Contents

1 Project Cost Management

1.1 Introduction

Project Cost Management
Consists of 3 Processes

1. Estimate Cost
2. Determine Budget
3. Control Costs

Project Cost Management is primarily concerned with the cost of resources needed to complete schedule activities Project Cost Management is not the same as Life-Cycle Costing

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Project Cost Management
Estimate Costs

- Developing an approximation of the costs of the resources needed to complete project activities

Determine Budget

- Aggregating the estimated costs on individual activities or work packages to establish a cost baseline

Control Costs

- Influencing the factors that create cost variances and controlling changes to the project budget

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Project Cost Management
Different stakeholders will measure project costs in different ways; this can have a major effect on finance reporting

- Typically these variances will be on how costs are booked to the project.
- e.g. Large AHUs (over €20k) may be booked to the project when the order is placed, and a portion of the bill item may be invoiced to the client when the equipment is delivered to site.

Project Cost Management

On small projects Estimating Costs and Determining Budget are sometimes so closely linked that determining where one finished and the other starts is virtually impossible This would rarely (if ever) apply to construction contracts.

- Estimating is carried out at tender stage; budgeting at construction stage
- Typically, construction firms struggle with cash-flow due to the time between incurring costs associates with work, and actually getting paid for it.
- Most construction contracts have a retention clause (circa 5%) which needs to be considered in cash flow projections and Earned Value Analysis.

Project Cost Management

Early stages of a project have the greatest influence in the overall costs associated with a project

- This is one of the main reasons why correctly scoping a project is so important.

Construction Projects can have difficulty with this aspect, especially when consideration is given to the concept of progressive elaboration; something that is inherent in construction projects Scope Creep is another issue that needs to be watched. . .

Cost Management Plan

Establishes the Precision Level to be used for cost estimates

- Nearest €100, €1000, etc.

Defines Units of Measure

- staff-hours, staff-weeks, lump sum etc.

Control Accounts

- As per WBS

Control Thresholds

- Limits to acceptable variations against budgeted figures

Cost Management Plan

Performance Measurement Rules

- Earned Value Management formulas
- WBS level to which Earned Value analysis will be applied
- Etc.

Reporting Formats Process Descriptions

Table 8.5.1 Proportions of Costs for Price Fluctuation

Proportions			
	Contract	**Private Service Provider's Alternative**	
(a)	0.30		In respect of Average Earnings & Hours worked by Skilled & Unskilled Operatives (Table 1 - CSO Statistical Release)
(b)	0.30		Wholesale Price Indices (excl VAT) for Building & Construction Materials (Table 3)
(c)	0.40	0.40	In respect of all other costs which shall not be subject to any adjustment
Total	**1.00**	**1.00**	

Figure 1: CPA Table

Project Cost Management **Points to Consider**

Cost Management is not Cost Monitoring

- Just because you know how much cost has been incurred (or booked) to a project, it does not necessarily mean you are in control of the situation

Poor cash flow can kill a company. If a project is due to run for a considerable length of time, longer than 12 months, pay particular attention to the CPA clause.

- Be wary of links to the Consumer Price Index; it may not represent your actual increases in cost
- Better to look for:
  - Table 1 Average Earnings and Hours Worked by Skilled and Unskilled Operatives for Earnings and Hours worked in Construction
  - Table 3 Wholesale Price Indices (excluding VAT) for Building and Construction Materials from the Wholesale Price Index

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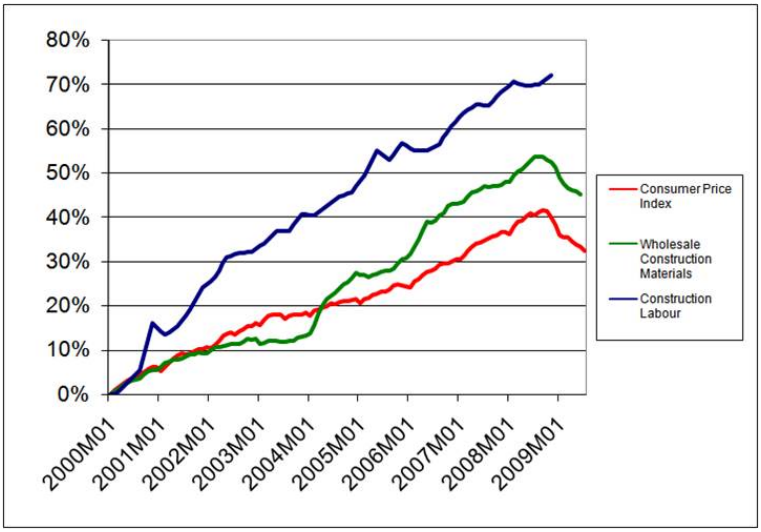
Project Cost Management

Example CPA table

Effects of Inflation

Estimate Costs

Part of the Planning Process Group



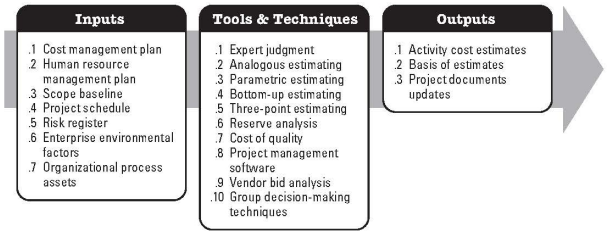


Figure 7-4. Estimate Costs: Inputs, Tools & Techniques, and Outputs

Estimate Costs

Cost Estimating is not the same as Pricing

- Pricing is concerned with what you should pay
- Cost estimating is concerned with what an activity will actually cost the performing organisation

Inputs

- As per book
- Enterprise Environmental Factors (Marketplace Conditions)
- What is available, from whom, and under what terms and conditions
  - Published Commercial Information. May be an electronic database (CSO) or printed (SPON)
- Information on skills and labour costs

Inputs **Organisational Process Assets**

Cost Estimating Policies

- Predefined approaches and rules for cost estimating
- Typically generated by finance department or PMO

Cost Estimating Templates

- Standardised forms and methods
- Can be restrictive; but lessen the likelihood of omissions
- For best effect, they need to be flexible

Historical Information

- The performing organisations experiences may influence costing
- Files from previous projects of a similar nature can be reviewed for costing techniques and validation of estimated costs
- Project Team Knowledge

Inputs **Organisational Process Assets**

Lessons Learned

- Lessons learned from previous projects of a similar nature
- Project Scope Statement: Includes information that is likely to impact cost estimates
  - Constraints, Assumptions, Requirements, Etc.
  - Also contains deliverables and acceptance criteria: these must be considered when estimating cost.

Technical Issues and Concerns

- again, likely to influence cost

Inputs **Project Schedule**

- The types and quantities of resources, and the amount of time they are applied clearly makes up the most significant element of a cost estimate.
- Estimate Activity Resources and Activity Duration Estimates provide key information for cost estimation
- Most construction projects run for 6-months or more; financing, interest rates, Contract Price Adjustment (CPA) will have a significant effect
- Consideration should also be given to time-sensitive cost estimates

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Tools and Techniques

Analogous Estimating

- Using actual costs from a similar project to estimate costs for current project

Determine Resource Cost Rates

- Staff Cost per hour
- Material Bulk Cost, m^3, m^2, etc.
- Quotations
- SPON etc

Bottom-up Estimating

- Involves estimating costs to the lowest levels of the WBS (work packages)

Tools and Techniques
Parametric Estimating

- Parametric Estimating involves using the relationship between historical data and other variables to generate an estimate
  - i.e. data: average cost of concrete over the last 12 months is €72.00 per m^3
  - Variable: estimate requires 1000m^3 of concrete
  - Cost Estimate for Concrete €72,000
  - Should also include an "x-factor" to cover inflation, profit, etc.

Tools and Techniques
Vendor Bid Analysis

- Solicitation of quotations for various project elements from a number of sources.
- These are then analysed to assist in determining cost
- Note: It is not always a good idea to use the lowest figures obtained. Better to analyse properly and determine an average or consensus figure at tender stage. (Why?)

Tools and Techniques
Reserve Analysis

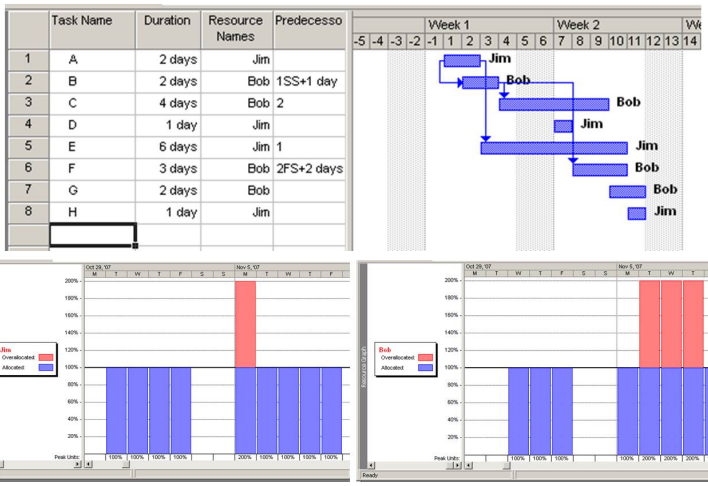
- AKA Contingency Sums : for use on known-unknowns identified in the scope or during risk management
- Can inflate project prices; impacts competitiveness

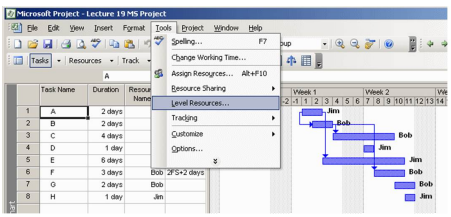
Project Management Estimating Software

- Cost Estimating elements of PM software
- Can also be spreadsheets, specialist estimating software, Buildsoft, etc.

Project Management Software
MS Project Example

Resource Leveling
Resource Graph (View — Resource Graph)


Task Name
Duration
Resource Names
Predecesso
Week 1
Week 2
A 2 days Jim
B 2 days Bob 1SS+1 day
C 4 days Bob 2
D 1 day Jim
E 6 days Jim 1
F 3 days Bob 2FS+2 days
G 2 days Bob
H 1 day Jim
Jim
Bob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File Edit View Insert Format Tools Project Window Help
Spelling... F7
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Tasks Resources Track
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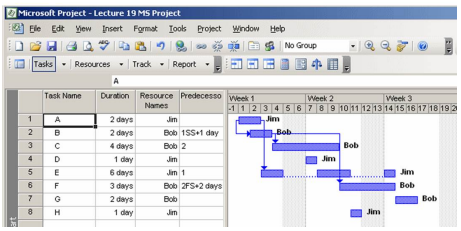
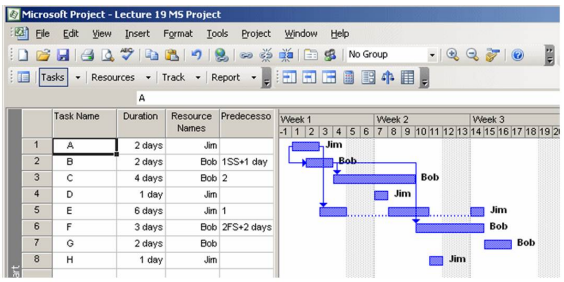
Week 1 Week 2


Microsoft Project - Lecture 19 MS Project
File Edit View Insert Format Tools Project Window Help
No Group
Tasks Resources Track Report
Task Name Duration Resource Names Predecesso
Week 1 Week 2 Week 3
A 2 days Jim
B 2 days Bob 1SS+1 day
C 4 days Bob 2
D 1 day Jim
E 6 days Jim 1
F 3 days Bob 2FS+2 days
G 2 days Bob
H 1 day Jim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File Edit View Insert Format Tools Project Window Help
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Tasks Resources Track Report
Task Name Duration Resource Names Predecesso
Week 1 Week 2 Week 3
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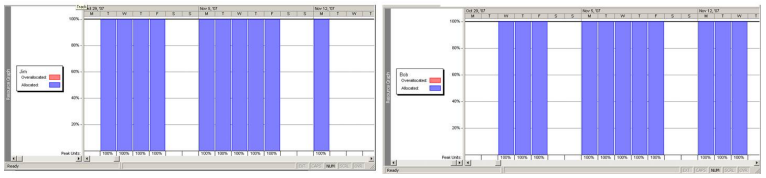
H 1 day Jim



	Resource Name	Type	Std. Rate	Ovt. Rate	Cost/Use	Accrue At	Base Calendar
1	Jim	Work	€50.00/hr	€75.00/hr	€0.00	Prorated	Standard
2	Bob	Work	€75.00/hr	€120.00/hr	€0.00	Prorated	Standard

	Resource Name	Cost	Baseline Cost	Variance	Actual Cost	Remaining
1	Jim	€4,000.00	€0.00	€4,000.00	€0.00	€4,000.00
2	Bob	€6,600.00	€0.00	€6,600.00	€0.00	€6,600.00

Resource Leveled

MS Project

View — Resource Sheet
View — Table : Cost
View — Gantt Chart then— View — Table : Cost

MS Project

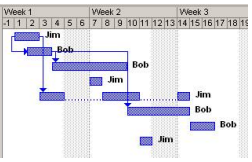
View — Task Usage

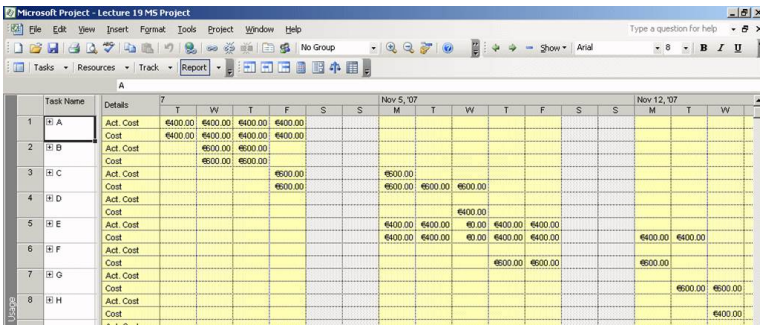
Imported to Excel

Tracked Costs

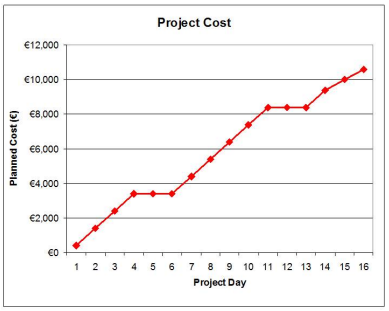
Imported to Excel

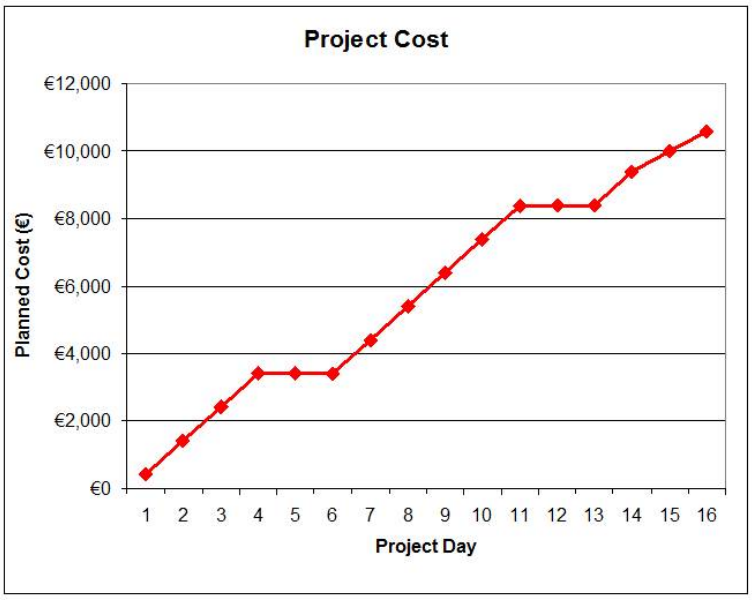
	Task Name	Fixed Cost	Fixed Cost Accrual	Total Cost	Baseline	Variance	Actual	Remaining
1	A	€0.00	Prorated	€800.00	€0.00	€800.00	€0.00	€800.00
2	B	€0.00	Prorated	€1,200.00	€0.00	€1,200.00	€0.00	€1,200.00
3	C	€0.00	Prorated	€2,400.00	€0.00	€2,400.00	€0.00	€2,400.00
4	D	€0.00	Prorated	€400.00	€0.00	€400.00	€0.00	€400.00
5	E	€0.00	Prorated	€2,400.00	€0.00	€2,400.00	€0.00	€2,400.00
6	F	€0.00	Prorated	€1,800.00	€0.00	€1,800.00	€0.00	€1,800.00
7	G	€0.00	Prorated	€1,200.00	€0.00	€1,200.00	€0.00	€1,200.00
8	H	€0.00	Prorated	€400.00	€0.00	€400.00	€0.00	€400.00

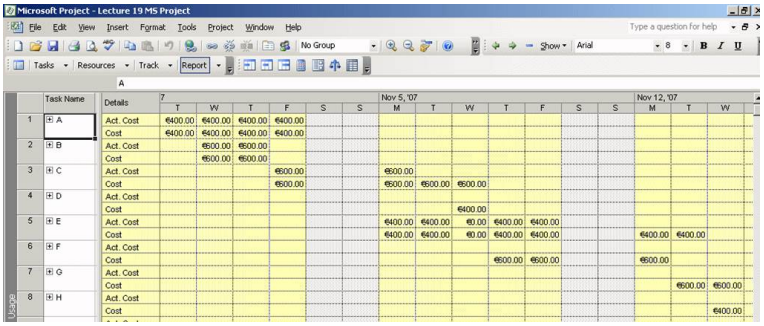




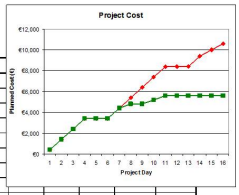
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A	€400	€400														
B		€600	€600													
C				€600			€600	€600	€600							
D							€400									
E			€400	€400			€0	€400	€400	€400	€0			€400		
F										€600	€600			€600		
G															€600	€600
H											€400					
Daily Total	€400	€1,000	€1,000	€1,000			€1,000	€1,000	€1,000	€1,000	€1,000			€1,000	€600	€600
Cumulative Total	**€400**	**€1,400**	**€2,400**	**€3,400**	**€3,400**	**€3,400**	**€4,400**	**€5,400**	**€6,400**	**€7,400**	**€8,400**	**€8,400**	**€8,400**	**€9,400**	**€10,000**	**€10,600**

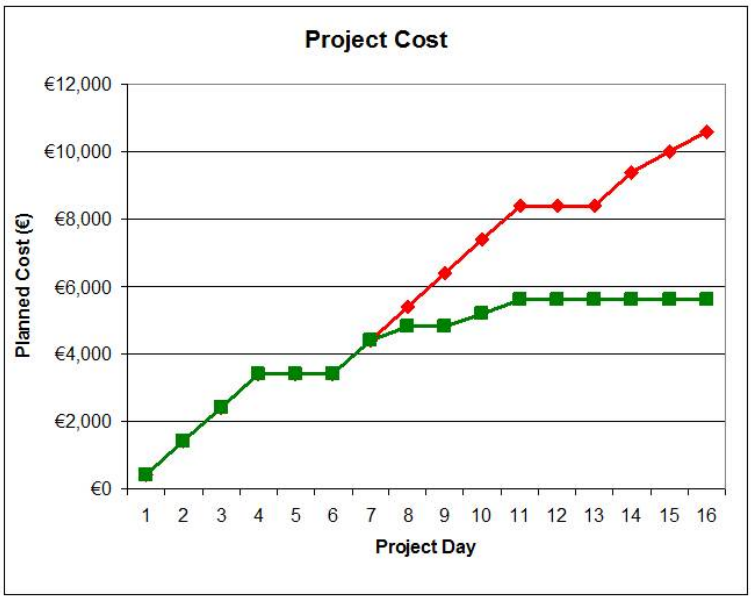






		1	2	3	4	5	6	7	8	9	10	11					
A	Planned	€400	€400														
	Actual	€400	€400	€400	€400												
B	Planned		€600	€600													
	Actual		€600	€600													
C	Planned				€600			€600	€600	€600							
	Actual				€600			€600									
D	Planned							€400									
	Actual																
E	Planned			€400	€400			€0	€400	€400	€400	€0			€400		
	Actual							€400	€400		€400	€400					
F	Planned										€600	€600			€600		
	Actual																
G	Planned															€600	€600
	Actual																
H	Planned											€400					
	Actual																
Daily Total	Planned	€400	€1,000	€1,000	€1,000	€0	€0	€1,000	€1,000	€1,000	€1,000	€1,000	€0	€0	€1,000	€600	€600
	Tracked	€400	€1,000	€1,000	€1,000	€0	€0	€1,000	€400	€0	€400	€400	€0	€0	€0	€0	€0
Cumulative Total	**Planned**	**€400**	**€1,400**	**€2,400**	**€3,400**	**€3,400**	**€3,400**	**€4,400**	**€5,400**	**€6,400**	**€7,400**	**€8,400**	**€8,400**	**€8,400**	**€9,400**	**€10,000**	**€10,600**
	Tracked	**€400**	**€1,400**	**€2,400**	**€3,400**	**€3,400**	**€3,400**	**€4,400**	**€4,800**	**€4,800**	**€5,200**	**€5,600**	**€5,600**	**€5,600**	**€5,600**	**€5,600**	**€5,600**





Cost Estimating **Outputs**

Activity Cost Estimates: Quantitative Estimates of the likely costs of the resources required to complete schedule activities

- Labour, Materials, Equipment, Services, Facilities, IT, etc.
- May also include Inflation, CPA, contingency, etc.

Basis of Estimates: Provide a clear breakdown of how estimates were calculated

- Description of schedule activities scope of work
- Documentation of basis of estimate
- Documentation of assumptions, constraints, etc.
- Indication of range and accuracy of estimates
  - €25,000 ± €2,000
  - €12,000 to €14000
  - €32,000 ± 10%
  - €32,000 @ 90% confidence

Cost Estimating **Outputs**

Project Document Updates

- The process of estimating may highlight specific issues that may not previously been considered.
- These new issues may have to be incorporated into the Project Documentation

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Estimating Pitfalls

- Misinterpretation of Statement of Work
- Omissions or Improperly defined Project Scope
- Poorly defined or over optimistic project schedule
- Inaccurate Work Breakdown Structure (WBS)
- Applying improper skill level to tasks
- Failure to account for Risk
- Failure to account for CPA and Inflation
- Failure to use forward pricing rates for overhead, general admin, etc.
- Most of these pitfalls are tend not to be recognised until the project is well underway.

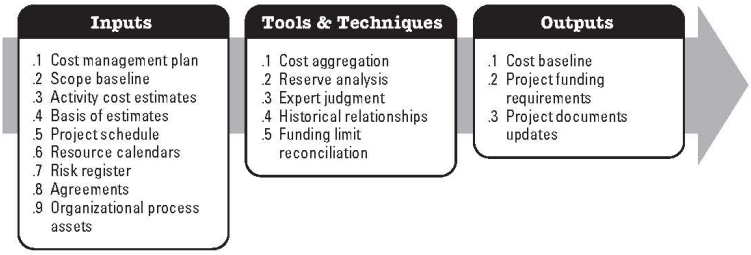


Figure 7-6. Determine Budget: Inputs, Tools & Techniques, and Outputs

1.2 Cost Budgeting

Cost Budgeting

Part of the Planning Process Group

Cost Budgeting

Golden Rule of Budgeting:

If you have the data; USE IT

- Most Project Management Systems, Accounts Systems, and other software systems will hold data that can be used for budgeting and subsequent cost control processes.
- Quantitative Data analysis is not that difficult to perform once you have setup a system that works.

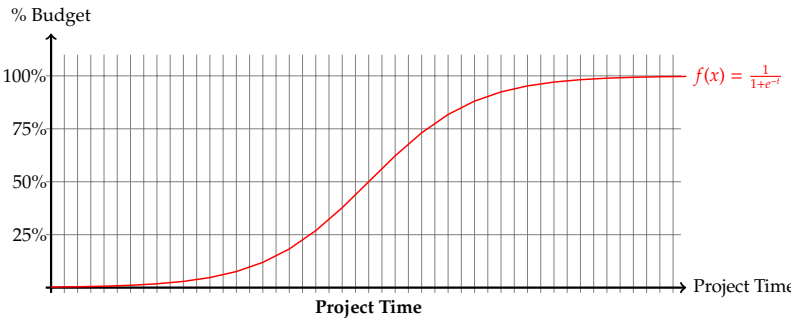
Sigmoid curve

Mathematical formula for S-curves:

$$f(x) = \frac{1}{1 + e^{-t}}$$

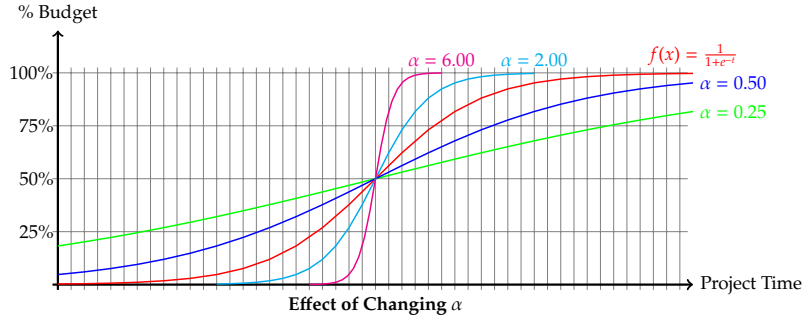
$$f(x) = \frac{1}{\lambda + \beta e^{-\alpha t}}$$

Sigmoid curve



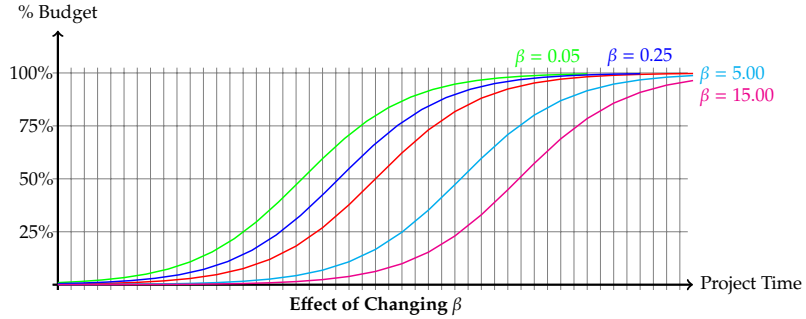
Mathematical formula for S-curves:

Effect of changing α



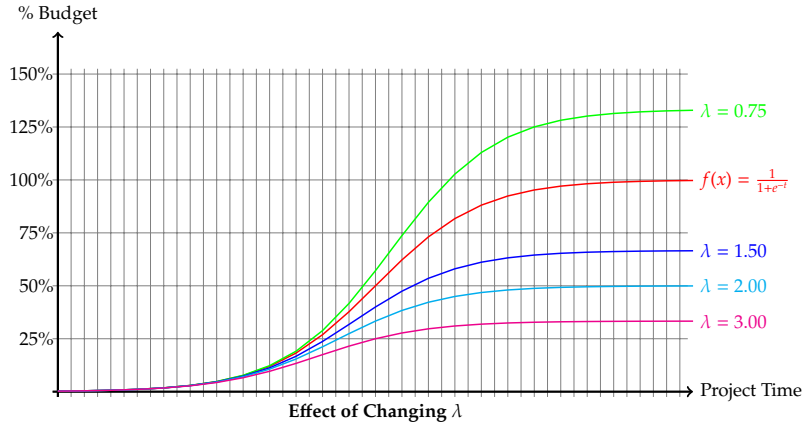
α controls the slope of the curve

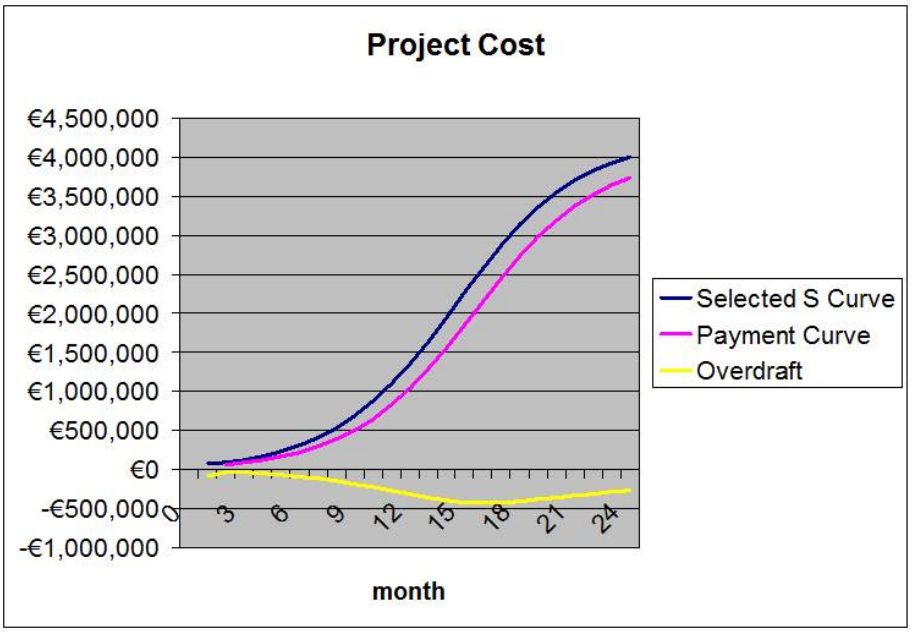
Effect of Changing β



β controls when the curve will start to increase

Effect of Changing λ





λ controls the end point; use this to correct to 100% when α and β distort the end point.

Consider a €4,000,000 contract (ex VAT) that is to be executed over 24 months. By examination of the cost estimates, the S-curve for project costs has been determined to have an α of 0.6, a β of 2.0 and a λ=0.945

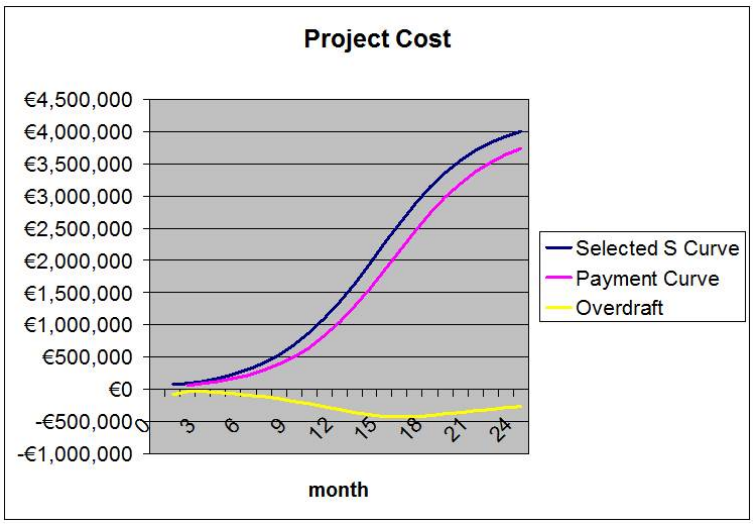
Assumptions

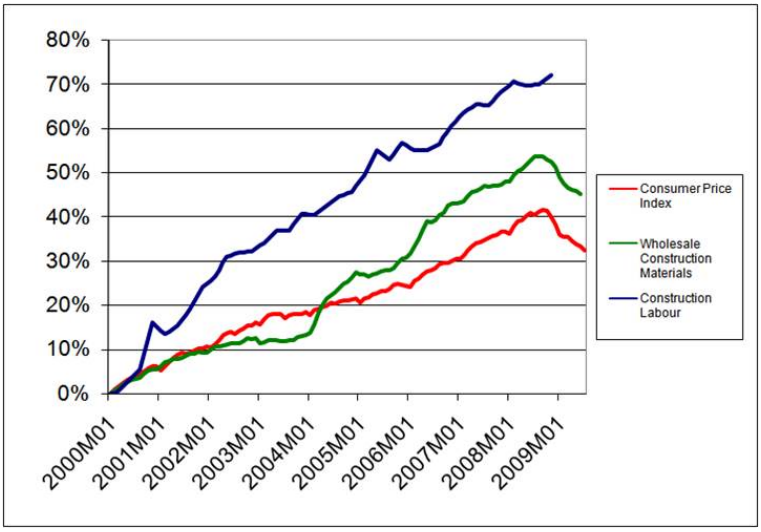
- Interim Payment Certification and Payment of Invoice takes 1 month
- Retention of 5% for 12 months

Results

- Based on this model the project will be overdrawn.
- Peak overdraft is €423k in month 16
- Total cost of overdraft is over €34,500 at 7% p.a. at month 24
- By month 36 the cost of overdraft is over €53k

Results





Results

- If the project is on a 10% margin (€400k), the cost of the overdraft will reduce the margin to approximately 8.67%
- This calculation assumes that all works claimed for are certified. If there is delay in certification then the cost of overdraft will be increased, and margins reduced further

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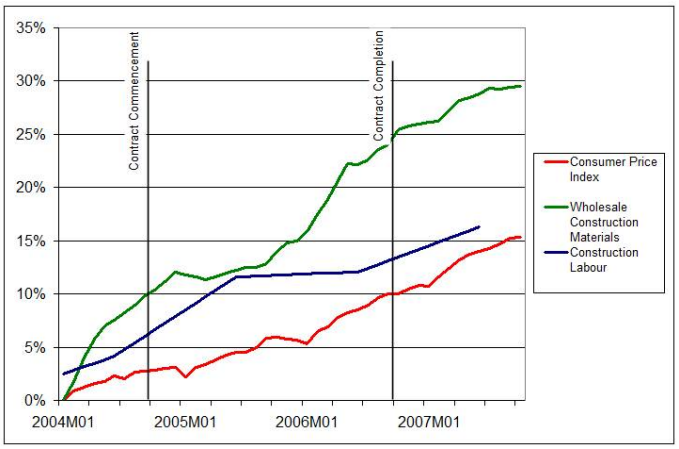
Effects of Inflation



Effects of Inflation

A tender was submitted at a value of €5,000,000 in Jan 2004.

- The tender was submitted at 15% margin
- The project is expected to run for 24 months.
- The validity of the tender was 180 days, which was extended by 90 days.
- The CPA clause in the contract was based on the Consumer Price Index (CPI).

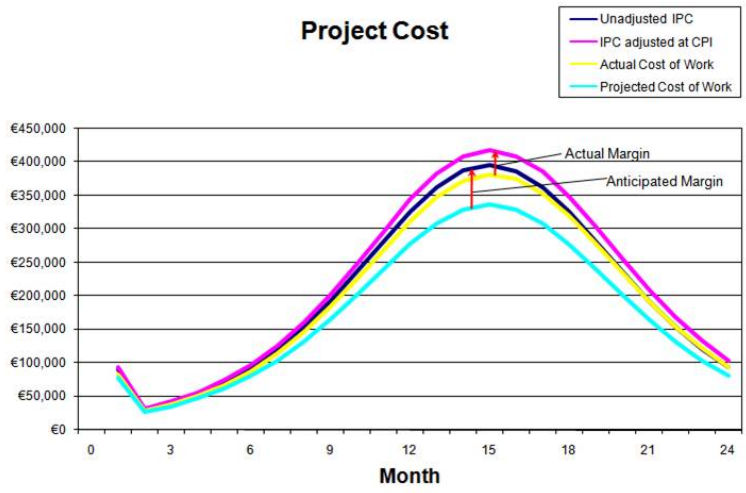
Inflation Data for Contract Period

Assumptions and known information Margin on the contract is €750,000 Costs are €4,250,000

- Indirect Costs are assumed to be included in labour.

There is an equal split between labour and materials; 50% materials, 50% labour

- Material Cost = €2,125,000
- Labour Cost = €2,125,000



At time of Contract Start

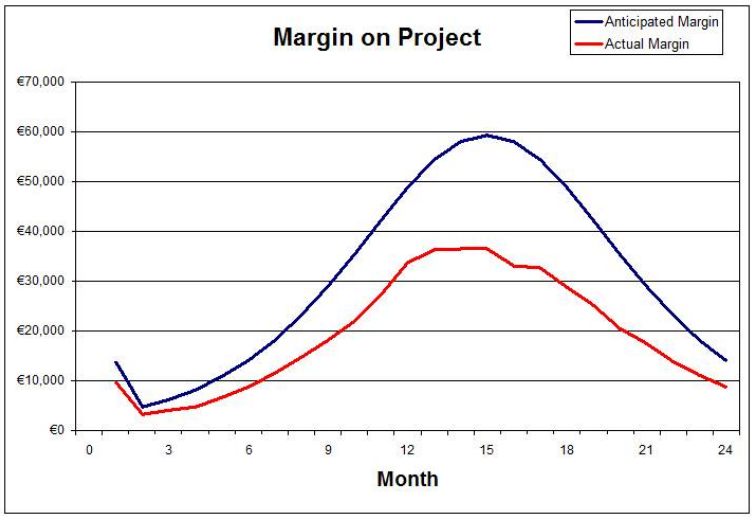
- CPI = 2.723%
- Labour Index = 6.044
- Material Index = 9.80

Cost Increase to Contractor

- €2,125,000 × 1.06044 = €2,253,435.00
- €2,125,000 × 1.0980 = €2,333,250.00
- Total €4,586,685.00

Recoverable via CPA based on CPI €5,000,000 × 1.02723 = €5,136,150 **Loss to Contractor** €336,685 €136,150 = €200,535

Excel Table on Moodle



Work Value	Value of IPC	Work Executed at end of Month	Work Cost (Base Date Value)	Material Index	Labour Index	Work Cost (at IPC Date)	CPI	IPC adjusted at CPI	Projected Margin	Actual Margin	Projected % Margin	Actual % Margin
				9.8004%	6.0436%		2.7230%					
€90,628.51	€90,628.51	€77,034.23	€77,034.23	10.3448%	6.6592%	€83,583.70	2.8169%	€93,191.42	€13,594.28	€9,597.73	15.00%	10.30%
€121,606.94	€30,978.43	€26,331.67	€103,365.90	11.1615%	7.2748%	€28,758.96	3.0047%	€31,909.24	€4,646.76	€3,150.28	15.00%	9.87%
€162,842.77	€41,235.83	€35,050.46	€138,416.36	12.0690%	7.8903%	€38,548.37	3.0986%	€42,513.56	€6,185.37	€3,965.19	15.00%	9.33%
€217,473.07	€54,630.29	€46,435.75	€184,852.11	11.7967%	8.5059%	€51,149.58	2.2535%	€55,861.40	€8,194.54	€4,711.81	15.00%	8.43%
€289,396.40	€71,923.34	€61,134.84	€245,986.94	11.6152%	9.1214%	€67,473.50	3.0986%	€74,151.95	€10,788.50	€6,678.44	15.00%	9.01%
€383,309.33	€93,912.93	€79,825.99	€325,812.93	11.3430%	9.7370%	€88,239.65	3.3803%	€97,087.45	€14,086.94	€8,847.80	15.00%	9.11%
€504,623.45	€121,314.12	€103,117.00	€428,929.94	11.6152%	10.3525%	€114,443.27	3.8498%	€125,984.43	€18,197.12	€11,541.16	15.00%	9.16%
€659,175.46	€154,552.00	€131,369.20	€560,299.14	11.9782%	10.9681%	€146,441.41	4.2254%	€161,082.37	€23,182.80	€14,640.97	15.00%	9.09%
€852,630.32	€193,454.86	€164,436.63	€724,735.77	12.2505%	11.5837%	€184,032.63	4.5070%	€202,173.95	€29,018.23	€18,141.31	15.00%	8.97%
€1,089,505.59	€236,875.27	€201,343.98	€926,079.75	12.5227%	11.6256%	€225,654.57	4.5070%	€247,551.34	€35,531.29	€21,896.77	15.00%	8.85%
€1,371,848.39	€282,342.81	€239,991.39	€1,166,071.13	12.5227%	11.6676%	€269,018.69	4.9765%	€296,393.67	€42,351.42	€27,374.98	15.00%	9.24%
€1,697,792.87	€325,944.48	€277,052.81	€1,443,123.94	12.8857%	11.7096%	€311,123.70	5.8216%	€344,919.65	€48,891.67	€33,795.95	15.00%	9.80%
€2,060,465.22	€362,672.36	€308,271.50	€1,751,395.44	13.9746%	11.7515%	€347,924.67	5.9155%	€384,126.21	€54,400.85	€36,201.55	15.00%	9.42%
€2,447,832.68	€387,367.46	€329,262.34	€2,080,657.78	14.7913%	11.7935%	€373,029.20	5.7277%	€409,554.70	€58,105.12	€36,525.50	15.00%	8.92%
€2,843,915.69	€396,083.01	€336,670.56	€2,417,328.34	14.9728%	11.8355%	€381,798.31	5.6338%	€418,397.55	€59,412.45	€36,599.24	15.00%	8.75%
€3,231,250.75	€387,335.05	€329,234.80	€2,746,563.13	15.8802%	11.8774%	€374,928.74	5.3521%	€408,065.66	€58,100.26	€33,136.92	15.00%	8.12%
€3,593,863.73	€362,612.98	€308,221.03	€3,054,784.17	17.4229%	11.9194%	€353,440.58	6.4789%	€386,106.22	€54,391.95	€32,665.63	15.00%	8.46%
€3,919,730.88	€325,867.16	€276,987.09	€3,331,771.25	18.8748%	11.9614%	€319,693.17	6.9484%	€348,509.57	€48,880.07	€28,816.38	15.00%	8.27%
€4,201,988.38	€282,257.50	€239,918.87	€3,571,690.13	20.6897%	12.0034%	€279,137.23	7.7934%	€304,255.03	€42,338.62	€25,117.80	15.00%	8.26%
€4,438,778.96	€236,790.58	€201,271.99	€3,772,962.11	22.2323%	12.0453%	€235,767.62	8.2629%	€256,356.37	€35,518.59	€20,588.74	15.00%	8.03%
€4,632,155.76	€193,376.80	€164,370.28	€3,937,332.40	22.1416%	12.0873%	€192,501.32	8.5446%	€209,900.08	€29,006.52	€17,398.76	15.00%	8.29%
€4,786,639.67	€154,483.91	€131,311.32	€4,068,643.72	22.5953%	12.1417%	€154,315.09	8.9202%	€168,264.16	€23,172.59	€13,949.07	15.00%	8.29%
€4,907,896.77	€121,257.10	€103,068.53	€4,171,712.25	23.5935%	12.7961%	€121,821.64	9.6714%	€132,984.31	€18,188.56	€11,162.67	15.00%	8.39%
€5,001,763.40	€93,866.63	€79,786.64	€4,251,498.89	24.0472%	13.1505%	€94,626.04	10.0469%	€103,297.36	€14,079.99	€8,671.32	15.00%	8.39%
	€5,001,763.40	€4,251,498.89				€4,837,451.63		€5,302,627.65	€750,264.51	€465,176.02	15.00%	8.77%
		€750,264.51						€465,176.02				
								€285,088.49				

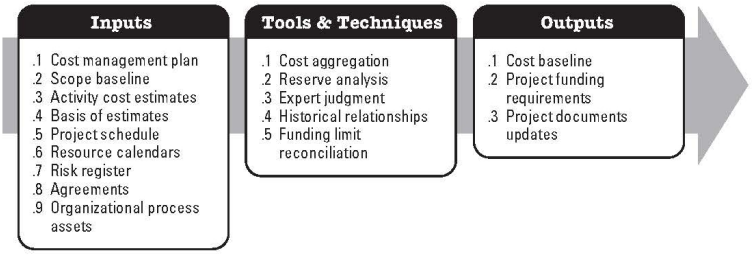


Figure 7-6. Determine Budget: Inputs, Tools & Techniques, and Outputs

Results

Results of Analysis

- Margin Reduced from 15% to 8.77%
- Margin per month ranged from 10.3% to 8.03%
- Value of Margin Reduced by approximately €285,000 from €750,000 to €465,176
- Margin is reduced the longer the contract continues
- Failure to perform, or EOTs, likely to have a further negative impact on margin
- Analysis does not include cost of cash-flow

Cost Budgeting

Part of the Planning Process Group

1.3 Deflation

Effects of Deflation

Effects of Deflation

- Difficult to predict current impact; economy appears to be on climb out.
- Tenders submitted at the peak (Sep 2008) may have been revised downwards during construction phase as part of the CPA clause
- If the CPI falls faster than costs, contractors margins will be under threat

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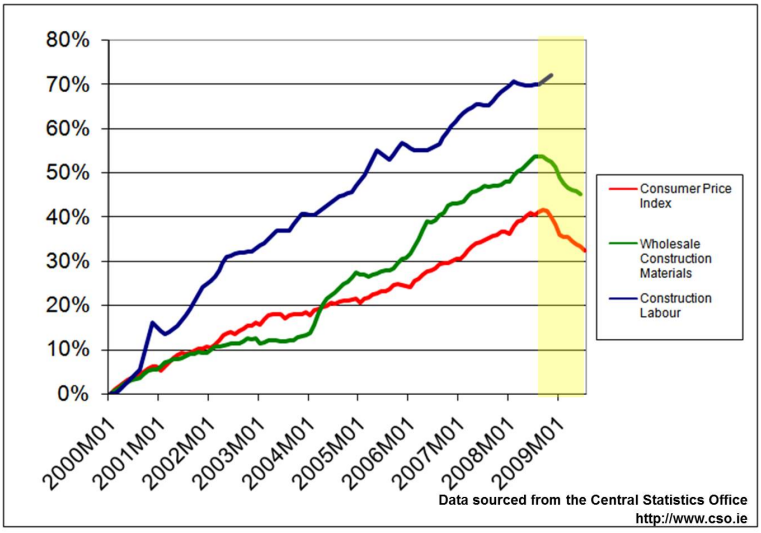
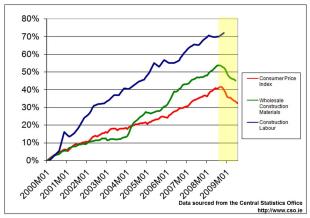
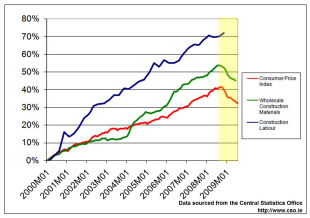

80%
70%
60%
50%
40%
30%
20%
10%
0%
2000M01
2001M01
2002M01
2003M01
2004M01
2005M01
2006M01
2007M01
2008M01
2009M01
Consumer Price Index
Wholesale Construction Materials
Construction Labour
Data sourced from the Central Statistics Office
http://www.cso.ie





2008M09	0.00%
2008M10	-0.23%
2008M11	-1.09%
2008M12	-2.34%
2009M01	-3.98%
2009M02	-4.38%
2009M03	-4.38%
2009M04	-5.08%
2009M05	-5.55%
2009M06	-5.86%
2009M07	-6.56%

Effects of Deflation

Delays in Interim Payment Certification, combined with retention (5% to 10%) leads to significant financial losses. Elapsed time between actually carrying out work and getting payment certification remains critical.

- In contractors interest to minimise time difference
- In clients interest to delay

Very Simple Example

Work carried out during Sept 2008 for €1000.00 including profit

- Consumer Price Index: 128

Payment approved Dec 2008

- Consumer Price Index: 125
- Adjustment (125-128) 128 = -2.3%
- Payment due to contractor €977.00

Many contractors operate at circa 5% margin

- this margin has effectively been halved.

Very Simple Example

The longer the delay the greater the profit erosion. By January 2009 margin is 1.02%; by April the work is generating a loss.

1.4 Contract Examples

CORK COUNTY COUNCIL
SOUTH CORK RURAL

NDP
NATIONAL DEVELOPMENT PLAN

CONTRACT DOCUMENTS FOR
KILNAMARTYRA WASTEWATER TREATMENT PLANT

CIVIL, MECHANICAL AND ELECTRICAL PLANT
CONTRACT

VOLUME 1

INSTRUCTIONS TO TENDERERS
AND CONDITIONS OF CONTRACT

Edmond Flynn BE, CEng, FIEI
County Engineer
Cork County Council
County Hall
Cork

Declan Daly
Director of Services
South Cork Rural
Cork County Council
Cork.

2.3 AMENDMENTS TO THE GENERAL CONDITIONS

Add the following new clauses:

Changes in Cost 6.3
Variations in the cost of materials and labour shall be calculated in accordance with the BEAMA formula using mechanical indices as follows:-

(a) Labour
The Contract Price shall be adjusted at the rate of 0.475 per cent of the Contract Price per 1.0 per cent difference between the BEAMA Mechanical Labour Index published for the month in which the Tender date falls and the average of the Index figures published for the last two thirds of the Contract period, this difference being expressed as a percentage of the former index figure

(b) Materials
The Contract Price shall be adjusted at the rate of 0.475 per cent of the Contract Price per 1.0 per cent difference between the price Index figure for materials used in the Mechanical Engineering Industry last published in the Trade and Industry Journal before the date of Tender and the average of the Index figures commencing with the Index last published before the two-fifths point of the Contract Period and ending with the Index last published before the four-fifths point of the Contract Period, this difference being expressed as a percentage of the former Index figure.

2.3 AMENDMENTS TO THE GENERAL CONDITIONS

For the purpose of these formulae:

1. *The Contract Period shall be deemed to be that period between the date of signing of the Contract and the date when the plant is taken over or ready for commercial use, whichever is the earlier, or such shorter period (ending with the completion date) corresponding to the manufacturing cycle of the plant or such portion and the time required for erection thereof as may be stipulated in the tender or agreed in the Contract.*
2. *The plant shall be deemed ready for commercial use even if though certain minor matters which do not affect the use for which the plant is intended remain to be completed.*
3. *Where any Index figure is stated to be provisional or is subsequently amended the figure shall apply as ultimately confirmed or amended.*

1.11 PERIOD OF VALIDITY FOR TENDER

The Tender shall remain open for acceptance for a period of **150 days** after the date as for return of Tenders. In exceptional circumstances, prior to expiry of the original tender validity period, the Purchaser may request that the Tenderers extend the period of validity for a specified additional period. The requests and the responses shall be made in writing. A Tenderer agreeing to the request will not be required or permitted to modify his Tender.

4.9.3. If the Contractor's programme most recently submitted to the Employer's Representative does not correspond with actual or reasonably projected progress or the Contractor's obligations, the Contractor shall, if so directed by the Employer's Representative, submit to the Employer's Representative a revised programme that complies with this sub-clause and the other provisions of the Contract, showing actual progress and progress projected by the Contractor. If the Contractor asserts that it is not possible to reach Substantial Completion of the Works or a Section by its Date for Substantial Completion, the revised programme shall show Substantial Completion by the earliest possible date. [Neither the programme nor its review will limit the Contractor's responsibility or liability for the delay.] If the Contractor fails to submit the revised programme within 15 working days of a request from the Employer's Representative, the Employer shall be entitled to withhold from the Contractor 15% of any payment to be made to the Contractor until the revised programme is submitted.

4.11. **Notice and time for Employer's obligations**

4.11.1. The Contractor shall give the Employer's Representative at least 10 working days advance notice of the date by which the Contractor requires any instructions that the Employer's Representative is to give, or Works Items or other things that the Employer is to give.

4.11.2. The latest date for the Employer's Representative to give required instructions, or the Employer to give the Contractor any required Works Item or other thing, shall be the latest of the following:

(1) the date stated in the Contract, if any

(2) the date shown in the Contractor's current programme

(3) the date for which the Contractor first notifies the Employer's Representative under this sub-clause that it is required

(4) the date the Contractor requires the instruction, Works Item or other thing in accordance with its actual progress.

On the ITTs for the tender:

New Gov Contracts

The new government contracts do not have a Contract Price Adjustment (CPA) Clause. As a result, the risk of inflation has been passed to the contractor. *Clause 4.9.3 Civil Engineering Works Designed by the Employer*.

- **Contractors need to learn how to price inflation risk**

More profit erosion.

Latest of . . . What about planning?

- actual progress may work in contractors favour if actual is taken to include administration time.

EoT Treatment in Gov Contracts

9.3.2. If Substantial Completion of the Works or any Section has been, is being or will be delayed beyond the Date for Substantial Completion by a Delay Event and if all of the following apply:

(1) the Delay Event is not a result of the Contractor's or Contractor's Personnel's act or omission or the Contractor's breach of the Contract

(2) the Contractor cannot avoid the delay and makes all reasonable efforts to minimise the delay

(3) the Contract does not provide otherwise

then, subject to this sub-clause 9.3, sub-clause 9.4 and clause 10, there shall be an extension to the Date for Substantial Completion of the Works and any affected Section equal to the amount of the delay beyond the Date for Substantial Completion caused by the Delay Event, taking into account only Site Working Days. The Contractor and the Employer's Representative shall follow the procedure in clause 10.

9.4. **Programme Contingency**

9.4.1. In this sub-clause, references to the **first threshold** and the **second threshold** are to the first threshold and the second threshold in the Schedule, part 1K.

9.4.2. The Contractor has included in the initial Contract Sum and shall include in its programme a contingency for delays to the Date for Substantial Completion of the Works caused by Compensation Events.

9.4.3. If the total number of Site Working Days' delay to Substantial Completion of the Works caused by Compensation Events (for which the Contractor would otherwise be entitled to an extension) is less than the first threshold, there shall be no extensions to the initial Date for Substantial Completion of the Works for delay caused by Compensation Events.

9.8. **Liquidated Damages**

9.8.1. If the Works do not reach Substantial Completion by the Date for Substantial Completion of the Works, the Contractor shall pay the Employer [and the Employer may deduct from payments to the Contractor] liquidated damages calculated at the rate stated in the Schedule, part 1G, for the period from the Date for Substantial Completion of the Works to the date of substantial completion of the Works.

No reciprocity in relation to LD's

EoT Treatment in Gov Contracts

EoT Treatment in Gov Contracts

From an Actual Contract

Note: Thresholds are the same. also, anything under 30 days will not yield an actual EoT

Model of EoT calculation

1.5 Determine Budget

Determine Budget

Part of the Planning Process Group

9.4.4. If the total number of Site Working Days' delay to Substantial Completion of the Works caused by Compensation Events (for which the Contractor would otherwise be entitled to an extension) exceeds the first threshold, there shall be deducted from the total number of Site Working Days' extension to the initial Date for Substantial Completion of the Works for delay caused by Compensation Events

(1) the number of Site Working Days stated as the first threshold and

(2) half the number of Site Working Days' delay to Substantial Completion of the Works caused by the Compensation Events (for which the Contractor would otherwise be entitled to an extension) after deducting the first threshold, but the total deduction under this paragraph (2) shall not exceed the second threshold.

[For example, if the first threshold is 20 Site Working Days, and the second threshold is 30 Site Working Days

- if the Contractor would otherwise be entitled to time extensions totalling 28 Site Working Days all due to Compensation Events, the time extension would be 4 Site Working Days (28–20–(8÷2)=4).

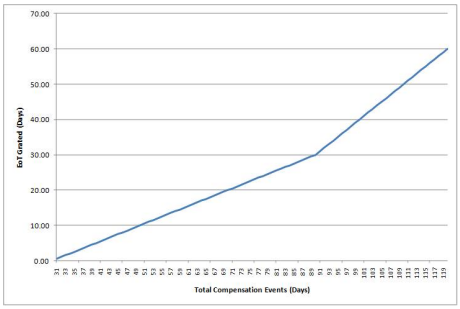
  The deduction under paragraph (2) is (28–20)÷2=4, or 8÷2=4, which is less than the second threshold.

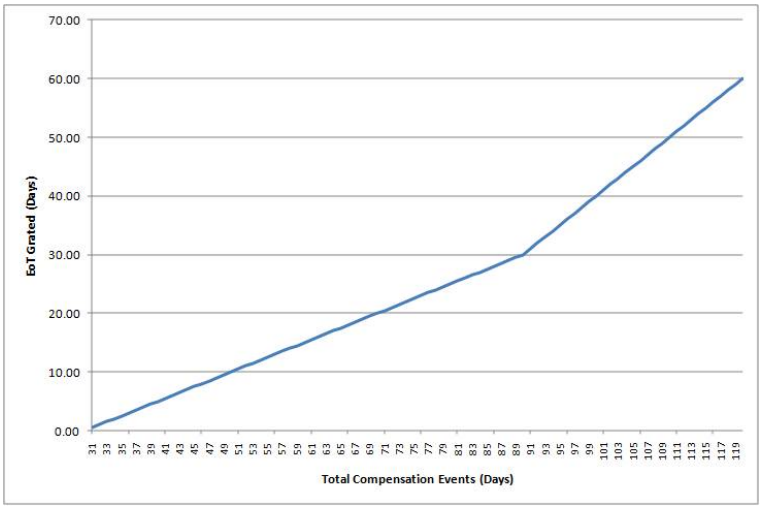
- if the Contractor would otherwise be entitled to time extensions totalling 90 Site Working Days all due to Compensation Events, the time extension would be 40 Site Working Days (90–20–30=40).

  The calculation under paragraph (2) is (90–20)÷2=35, but this is higher than the second threshold, so this deduction is 30, the amount of the second threshold.]

In sub-clause 9.4:

- the **first threshold** is 30 Site Working Days of delay caused by Compensation Events;
- the **second threshold** is 30 Site Working Days of delay caused by Compensation Events.





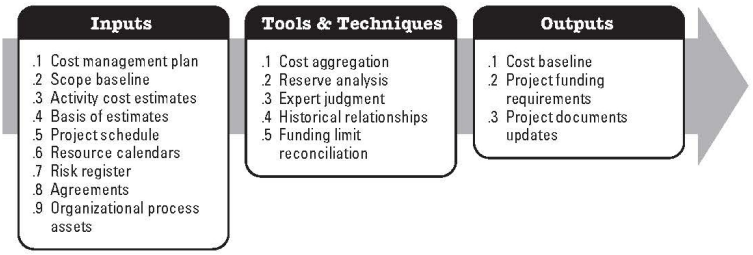
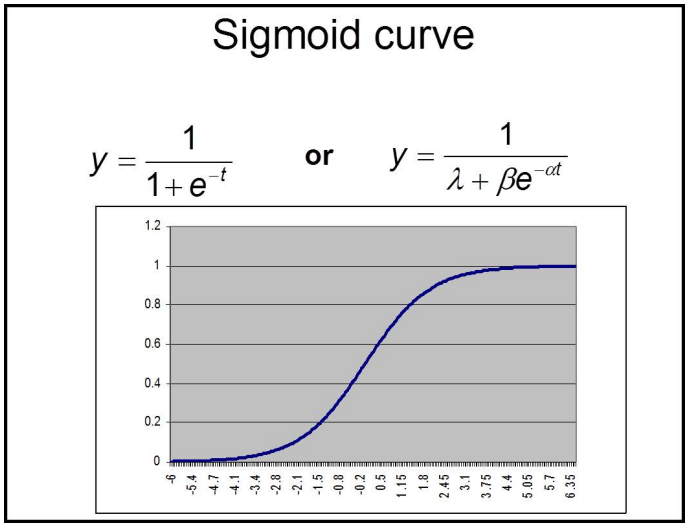


Figure 7-6. Determine Budget: Inputs, Tools & Techniques, and Outputs



Remember from Previous Lecture

Some notes on S-Curve

- S-curves are useful in at the beginning of a project
- As time progresses, estimates can be refined, and a more realistic financial model can be developed
- Over-reliance on S-curves can create cash-flow difficulties
  - What if the α, β, or λ are not a good fit to the actual cash flow of the project?

Determine Budget
Inputs

- As per book

Tools and Techniques

- Cost Aggregation
  - Sum of the costs associated with individual work packages and elements from the WBS
- Reserve Analysis
  - Sum of project cost reserves, such as risk reserve and others
- Historical Relationships
  - Parametric and/or analogous estimates
  - Mathematical Models to predict total cost
  - Refer to book
  - **CAUTION:** models should be treated with care; before use they should be fully understood

---

Determine Budget **Tools and Techniques**
Funding Limit Reconciliation

- Modification of the project program in order to smooth out the funding requirements of the project.
- Needs to be treated with extreme caution by the contractor
- Generally beneficial to the client.

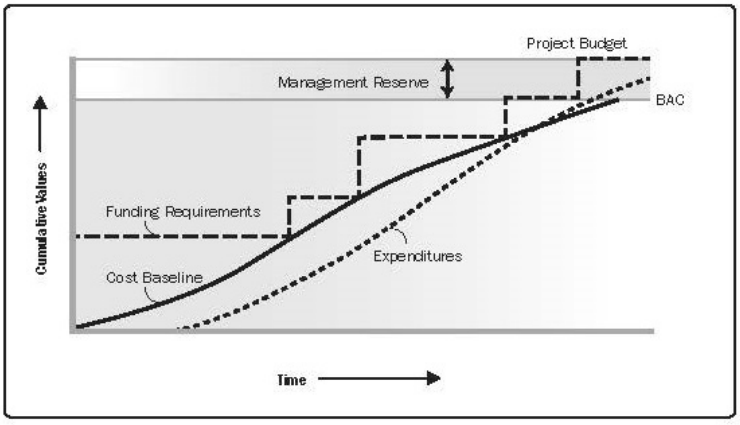


Figure 7-9. Cost Baseline, Expenditures, and Funding Requirements

  - Projects generally have a value to the client, and generate a return on investment. The shorter the time between paying the contractor and realising a return from the investment, the better it is for the client
  - Also, loan interest is incurred from drawdown. If drawdown can be postponed, less loan interest is incurred.
- Both parties need to be aware of Contract Price Adjustment (CPA) Clause and effects

---

Determine Budget

Determine Budget **Outputs**

Cost Performance Baseline

- Time based budget that is used as a basis against which to measure, monitor, and control overall cost performance on the project.
- Can be shown as an S-curve
- For large construction projects it is normal to include far more detail and track costs against specific cost codes and cost centres.

Determine Budget **Outputs**

Project Funding Requirements

- Details the total and periodic funding requirements
- Also included a margin for error or changes that may be required

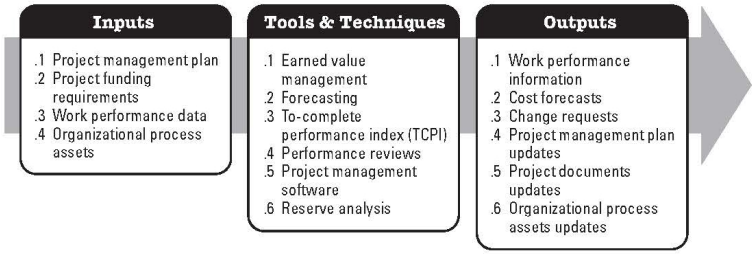


Figure 7-10. Control Costs: Inputs, Tools & Techniques, and Outputs

- Generally funding requirement are represented by a step function, See Fig 7-9
- Contingency reserves are normally spread evenly over the duration of the project.

Determine Budget **Outputs**

Project Document Updates

- Cost Estimates
- Risk Register
- Project Schedule

Control Costs

Part of the Monitoring & Controlling Process Group

Control Costs

- Influencing the factors that create changes to the cost baseline
- Ensuring requested changes are agreed upon
- Managing the actual changes when and as they occur
- Assuring that potential cost overruns do not exceed the authorised funding for the project (total and periodic)
- Monitoring cost performance to detect and understand variances from the cost baseline

---

Control Costs

- Recording all appropriate changes accurately against the cost baseline
- Preventing incorrect, inappropriate, or unapproved changes from being included in the reported cost or resource usage
- Informing appropriate stakeholders of approved changes
- Acting to bring expected cost overruns within acceptable limits (Variations)

Control Costs **Inputs**

Cost Baseline and Management Plan

- Already covered

Project Funding Requirements

- Already covered

Performance Reports

- Information and reports on actual cost and resource performance

Work Performance Information

- Deliverables completed and not yet completed
- Costs authorised and incurred
- Estimates to complete schedule activities
- %age completion of schedule activities

Control Costs **Inputs**

Organisational Process Assets

- Cost Control policies, procedures & guidelines
- Cost Control Tools
- Monitoring and Reporting Methods

Tools and Techniques

- Earned Value Management
- Forecasting
- To-Complete Performance Index (TCPI)
- Performance Reviews
- Variance Analysis
- PM Software

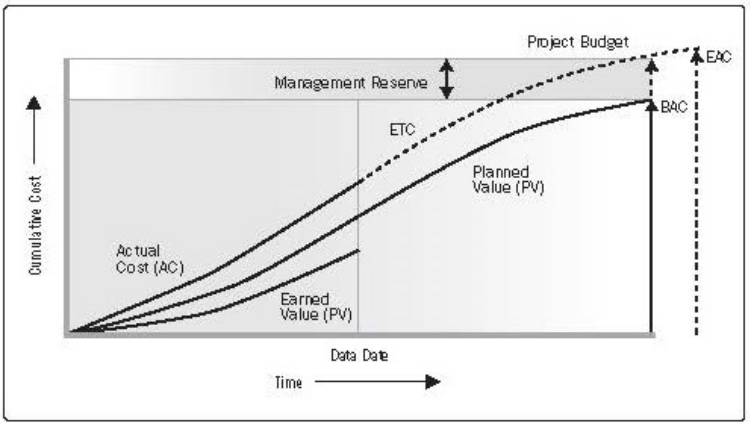


Figure 7-12. Earned Value, Planned Value, and Actual Costs

Control Costs Key Terms

- Planned Value (PV)
- Earned Value (EV)
- Actual Cost (AC)
- Estimate to Completion (ETC)
- Estimate at Completion (EAC)
- Cost Variance (CV)
- Schedule Variance (SV)
- Cost Performance Index (CPI)
- Schedule Performance Index (SPI)

Control Costs- Performance Measurement Analysis

Cost Variance

$$CV = Earned\ Value - Actual\ Cost$$

$$CV = EV - AC$$

Schedule Variance

$$SV = Earned\ Value - Planned\ Value$$

$$SV = EV - PV$$

Control Costs- Performance Measurement Analysis

Cost Performance Index Do not confuse with consumer price index..

$$CPI = \frac{EV}{AC}$$

- CPI less than 1.0 indicates cost overrun
- CPI greater than 1.0 indicates cost underrun

Schedule Performance Index

$$SPI = \frac{Earned\ Value}{Planned\ Value}$$

$$SPI = \frac{EV}{PV}$$

1.6 Earned Value Management

Earned Value Management System

- **Earned Value** is a management technique that relates resource planning to schedules and technical performance requirements
- **Earned Value Management (EVM)** is a systematic process that uses earned value as the primary tool for integrating cost, schedule, technical performance management and risk management

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For most projects, determination of project progress is extremely difficult without an Earned Value Measurement System (EVMS) Consider a 12 month project:

- value €2.5M
- 10 deliverables

Report at month 6:

- cost €1.75M;
- 4 deliverables complete; 3 deliverables started.

Is the project 50%, 70% or 40% complete?

By integrating cost, schedule, technical performance management and risk management, an EVMS will:

- Accurately show project status
- Assist in the early detection of problems
- Assist in the early detection of cost trends
- Assist in determining the success of corrective actions

EVMS emphasises prevention over cure by identifying and resolving potential issues early.

Variance

Cost Variance

$$CV = Earned\ Value - Actual\ Cost$$

- Compares deviation from budget
- Does not provide a measure of work scheduled against work completed

Schedule Variance

$$SV = Earned\ Value - Planned\ Value$$

- Provides a comparison between planned and actual performance, but does not include costs.

Example

A project was expected to incur costs of €100k each week for 4 weeks (PV) Actual expenditure by the end of week 4 was €325k (AC), and the Earned Value (EV) was measured at €300k. What is the project status?

- Cost Variance = 300k - 325k = -25k (cost overrun)
- Schedule Variance = 300k 400k = -100k (behind schedule)
- CPI = 300/325 = 0.92 (less than 1.0 therefore cost overrun)
- SPI = 300/400 = 0.75 (less than 1.0 therefore behind schedule)

CV,SV, CPI and SPI Trends

Taken in isolation, CV, SV, CPI and SPI have relatively little value; however when graphed over the course of a project trends will emerge that will indicate the project status in a more meaningful way

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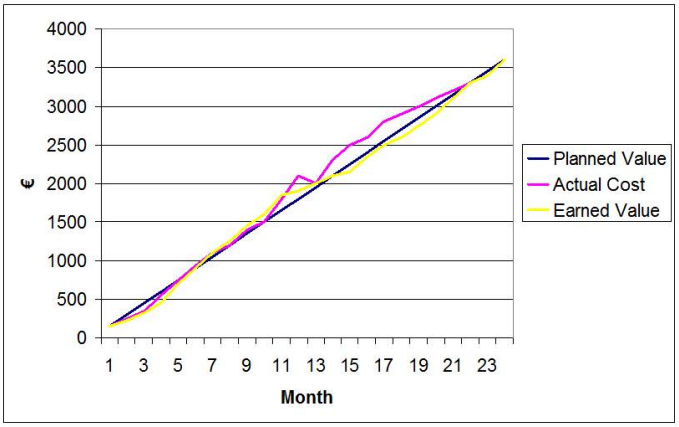
Month	PV	AC	EV	CV	PV	CPI	SPI
1	150	150	150	0	0	1	1
2	300	250	225	-25	-75	0.9	0.75
3	450	350	325	-25	-125	0.928571	0.722222
4	600	550	450	-100	-150	0.818182	0.75
5	750	750	700	-50	-50	0.933333	0.933333
6	900	925	900	-25	0	0.972973	1
7	1050	1100	1100	0	50	1	1.047619
8	1200	1200	1250	50	50	1.041667	1.041667
9	1350	1400	1450	50	100	1.035714	1.074074
10	1500	1500	1600	100	100	1.066667	1.066667
11	1650	1800	1850	50	200	1.027778	1.121212
12	1800	2100	1900	-200	100	0.904762	1.055556
13	1950	2000	2000	0	50	1	1.025641
14	2100	2300	2100	-200	0	0.913043	1
15	2250	2500	2150	-350	-100	0.86	0.955556
16	2400	2600	2350	-250	-50	0.903846	0.979167
17	2550	2800	2500	-300	-50	0.892857	0.980392
18	2700	2900	2600	-300	-100	0.896552	0.962963
19	2850	3000	2750	-250	-100	0.916667	0.964912
20	3000	3100	2900	-200	-100	0.935484	0.966667
21	3150	3200	3100	-100	-50	0.96875	0.984127
22	3300	3300	3300	0	0	1	1
23	3450	3400	3400	0	-50	1	0.985507
24	3600	3600	3600	0	0	1	1



CV,SV, CPI and SPI Trends

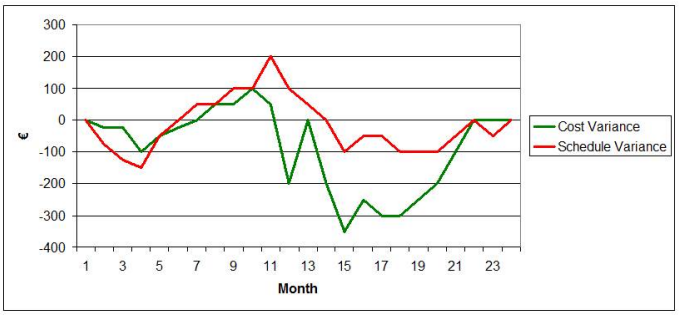
Consider the following example:

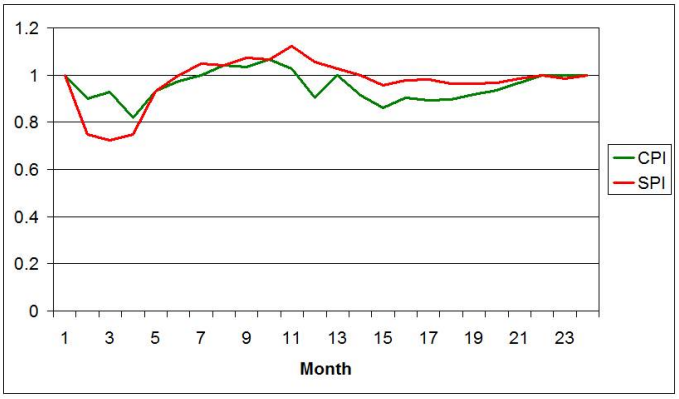
PV, AC, and EV Trends

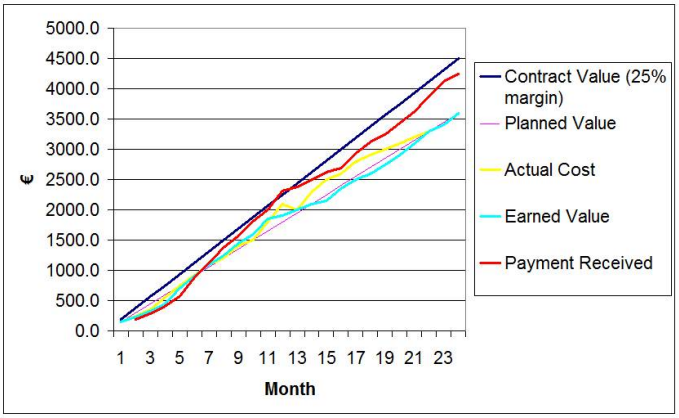
CV and SV Trends

CPI and SPI Trends

Favourable or unfavourable trends are very easily identified when the data is graphed.


300
200
100
0
-100
-200
-300
-400
€
1 3 5 7 9 11 13 15 17 19 21 23
Month
Cost Variance
Schedule Variance


1.2
1
0.8
0.6
0.4
0.2
0
1 3 5 7 9 11 13 15 17 19 21 23
Month
CPI
SPI


5000.0
4500.0
4000.0
3500.0
3000.0
2500.0
2000.0
1500.0
1000.0
500.0
0.0
€
1 3 5 7 9 11 13 15 17 19 21 23
Month
Contract Value (25% margin)
Planned Value
Actual Cost
Earned Value
Payment Received

Additional data can also be easily added:

- In this case Contract Value and Payments Received have been included on a PV,AC and EV graph

---

Variance Analysis

When analysing variance, a number of key questions need to be considered

- What is the problem causing the variance?
- What is the impact on time, cost and performance?
- What is the impact on other efforts, if any?
- What corrective action is planned or underway?
- What are the expected results of the corrective action?

Work in Progress : 50-50 Rule

One of the drawbacks of EVM systems is determining the earned value (EV) of Work in Progress (WIP) where estimating resource input is impractical. Often the 50-50 rule is used to estimate the earned value of WIP in these cases
Example:

- Work package cost, €15,000
- Work package duration, 2 weeks
- Cost at end of week 1 is €10,000
- Therefore %age completion of the task using the 50-50 rule is:
  - 0.5(1/2) + 0.5(10,000/15,000)
  - 0.25 + 0.333 = .583 or 58.3
- Therefore EV of work package is €8,745

Estimate to Completion (ETC)

- The baseline budget for a project is often referred to in EVM as the Budget at Completion, or BAC. (see fig. 7-7)
- In general projects rarely follow the baseline budget
- Therefore, it is necessary to estimate the remaining cost to complete the project at various intervals as the project progresses
- As the project progresses the accuracy of the ETC will be improved.
- Revisions of the ETC are carried out at appropriate intervals, such as weekly or monthly.

Estimate to Completion (ETC)
ETC can be calculated in a number of ways

- ETC using a new estimate
- ETC using the remaining budget
- ETC using CPI

ETC using new estimate

- Normally only used when the original estimate is fundamentally flawed

---

Estimate to Completion (ETC)
ETC using the remaining budget

- Used when variances are seen as atypical, and the project team is confident that further variances are unlikely

$$ETC_{BGT} = BAC - EV$$

ETC using CPI

- Used when variances to date are seen as being indicative of future variances

$$ETC_{CPI} = \frac{(BAC - EV)}{CPI}$$

Estimate at Completion (EAC)
Another common measure used is the **Estimate at Completion, EAC** In general the EAC is:

$$EAC = AC + ETC$$

- As the project progresses the accuracy of the EAC will be improved.
- Revisions of the EAC are carried out at appropriate intervals, such as weekly or monthly.

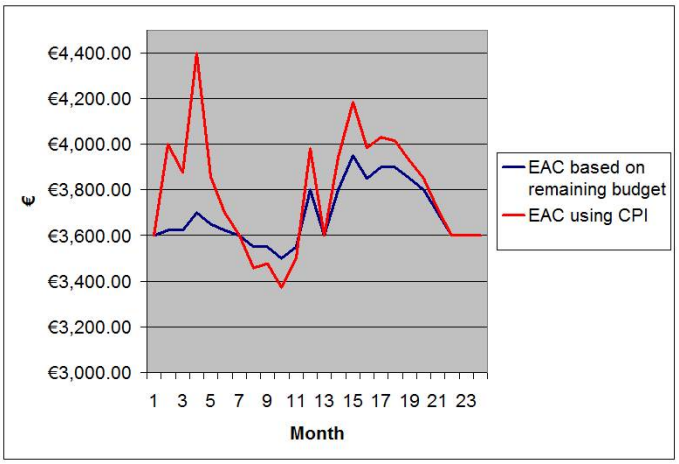
Estimate at Completion (EAC)
Like ETC, EAC can be calculated in a number of ways

- EAC using a new estimate
- EAC using the remaining budget
- EAC using CPI

EAC using new estimate

- Normally only used when the original estimate is fundamentally flawed

$$EAC = AC + ETC$$



Estimate at Completion (EAC)

EAC using the remaining budget

- Used when variances are seen as atypical, and the project team is confident that further variances are unlikely

$$EAC_{BGT} = AC + BAC - EV$$

EAC using CPI

- Used when variances to date are seen as being indicative of future variances

$$EAC_{CPI} = AC + \frac{(BAC - EV)}{CPI}$$

Comparison of EAC results

Cost Control Problems

- Poor estimating techniques and/or Standards, resulting in unrealistic budgets
- Out of sequence start and completion of activities
- Inadequate WBS
- Lack of Management policy on reporting and control practices
- Reducing budgets or bids to be competitive or eliminate fat
- Unnoticed or uncontrolled scope change
- Poor comparison of actual and planned costs

- Unforeseen technical problems
- Schedule delays that require overtime or idle time
- Unrealistic CPA clause

Causes of Cost Overrun
Proposal Phase

- Failure to understand requirements
- Unrealistic appraisal of in-house capability
- Underestimation of time requirements

Planning Phase

- Omissions
- Inaccurate WBS
- Misinterpretation of information
- Wrong or inaccurate estimating techniques
- Failure to identify and concentrate on major cost elements
- Failure to assess and provide for Risk

Causes of Cost Overrun
Negotiation Phase

- Forcing a speedy compromise
- Procurement ceiling costs
- *Must win the job* attitude

Contractual Phase

- Contractual discrepancies
- SOW different from RFP requirements
- Proposal team different from project team

Design Phase

- Accepting customer requests without management approval
- Problems in customer communications channels and data items
- Problems in Design Review meetings

Activity	Planned Duration (weeks)	Work to Date on Activity (weeks)	Activity Status	Planned Value (PV)	Actual Cost (AC)
A	5	5	Complete	€8,000.00	€11,000.00
B	6	8	Complete	€12,000.00	€18,500.00
C	10	8	WIP	€15,000.00	€10,500.00
D	12	9	WIP	€25,000.00	€12,500.00
E	9	8	Complete	€30,000.00	€32,000.00
F	16	4	WIP	€45,000.00	€18,000.00
G	8	3	WIP	€15,000.00	€3,000.00
H	4	0	WIP	€10,000.00	€1,000.00

a)	PV at week 12	b)	EV	c)	CV
d)	CPI	e)	SV	f)	SPI
g)	ETC based on budget	h)	ETC based on CPI	i)	EAC -budget
j)	ETC based on CPI	k)	%age Completion	l)	% Budget Spent
m)	New Project Duration based on SPI				

Causes of Cost Overrun

Build Phase

- Excessive material cost
- Specification that are not acceptable
- Disagreement between engineering team, design team, and construction team

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Cost Control Process **Outputs**

- Cost Estimate (Updates)
- Cost Baseline (Updates)
- Performance Measurements
  - CV, SV, CPI, SPI
- Forecasted Completion
  - ETC, EAC
- Requested Changes
- Recommended Corrective Actions
- Organizational Process Assets (Updates)
- Project Management Plan (Updates)

1.7 EVMS Worked Example

EVMS Worked Example

The above project has a total planned duration of 35 weeks. The project is currently at the end of week 12. Calculate:

Activity	Planned Duration (weeks)	Work to Date on Activity (weeks)	Activity Status	Planned Value (PV)	Actual Cost (AC)	50-50 Rule			Earned Value (EV)	Planned Value (PV) at end of Week 12
						% schedule	% cost	% Completion		
A	5	5	Complete	€8,000.00	€11,000.00					
B	6	8	Complete	€12,000.00	€18,500.00					
C	10	8	WIP	€15,000.00	€10,500.00					
D	12	9	WIP	€25,000.00	€12,500.00					
E	9	8	Complete	€30,000.00	€32,000.00					
F	16	4	WIP	€45,000.00	€18,000.00					
G	8	3	WIP	€15,000.00	€3,000.00					
H	4	0	WIP	€10,000.00	€1,000.00					

Activity	Planned Duration (weeks)	Work to Date on Activity (weeks)	Activity Status	Planned Value (PV)	Actual Cost (AC)	50-50 Rule			Earned Value (EV)	Planned Value (PV) at end of Week 12
						% schedule	% cost	% Completion		
A	5	5	Complete	€8,000.00	€11,000.00				€8,000.00	€8,000.00
B	6	8	Complete	€12,000.00	€18,500.00				€12,000.00	€12,000.00
C	10	8	WIP	€15,000.00	€10,500.00					
D	12	9	WIP	€25,000.00	€12,500.00					
E	9	8	Complete	€30,000.00	€32,000.00				€30,000.00	€26,666.67
F	16	4	WIP	€45,000.00	€18,000.00					
G	8	3	WIP	€15,000.00	€3,000.00					
H	4	0	WIP	€10,000.00	€1,000.00					
				€160,000.00	**€106,500.00**					

Construct a table

Step 2 Known Information

1. Activities A, B and E are complete, therefore the Earned Value (EV) of each activity is equal to its Planned Value (PV).
2. The Planned Values of A and B at the end of week 12 are also equal to their original Planned Values.
3. Activity E has finished ahead of schedule and requires different treatment.

Step 2 Known Information

The Planned value for activity E at end of Week 12:

1. We are assuming that the planned value will accumulate linearly over the task duration.
2. Note that this is a simplified method; ideally it will be dependent on the task nature.

$$\frac{8\ weeks}{9\ weeks} \times €30,000 = €26,666.67$$

Activity	Planned Duration (weeks)	Work to Date on Activity (weeks)	Activity Status	Planned Value (PV)	Actual Cost (AC)	50-50 Rule			Earned Value (EV)	Planned Value (PV) at end of Week 12
						% schedule	% cost	% Completion		
A	5	5	Complete	€8,000.00	€11,000.00				€8,000.00	€8,000.00
B	6	8	Complete	€12,000.00	€18,500.00				€12,000.00	€12,000.00
C	10	8	WIP	€15,000.00	€10,500.00					
D	12	9	WIP	€25,000.00	€12,500.00					
E	9	8	Complete	€30,000.00	€32,000.00				€30,000.00	€26,666.67
F	16	4	WIP	€45,000.00	€18,000.00					
G	8	3	WIP	€15,000.00	€3,000.00					
H	4	0	WIP	€10,000.00	€1,000.00					
				€160,000.00	**€106,500.00**					

Activity	Planned Duration (weeks)	Work to Date on Activity (weeks)	Activity Status	Planned Value (PV)	Actual Cost (AC)	50-50 Rule			Earned Value (EV)	Planned Value (PV) at end of Week 12
						% schedule	% cost	% Completion		
A	5	5	Complete	€8,000.00	€11,000.00				€8,000.00	€8,000.00
B	6	8	Complete	€12,000.00	€18,500.00				€12,000.00	€12,000.00
C	10	8	WIP	€15,000.00	€10,500.00					
D	12	9	WIP	€25,000.00	€12,500.00					
E	9	8	Complete	€30,000.00	€32,000.00				€30,000.00	€26,666.67
F	16	4	WIP	€45,000.00	€18,000.00					
G	8	3	WIP	€15,000.00	€3,000.00					
H	4	0	WIP	€10,000.00	€1,000.00					
				€160,000.00	€106,500.00					

Budget At Completion (BAC) **Actual Cost (AC) at end of Week 12**

Activity	Planned Duration (weeks)	Work to Date on Activity (weeks)	Activity Status	Planned Value (PV)	Actual Cost (AC)	50-50 Rule			Earned Value (EV)	Planned Value (PV) at end of Week 12
						% schedule	% cost	% Completion		
A	5	5	Complete	€8,000.00	€11,000.00				€8,000.00	€8,000.00
B	6	8	Complete	€12,000.00	€18,500.00				€12,000.00	€12,000.00
C	10	8	WIP	€15,000.00	€10,500.00	80.00%	70.00%	75.00%	€11,250.00	€12,000.00
D	12	9	WIP	€25,000.00	€12,500.00	75.00%	50.00%	62.50%	€15,625.00	€18,750.00
E	9	8	Complete	€30,000.00	€32,000.00				€30,000.00	€26,666.67
F	16	4	WIP	€45,000.00	€18,000.00	25.00%	40.00%	32.50%	€14,625.00	€11,250.00
G	8	3	WIP	€15,000.00	€3,000.00	37.50%	20.00%	28.75%	€4,312.50	€5,625.00
H	4	0	WIP	€10,000.00	€1,000.00	0.00%	10.00%	5.00%	€500.00	€0.00
				€160,000.00	**€106,500.00**				**€96,312.50**	**€94,291.67**

Step 2 Known Information

- Sum the Planned Value (PV) Column: This gives the Planned Value for the entire project
- Sum the Actual Cost (AC) Column: This give the total spend to date on the project

---

For the 50-50 Rule, calculate the percentage of schedule by dividing the work to date by the Planned duration, e.g. Activity C:

$$\frac{8\ weeks}{10\ weeks} = 80.00\%$$

Now, calculate the percentage of cost by dividing the Actual Cost (AC) of each activity by its Planned Value (PV), e.g. Activity D:

$$\frac{€12,500.00}{€25,000.00} = 50.00\%$$

Activity	Planned Duration (weeks)	Work to Date on Activity (weeks)	Activity Status	Planned Value (PV)	Actual Cost (AC)	50-50 Rule			Earned Value (EV)	Planned Value (PV) at end of Week 12
						% schedule	% cost	% Completion		
A	5	5	Complete	€8,000.00	€11,000.00				€8,000.00	€8,000.00
B	6	8	Complete	€12,000.00	€18,500.00				€12,000.00	€12,000.00
C	10	8	WIP	€15,000.00	€10,500.00	80.00%	70.00%	75.00%	€11,250.00	€12,000.00
D	12	9	WIP	€25,000.00	€12,500.00	75.00%	50.00%	62.50%	€15,625.00	€18,750.00
E	9	8	Complete	€30,000.00	€32,000.00				€30,000.00	€26,666.67
F	16	4	WIP	€45,000.00	€18,000.00	25.00%	40.00%	32.50%	€14,625.00	€11,250.00
G	8	3	WIP	€15,000.00	€3,000.00	37.50%	20.00%	28.75%	€4,312.50	€5,625.00
H	4	0	WIP	€10,000.00	€1,000.00	0.00%	10.00%	5.00%	€500.00	€0.00
				€160,000.00	**€106,500.00**				**€96,312.50**	**€94,291.67**

Activity	Planned Duration (weeks)	Work to Date on Activity (weeks)	Activity Status	Planned Value (PV)	Actual Cost (AC)	50-50 Rule			Earned Value (EV)	Planned Value (PV) at end of Week 12
						% schedule	% cost	% Completion		
A	5	5	Complete	€8,000.00	€11,000.00				€8,000.00	€8,000.00
B	6	8	Complete	€12,000.00	€18,500.00				€12,000.00	€12,000.00
C	10	8	WIP	€15,000.00	€10,500.00	80.00%	70.00%	75.00%	€11,250.00	€12,000.00
D	12	9	WIP	€25,000.00	€12,500.00	75.00%	50.00%	62.50%	€15,625.00	€18,750.00
E	9	8	Complete	€30,000.00	€32,000.00				€30,000.00	€26,666.67
F	16	4	WIP	€45,000.00	€18,000.00	25.00%	40.00%	32.50%	€14,625.00	€11,250.00
G	8	3	WIP	€15,000.00	€3,000.00	37.50%	20.00%	28.75%	€4,312.50	€5,625.00
H	4	0	WIP	€10,000.00	€1,000.00	0.00%	10.00%	5.00%	€500.00	€0.00
				€160,000.00	**€106,500.00**				**€96,312.50**	**€94,291.67**

Activity	Planned Duration (weeks)	Work to Date on Activity (weeks)	Activity Status	Planned Value (PV)	Actual Cost (AC)	50-50 Rule			Earned Value (EV)	Planned Value (PV) at end of Week 12
						% schedule	% cost	% Completion		
A	5	5	Complete	€8,000.00	€11,000.00				€8,000.00	€8,000.00
B	6	8	Complete	€12,000.00	€18,500.00				€12,000.00	€12,000.00
C	10	8	WIP	€15,000.00	€10,500.00	80.00%	70.00%	75.00%	€11,250.00	€12,000.00
D	12	9	WIP	€25,000.00	€12,500.00	75.00%	50.00%	62.50%	€15,625.00	€18,750.00
E	9	8	Complete	€30,000.00	€32,000.00				€30,000.00	€26,666.67
F	16	4	WIP	€45,000.00	€18,000.00	25.00%	40.00%	32.50%	€14,625.00	€11,250.00
G	8	3	WIP	€15,000.00	€3,000.00	37.50%	20.00%	28.75%	€4,312.50	€5,625.00
H	4	0	WIP	€10,000.00	€1,000.00	0.00%	10.00%	5.00%	€500.00	€0.00
				€160,000.00	**€106,500.00**				**€96,312.50**	**€94,291.67**

Next, calculate the actual percentage completion of each activity using the 50-50 rule; add 50% of the percentage schedule completion and 50% of the percentage of cost: e.g. Activity F:

$$(25.00\% \times 0.5) + (40.00\% \times 0.5) = 32.50\%$$
$$12.50\% + 20.00\% = 32.50\%$$

There is an alternative calculation that is ONLY applicable if the %age weightings are 0.5 and 0.5. This is to take an average e.g. Activity F:

$$\frac{25.00\% + 40.00\%}{2} = 32.50\%$$

To calculate the Earned Value (EV) for each activity, multiply the percentage Completion by its Planned Value (PV), e.g. Activity C:

$$€15,000.00 \times 75.00\% = €11,250.00$$

Activity	Planned Duration (weeks)	Work to Date on Activity (weeks)	Activity Status	Planned Value (PV)	Actual Cost (AC)	50-50 Rule			Earned Value (EV)	Planned Value (PV) at end of Week 12
						% schedule	% cost	% Completion		
A	5	5	Complete	€8,000.00	€11,000.00				€8,000.00	€8,000.00
B	6	8	Complete	€12,000.00	€18,500.00				€12,000.00	€12,000.00
C	10	8	WIP	€15,000.00	€10,500.00	80.00%	70.00%	75.00%	€11,250.00	€12,000.00
D	12	9	WIP	€25,000.00	€12,500.00	75.00%	50.00%	62.50%	€15,625.00	€18,750.00
E	9	8	Complete	€30,000.00	€32,000.00				€30,000.00	€26,666.67
F	16	4	WIP	€45,000.00	€18,000.00	25.00%	40.00%	32.50%	€14,625.00	€11,250.00
G	8	3	WIP	€15,000.00	€3,000.00	37.50%	20.00%	28.75%	€4,312.50	€5,625.00
H	4	0	WIP	€10,000.00	€1,000.00	0.00%	10.00%	5.00%	€500.00	€0.00
				€160,000.00	**€106,500.00**				**€96,312.50**	**€94,291.67**

Activity	Planned Duration (weeks)	Work to Date on Activity (weeks)	Activity Status	Planned Value (PV)	Actual Cost (AC)	50-50 Rule			Earned Value (EV)	Planned Value (PV) at end of Week 12
						% schedule	% cost	% Completion		
A	5	5	Complete	€8,000.00	€11,000.00				€8,000.00	€8,000.00
B	6	8	Complete	€12,000.00	€18,500.00				€12,000.00	€12,000.00
C	10	8	WIP	€15,000.00	€10,500.00	80.00%	70.00%	75.00%	€11,250.00	€12,000.00
D	12	9	WIP	€25,000.00	€12,500.00	75.00%	50.00%	62.50%	€15,625.00	€18,750.00
E	9	8	Complete	€30,000.00	€32,000.00				€30,000.00	€26,666.67
F	16	4	WIP	€45,000.00	€18,000.00	25.00%	40.00%	32.50%	€14,625.00	€11,250.00
G	8	3	WIP	€15,000.00	€3,000.00	37.50%	20.00%	28.75%	€4,312.50	€5,625.00
H	4	0	WIP	€10,000.00	€1,000.00	0.00%	10.00%	5.00%	€500.00	€0.00
				€160,000.00	**€106,500.00**				**€96,312.50**	**€94,291.67**

Activity	Planned Duration (weeks)	Work to Date on Activity (weeks)	Activity Status	Planned Value (PV)	Actual Cost (AC)	50-50 Rule			Earned Value (EV)	Planned Value (PV) at end of Week 12
						% schedule	% cost	% Completion		
A	5	5	Complete	€8,000.00	€11,000.00				€8,000.00	€8,000.00
B	6	8	Complete	€12,000.00	€18,500.00				€12,000.00	€12,000.00
C	10	8	WIP	€15,000.00	€10,500.00	80.00%	70.00%	75.00%	€11,250.00	€12,000.00
D	12	9	WIP	€25,000.00	€12,500.00	75.00%	50.00%	62.50%	€15,625.00	€18,750.00
E	9	8	Complete	€30,000.00	€32,000.00				€30,000.00	€26,666.67
F	16	4	WIP	€45,000.00	€18,000.00	25.00%	40.00%	32.50%	€14,625.00	€11,250.00
G	8	3	WIP	€15,000.00	€3,000.00	37.50%	20.00%	28.75%	€4,312.50	€5,625.00
H	4	0	WIP	€10,000.00	€1,000.00	0.00%	10.00%	5.00%	€500.00	€0.00
				€160,000.00	**€106,500.00**				**€96,312.50**	**€94,291.67**

Earned Value (EV) at end of Week 12

Planned Value (PV) at end of Week 12

To calculate the Planned Value at this point in time it is necessary to calculate the Planned Values for each activity, e.g Activity G:

$$€15,000.00 \times 37.50\% = €5,625.00$$

To calculate the Planned Value and Earned Value at this point in time, Sum the individual Earned Values and Planned Values.

Summary of information:

Further Calculations

Activity	Planned Duration (weeks)	Work to Date on Activity (weeks)	Activity Status	Planned Value (PV)	Actual Cost (AC)	50-50 Rule			Earned Value (EV)	Planned Value (PV) at end of Week 12
						% schedule	% cost	% Completion		
A	5	5	Complete	€8,000.00	€11,000.00				€8,000.00	€8,000.00
B	6	8	Complete	€12,000.00	€18,500.00				€12,000.00	€12,000.00
C	10	8	WIP	€15,000.00	€10,500.00	80.00%	70.00%	75.00%	€11,250.00	€12,000.00
D	12	9	WIP	€25,000.00	€12,500.00	75.00%	50.00%	62.50%	€15,625.00	€18,750.00
E	9	8	Complete	€30,000.00	€32,000.00				€30,000.00	€26,666.67
F	16	4	WIP	€45,000.00	€18,000.00	25.00%	40.00%	32.50%	€14,625.00	€11,250.00
G	8	3	WIP	€15,000.00	€3,000.00	37.50%	20.00%	28.75%	€4,312.50	€5,625.00
H	4	0	WIP	€10,000.00	€1,000.00	0.00%	10.00%	5.00%	€500.00	€0.00
				€160,000.00	**€106,500.00**				**€96,312.50**	**€94,291.67**

Budget at Completion (BAC)	€160,000.00
Actual Cost of Contract to date (AC)	€106,500.00
Earned Value to date (EV)	€96,312.50
Planned Vale to date (PV)	€94,291.67

Budget at Completion (BAC)	€160,000.00
Actual Cost of Contract to date (AC)	€106,500.00
Earned Value to date (EV)	€96,312.50
Planned Vale to date (PV)	€94,291.67
Cost Variance (CV)	–€10,187.50
Cost Performance Index (CPI)	0.9043
Schedule Variance (SV)	€2,020.83
Schedule Performance Index (SPI)	1.0214

Cost Variance (CV)

Cost Variance equals the Earned Value less Actual Costs to date

$$CV = EV - AC$$
$$CV = €96,312.50 - €106,500.00$$
$$CV = € - 10,187.50$$

Cost Performance Index (CPI)

Cost Performance Index equals the Earned Value divided by Actual Costs to date

$$CPI = \frac{EV}{AC} = \frac{€96,312.50}{€106,500.00}$$
$$CPI = 0.9043$$

Schedule Variance (SV)

Schedule Variance equals the Earned Value less Planned Value to date

$$SV = EV - PV$$
$$SV = €96,312.50 - €94,291.67$$
$$SV = €2,020.83$$

Budget at Completion (BAC)	€160,000.00
Actual Cost of Contract to date (AC)	€106,500.00
Earned Value to date (EV)	€96,312.50
Planned Vale to date (PV)	€94,291.67
Cost Variance (CV)	–€10,187.50
Cost Performance Index (CPI)	0.9043
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Budget at Completion (BAC)	€160,000.00
Actual Cost of Contract to date (AC)	€106,500.00
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Cost Variance (CV)	−€10,187.50
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Budget at Completion (BAC)	€160,000.00
Actual Cost of Contract to date (AC)	€106,500.00
Earned Value to date (EV)	€96,312.50
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Cost Performance Index (CPI)	0.9043
Schedule Variance (SV)	€2,020.83
Schedule Performance Index (SPI)	1.0214

Schedule Performance Index (SPI)

Schedule Performance Index equals the Earned Value divided by Planned Value to date

$$SPI = \frac{EV}{PV} = \frac{€96,312.50}{€94,291.67}$$

$$SPI = 1.0214$$

Estimate to Completion (ETC) based on Budget

ETC equals the Budget at Completion less the Earned Value to date

$$ETC_{BGT} = BAC - EV$$

$$ETC_{BGT} = €160,000 - €96,312.50$$

$$ETC_{BGT} = €63,687.50$$

Estimate to Completion (ETC) based on CPI

Two Methods of Calculation

$$ETC_{CPI} = \frac{BAC - EV}{CPI} = \frac{ETC_{BGT}}{CPI}$$

$$ETC_{CPI} = \frac{€160,000 - €96,312.50}{0.9043}$$

$$ETC_{CPI} = €70,427.40$$

Estimate at Completion (EAC) based on Budget

Two Methods of Calculation

$$EAC_{BGT} = (BAC - EV) + AC = ETC_{BGT} + AC$$

$$EAC_{BGT} = €63,687.50 + €106,500.00$$

$$EAC_{BGT} = €170,187.50$$

Budget at Completion (BAC)	€160,000.00
Actual Cost of Contract to date (AC)	€106,500.00
Earned Value to date (EV)	€96,312.50
Planned Vale to date (PV)	€94,291.67
Cost Variance (CV)	−€10,187.50
Cost Performance Index (CPI)	0.9043
Schedule Variance (SV)	€2,020.83
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Budget at Completion (BAC)	€160,000.00
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Estimate at Completion (EAC) based on CPI

Two Methods of Calculation

$$EAC_{CPI} = \frac{BAC - EV}{CPI} + AC = ETC_{CPI} + AC$$
$$EAC_{CPI} = €70,427.40 + €106,500.00$$
$$EAC_{CPI} = €176,927.40$$

Percentage Completion

Earned Value divided by Budget at Completion expressed as a percentage

$$\%_{complete} = \frac{EV}{BAC} = \frac{€96,312.50}{€160,000.00}$$
$$\%_{complete} = 0.60195 = 60.195\%$$

Percentage of Budget Spent

Actual Costs divided by Budget at Completion expressed as a percentage

$$\%_{budget} = \frac{AC}{BAC} = \frac{€106,500.00}{€160,000.00}$$
$$\%_{budget} = 0.66563 = 66.563\%$$

Project Duration Estimate using the Schedule Performance Index (SPI)

The original project duration was stated as 35 weeks. Therefore,

$$\text{Estimated Duration} = \frac{\text{Original Duration}}{SPI}$$
$$= \frac{35\ weeks}{1.0214}$$
$$\text{Estimated Duration} = 34.27\ weeks$$

Budget at Completion (BAC)	€160,000.00
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Schedule Performance Index (SPI)	1.0214

Some Alternatives to the 50-50 Rule

0/100 Rule

- Usually limited to small work packages; no value is earned until the task is complete

Milestone

- Used for long duration work packages. Value is earned when milestones are completed.

% complete

- Used for long duration work packages where milestones cannot be identified. % complete is determined by measurement.

Equivalent Units

- Used for similar-unit work packages, where earnings are on completed units rather than labour. e.g kitchen contractor; number of kitchen units installed.

Comment on EVM

- EVM works best when applied to the top 4 levels of the WBS.
- Unless the model is linked to the project schedule, the determination of PV can be problematic.
- EVM will only highlight issues in relation to cost and schedule.
- EVM will not highlight issues on quality, deliverables, scope, etc.
- WIP (and thus EV) can be calculated in a number of ways; leaves the system open to manipulation.

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- EAC and ETC predictions likely to be inaccurate due to unforeseen future for variances. EAC and ETC are indicative only.

In summary, EVM is very useful. However, it must be treated with caution.
