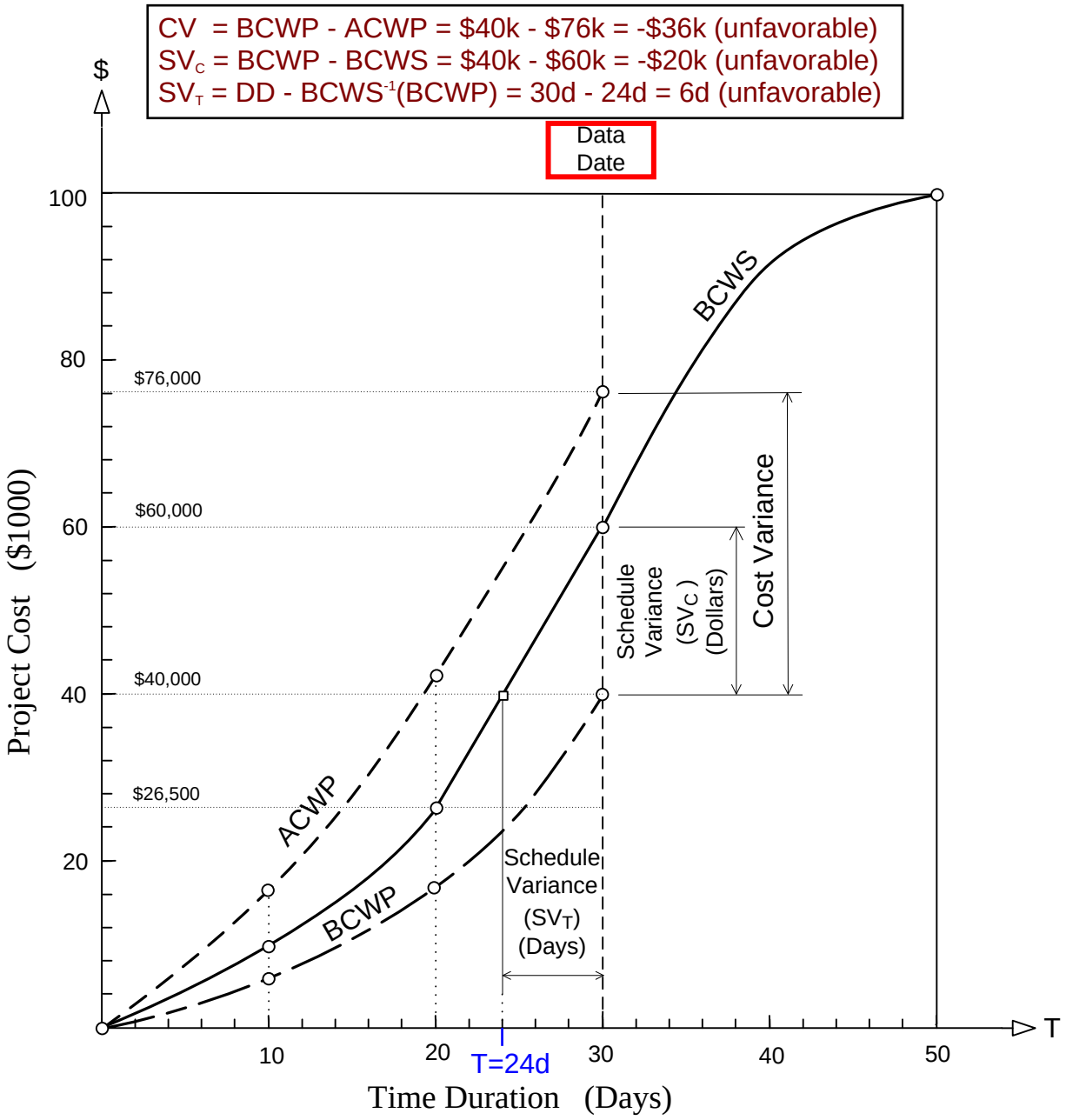


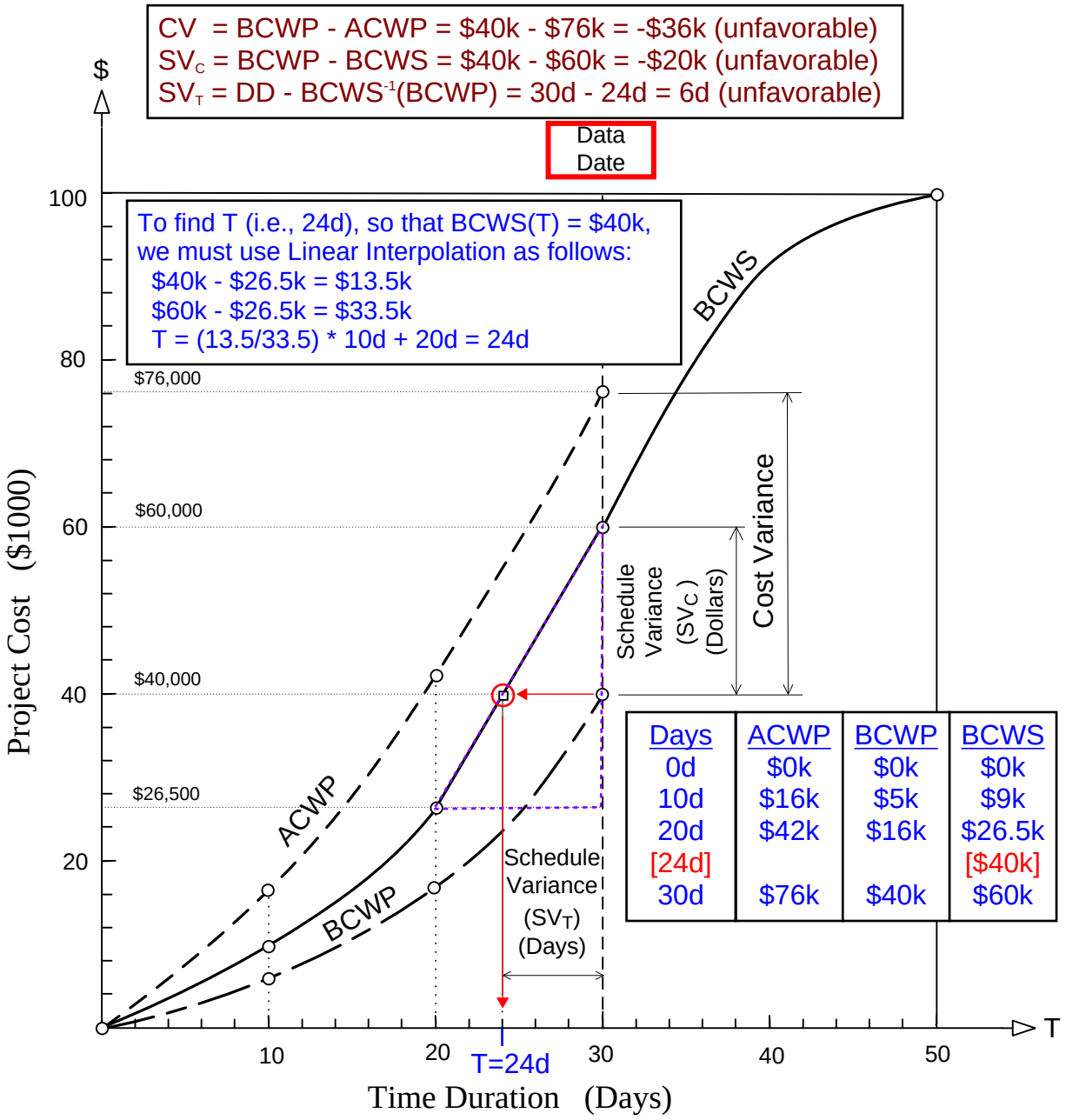
Figure 9.8 Actual Cost Versus the Target S-curve



ACWP = Actual Cost of Work Performed
BCWP = Budgeted Cost of Work Performed
BCWS = Budgeted Cost of Work Scheduled

ACWP = $76k
BCWP = $40k
BCWS = $60k

Figure 9.9 S-Curves of Actual and Budgeted Costs for Project Control



ACWP = Actual Cost of Work Performed
BCWP = Budgeted Cost of Work Performed
BCWS = Budgeted Cost of Work Scheduled

ACWP = $76k
BCWP = $40k
BCWS = $60k

Figure 9.9 S-Curves of Actual and Budgeted Costs for Project Control

C/SCSC

(C-spec)

COST / SCHEDULE CONTROL SYSTEMS CRITERIA

THREE PERFORMANCE MEASURES

BCWS (BUDGETED COST FOR WORK SCHEDULED)

WHAT IS THE VALUE OF THE WORK (BASED ON THE BUDGET) THAT IS SUPPOSED TO HAVE BEEN PERFORMED (BASED ON THE BASELINE SCHEDULE) AS OF TODAY?

(i.e., TARGET SCHEDULE)

BCWP (BUDGETED COST FOR WORK PERFORMED) -- EARNED VALUE

WHAT IS THE VALUE OF THE WORK (BASED ON THE BUDGET) THAT HAS BEEN ACTUALLY PERFORMED AS OF TODAY?

ACWP (ACTUAL COST FOR WORK PERFORMED)

WHAT IS THE ACTUAL COST OF THE WORK THAT HAS BEEN PERFORMED AS OF TODAY? HOW MUCH HAS BEEN PAID TO WORKERS, VENDORS, AND SUPPLIERS AS OF TODAY?

C/SCSC

(C-spec)

COST / SCHEDULE CONTROL SYSTEMS CRITERIA

EARNED VALUE MATHEMATICS

SCHEDULE VARIANCE (SV):

$$SV = BCWP - BCWS$$

[SV > 0 : Favorable]

COST VARIANCE (CV):

$$CV = BCWP - ACWP$$

[CV > 0 : Favorable]

SCHEDULE PERFORMANCE INDEX (SPI):

$$SPI = BCWP / BCWS$$

[SPI > 1 : Favorable]

COST PERFORMANCE INDEX (CPI):

$$CPI = BCWP / ACWP$$

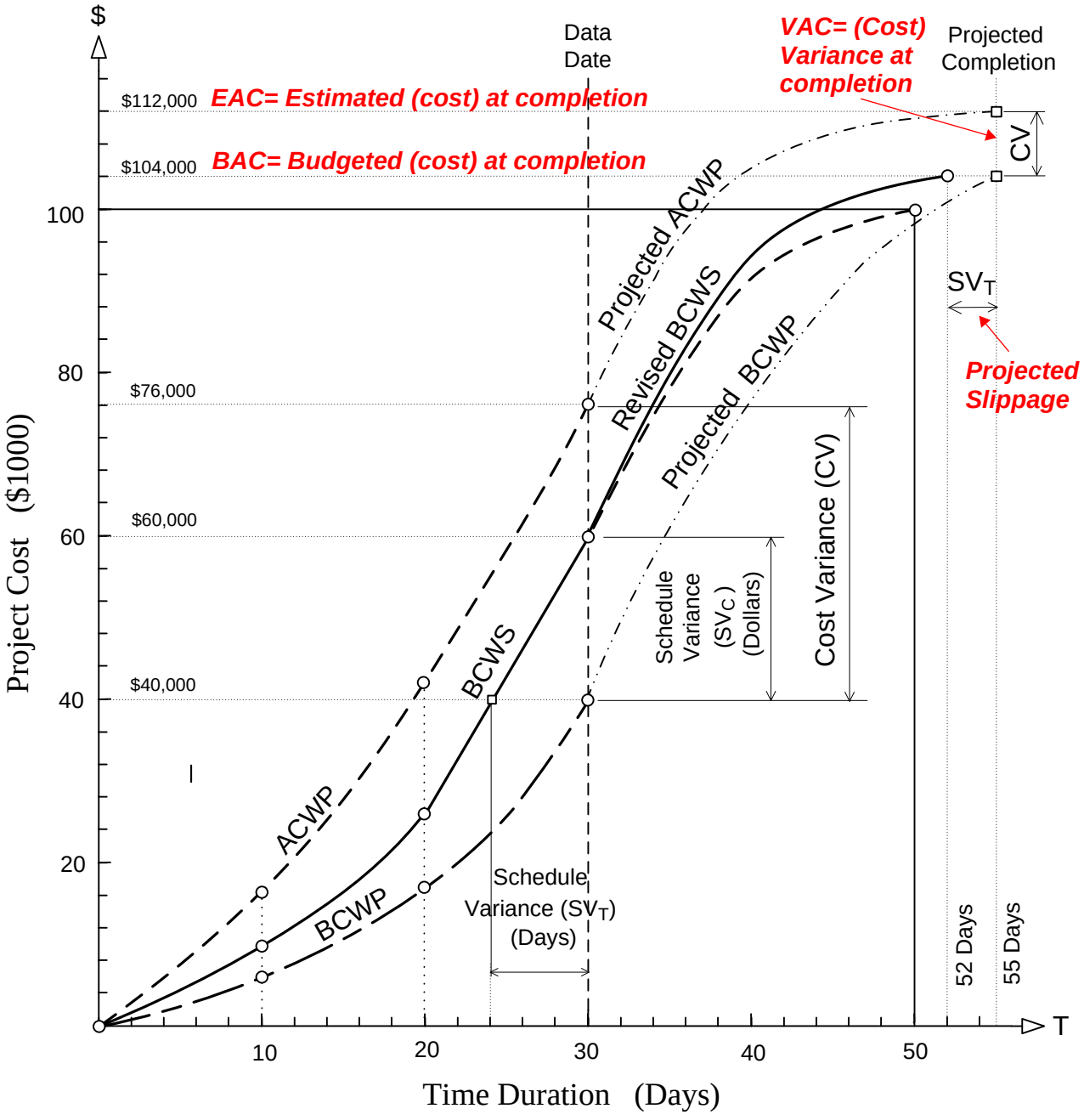
[CPI > 1 : Favorable]

TO-COMPLETE COST PERFORMANCE INDEX (TCPI):

$$TCPI = (BAC-BCWP) / (BAC-ACWP)$$

$$TCPI = \frac{\text{BUDGETED \$ FOR REMAINING WORK}}{\text{ACTUAL \$ FOR REMAINING WORK}}$$

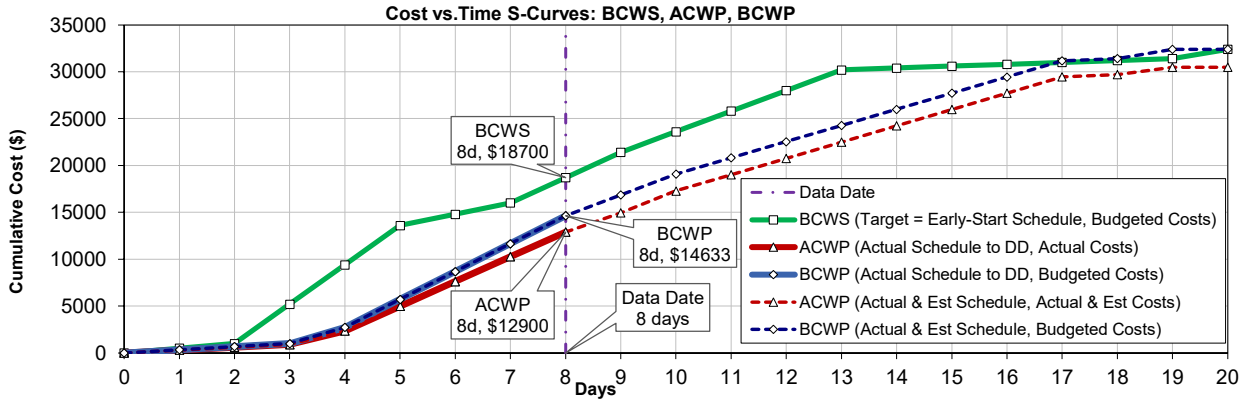
[TCPI < 1 : Favorable]



ACWP = Actual Cost of Work Performed
BCWP = Budgeted Cost of Work Performed
BCWS = Budgeted Cost of Work Scheduled

Figure 9.10 S-Curves of Actual and Budgeted Costs for Projected Variances at 30 Weeks

Project Control --- Updating a Project with Actual Time and Cost Performance --- Earned Value in Excel



Act	Pred	Dur days	Rate $/day	BCost 32400	ESD	EFD	BCWS (Target = Early-Start Schedule, Budgeted Costs) 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	-	2	500	1000	0	2		500	500																		
B	A	17	200	3400	2	19				200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	
C	A	3	3000	9000	2	5				3000	3000	3000															
D	A	5	1000	5000	2	7				1000	1000	1000	1000	1000													
E	C,D	6	2000	12000	7	13									2000	2000	2000	2000	2000	2000							
F	D	2	500	1000	7	9									500	500											
G	B,E,F	1	1000	1000	19	20																					1000
	Daily Costs ($)						0	500	500	4200	4200	4200	1200	1200	2700	2700	2200	2200	2200	2200	200	200	200	200	200	200	1000
	Cumulative Cost ($)						0	500	1000	5200	9400	13600	14800	16000	18700	21400	23600	25800	28000	30200	30400	30600	30800	31000	31200	31400	32400

Data Date (days): 8

Act	Pred	Dur days	Rate $/day	ACost 30500	ASD	AFD	ACWP (Actual & Est Schedule, Actual & Est Costs) 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	-	3	300	900	0	3		300	300	300																	
B	A	15	240	3600	3	18					240	240	240	240	240	240	240	240	240	240	240	240	240	240	240		
C	A	6	1200	7200	3	9					1200	1200	1200	1200	1200	1200											
D	A	4	1200	4800	4	8						1200	1200	1200	1200												
E	C,D	8	1500	12000	9	17											1500	1500	1500	1500	1500	1500	1500	1500			
F	D	2	600	1200	8	10										600	600										
G	B,E,F	1	800	800	18	19																				800	
	Daily Costs ($)						0	300	300	300	1440	2640	2640	2640	2640	2040	2340	1740	1740	1740	1740	1740	1740	1740	240	800	0
	Cumulative Cost ($)						0	300	600	900	2340	4980	7620	10260	12900	14940	17280	19020	20760	22500	24240	25980	27720	29460	29700	30500	30500

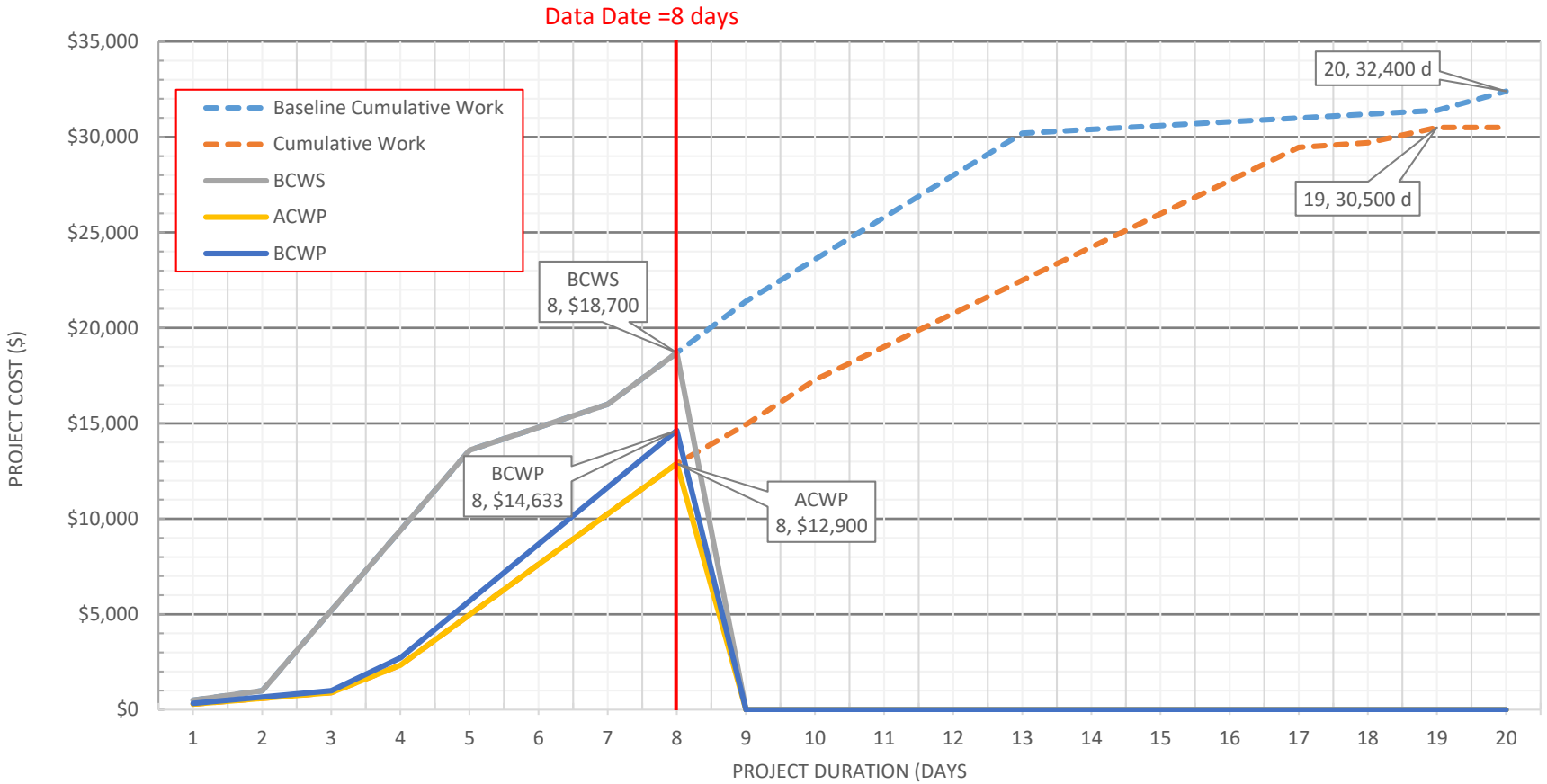
Act	Pred	Dur days	Rate $/day	BCost 32400	ASD	AFD	BCWP (Actual & Est Schedule, Budgeted Costs) 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	-	3	333.3	1000	0	3		333.3	333.3	333.3																	
B	A	15	226.7	3400	3	18					226.7	226.7	226.7	226.7	226.7	226.7	226.7	226.7	226.7	226.7	226.7	226.7	226.7	226.7	226.7		
C	A	6	1500	9000	3	9					1500	1500	1500	1500	1500	1500											
D	A	4	1250	5000	4	8						1250	1250	1250	1250												
E	C,D	8	1500	12000	9	17											1500	1500	1500	1500	1500	1500	1500	1500			
F	D	2	500	1000	8	10										500	500										
G	B,E,F	1	1000	1000	18	19																				1000	
	Daily Costs ($)						0	333.3	333.3	333.3	1727	2977	2977	2977	2977	2227	2227	1727	1727	1727	1727	1727	1727	1727	226.7	1000	0
	Cumulative Cost ($)						0	333	667	1000	2727	5703	8680	11657	14633	16860	19087	20813	22540	24267	25993	27720	29447	31173	31400	32400	32400

Project Control Metrics																						
CV	0	33.33	66.67	100	386.7	723.3	1060	1397	1733	1920	1807	1793	1780	1767	1753	1740	1727	1713	1700	1900	1900
SV	0	-167	-333	-4200	-6673	-7897	-6120	-4343	-4067	-4540	-4513	-4987	-5460	-5933	-4407	-2880	-1353	173.3	200	1000	0
CPI		1.111	1.111	1.111	1.165	1.145	1.139	1.136	1.134	1.129	1.105	1.094	1.086	1.079	1.072	1.067	1.062	1.058	1.057	1.062	1.062
SPI		0.667	0.667	0.192	0.29	0.419	0.586	0.729	0.783	0.788	0.809	0.807	0.805	0.804	0.855	0.906	0.956	1.006	1.006	1.032	1
EAC		29160	29160	29160	27805	28291	28443	28518	28562	28710	29333	29608	29841	30041	30215	30366	30500	30619	30646	30500	30500

EAC = Estimate At Completion (as computed by MS Project) = ACWP + ("BaselineX" cost - BCWP) / CPI = ACWP + (BAC - BCWP) / CPI

Lab 4 - Project Control - C/SCSC Metrics

Baseline Cost	EAC	VAC	BCWS	ACWP	BCWP	CV	SV
$32,400	$28,562	$3,838	$18,700	$12,900	$14,633	$1,733	($4,067)



BCWS: Estimated by "Baseline Cumulative Work" past the Data Date
ACWP: Estimated by "Cumulative Work" = "Cumulative Cost" past the Data Date
BCWP: MS Project cannot show estimated "Earned Value" past the Data Date

CEE501-028
P.G. Ioannou

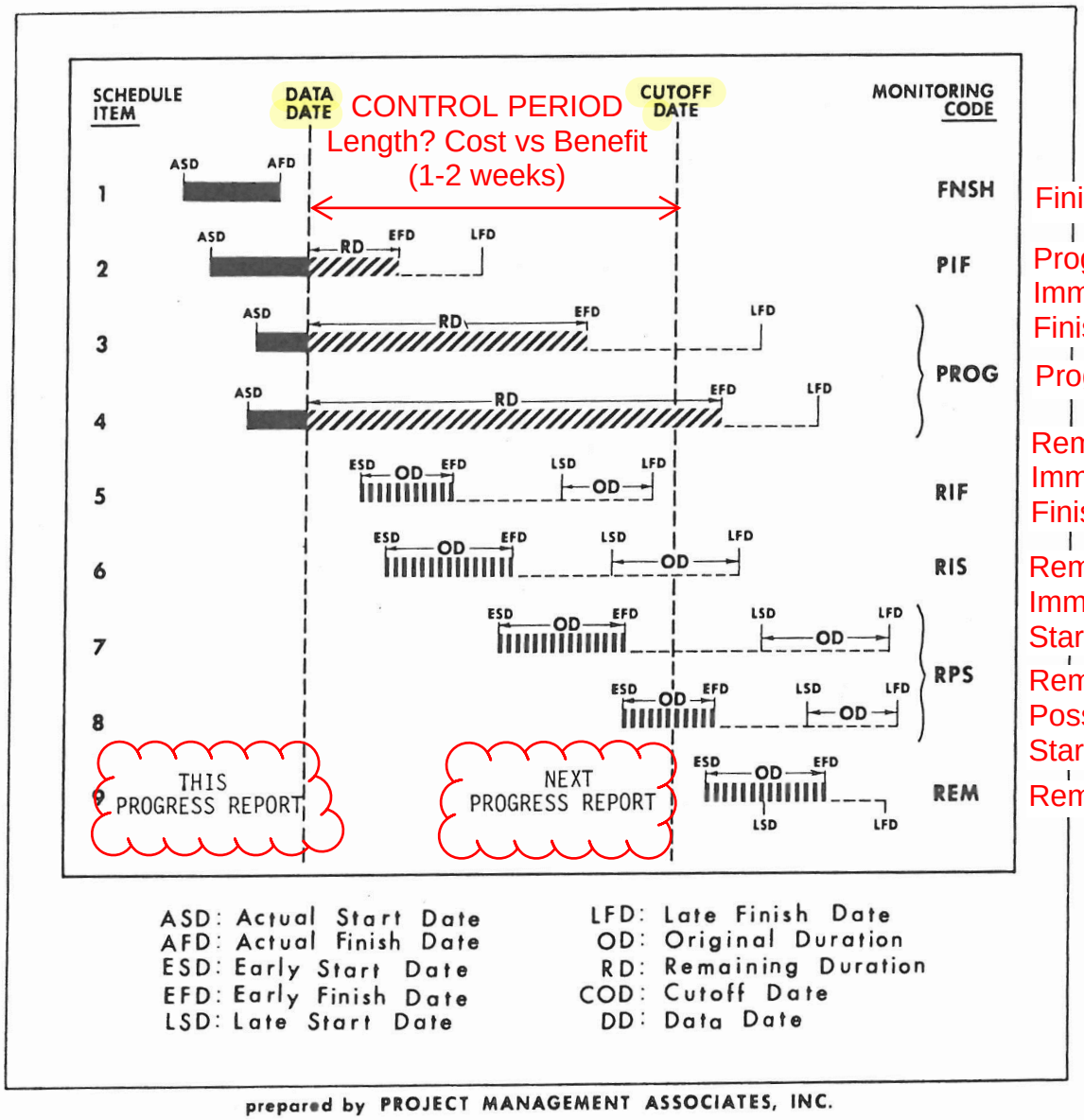


Figure 9.10 Monitoring codes.

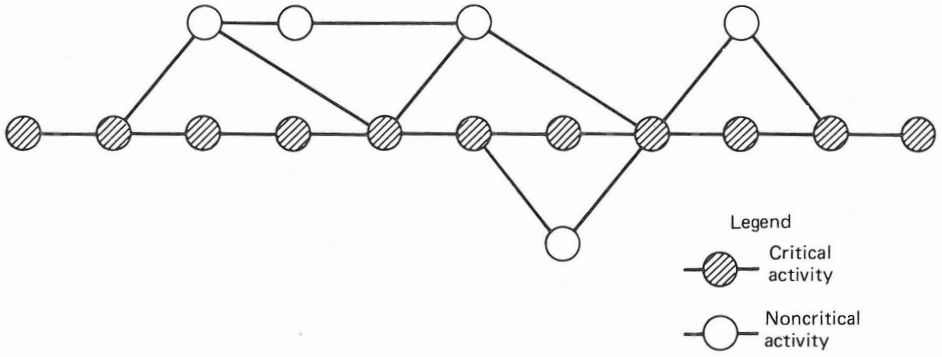


Figure 9.13 A linear precedence network.

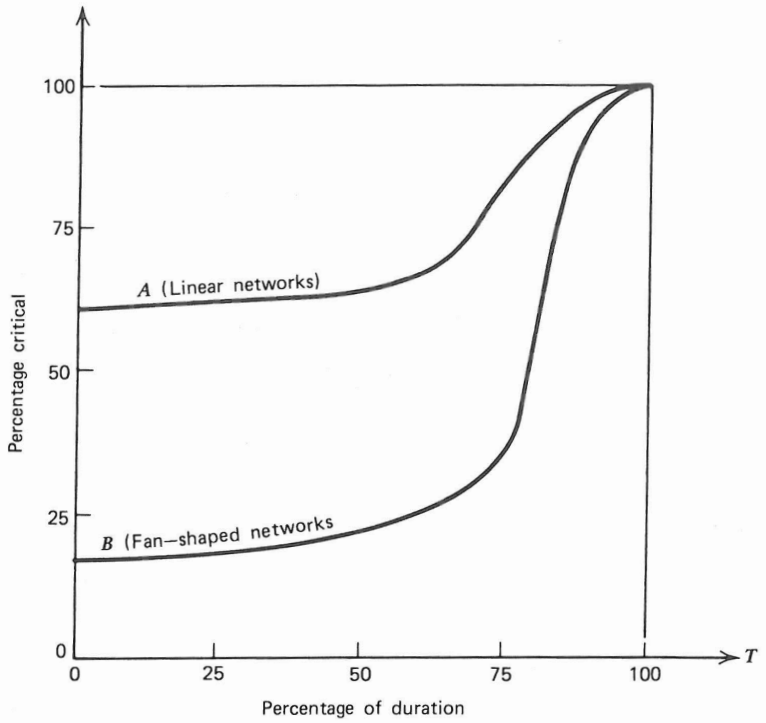


Figure 9.14 Variations in network criticality.

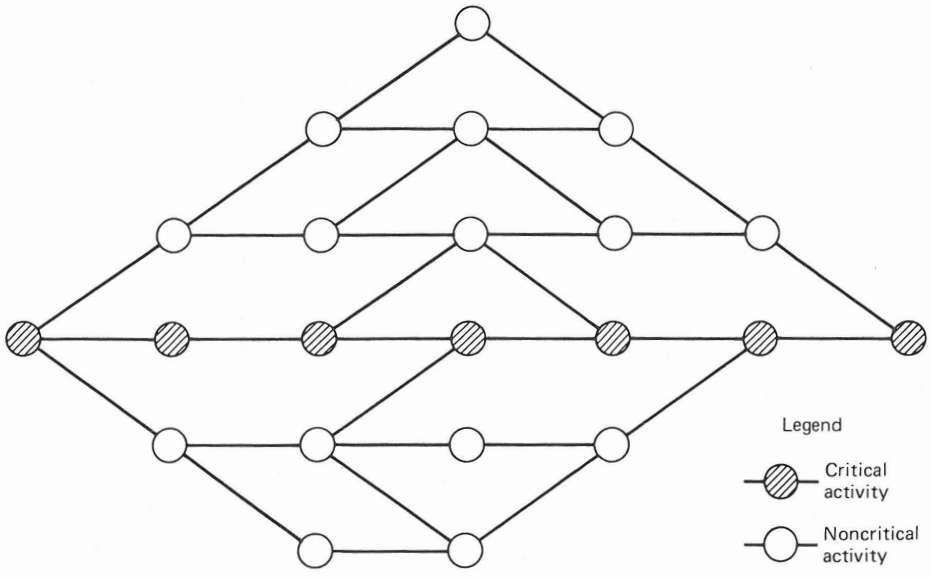
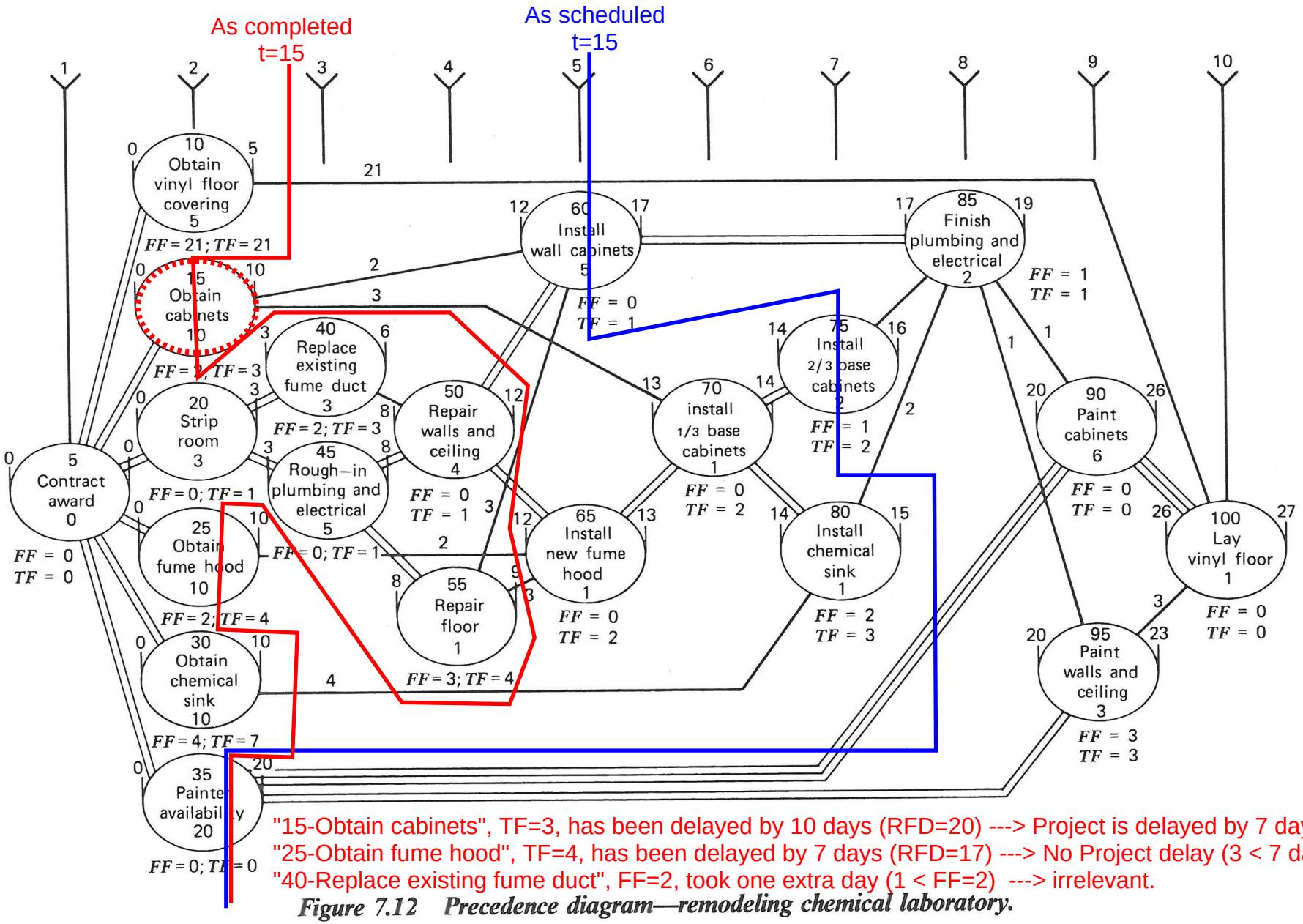


Figure 9.15 A fan-shaped precedence network.



"15-Obtain cabinets", TF=3, has been delayed by 10 days (RFD=20) ---> Project is delayed by 7 days.
"25-Obtain fume hood", TF=4, has been delayed by 7 days (RFD=17) ---> No Project delay (3 < 7 days)
"40-Replace existing fume duct", FF=2, took one extra day (1 < FF=2) ---> irrelevant.

Figure 7.12 Precedence diagram—remodeling chemical laboratory.

All activities currently going on are procurement activities.
No production activities can be performed. Nobody is working at jobsite.

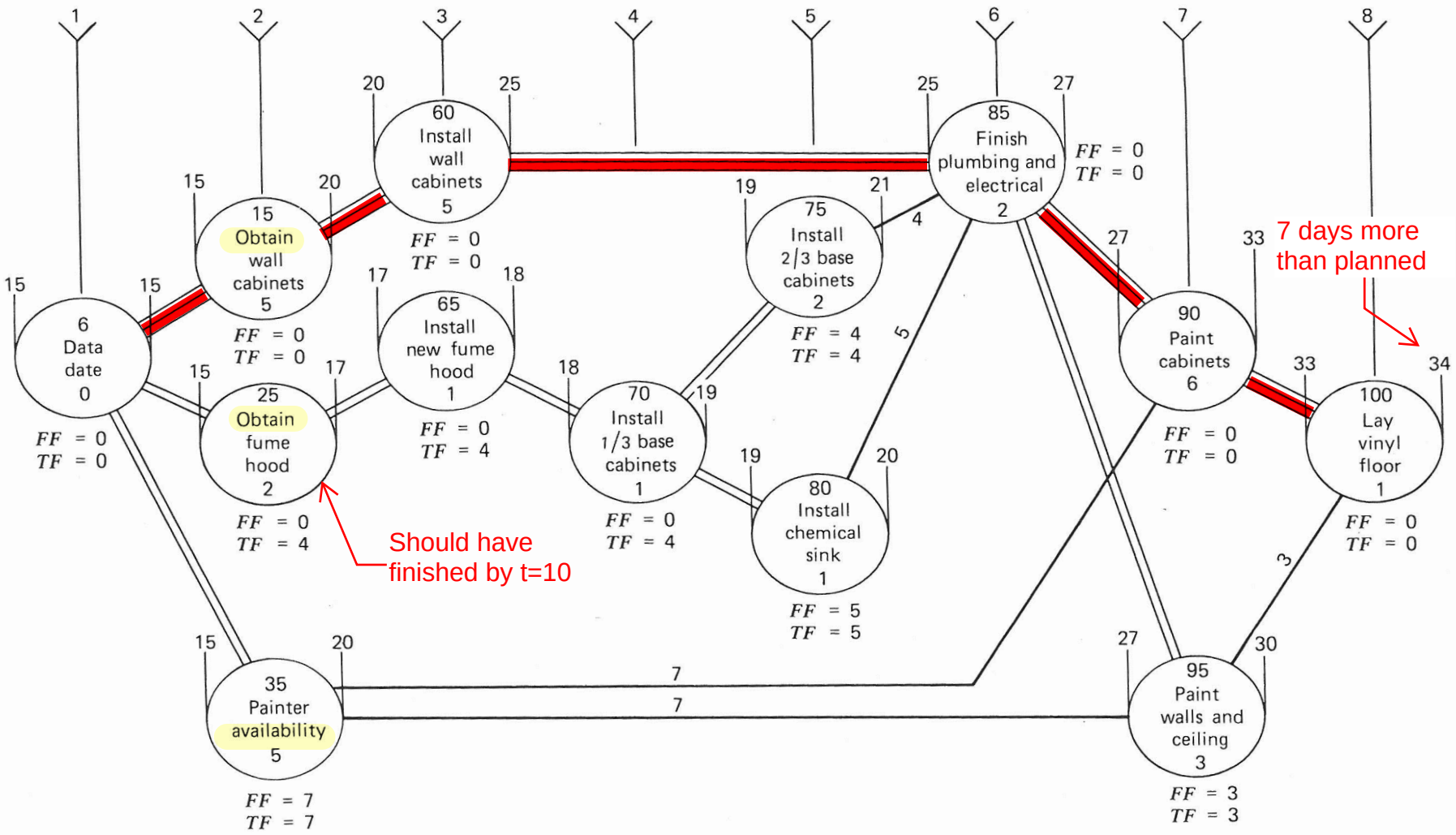


Figure 9.11 Update analysis—remodeling chemical laboratory.

"15-Obtain cabinets", TF=3, has been delayed by 10 days (RFD=20) ---> Project is delayed by 7 days.
"25-Obtain fume hood", TF=4, has been delayed by 7 days (RFD=17) ---> No Project delay (3 < 7 days)
"40-Replace existing fume duct", FF=2, took one extra day (1 < FF=2) ---> irrelevant.

Paint Crew: Works from t=20 to t=27
On day 25 it paints both "base" and "wall cabinets".
On day 27 it paints both "cabinets" and "walls & ceiling".

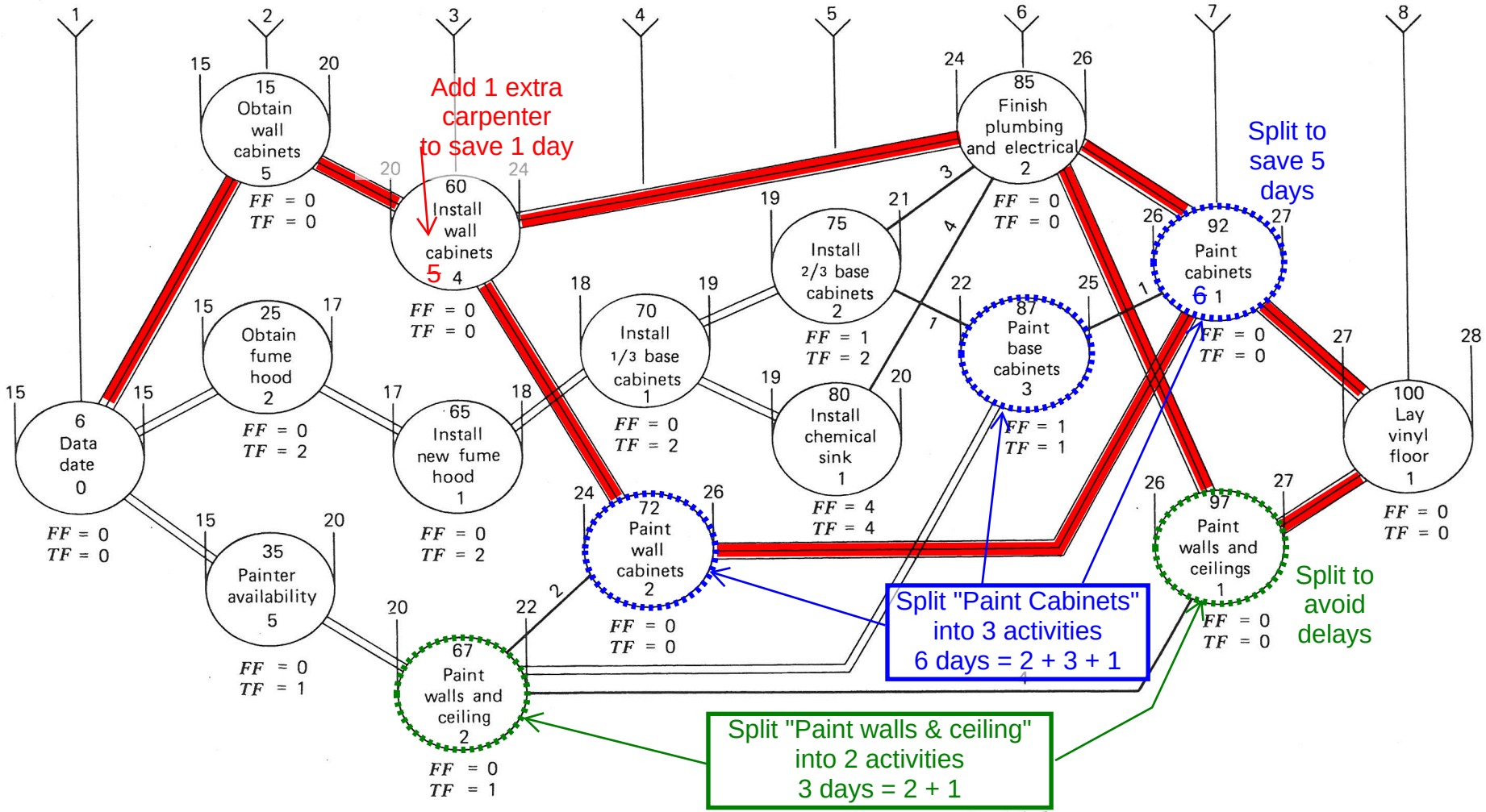


Figure 9.12 Updated network—remodeling chemical laboratory.

WORK BREAKDOWN STRUCTURE

- A WORK BREAKDOWN STRUCTURE IS A PRODUCT-ORIENTED FAMILY TREE COMPOSED OF HARDWARE, SERVICES AND DATA WHICH RESULT FROM PROJECT ENGINEERING EFFORTS DURING THE DEVELOPMENT AND PRODUCTION OF A DEFENSE MATERIAL ITEM, AND WHICH COMPLETELY DEFINES THE PROJECT/PROGRAM. A WBS DISPLAYS AND DEFINES THE PRODUCT(S) TO BE DEVELOPED OR PRODUCED AND RELATES THE ELEMENTS OF WORK TO BE ACCOMPLISHED TO EACH OTHER AND TO THE END-PROJECT.
- SOURCE: DOD DIRECTIVE 5010.20 JULY 31, 1968
- MILITARY STANDARD 881 NOVEMBER 1, 1968

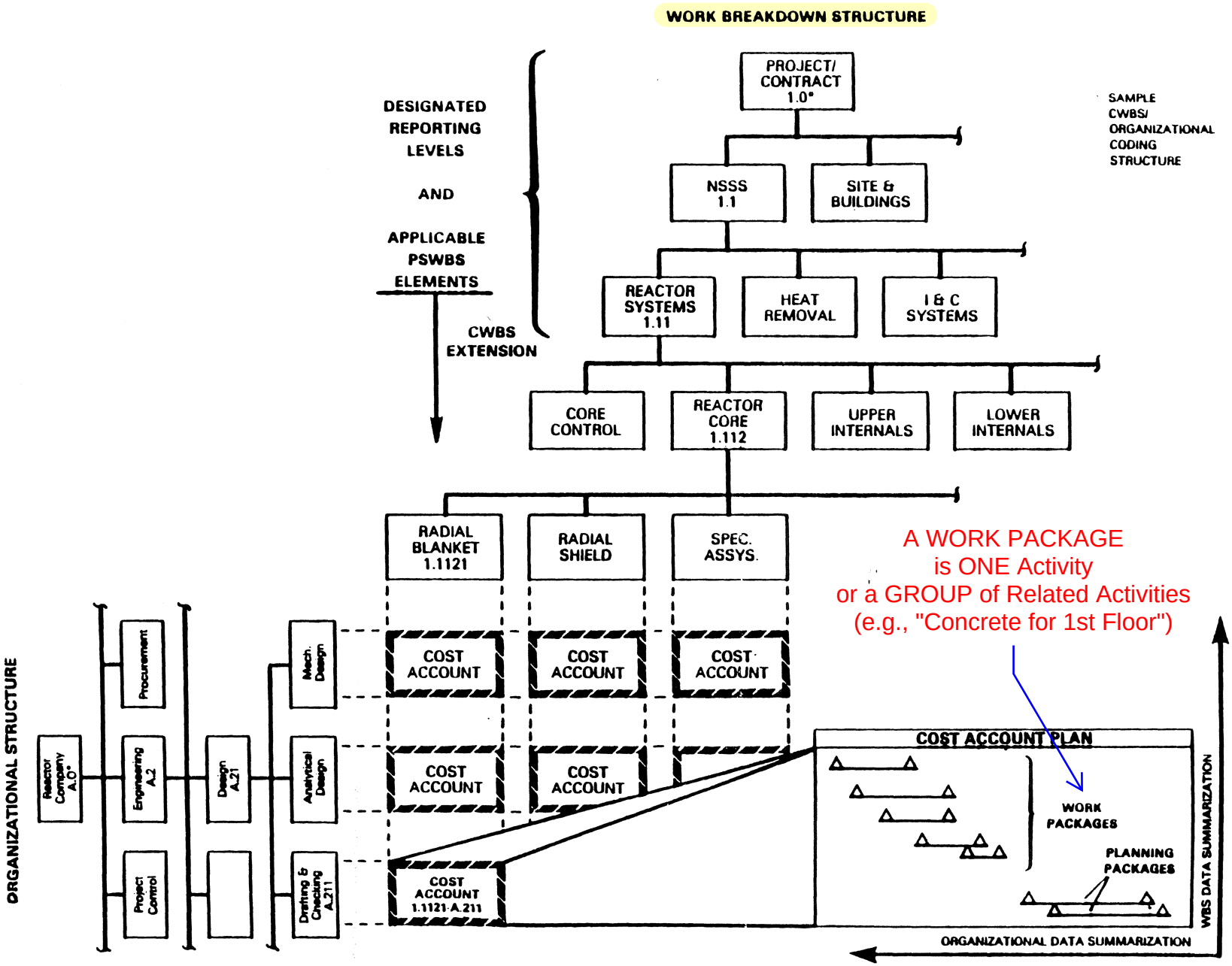


FIGURE 3 INTEGRATION OF WORK BREAKDOWN STRUCTURE AND ORGANIZATIONAL STRUCTURE

COST ACCOUNT–VEHICLE OF INTEGRATION

- **A MANAGEMENT CONTROL POINT AT WHICH ACTUAL COSTS CAN BE ACCUMULATED AND COMPARED TO BUDGETED COSTS FOR WORK PERFORMED. EARNED VALUE IS ALSO MEASURED AT THE COST ACCOUNT LEVEL.**
- **A COST ACCOUNT IS A NATURAL CONTROL POINT FOR COST/SCHEDULE PLANNING AND CONTROL, SINCE IT REPRESENTS THE WORK ASSIGNED TO ONE OBS ELEMENT AND ONE WBS ELEMENT.**
- **A COST ACCOUNT CAN BE DEFINED AS A GROUP OF ACTIVITIES THAT MUST REPRESENT THE WORK ASSIGNED TO ONE OBS ELEMENT AND ONE WBS ELEMENT.**
- **A COST ACCOUNT'S ACTIVITIES CAN BE:**
  - "DISCRETE WORK PACKAGES" (PRODUCTION TASKS, E.G., CONCRETE)
  - "PLANNING PACKAGES" (LOE ACTIVITIES–MANAGEMENT TASKS, E.G. PROJECT MANAGER TASKS)
  - "APPORTIONED-EFFORT ACTIVITIES" (SECONDARY ACTIVITIES, SUCH AS TESTING ELEVATORS, THAT NEED TO BE CONTROLLED SEPARATELY)
- **SINCE BCWS, BCWP, AND ACWP ARE ALL CAPTURED AT THE COST ACCOUNT LEVEL, COST ACCOUNTS ARE THE IDEAL PLACE TO DO PERFORMANCE MEASUREMENTS, VARIANCE ANALYSES, AND OTHER PROGRESS REPORTING.**

OBJECTIVE MEASUREMENTS OF EARNED VALUE

- **THE SINGLE MOST IMPORTANT COMPONENT FOR THE MEANINGFUL AND SUCCESSFUL C/SCSC IMPLEMENTATION IS OBJECTIVE MEASUREMENT OF EARNED VALUE. EARNED VALUE IS COMPUTED AS,**

  % COMPLETE X BASELINE BUDGET = EARNED VALUE

- **THE MAIN ISSUE IS HOW TO MEASURE % COMPLETE OBJECTIVELY**

- **C-SPEC REQUIRES THAT % COMPLETE AND BCWS, BCWP, AND ACWP MUST BE COMPUTED AT THE COST ACCOUNT LEVEL.**

- **FIVE WAYS TO MEASURE % COMPLETE. THESE ARE APPLIED TO COST ACCOUNT UNLESS IT HAS MANY ACTIVITIES. THEN IT IS BETTER TO APPLY TO ACTIVITIES AND ROLL UP.**

  1. ACTUAL QUANTITY INSTALLED–BY OUTPUT
  2. MILESTONE
  3. BINARY METHOD (0/1)
  4. 50-50 METHOD
  5. EQUIVALENT UNIT

EARNED VALUE COMPUTATION FOR ACTIVITIES
WORK PACKAGE (OR DISCRETE) ACTIVITY

- **BY OUTPUT**
  - OUTPUT IS THE MEASURE OF THE AMOUNT OF BULK QUANTITY PRODUCED. IT CAN BE CUBIC YARDS OF PAVEMENT LAID, THOUSANDS OF CONCRETE BLOCK PLACED, PAGES OF DESIGN DRAWINGS PRODUCED, OR LINEAR FEET OF SMALL BORE PIPE DESIGNED.
  - PROVIDES A DIRECT MEASURE OF WORK PRODUCED VERSUS A BUDGET OF WORK REQUIRED.
    - If half of the budgeted amount has been produced, it is assumed that half of the work item is completed and half of the value associated with the element has been earned.
  - THERE ARE TWO MAJOR SOURCES OF INACCURACY IN OUTPUT MEASURES:
    1. Not all items of output may be the same.
       - Earth near the surface may be easier to excavate than earth below, but they all count the same. First efforts at paving may take longer than later efforts, after shakedown has occurred. Some pages of design drawing require less work than others. Some pipe installations are more easily designed than others.
         By randomness, but more often by selection or bias, progress is not usually constant. As associated difficulty is recording work as finished, which requires significant rework or repair, or which is only partially complete. For example, drawings may be shown as finished when they require substantial additional drafting.
    2. Actual quantities may differ significantly from budget.
       - For example, if budgeted quantity of earth was 100,000 cy, but 120,000 cy were required, completion based on budget would be inaccurate. Upon completion of 60,000 CY, 60% of budget is complete, but only 50% of the activity has actually been completed. If $400,000 were allocated to earthwork, $240,000 might be reported earned; whereas 50% (400,000) = $200,000 is the correct earned value.

- **MILESTONE METHOD**
  - A CONVENIENT WAY OF RECORDING COMPLETION FOR ACTIVITIES WHICH CAN BE BROKEN DOWN INTO SHORT TERM, DISCRETE UNITS WITH READILY ALLOCABLE COSTS.
    - Installation of a major piece of equipment may be described by several steps, such as foundation, delivery, rigging and setting, connection to power, instrumentation, testing, and startup.
    - Each of these may be considered a milestone with a budget which is earned when the milestone is completed.
    - An alternative is to assign two milestones, at start and at finish, to an element, such as connection or testing. A percentage of the budget is allocated to each of the two milestones, such as 40% to the start milestone and 60% to its finish milestone.
    - Small equipment items may be represented by a single finish milestone or start/finish milestone.
  - EARNED VALUE IS MEASURED BASED ON WEIGHTED MILESTONES. THE WEIGHT OF EACH MILESTONE COULD BE REPRESENTED EITHER IN RELATIVE NUMBERS (WITHOUT ANY PARTICULAR UNIT) OR IN BUDGETED DOLLAR AMOUNT.
    1. Weight is Represented in relative numbers.
       The earned value for the activity is computed as,
       BCWP = (%Progress) x (Activity Budgeted Cost)
       where %Progress is defined as,
       %Progress = (Total Weight of Completed Milestones for this Activity) / (Total Weight of All Milestones for this Activity)
    2. Weight is represented in budgeted dollar amount
       The earned value for this activity is computed as,
       BCWP = Total Weight of Completed Milestones for this Activity
  - BEWARE OF LONGER TERM, CONTINUOUS ACTIVITIES. EARNED VALUE BECOMES INACCURATE AS IT MOVES IN LARGE STEPS INSTEAD OF SMOOTH CONTINUITY.
    - For example, if a 40 day brick laying task budgeted at $80,000 on a $1,000,000 building is represented by a finish milestone, earned value will jump by $80,000 upon completion. Obviously, earned value measured by output is better.

- **BINARY (OR 0-1) METHOD:**
  - NORMALLY USED FOR ACTIVITIES WITH RELATIVELY SHORTER DURATION (E.G., LESS THAN ONE MONTH).
    1. Activity has not started yet, or has started by not completed yet
       BCWP = 0
    2. Activity has started, but not completed yet
       BCWP = Activity Budget Cost

- **50/50 METHOD:**

  THE EARNED VALUE FOR THIS ACTIVITY IS COMPUTED AS FOLLOWS:

  1. ACTIVITY HAS NOT STARTED YET
     BCWP = 0
  2. ACTIVITY HAS STARTED, BUT NOT COMPLETED YET.
     BCWP = 50% of Activity Budgeted Cost
  3. ACTIVITY HAS BEEN COMPLETED
     BCWP = Activity Budgeted Cost

- **USER INPUTS % PROGRESS:**
  - USERS ARE ALLOWED TO MANUALLY ENTER %PROGRESS AS INPUT. ONCE ENTERED, THE %PROGRESS IS USED TO COMPUTE EARNED VALUE DIRECTLY AS FOLLOWS.
    BCWP = (% Progress) x (Activity Budgeted Cost)

- **EQUIVALENT UNIT:**
  - A PREDETERMINED VALUE IS GIVEN TO EACH UNIT PRODUCED. EARNED VALUE IS COMPUTED AS FOLLOWS:
    BCWP = (Equivalent Unit Price) x (No. of Units manufactured)

WASTE DISPOSAL PLANT
~600 activities
~100 work packages

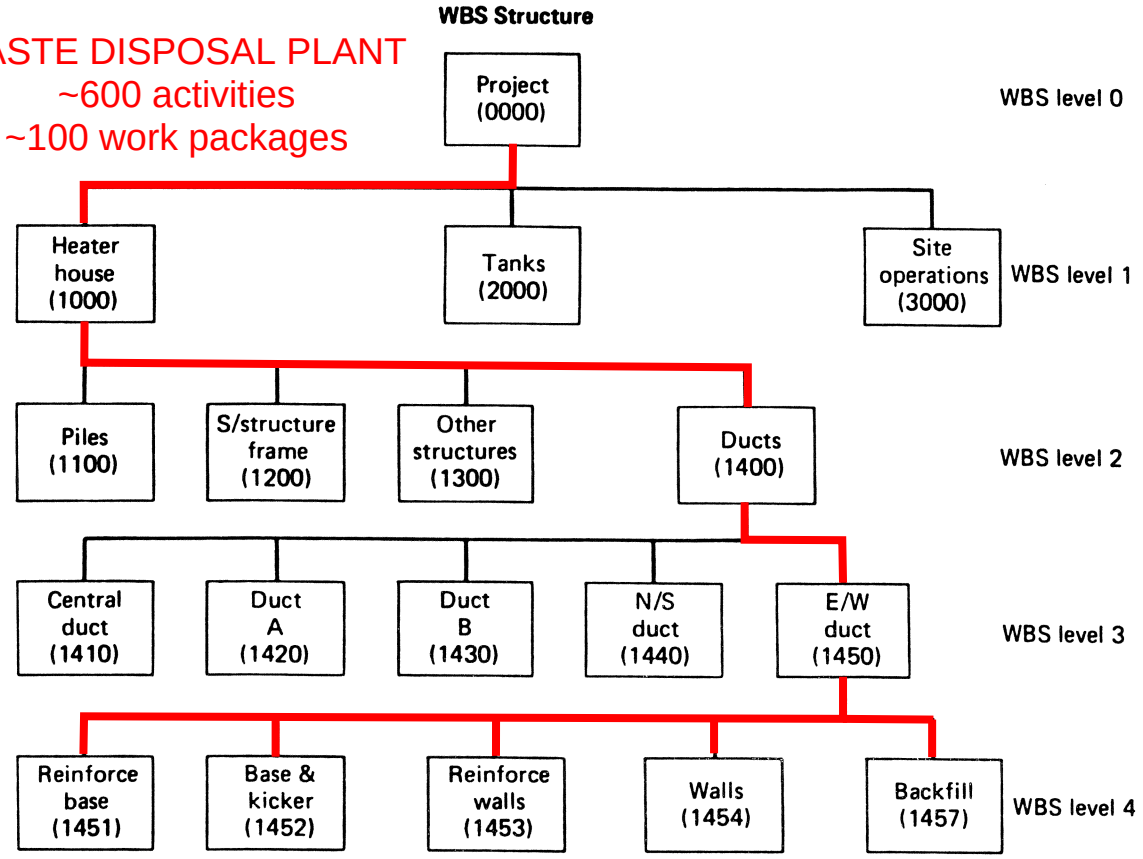


Figure 5-10 Work breakdown structure for demonstration project.

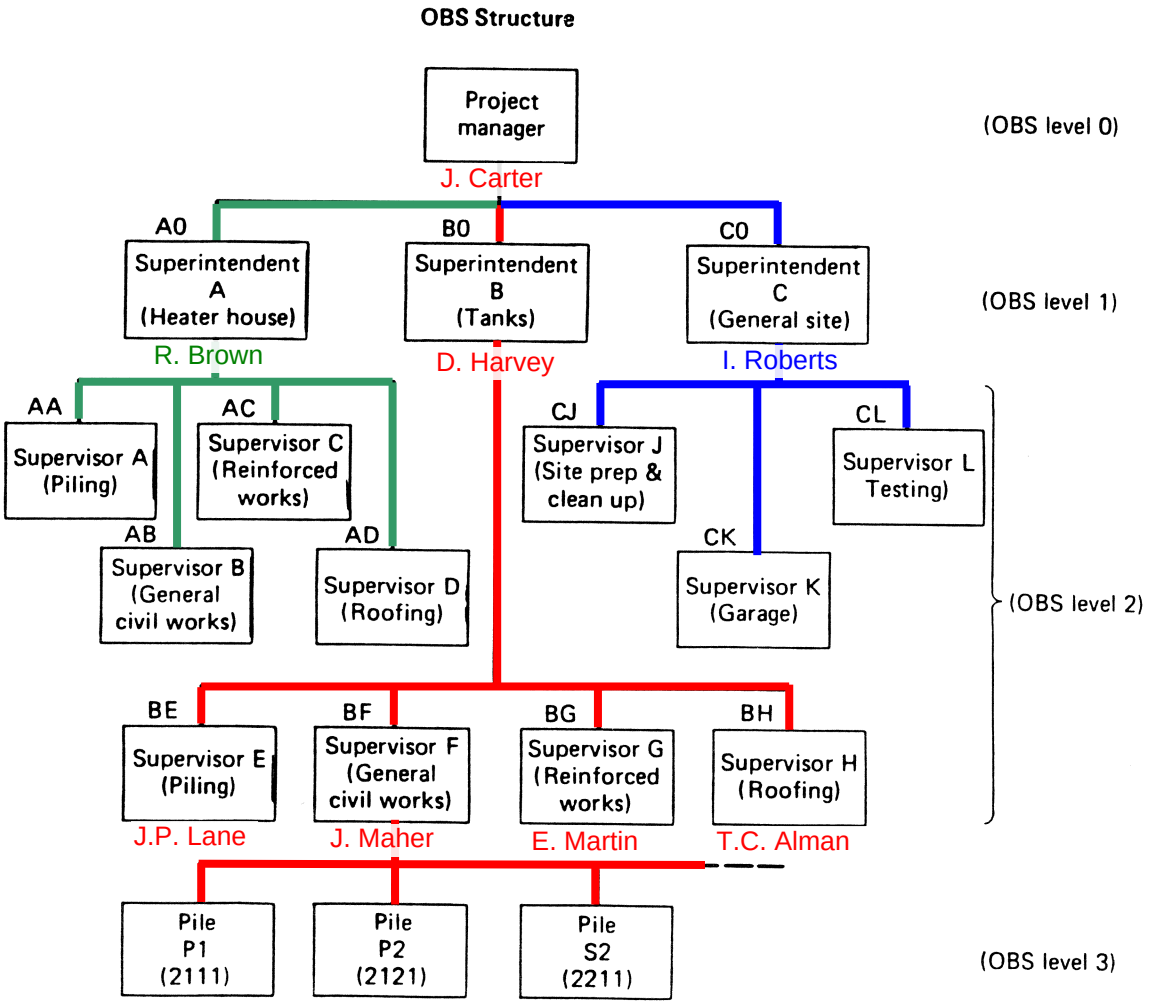


Figure 5-11 Organizational breakdown structure for demonstration project.

PROJECT COST PLAN

METIER/ARTEMIS :
DEMONSTRATION OF AN EARNED VALUE SYSTEM

CONTRACT NUMBER : 1/08/1932

LEVEL 1 SUMMARY : HEATER HOUSE

COMPANY : XYZ COMPANY

WBS CODE	WBS ELEMENT DESCRIPTION	BUDGET $	APR 79	JUN 79	AUG 79	OCT 79	DEC 79	FEB 80	APR 80	JUN 80	AUG 80	OCT 80	DEC 80	FEB 81	APR 81	JUN 81	AUG 81
1100	PILES	11200															
1200	S/STRUCTURE FRAME	38400															
1300	OTHER STRUCTURES	19592															
1400	DUCTS	109772															
	SUMMARY																
1000	HEATER HOUSE	178964															

WBS Level 2

Level 1

(a) WBS Level 1 Summary.

PROJECT COST PLAN

METIER/ARTEMIS
DEMONSTRATION OF AN EARNED VALUE SYSTEM

CONTRACT NUMBER : 1/08/1932
COMPANY : XYZ COMPANY
PROJECT MANAGER : J.CARTER

SUPERINTENDENT : TANKS - D. HARVEY

SUPERVISOR	BUDGET $	APR 79	JUN 79	AUG 79	OCT 79	DEC 79	FEB 80	APR 80	JUN 80	AUG 80	OCT 80	DEC 80	FEB 81	APR 81	JUN 81	AUG 81
PILING - J.P.LANE	79976															
GENERAL CIVIL WORKS - J.MAHER	133280															
REINFORCED WORKS - E.MARTIN	160840															
ROOFING - T.C.ALMAN	91296															
OVERALL WORK SPAN																
Harvey	464680															

OBS Level 2

Level 1

(b) OBS format (tank superintendent's areas).

Figure 5-12 Project cost plan reports.

~600 Activities

ACTIVITY SCHEDULE PAGE 1

WASTE DISPOSAL PLANT

WBS element 1000 = Heater House (HH)
WBS element 1450 = E/W Duct (of HH)
Work package 1451 = Reinforced Base (of E/W Duct of HH)

RUN DATE: 1-JUL-79

AOA Network

PREC ACT. *i*	SUCC ACT. *j*	DESCRIPTION	PROJECT SECTION	WORK PACKAGE	DURATION	EARLIEST START	EARLIEST FINISH	LATEST START	LATEST FINISH	TOTAL FLOAT
86	88	COMPLETE REINF BASE TANK S1	S1	2212	6	8-OCT-79	15-OCT-79	23-NOV-79	30-NOV-79	34
18	22	COMPLETE REINF BASE TANK P1	P1	2112	14	8-OCT-79	25-OCT-79	8-OCT-79	25-OCT-79	0
18	20	FORM RING BEAM TANK P1	P1	2113	8	8-OCT-79	17-OCT-79	29-OCT-79	7-NOV-79	15
128	130	STRIKE WALLS (TANK P2)	P2	1415	8	8-OCT-79	17-OCT-79	19-NOV-79	28-NOV-79	30
208	210	STRIKE WALLS DUCT B		1435	2	8-OCT-79	9-OCT-79	18-FEB-80	19-FEB-80	95
256	258	FORM DUCT "A" (TANK P2)	P2	1426	8	8-OCT-79	17-OCT-79	4-DEC-79	13-DEC-79	41
210	212	BACKFILL DUCT B		1437	8	10-OCT-79	19-OCT-79	20-FEB-80	29-FEB-80	95
130	132	FORM (TANK P2) ROOF SOFFIT	P2	1416	8	18-OCT-79	29-OCT-79	29-NOV-79	10-DEC-79	30
130	134	COMMENCE FIX REINF TO ROOF CEN		1416	8	18-OCT-79	29-OCT-79	29-NOV-79	10-DEC-79	30
154	156	CONC RING BEAM TANK P1(1)	P1	2113	2	18-OCT-79	19-OCT-79	8-NOV-79	9-NOV-79	15
260	262	COMPLETE FIX REINF TO ROOF DUC		1426	2	18-OCT-79	19-OCT-79	14-DEC-79	17-DEC-79	41
156	158	STRIKE RB TANK P1(1) AND FORM	P1	2113	3	22-OCT-79	24-OCT-79	12-NOV-79	14-NOV-79	15
262	264	CONC ROOF DUCT A		1426	2	22-OCT-79	23-OCT-79	18-DEC-79	19-DEC-79	41
264	370	DELAY			1	24-OCT-79	24-OCT-79	20-DEC-79	20-DEC-79	41
264	266	DELAY			1	24-OCT-79	24-OCT-79	21-DEC-79	21-DEC-79	42
158	160	CONC RING BEAM TANK P1(2)	P1	2113	2	25-OCT-79	26-OCT-79	15-NOV-79	16-NOV-79	15
370	372	STRIKE FORM SOFFIT DUCT A		1426	2	25-OCT-79	26-OCT-79	21-DEC-79	24-DEC-79	41
266	268	STRIKE FORM ROOF DUCT "A"		1426	2	25-OCT-79	26-OCT-79	24-DEC-79	25-DEC-79	42
22	24	FIX FORM TO CTR BASE TANK P1	P1	2114	10	26-OCT-79	8-NOV-79	26-OCT-79	8-NOV-79	0
160	162	STRIKE FORM RB TANK P1(2)	P1	2113	2	29-OCT-79	30-OCT-79	19-NOV-79	20-NOV-79	15
372	268	DELAY			1	29-OCT-79	29-OCT-79	25-DEC-79	25-DEC-79	41
134	136	COMPLETE FIX REINF TO ROOF CEN		1416	2	30-OCT-79	31-OCT-79	11-DEC-79	12-DEC-79	30
268	270	BACKFILL DUCT A		1427	8	30-OCT-79	8-NOV-79	26-DEC-79	4-JAN-80	41
162	164	FORM RING BEAM TANK S1(1)	S1	2213	8	31-OCT-79	9-NOV-79	27-NOV-79	6-DEC-79	19
136	138	CONC ROOF CENT DUCT		1416	2	1-NOV-79	2-NOV-79	13-DEC-79	14-DEC-79	30
138	358	DELAY			1	5-NOV-79	5-NOV-79	17-DEC-79	17-DEC-79	30
138	140	DELAY			1	5-NOV-79	5-NOV-79	18-DEC-79	18-DEC-79	31
358	360	STRIKE FORM CENT DUCT		1416	2	6-NOV-79	7-NOV-79	18-DEC-79	19-DEC-79	30
140	142	STRIKE FORM CTR DUCT ROOF		1416	2	6-NOV-79	7-NOV-79	19-DEC-79	20-DEC-79	31
360	142	DELAY			1	8-NOV-79	8-NOV-79	20-DEC-79	20-DEC-79	30
24	26	CONC CTR BASE TANK P1	P1	2114	4	9-NOV-79	14-NOV-79	9-NOV-79	14-NOV-79	0
142	144	BACKFILL CENT DUCT		1417	3	9-NOV-79	13-NOV-79	21-DEC-79	25-DEC-79	30
270	374	EXC TRIM & BLIND TANK P2	P2	2122	12	9-NOV-79	26-NOV-79	7-JAN-80	22-JAN-80	41
164	166	CONC RING BEAM TANK S1(1)	S1	2213	2	12-NOV-79	13-NOV-79	7-DEC-79	10-DEC-79	19
144	362	COMMENCE EXC TRIM AND BLIND HH	HH	1451	2	14-NOV-79	15-NOV-79	26-DEC-79	27-DEC-79	30
166	168	STRIKE RB TANK S1(1) AND FORM	S1	2213	3	14-NOV-79	16-NOV-79	11-DEC-79	13-DEC-79	19
26	28	STRIKE FORM CTR BASE TANK P1	P1	2114	4	15-NOV-79	20-NOV-79	15-NOV-79	20-NOV-79	0
362	364	COMPLETE EXC TRIM AND BLIND HH	HH	1451	2	16-NOV-79	19-NOV-79	31-DEC-79	1-JAN-80	31
362	366	COMMENCE REINF BASES E & W DUC		1451	3	16-NOV-79	20-NOV-79	28-DEC-79	1-JAN-80	30
168	170	CONC RING BEAM TANK S1(2)	S1	2213	2	19-NOV-79	20-NOV-79	14-DEC-79	17-DEC-79	19
580	582	COMMENCE EXC TRIM & BLIND HH D	HH	1441	8	20-NOV-79	29-NOV-79	27-FEB-80	7-MAR-80	71
88	90	FIX FORM CTR BASE TANK S1	S1	2214	4	21-NOV-79	26-NOV-79	3-DEC-79	6-DEC-79	8
28	30	FIX SCREED & CONC INCL BASE TA	P1	2115	4	21-NOV-79	26-NOV-79	21-NOV-79	26-NOV-79	0
366	368	COMPLETE REINF BASES E & W DUC		1451	3	21-NOV-79	23-NOV-79	9-JAN-80	11-JAN-80	35

Figure 5-13 Activity schedule (portion of project).

```
ARTEMIS REPORT                                                                                    RUN DATE:   1-JUL-79      PAGE NO.    1

PROJECT : WASTE DISPOSAL PLANT

SECTION : CRANE

PRES SUCC  WORK              ACTIVITY                                  BAR CHART SHOWS THE ORIGINAL AND CURRENT SCHEDULE FOR ALL ACTIVITIES WHOSE CURRENT EARLY START BEFORE 15-JAN-80
ACT. ACT. PACKAGE            DESCRIPTION                                                  CRITICAL ACTIVITIES ARE SHOWN WITH THE SYMBOL C
                                                                  10.SEP.79          8.OCT.79          5.NOV.79          3.DEC.79          31.DEC.79          28.JAN.80
                                                                  I-------------------I-------------------I-------------------I-------------------I-------------------I-------------------
536  530    3220 COMMENCE EXTEND CRANE TRACK A                    I                   I                   I                   I          ***  *****  XXXX                I
538  540    3220 CONTINUE EXTEND CRANE TRACK A                    I                   I                   I                   I                   *****  ***XX  XX        I
540  498    3220 CONTINUE EXTEND CRANE TRACK A                    I                   I                   I                   I                   I        **  *-XXX      I

SECTION : PRIMARY DIGESTION  TANK NO.1

PRES SUCC  WORK              ACTIVITY                                  BAR CHART SHOWS THE ORIGINAL AND CURRENT SCHEDULE FOR ALL ACTIVITIES WHOSE CURRENT EARLY START BEFORE 15-JAN-80
ACT. ACT. PACKAGE            DESCRIPTION                                                  CRITICAL ACTIVITIES ARE SHOWN WITH THE SYMBOL C
                                                                  10.SEP.79          8.OCT.79          5.NOV.79          3.DEC.79          31.DEC.79          28.JAN.80
                                                                  I-------------------I-------------------I-------------------I-------------------I-------------------I-------------------
 18   22    2112 COMPLETE REINF BASE TANK P1                      I                 ****  *****  *****  CCCC   I                   I                   I                   I
 18   20    2113 FORM RING BEAM TANK P1                           I                 ****  *****X  XXX          I                   I                   I                   I
154  156    2113 CONC RING BEAM TANK P1(1)                        I                   I  *  *--XX          I                   I                   I                   I
156  158    2113 STRIKE RB TANK P1(1) AND FORM RB P1(2            I                   I      ***-  XXX      I                   I                   I                   I
158  160    2113 CONC RING BEAM TANK P1(2)                        I                   I         *  *--XX   I                   I                   I                   I
 22   24    2114 FIX FORM TO CTR BASE TANK P1                     I                   I           *****  *****  CCCC                I                   I                   I
160  162    2113 STRIKE FORM RB TANK P1(2)                        I                   I            **--  XX  I                   I                   I                   I
 24   26    2114 CONC CTR BASE TANK P1                            I                   I                   ****C  CCC          I                   I                   I
 26   28    2114 STRIKE FORM CTR BASE TANK P1                     I                   I                   I  *  ***CC  CC      I                   I                   I
 28   30    2115 FIX SCREED & CONC INCL BASE TANK P1 (            I                   I                   I        **  **CCC  C  I                   I                   I
 30   32    2115 STRIKE SCREED & CONC INCL BASE TANK P            I                   I                   I             ***  *CCCC I                   I                   I
 32   34    2116 FIX SCAFFOLD TANK P1 FIRST LIFT                  I                   I                   I                  ****  *****  *CCCC         I                   I
 34   39    2116 COMMENCE REINF WALLS TANK P1(1)                  I                   I                   I                   I      **--  CC       I                   I
 39   40    2116 COMPLETE REINF WALLS TANK P1(1)                  I                   I                   I                   I        **  *****  ***CC  CC                I
 40   42    2117 FIX FORM WALLS TANK P1 (1)                       I                   I                   I                   I                   **  *****  ****C  CCC      I
620  624    1444 FORM WALL N DUCT (TANK P1)                       I                   I                   I                   I                   I  **  --XX           I
624  626    1444 CONC WALLS N DUCT (TANK P1)                      I                   I                   I                   I                   I     **--X  X        I
620  630    1444 STRIKE WALLS N DUCT TANK P1                      I                   I                   I                   I                   I        **  *-XXX      I
 42   44    2117 CONC WALLS TANK P1 (1)                           I                   I                   I                   I                   I         *  *--CC      I

LEGEND  : '*' FROM ORIGINAL EARLY START TO ORIGINAL EARLY FINISH  : '-' FROM ORIGINAL EARLY FINISH TO CURRENT EARLY START : 'X' FROM CURRENT EARLY START TO CURRENT EARLY FINISH
          'C' DENOTES A CRITIAL ACTIVITY
```

Figure 5-14 Slippage bar chart report (portion of project).

METIER/ARTEMIS :
DEMONSTRATION OF AN EARNED VALUE SYSTEM

SCHEDULE PERFORMANCE REPORT

CONTRACT NUMBER : 1/08/1932
COMPANY : XYZ COMPANY

PROJECT MANAGER : J.CARTER

ACHIEVEMENTS : BASELINE SCHEDULE (B) : ACTUAL (A) : FORECAST (F) : TIMENOW (*)

SUPERINTENDENT	KEY	APR 79	JUN 79	AUG 79	OCT 79	DEC 79	FEB 80	APR 80	JUN 80	AUG 80	OCT 80	DEC 80	FEB 81	APR 81	JUN 81	FORECAST OVERRUN (DAYS)
HEATER HOUSE - R.BROWN	B	BBBBBBBBBBBB*BBBBBBBBBBB

METIER/ARTEMIS :
DEMONSTRATION OF AN EARNED VALUE SYSTEM

SCHEDULE PERFORMANCE REPORT
==========

CONTRACT NUMBER : 1/08/1932

LEVEL 1 SUMMARY : SITE OPERATIONS

COMPANY : XYZ COMPANY

ACHIEVEMENTS : BASELINE SCHEDULE (B) : ACTUAL (A) : FORECAST (F) : TIMENOW (*)

WBS CODE	WBS ELEMENT DESCRIPTION	KEY	APR 79	JUN 79	AUG 79	OCT 79	DEC 79	FEB 80	APR 80	JUN 80	AUG 80	OCT 80	DEC 80	FEB 81	APR 81	JUN 81	FORECAST OVERRUN (DAYS)
3100	SITE PREPARATION	B	BBBBBBBBBB			*											0
		AF	AAAAAAAAA			*											2
3200	CRANAGE	B				BBBBBB*BBBBBBBBB

COST PERFORMANCE REPORT
WORK BREAKDOWN STRUCTURE

REPORT DATE : 1-JUL-79

METIER/ARTEMIS :
DEMONSTRATION OF AN EARNED VALUE SYSTEM

PROJECT NAME : WASTE DISPOSAL PLANT
CONTRACT TYPE/NUMBER : FP. 1/08/1932

TOTAL PROJECT SUMMARY

COMPANY : XYZ COMPANY
CONTRACTOR : BUCKSHEE ENG.
LOCATION : CINCINATTI

REPORT PERIOD : OCT-1979

ITEM	CURRENT PERIOD					CUMULATIVE TO DATE					AT COMPLETION		
	BUDGETED COST		ACTUAL	VARIANCE		BUDGETED COST		ACTUAL	VARIANCE				
	WORK SCHED ULED	WORK PER FORM'D	COST WORK PERF'D	SCHED ULE	COST	WORK SCHED ULED	WORK PER FORM'D	COST WORK PERF'D	SCHED ULE	COST	BUDGETED	LATEST REVISED ESTIMATE	VARIANCE
HEATER HOUSE	13473	11889	15800	-1584	-3911	64996	54643	56461	-10353	-1818	178964	189227	-10263
TANKS	22996	22146	18324	-850	3822	103476	102854	105446	-622	-2592	488120	499139	-11019
SITE OPERATIONS	2040	2880	288	840	2592	57694	56605	56820	-1089	-215	107848	109296	-1448
TOTAL PROJECT SUMMARY	38509	36914	34412	-1595	2502	226166	214102	218728	-12064	-4626	774932	797662	-22730

CURRENT TOTAL BUDGET = $774932

ESTIMATED FINAL TOTAL COST = $797662

COST PERFORMANCE INDEX =0.98
SCHED PERFORMANCE INDEX =0.95

PRODUCED BY METIER/ARTEMIS

Figure 5-16 Cost performance report organized by WBS (Level 1 summary).

COST PERFORMANCE REPORT
FUNCTIONAL STRUCTURE

REPORT DATE : 1-JUL-79

METIER/ARTEMIS :
DEMONSTRATION OF AN EARNED VALUE SYSTEM

PROJECT NAME : WASTE DISPOSAL PLANT
CONTRACT TYPE/NUMBER : FP. 1/08/1932
SUPERINTENDENT : TANKS - D. HARVEY

SUPERVISOR : REINFORCED WORKS - E.MARTIN

COMPANY : XYZ COMPANY
CONTRACTOR : BUCKSHEE ENG.
LOCATION : CINCINATTI

REPORT PERIOD : OCT-1979

ITEM	CURRENT PERIOD					CUMULATIVE TO DATE					AT COMPLETION		
	BUDGETED COST		ACTUAL	VARIANCE		BUDGETED COST		ACTUAL	VARIANCE				
	WORK SCHEDULED	WORK PERFORM'D	COST WORK PERF'D	SCHEDULE	COST	WORK SCHEDULED	WORK PERFORM'D	COST WORK PERF'D	SCHEDULE	COST	BUDGETED	LATEST REVISED ESTIMATE	VARIANCE
REINFORCE BASE (P1)	5040	0	960	-5040	-960	6720	961	1075	-5759	-114	6720	7526	-806
RING BEAM (P1)	5906	0	880	-5906	-880	5906	810	898	-5096	-88	7296	8172	-876
REINFORCE WALLS (P1)	0	0	0	0	0	0	0	0	0	0	13200	13200	0
REINFORCE BASE (P2)	0	0	0	0	0	0	0	0	0	0	11904	11904	0
RING BEAM (P2)	0	0	0	0	0	0	0	0	0	0	12136	12136	0
REINFORCE WALLS (P2)	0	0	0	0	0	0	0	0	0	0	16080	17040	-960
REINFORCE BASE (S1)	6720	6720	6720	0	0	6720	6720	7526	0	-806	6720	7526	806
RING BEAM (S1)	304	0	0	-304	0	304	0	0	-304	0	7296	7296	0
REINFORCE WALLS (S1)	0	0	0	0	0	0	0	0	0	0	17040	17040	0
REINFORCE BASE (S2)	0	0	0	0	0	0	0	0	0	0	11904	12576	672
RING BEAM (S2)	0	0	0	0	0	0	0	0	0	0	7296	7296	0
REINFORCE BASE (C1)	1926	796	440	-1130	356	8560	8560	9058	0	-498	8560	9058	498
RING BEAM (C1)	0	0	0	0	0	0	0	0	0	0	0	0	0
REINFORCE WALLS (C1)	350	1439	1440	1089	-1	402	1439	1613	1036	-174	4320	4838	518
REINFORCE BASE (C2)	569	3786	3816	3217	-30	1281	7976	8337	6695	-361	9168	10268	-1100
RING BEAM (C2)	0	0	0	0	0	0	0	0	0	0	0	0	0
REINFORCE WALLS (C2)	224	0	240	-224	-240	224	246	269	22	-23	4320	4838	-518
TOTAL - SUPERVISOR	21039	12741	14496	-8298	-1755	30118	26712	28776	-3406	-2064	160040	167755	-7715

CURRENT BUDGET = $ 160040 ESTIMATED FINAL COST = $ 167755

Figure 5-17 Cost performance report organized by OBS (for reinforced works supervisor, tanks area).

WORK PACKAGE / COST CODE REPORT — WP 2121

METIER/ARTEMIS :
DEMONSTRATION OF AN EARNED VALUE SYSTEM

REPORT PERIOD : OCT-1979
CONTRACT NUMBER - 1/08/1932

WORK PACKAGE # 2121 DESCRIPTION : PILES (P2)
SUMMARY WBS CODE 212 DESCRIPTION : PRIMARY TANK NO.2

WORK PACKAGE SUMMARY

DATES :

BUDGET DATES : START = 12-JUL-79 FINISH = 16-NOV-79
CURRENT DATES : START = 17-JUL-79 FINISH = 29-NOV-79

COST INFORMATION

CURRENT BUDGET : $18976.00 ACTUAL COST TO DATE : $8691.20 REVISED ESTIMATE : $12293.12

PERCENTAGE COMPLETION TO DATE : 76.90

COST CODE DETAIL TO DATE

COST CODE	BUDGET MANHOURS	BUDGET $	ACTUALS TO DATE MANHOURS	ACTUALS TO DATE $	FORECAST MANHOURS	FORECAST $
A103	192	2016	0	0	197	2258
A105	640	8960	697	8691	659	10035

REPORT SHOULD BE RETURNED TO SUPERVISOR : PILING - J.P.LANE

PRODUCED BY METIER/ARTEMIS

Figure 5-18 Sample of detailed cost information for individual work package.

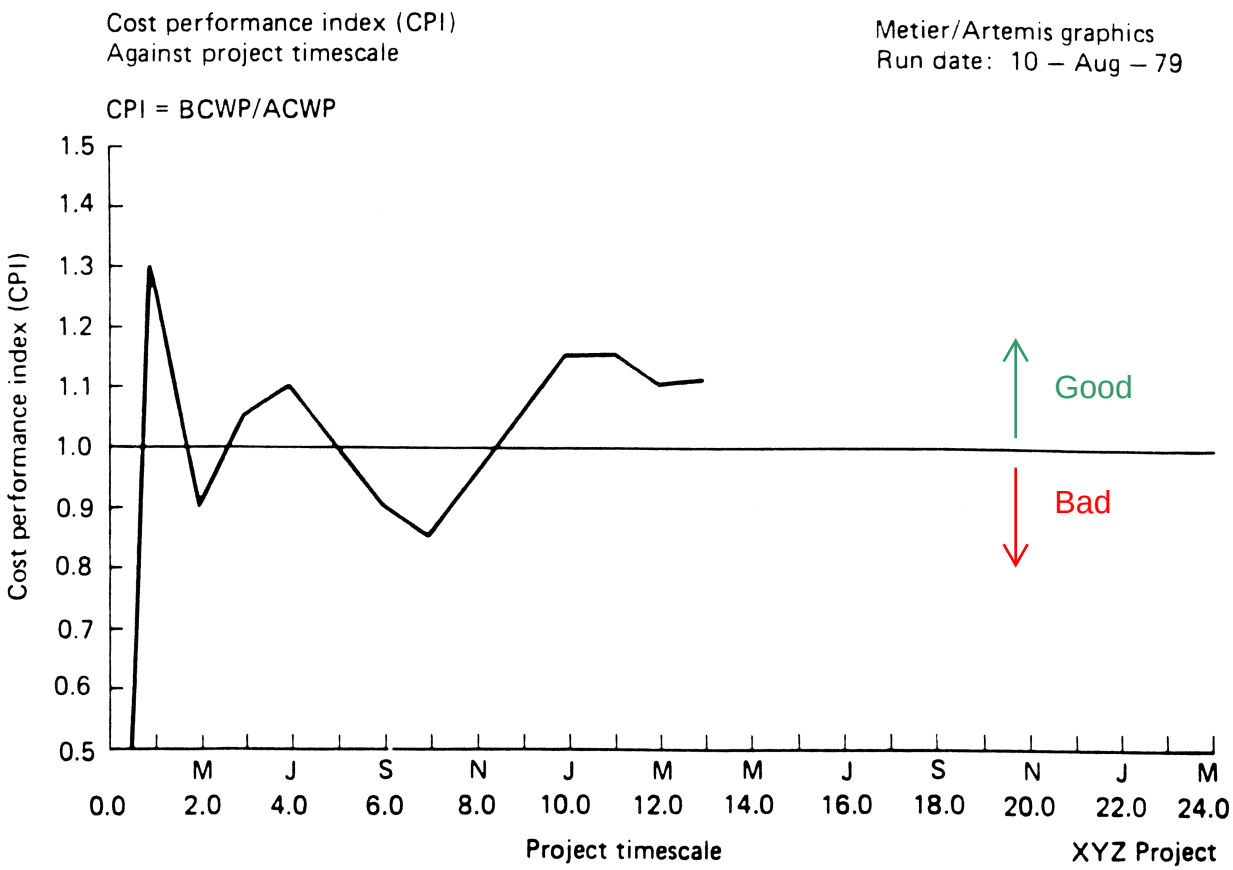


Figure 5-19(a) Project cost performance index over time.

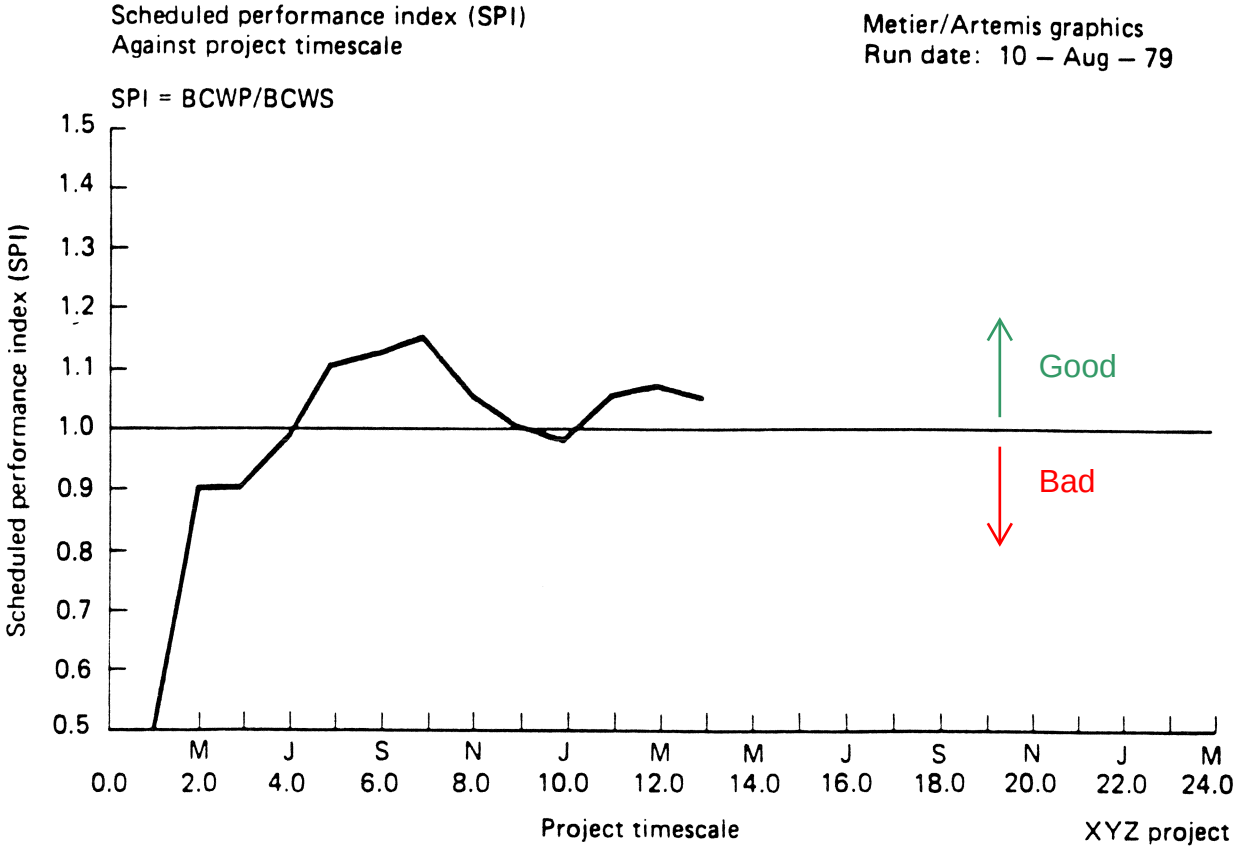


Figure 5-19(b) Project schedule performance index over time.

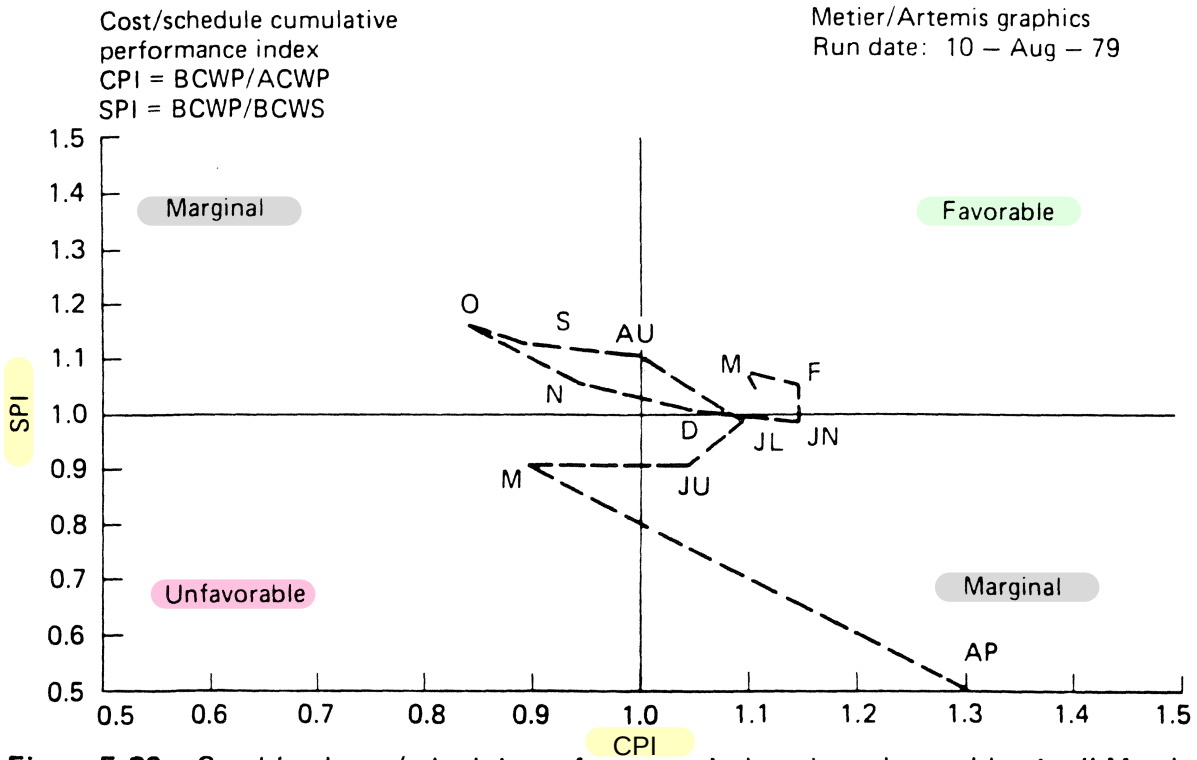


Figure 5-20 Combined cost/schedule performance index plotted monthly, April-March.