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ENGINEERING MANAGEMENT

(GE 404)

LECTURE #11

Project Cost-Control

Contents

- Objectives of the present lecture
- Integration of cost and schedule
- Aim of project cost control system
- Cost control
- Three Key indicators in performance measurement
- Performance equations
- Cost forecasting equations
- Problems
- Further reading

Objectives of the Present lecture

- To discuss key indicators in performance measurement of a project
- To learn how to estimate and forecast different types of costs

Integration of Cost and Schedule

- The integration of cost and schedule control systems is of natural interest to construction professionals, because the true "status" of a project can only be assessed if both cost and schedule data are examined in conjunction with one another
  - Example: A project may
  - appear to be well under budget based on the amount of money spent to date compared to what was projected. However, this figure alone could be very misleading; costs may be very low because the project is well behind the schedule.
  - Thus it is necessary to know what actual project costs are relative to expected costs while knowing where the project is on a time basis.
- The critical path method (CPM) system can also be used as a cost-monitoring system
- In the1960s, U.S. defense agencies combined guides and requirements related to integration of cost and schedule data into a single system

Aim of Project Cost Control System

- To identify those work types having excessive costs and to give an indication of how serious those overruns are
- To forecast the final total job cost
- To indicate the trend for each cost code, that is, whether the unit cost involved has been increasing or decreasing (evaluation of the effectiveness of cost reduction efforts)
- To update the database of the company that will be used to estimate future works

Cost Control

- The cost estimate prepared for the project during the bidding process is the basis for cost control
- Cost control for an engineering project is limited to the cost of labor, equipment, materials and site overheads
- Control of cost and time should be linked together

Three Key Indicators in Performance Measurement

- **Budgeted Cost of Work Scheduled (BCWS)**
- **Budgeted Cost of Work Performed (BCWP)**
- **Actual Cost of Work Performed (ACWP)**

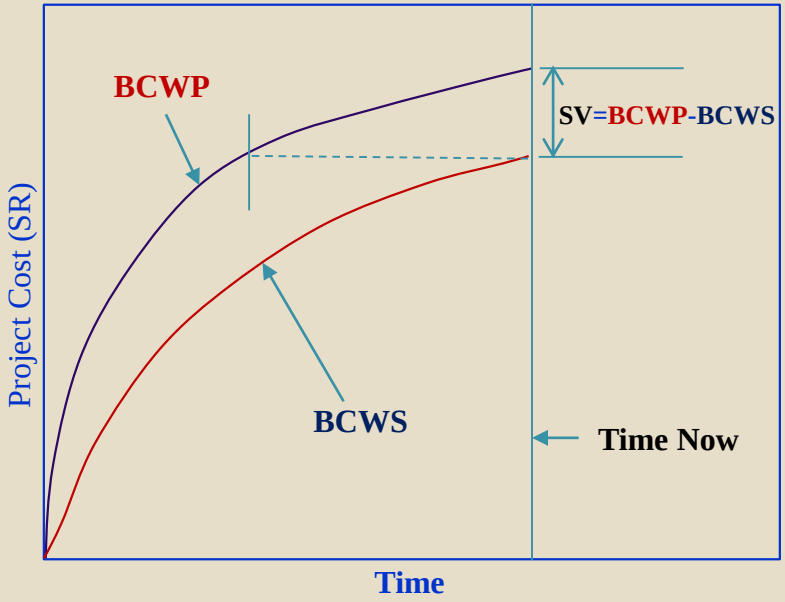
BCWS

- **BCWS** is the budgeted amount of cost of the work scheduled to be accomplished in a given time period
- This can be referred to as **planned value** of work to be accomplished [PV]

BCWP

- **BCWP** is the budgeted amount of cost for the work completed in a given time period.
- This can be referred to as **earned value** of work accomplished [EV]
- How to calculate BCWP
  - Budgeted cost for work performed (BCWP) = Earned value of an activity = Percent completed for the activity × the activity budget
  - Percent completed for an activity = [(Projected duration – Remaining duration) / Projected duration] ×100

Schedule Variance, SV

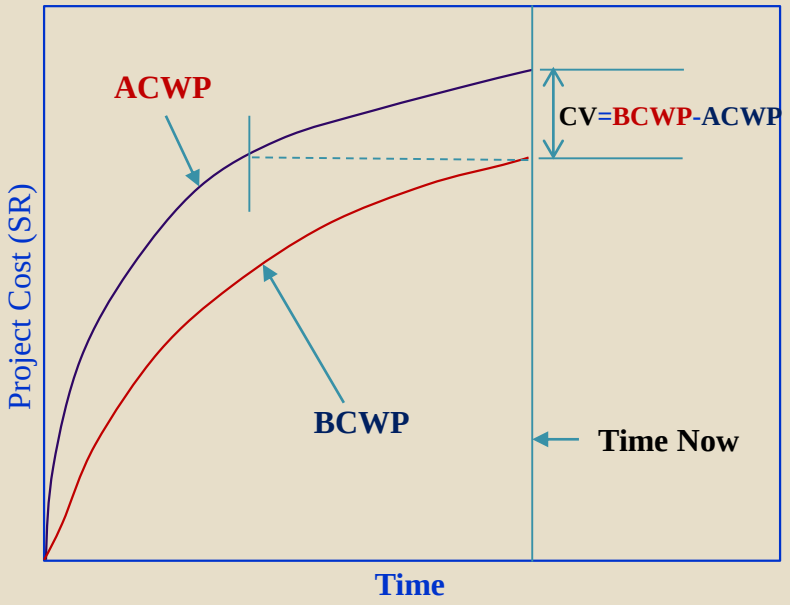


SV>0: ahead of schedule
SV<0: behind schedule

ACWP

- **ACWP** is the amount reported as actually spent in completing the particular work accomplished within a given time period

Cost variance, CV



CV>0: under budget
CV<0: over budget

Performance Equations

Symbol	Definition	التعريف
(BCWS) [PV]"	Budgeted Cost of Work Scheduled "**planned value** of work to be accomplished	تكلفة موازنة للأعمال المجدولة وفقا للخطة
(BCWP) [EV]	Budgeted Cost of Work Performed "**earned value** of work accomplished	تكلفة موازنة لما تم من أعمال
(ACWP) [AC]	**Actual Cost** of Work Performed	التكلفة الفعلية لما تم من أعمال وتم دفعها

Cost Performance

BCWP
ACWP

Cost Variance | **CV = BCWP-ACWP**

- > 0 → Under budget — Work performed cost > Actual cost
- = 0 → Within budget — Work performed cost = Actual cost
- < 0 → Over budget — Work performed cost < Actual cost

Cost Performance

BCWP
ACWP

Cost Performance Index | **CPI = BCWP/ACWP**

- > 1 → Under budget — Work performed cost > Actual cost
- = 1 → Within budget — Work performed cost = Actual cost
- < 1 → Over budget — Work performed cost < Actual cost

Cost Performance

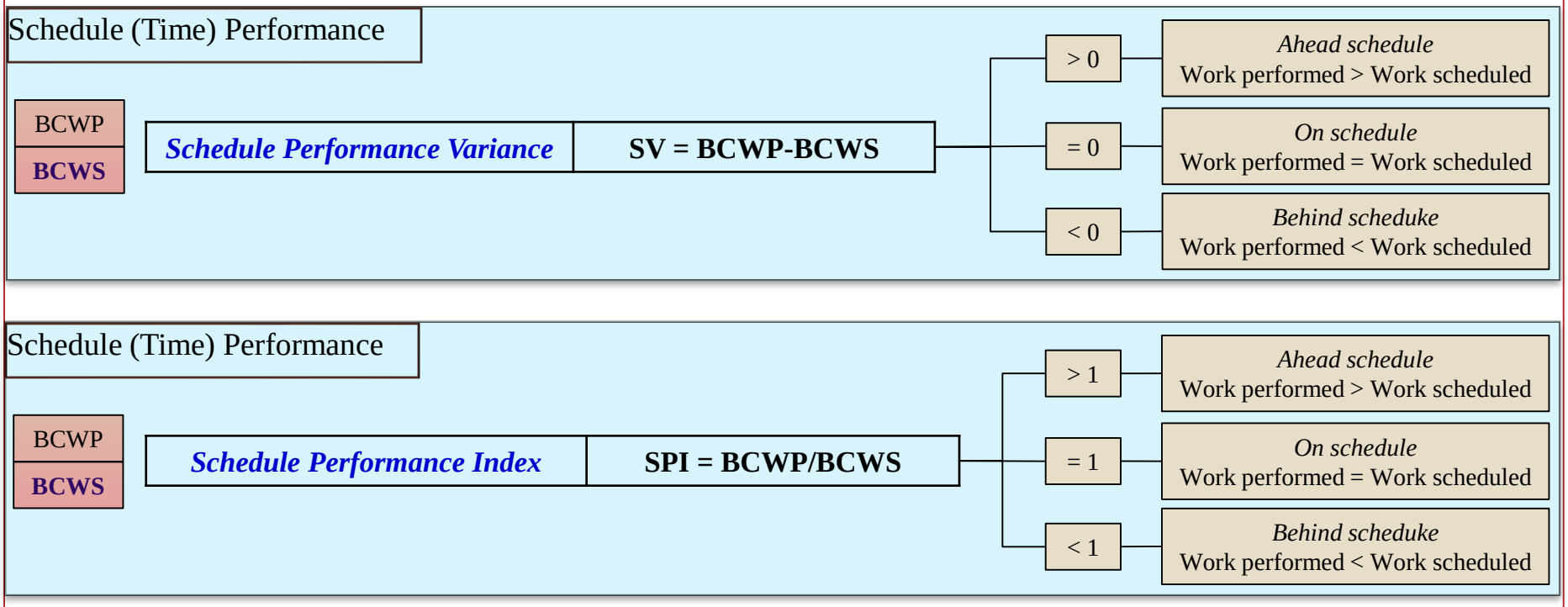
BCWP
ACWP

% Cost Overrun/ Underrun | $\frac{\text{(BCWP – ACWP)}}{\text{BCWP}}$

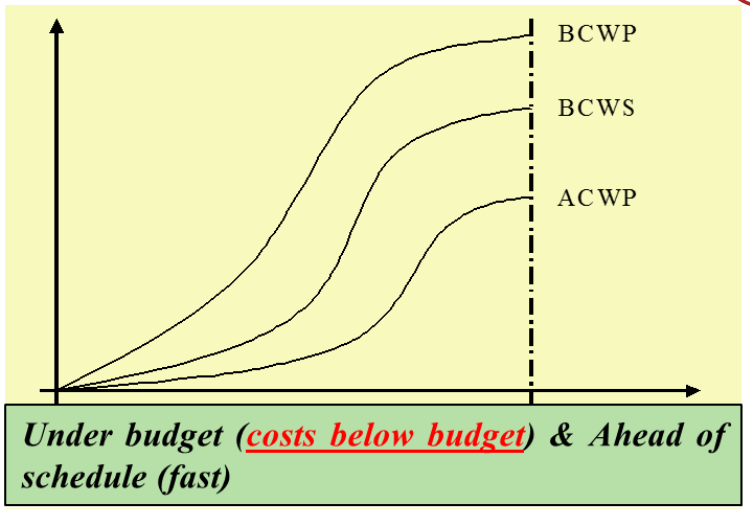
- > 0 → Under run — Performed cost > Earned
- = 0 → on run — Performed cost = Earned
- < 0 → Over run — Performed cost < Earned

The "Cost Overrun" curve is a plot of the calculated percent ver- or underrun at any given time.

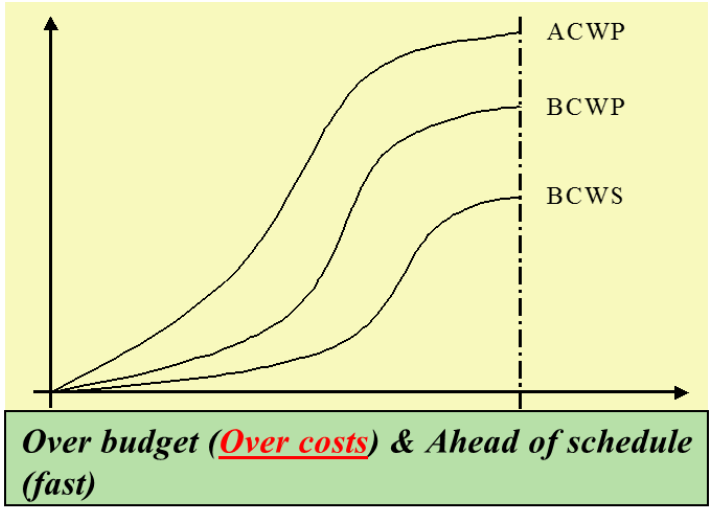
Performance Equations (Contd.)



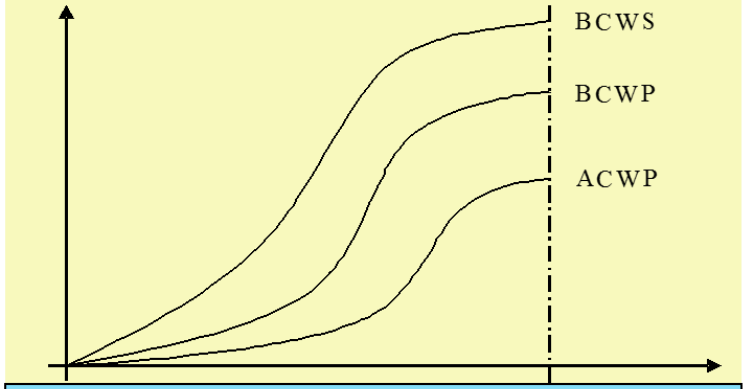
BCWP, BCWS and ACWP



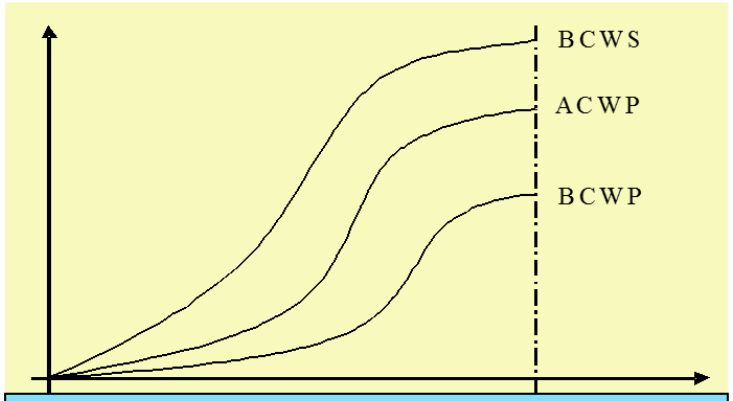
Under budget (costs below budget) & Ahead of schedule (fast)



Over budget (Over costs) & Ahead of schedule (fast)



Under budget (costs below budget) & Behind schedule (Slow)

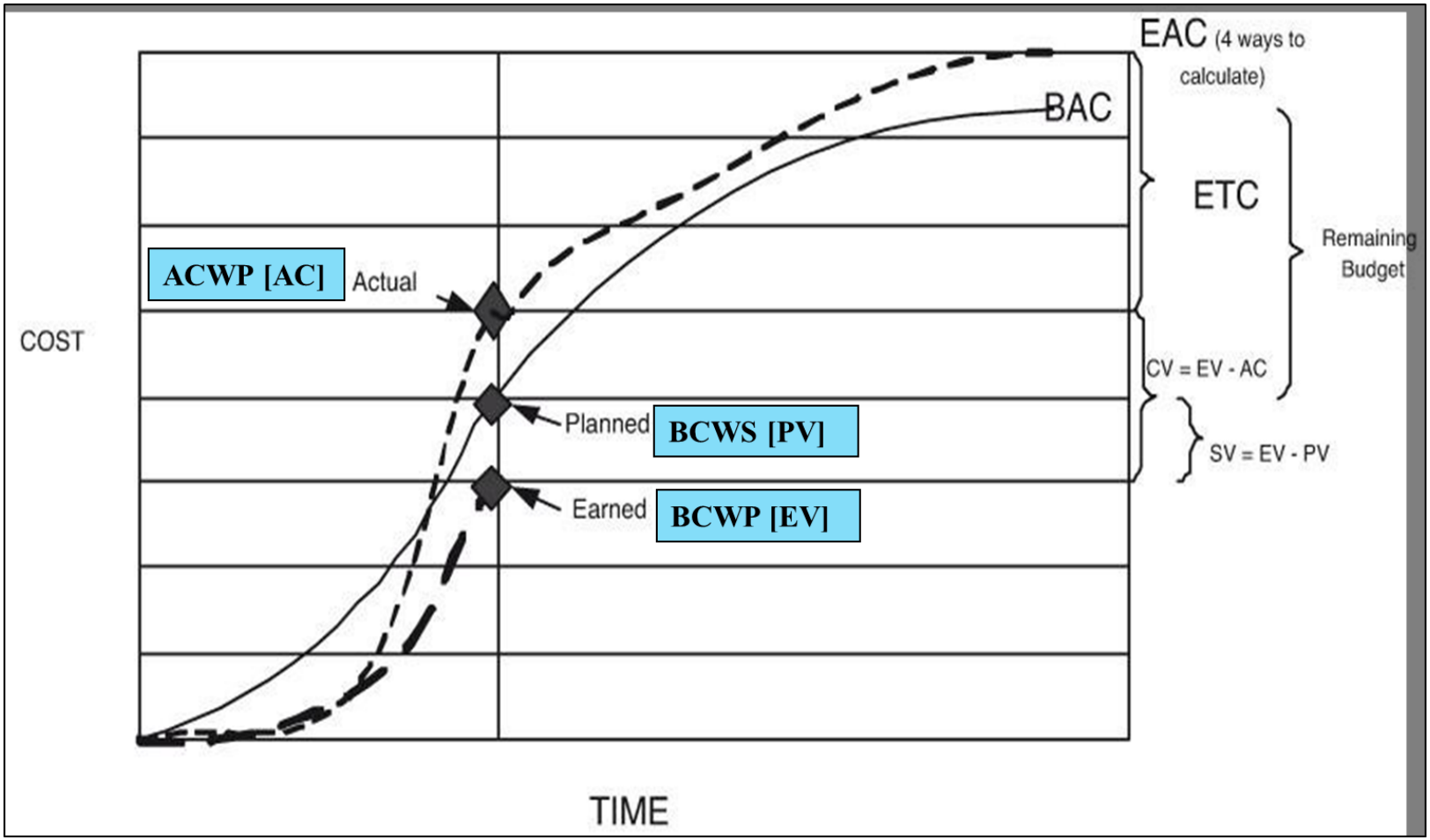


Over budget (Over cost) & Behind schedule (Slow)

Cost Forecasting Equations

Budget Cost At Completion	$BAC = BCWS_{end}$
Estimated Cost At Completion	$EAC = \frac{ACWP_{to\ date}}{BCWP_{to\ date}} \times BAC$ Or $EAC = ACWP_{to\ date} + \frac{(BAC - BCWP_{to\ date})}{CPI_{this\ period}}$
Estimate to Completion	$ETC = EAC - ACWP$
Variance from original budget	$VB = EAC - BAC$

BCWS [PV], BCWP [EV], and ACWP[AC] – S-curves



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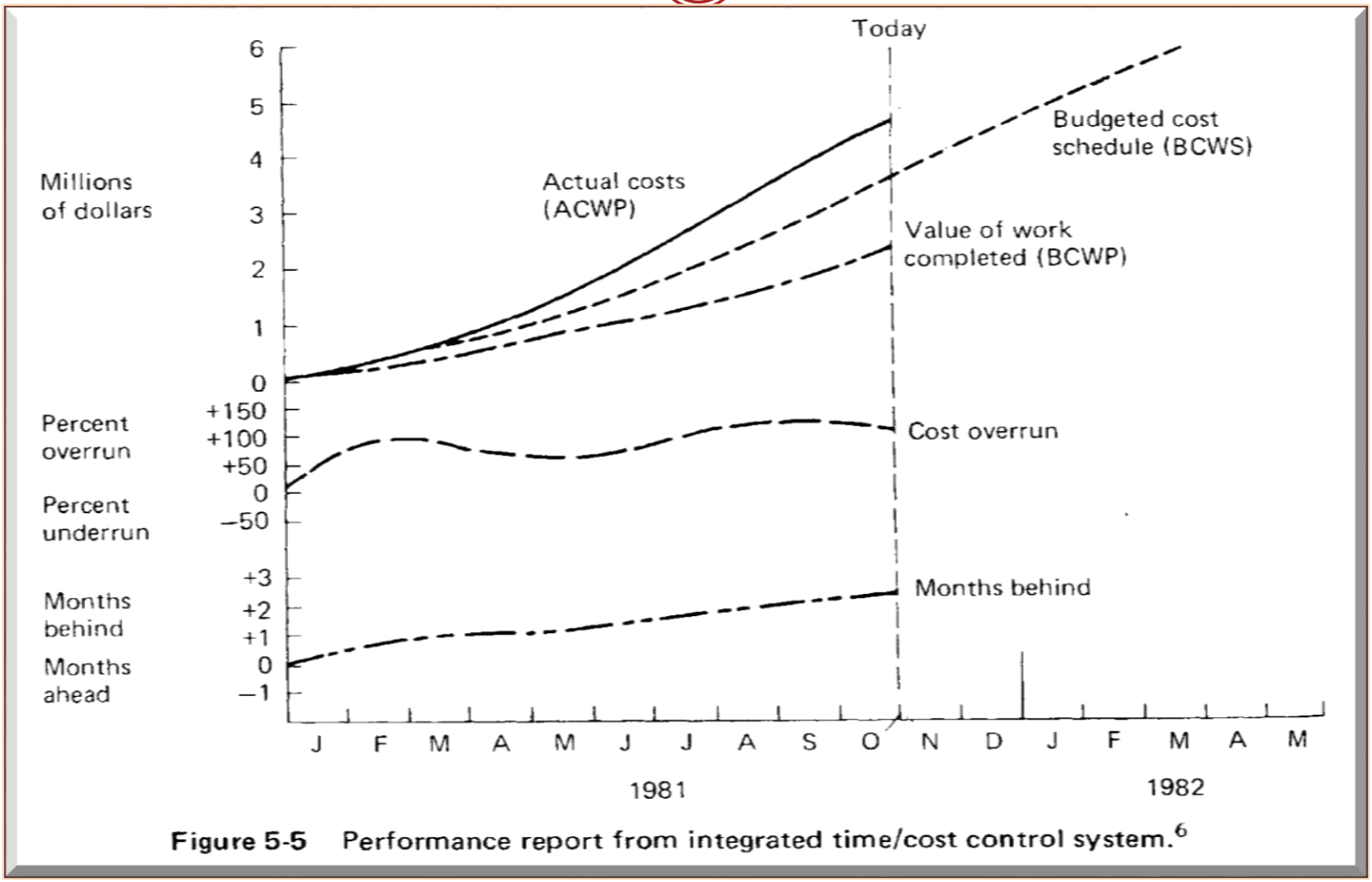
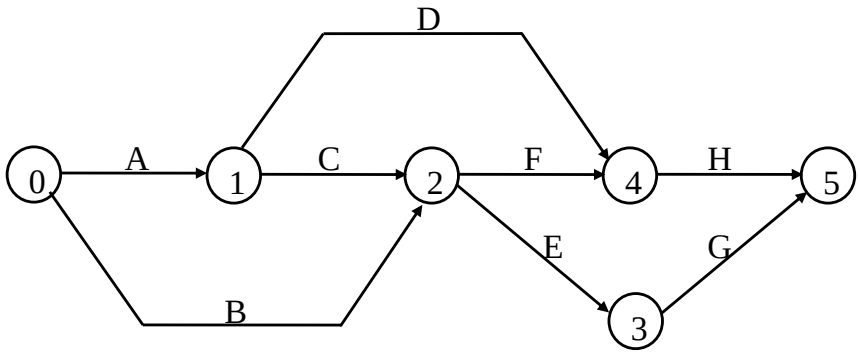


Figure 5-5 Performance report from integrated time/cost control system.[6]

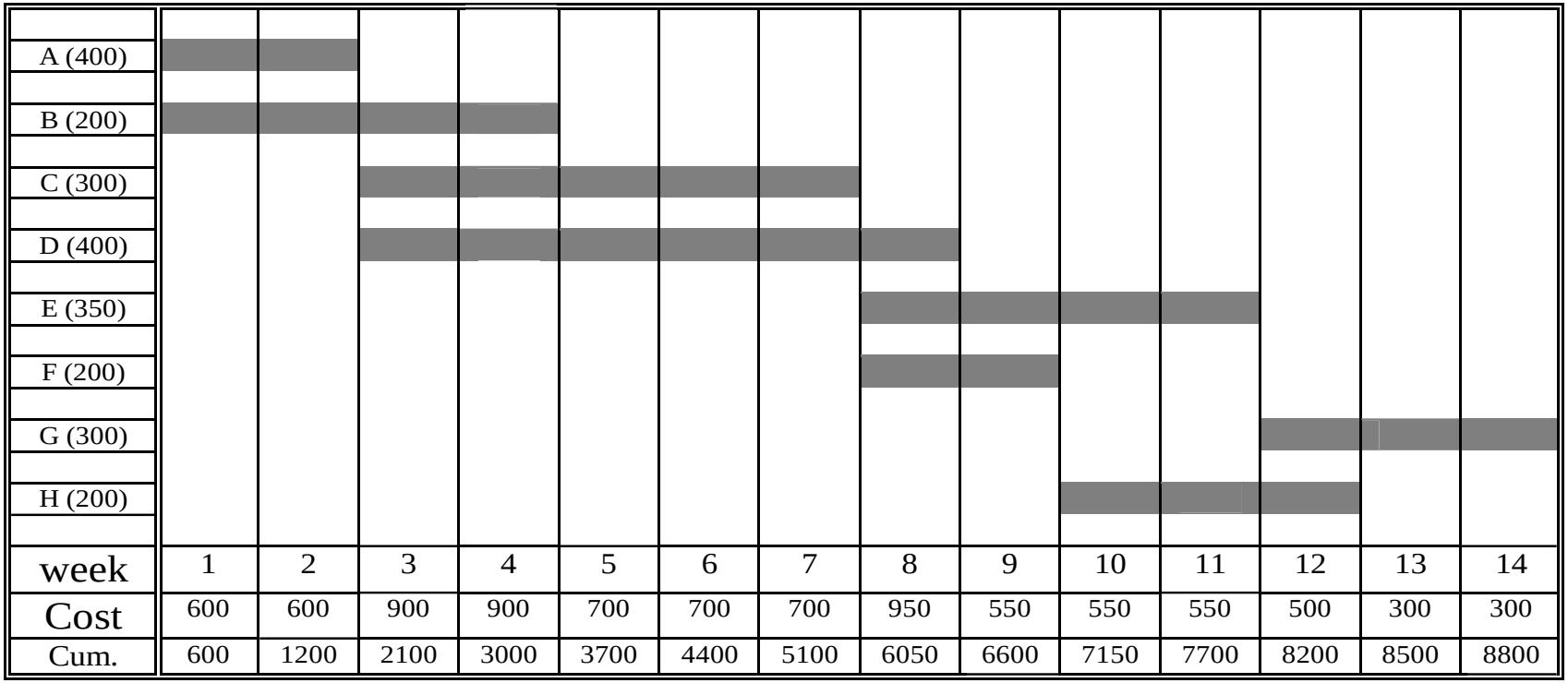
Problem-1

For the following network, compute the early and late start cumulative costs for the project, and draw the conclusion.



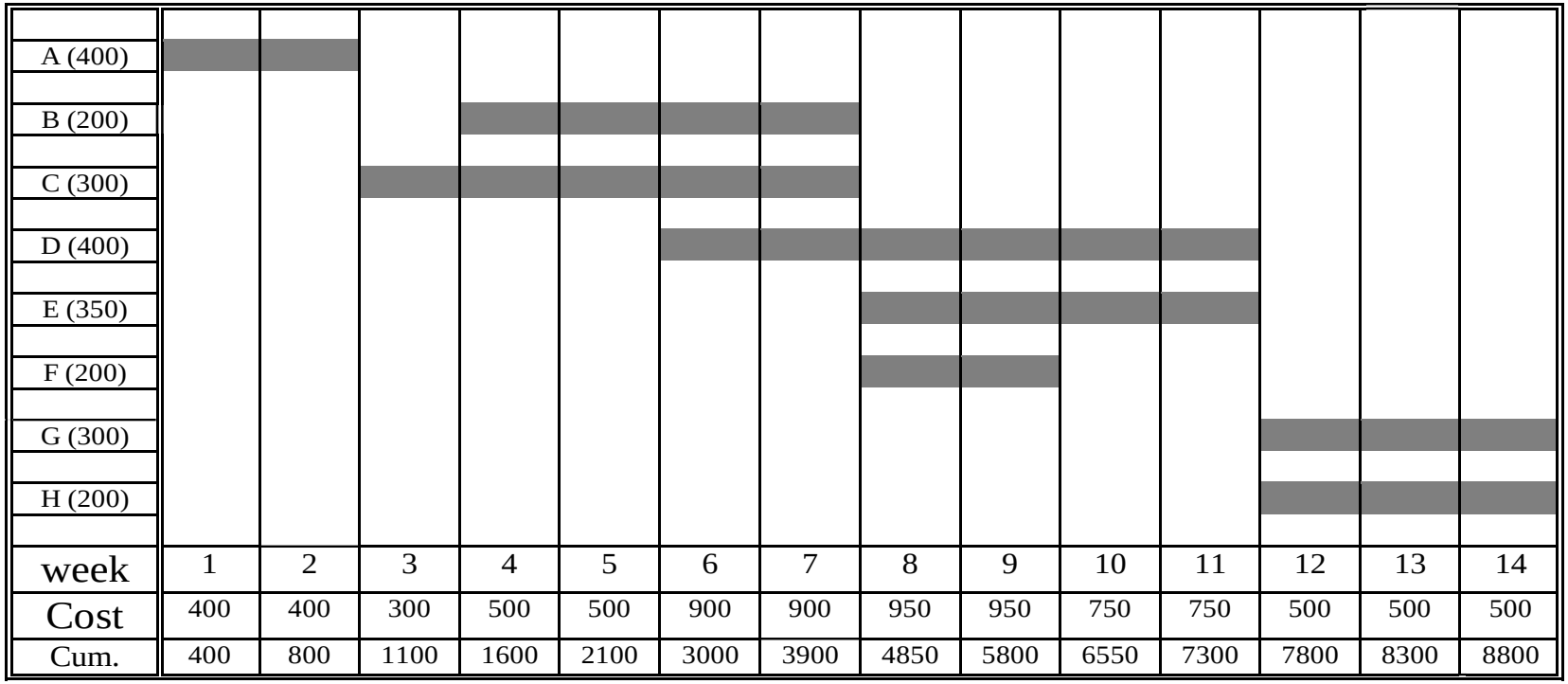
Activity	Depends on	Duration Week	ES Time	LS Time	Cost per week, SR
A	—	2	0	0	400
B	—	4	0	3	200
C	A	5	2	2	300
D	A	6	2	5	400
E	B, C	4	7	7	350
F	B, C	2	7	7	200
G	E	3	11	11	300
H	D, F	3	9	11	200

Solution
(Cost based on ES)



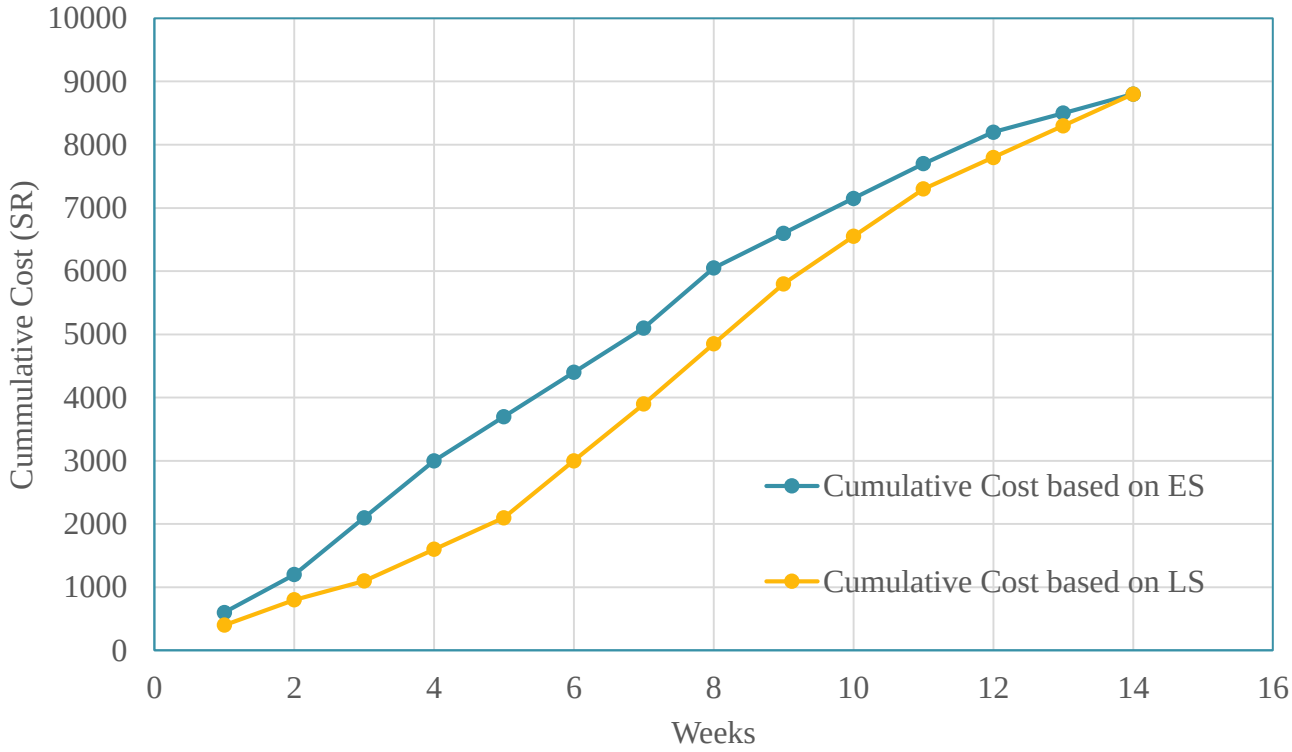
A (400)														
B (200)														
C (300)														
D (400)														
E (350)														
F (200)														
G (300)														
H (200)														
week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Cost	600	600	900	900	700	700	700	950	550	550	550	500	300	300
Cum.	600	1200	2100	3000	3700	4400	5100	6050	6600	7150	7700	8200	8500	8800

Solution (Contd.)
(Cost based on LS)



week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Cost	400	400	300	500	500	900	900	950	950	750	750	500	500	500
Cum.	400	800	1100	1600	2100	3000	3900	4850	5800	6550	7300	7800	8300	8800

Conclusion



The above curves show that although the final cumulative cost is the same at the end of the project but the cumulative cost at the early age of project is substantially lesser in LS based schedule.

Problem-2

You are required to submit a progress report to your boss about the performance of an activity of a project. The activity's information as follow: number of units is (800); unit cost is SR 12 ; and planned productivity is 100 unit/day. Performances were measured at the end of day (3) and day (6) as follows:

Period	Cost at this period	Number of units finished
day 0 to day 3	SR 3,600	250
day 4 to day 6	SR 3,700	320

a) Calculate BCWP, ACWP, and BCWS for (i) each of the two periods (i.e. day 0 to day 3 and day 4 to day 6) and (ii) to date (i.e. day 0 to day 3 and day 0 to day 6).
b) Draw a graphical report for ACWP and BCWP. Also calculate estimated cost at completion and days by which activity is ahead or behind.

Solution part a(i)

SV=BCWP-BCWS
CV = BCWP-ACWP

0-3 period

Period	Cost at this period	Number of units finished
day 0 to day 3	SR 3,600	250
day 4 to day 6	SR 3,700	320

BCWP= (250×12)=3000

ACWP= 3600 (Given)

BCWS= (300×12)=3600

CV = BCWP-ACWP=3000-3600=-600 (over budget)

SV = BCWP-BCWS=3000-3600=-600 (Behind schedule)

Following the above procedure the above parameters can also be estimated for 4-6 period

Summary

Period	BCWP	ACWP	BCWS	Variance		STATUS	
				Cost	Sch.	Schedule	Cost
0 - 3	SR 3000	SR 3600	SR 3600	-600	-600	Behind	Over Bud.
4 - 6	SR 3840	SR 3700	SR 3600	140	240	Ahead	under Bud.

Solution part a(ii)

SV=BCWP-BCWS
CV = BCWP-ACWP

Period	Cost at this period	Number of units finished
day 0 to day 3	SR 3,600	250
day 4 to day 6	SR 3,700	320

At 3rd day,

BCWP= (250×12)=3000 BCWS= (300×12)=3600

BAC =$BCWS_{end}$ = (800×12) $EAC = \frac{ACWP_{to\ date}}{BCWP_{to\ date}} \times BAC$=3600/3000×(800×12)=11,520

No. of units behind = 300-250=50 which will require =50/100 = 0.5 day to finish

At 6th day,

BCWP= (570×12)=6840

BAC =$BCWS_{end}$ = (800×12)

$EAC = \frac{ACWP_{to\ date}}{BCWP_{to\ date}} \times BAC$=7300/6840×(800×12)=10,246

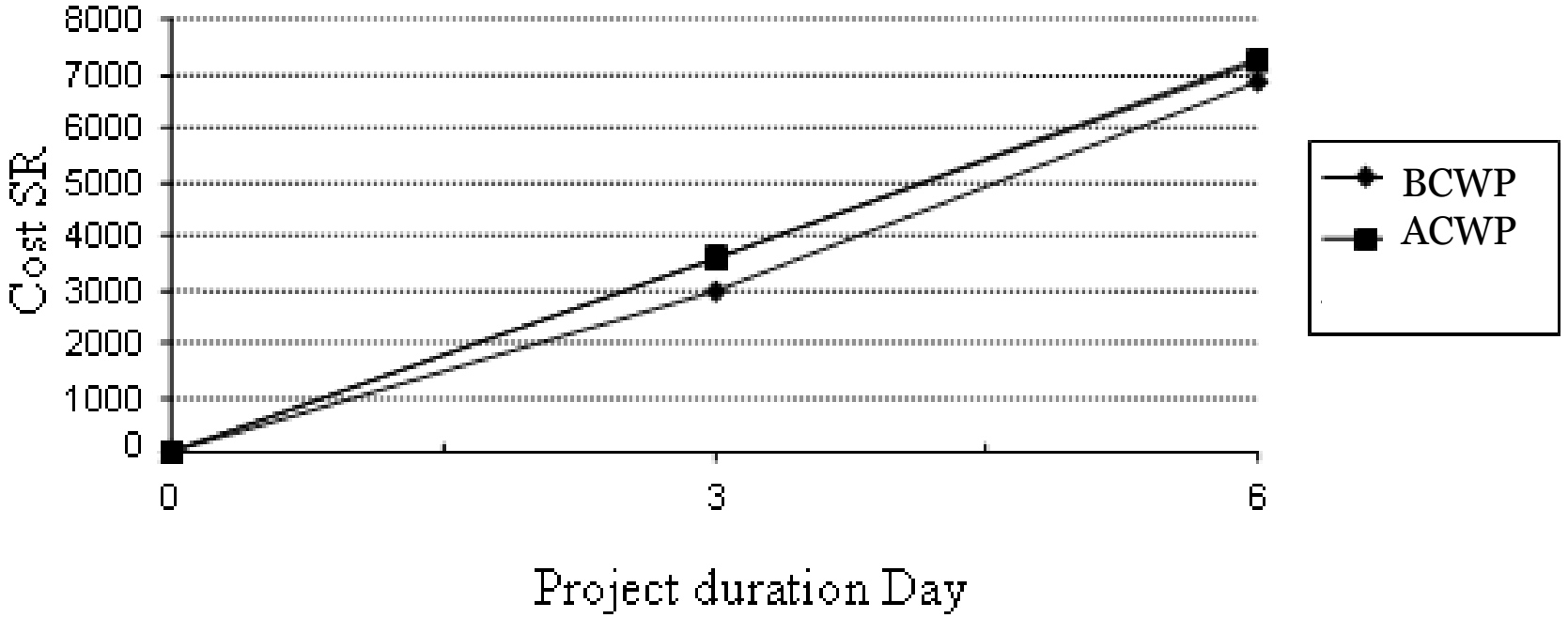
At 6th day, No. of units behind = 600-570=30 which will require =30/100 = 0.3 day to finish

To Date Summay

Period	BCWP	ACWP	BCWS	Variance		STATUS		Estimate at completion	Day ahead or behind
				Cost	Sch.	Sch.	Cost		
0 - 3	SR 3000	SR 3600	SR 3600	-600	-600	Behind	Over Bud.	SR 11,520	0.5
0 - 6	SR 6840	SR 7300	SR 7200	-460	-360	Behind	Over Bud.	SR 10,246	0.3

Solution Part (b)

b) At this rate, the contractor needs actions to reduce the cost and accelerate the time.



Problem-3

The following time-scale diagram represents a small engineering project. The budgeted cost of each activity is shown in the table below. At the end of the 10th week, the field progress report gives you the following information:

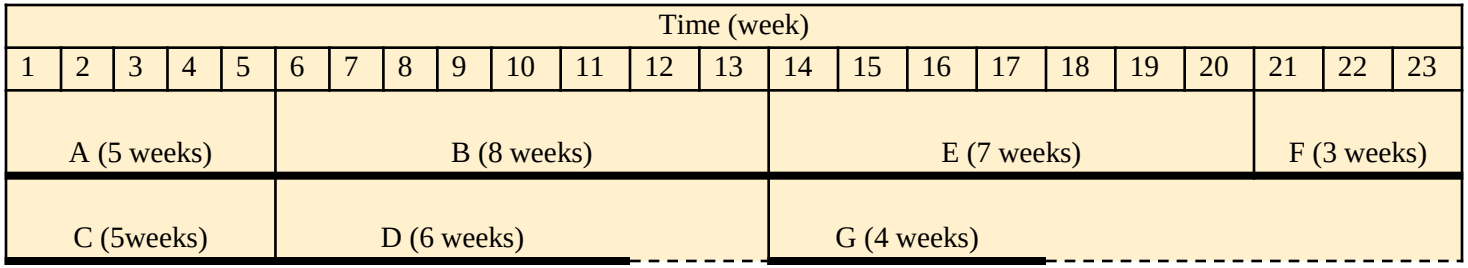
Activity "A" was completed on schedule.

Activity "B" started as planned but it is expected to take four weeks more.

Activity "C" started as planned but finished one week later.

Percentage completion of activity "D" is 60%.

ACWP at the end of week 10 = SR 90,400



Activity	A	B	C	D	E	F	G
Budgeted cost (SR)	50000	12000	16000	24000	12000	21000	20000

Calculate the CV, SV, BAC, EAC, ETC, and comment on the progress of the work.

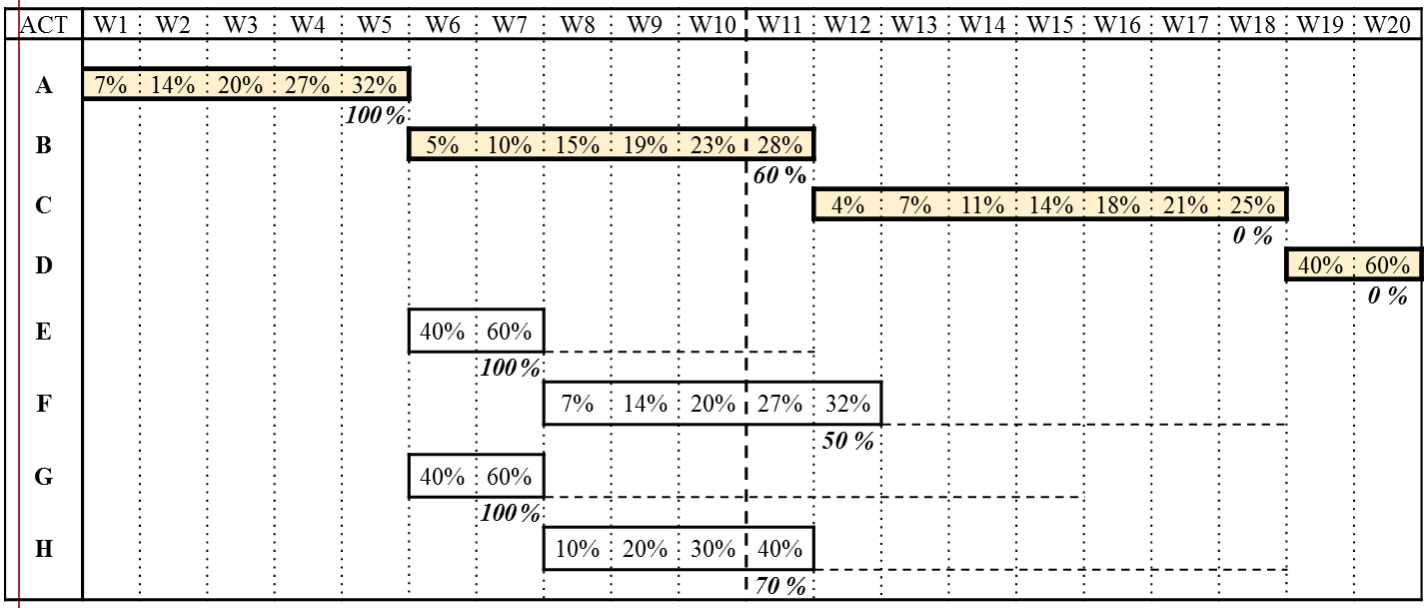
Solution

- Percentage completion of activity "A" = 100%
- Projected duration of activity "B" = 8 + 4 = 12 weeks
- Percentage completion of activity "B" = 5/12×100 = **41.67**%
- Percentage completion of activity "C" = 100%
- $BCWS_{10}$ = A + C + ***5/8***×B + ***5/6***×D = 50000 + 16000 + ***5/8***×12000 + ***5/6***×24000 = SR 93500 [**Note:** 5/8 & 5/6 represent ratio of completion of activities B&D with respect to scheduled duration]
- $BCWP_{10}$ = A + C + ***0.4167***×12000 + ***0.60***×24000 = SR 85400 [**Note:** 0.4167 & 0.6 represent ratio of completion of activities B&D with respect to actual completion duration]
- CV = BCWP – ACWP = 85400 – 90400 = SR -5000 (Over Budget)
- SV = BCWP – BCWS = 85400 – 93500 = SR -8100 (Behind Schedule)
- BAC = 50000 + 12000 + 16000 + 24000 + 12000 + 21000 + 20000 = SR 155000
- EAC = [ACWP/BCWP] ×BAC = [90400/85400] × 155000 = SR 164075
- ETC = EAC – ACWP = 164075 – 90400 = SR 73675

Problem-4

The following eight activities constitute an overall bar chart project that has twenty-week. Now 10 weeks finished on the project with and the project manager has the following Data:

- The weekly planned percentage of completion ***(inside each activity bar),***
- The actual percentage of completion up to week 10 ***(in below activity bar and table),***
- The Budget cost of each activity ***(in the table),***
- Actual Expenses up to week 10 of each activity ***(in below table),***
- The Critical Path is A-B-C-D (Colored bar), and Total Float of each activity (dash lines)



Act.	% of Completion	Budget Cost (SR)	Actual Expenses (SR)
A	100%	8000	9000
B	60%	10000	6000
C	0%	11000	0
D	0%	3000	0
E	100%	4000	3500
F	50%	7000	4000
G	100%	5000	4000
H	70%	6000	3900
Total		***54,000***	***30,400***

Problem-4 (contd.)

For this point in time (10 weeks after the start date):

a) Calculate the values of the BCWP and BCWS for each activity?

b) For each activity in progress, calculate the Cost and Schedule Performed Indices and state its budget and schedule status.

c) Draw the weekly **cumulative** BCWS of activity B, determine its delay/ahead week, and whether it will delay/accelerate the project or not and why.

d) Determine the project cost variance and state if the project is over or under budget.

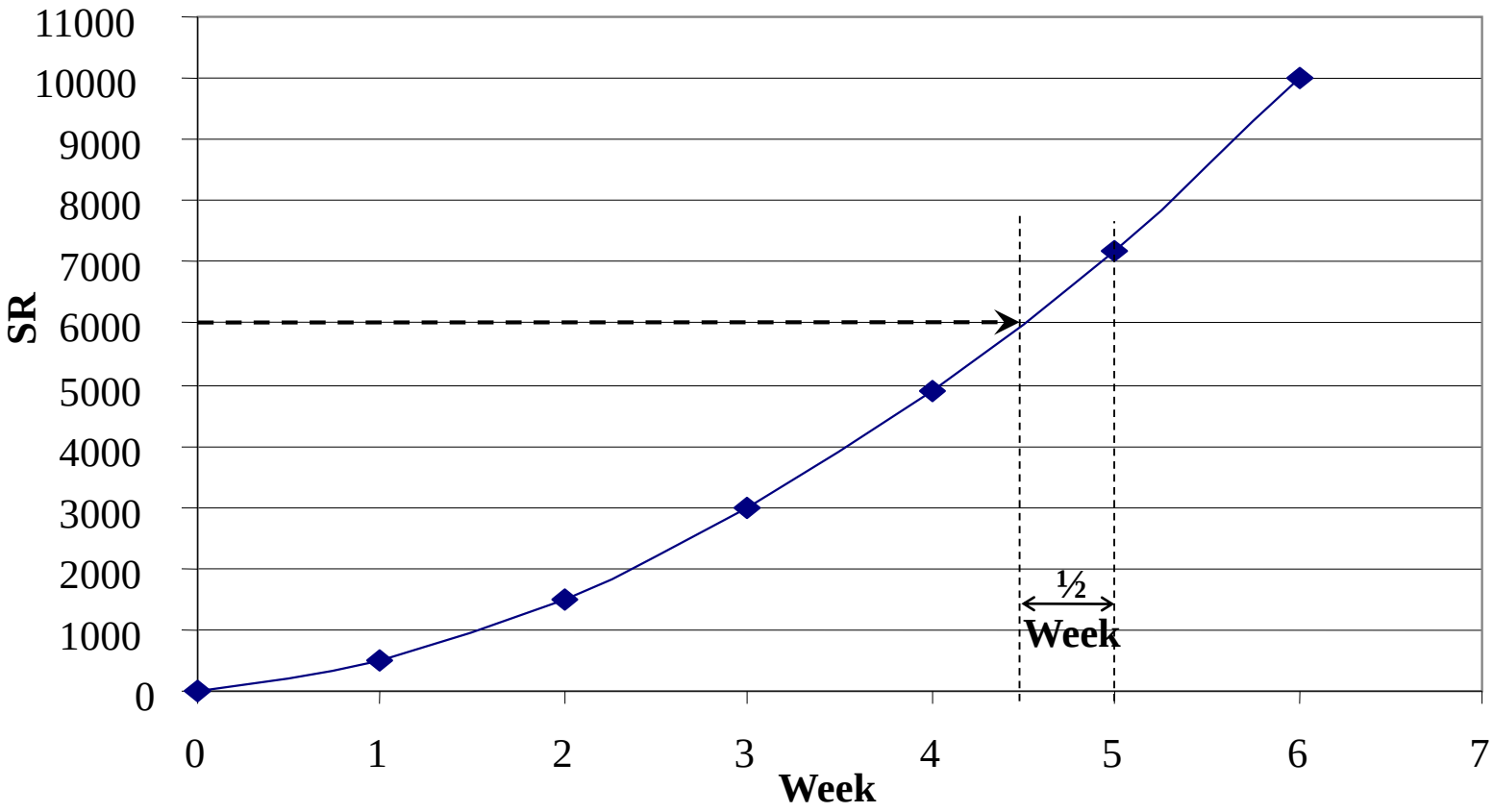
e) Based on the performance of past 10 weeks, forecast the project completion cost at the end of the project, and its variance from original project budget.

Solution

Parts (a) and (b)

Act.	% of Completion	Budget Cost (SR)	Actual Expenses (SR)	BCWS (SR)	BCWP (SR)	CPI	SPI	Cost Status	Schedule Status
A	100%	8000	9000	*8000*	*8000*	*0.888*	*1*	*Over Bud.*	*On Sched.*
B	60%	10000	6000	*7200*	*6000*	*1*	*0.833*	*On Budget*	*Behind*
C	0%	11000	0	*0*	*0*	–	–	–	–
D	0%	3000	0	*0*	*0*	–	–	–	–
E	100%	4000	3500	*4000*	*4000*	*1.143*	*1*	*Under Bud.*	*On Sched.*
F	50%	7000	4000	*2870*	*3500*	*0.875*	*1.22*	*Over Bud.*	*Ahead*
G	100%	5000	4000	*5000*	*5000*	*1.25*	*1*	*Under Bud.*	*On Sched.*
H	70%	6000	3900	*3600*	*4200*	*1.08*	*1.17*	*Under Bud.*	*Ahead*
Total		***54,000***	***30,400***	***30,670***	***30,700***				

Solution (Contd.) Part (c): Cumulative BCWS of activity B with time



Note:
The cost is cumulative and weeks are the weeks of activity B (not the weeks of the project)

ACWP at the end of week 10 (i.e. at the end of week 5 of activity B) = SR 6000.

From the graph, as per schedule, SR 6000 should have been spent at the end of 4.5th week, but actually it is spent at the end of 5th week. This shows that the activity is delayed by 0.5 week.

This activity (i.e. B) will delay the project because it is a critical activity.

Solution(Contd.)

Part (d)

Project cost Variance = $BCWP_{project} - ACWP_{project}$

= 30,700–30,400 = SR 300 (under budget)

Part (e)

Budgeted Cost At Completion (BAC) = ∑ Budget Cost = SR 54,000

Estimated Cost At Completion (EAC) = [ACWP/BCWP]×BAC = SR 53,472.3

OR

Estimated Cost At Completion (EAC) = ACWP + [(BAC – BCWP) / CPI] = SR 53,472.3

Variance from original project budget = EAC – BAC = SR -527.7 (~~Over~~ Under budget)

Since EAC < BAC Project is performing under budget.

Further Reading

Read more about the Project Cost Control from Chapter 10 of:

Jimmie W. Hinze. “Construction Planning and Management,” Fourth Edition, 2012, Pearson.

Thank You

Questions Please