

Project Management

Lecture 6- Resourcing and Budgets

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This Session

Budgets and Estimation

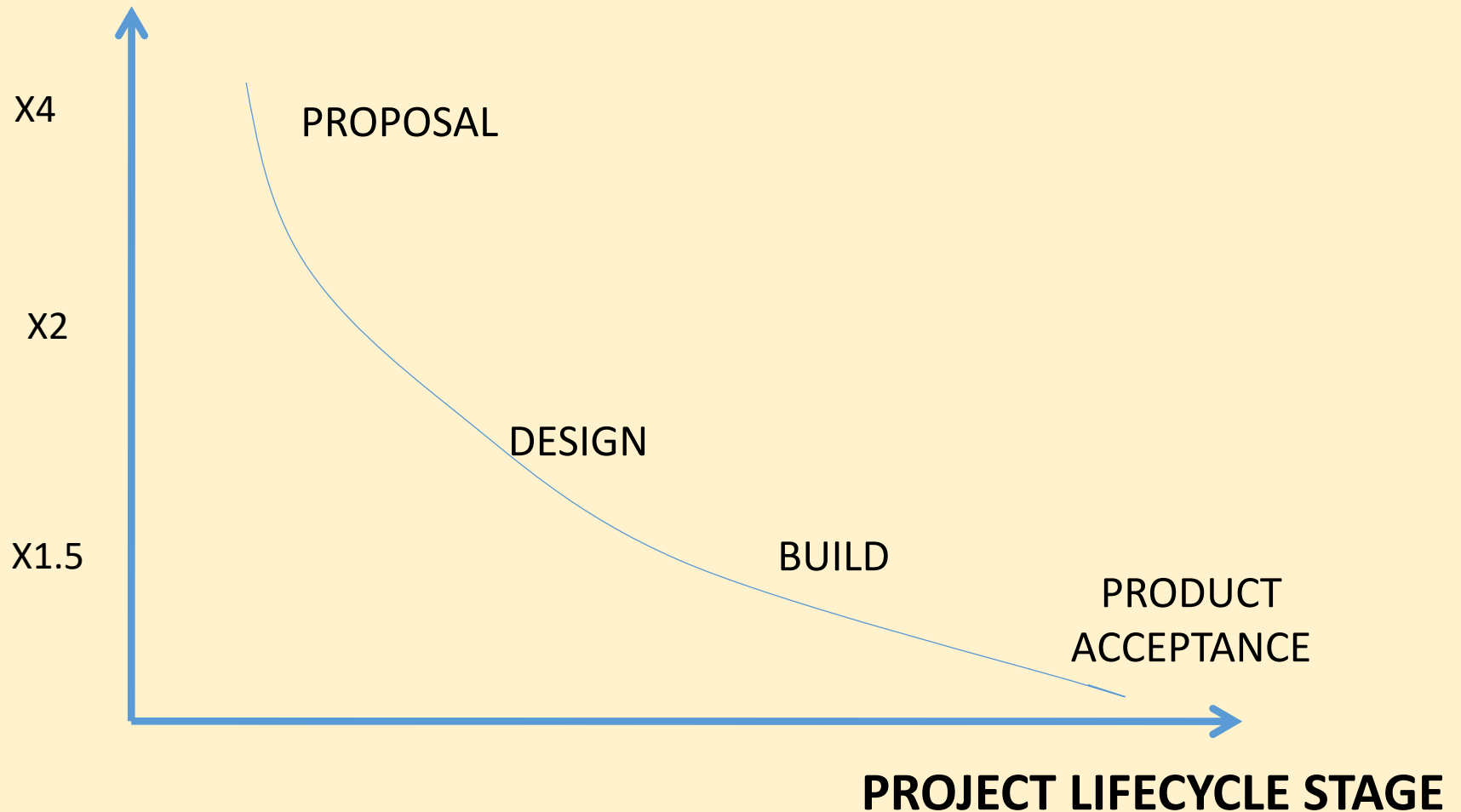
- Estimation Principles
- Estimation Techniques
- Cost Estimating

Estimation Principles

- Prediction of project costs, resources and durations
- The process of estimating maybe carried out several times during a project.
- Each providing greater accuracy and confidence than the one before

Accuracy by lifecycle stage

COST RANGE



Estimation Accuracy

REQUIREMENTS  ESTIMATE

- Proportional to:
 - Clearly defined and stable scope (WBS)
 - Known specification
 - Expert judgment available
 - Normal conditions

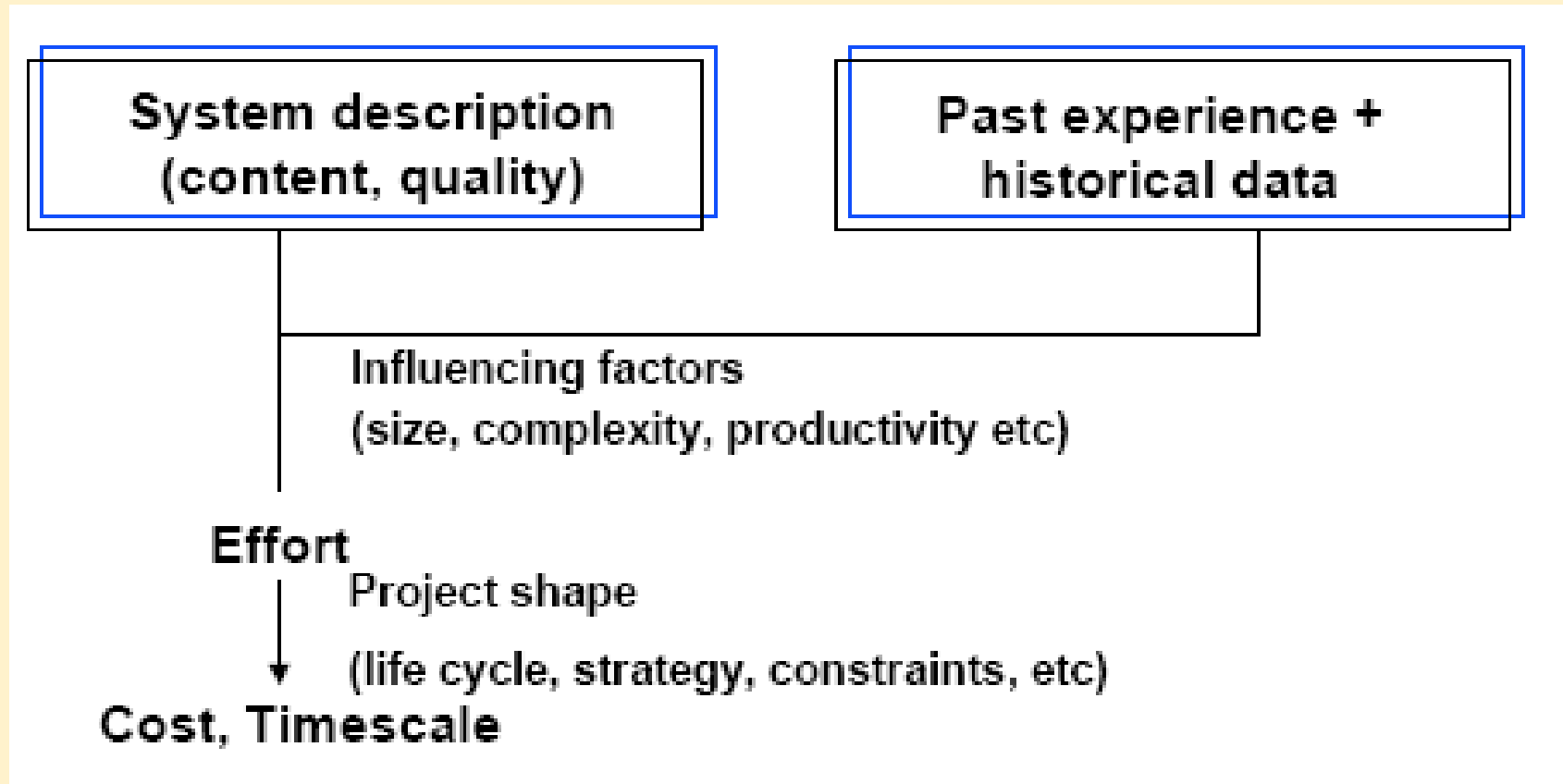
Useful guidelines for Estimating

- **Agree of scope and quality for product**
- Agree tolerances
- Review estimates frequently
- Maintain accurate historical data

Estimation Pitfalls

- Misinterpretation of Scope of work
- Omissions or improperly defined scope
- Poorly defined or optimistic schedule
- Inaccurate work breakdown structure
- Failure to account for risks
- Failure to understand or account for cost escalation and inflation
- Failure to use correct estimation technique

Basic Estimation Process



Estimation Problems

- Optimism
- Politics
- Poor Bid Management
- No Process
- No Magic Solution

Estimation Techniques

Estimation Techniques

- **Ballpark** – made only when vague information exists and when all details of the work have yet to be decided.
- **Analogy**- uses actual cost of a previous , similar project as a basis for current project.
- **Parametric**- this involves using project characteristics such as weight, volume, lines of software code, hours of contact and so on to predict project costs

Three Point Estimation

- **Most likely (cM)**- The cost of the activity, based on realistic effort assessment for the required work and any predicted expenses.
- **Optimistic (cO)**- The activity cost based on analysis of the best-case scenario for the activity.
- **Pessimistic (cP)**- The activity cost based on analysis of the worst-case scenario for the activity

- Triangular Distribution.

$$cE = (cO + cM + cP) / 3$$

- PERT Estimate

$$cE = (cO + 4cM + cP) / 6$$

Example- Estimating Durations:

Activity	Optimistic	Most Likely	Pessimistic	PERT Estimate
A	4	5	8	5.3
B	5	6	7	6
C	6	7	8	7
Total	15	18	23	18.3

Approaches to Estimation

- Top-Down
- Bottom-Up

Top-Down Estimating

- **Senior management sets budget**
- These are often fixed before detailed planning has taken place
- The trigger is usually the strategic long term plan in response to their perception of organization's goals and objectives
- Major drawback is that the budget is rooted in senior management's limited knowledge of specifics of the project
- Detailed information is not available when preparing long term plan

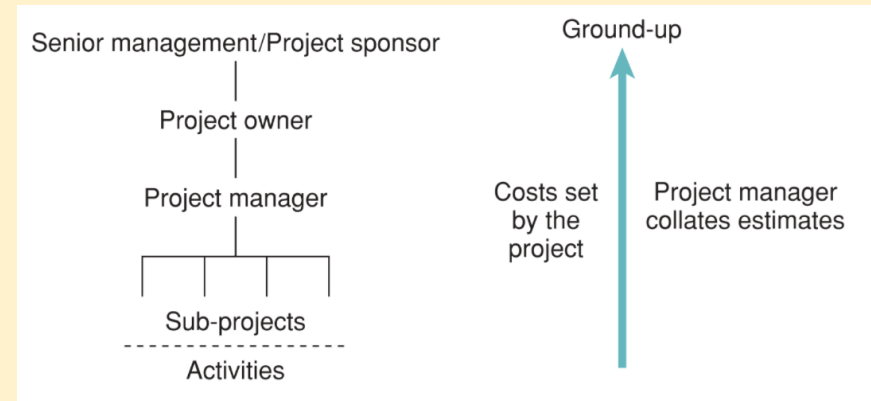
Bottom-Up Estimation

- Estimating **cost of individual work items** then rolling up the individual estimates to get a project total
- It begins at the lowest level of detail and is gradually extended up through the WBS
- Can only take place when a good project specification exists and a task list is compiled
- Basically it utilize the **WBS to develop a Cost Breakdown Structure (CBS)**

Bottom Up

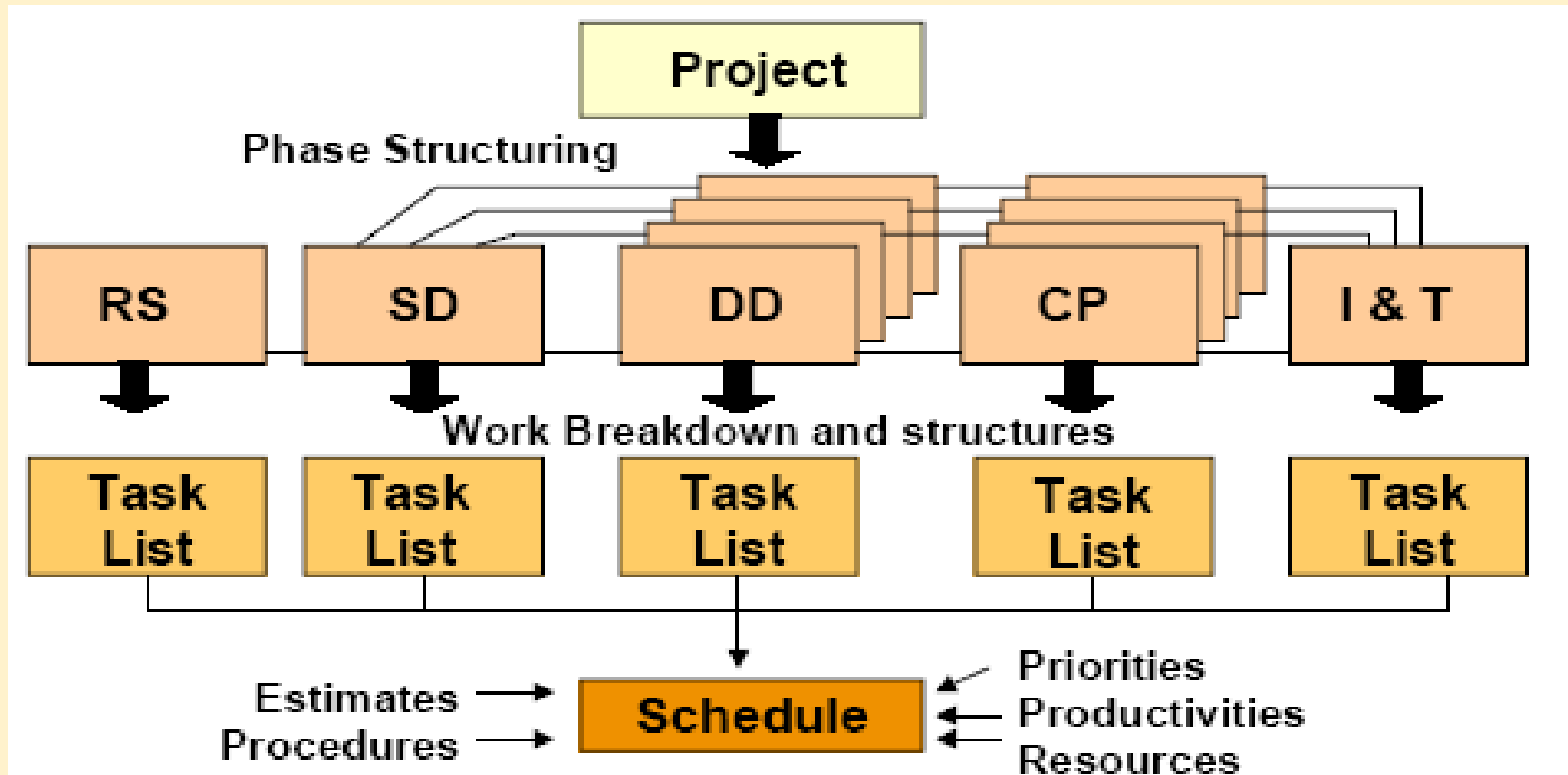
The Bottom Up approach:

- Project managers and planning/cost engineers prepare the budget based on a detailed analysis of all the resources required for the project tasks
- Once prepared, the project budget is passed up the chain of command for review and approval
- By definition bottom-up budgets tend to be more accurate and can have a positive impact on project morale because staff have played an active role in the budgeting process (rather than having a budget imposed on them from above)



(Maylor, 2017, pp. 177)

Example of Bottom Up

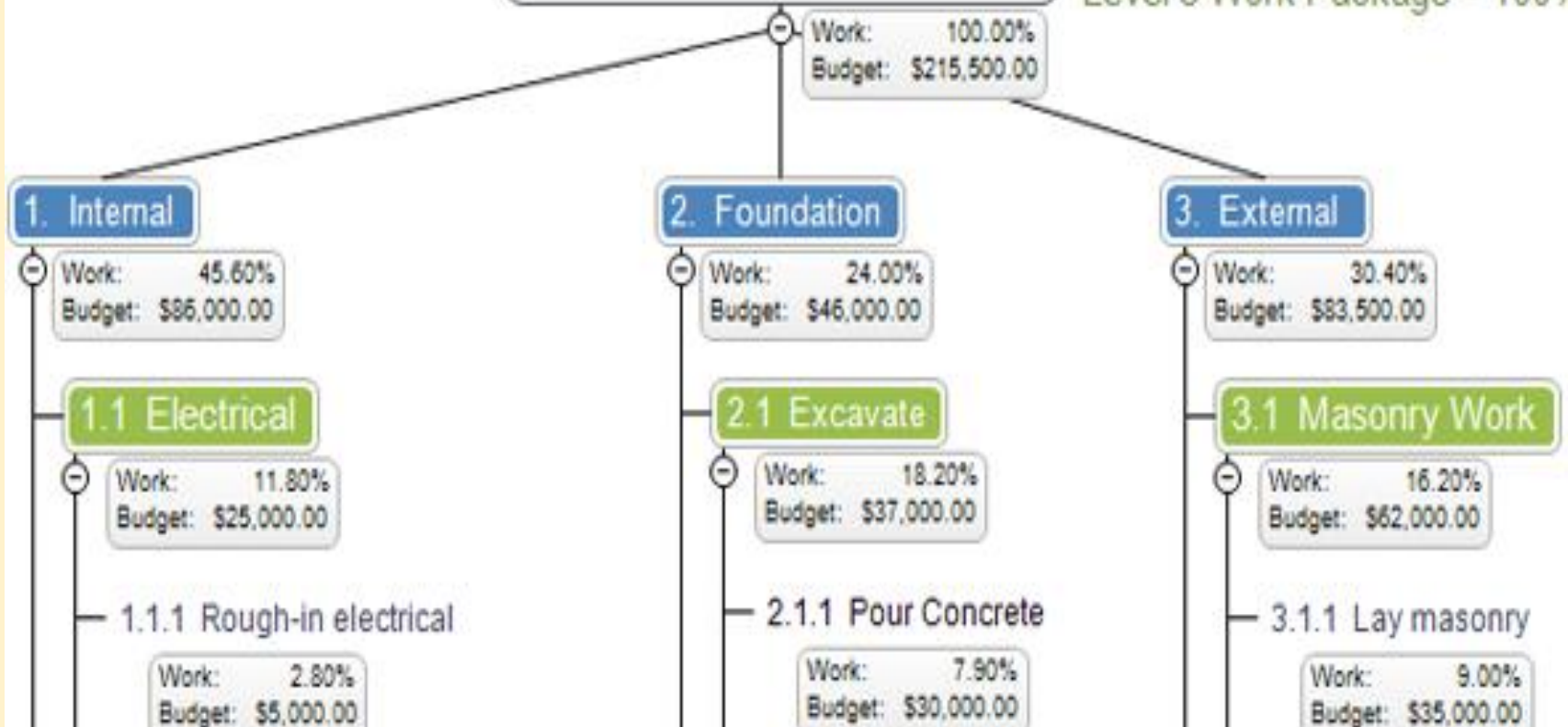


Construction of a House

Level 1 Deliverables = 100%

Level 2 = 100%

Level 3 Work Package = 100%



Resourcing

Project Resourcing



- Once a project plan has been drafted (but not finalised), resources can be estimated and attached to the plan



- This is a valuable exercise – evaluating at an early stage the potential **impact of any resource constraints** on a proposed schedule...



- ... and facilitate resource-based budgeting to develop a detailed “bottom up” budget for the entire project


What is meant by the term: 'Resource'?

- A project may have an excellent plan but this is of little use unless the plan can be carried out in practice
- This leads us to consider the important question: Just what things do we need to carry out the project? (i.e. the resources required)
- Quickly followed by quantifying:
 - How many of each thing do we need?
 - How much will they cost?
 - What is the overall total cost?
(the project budget)

Resource categorisation

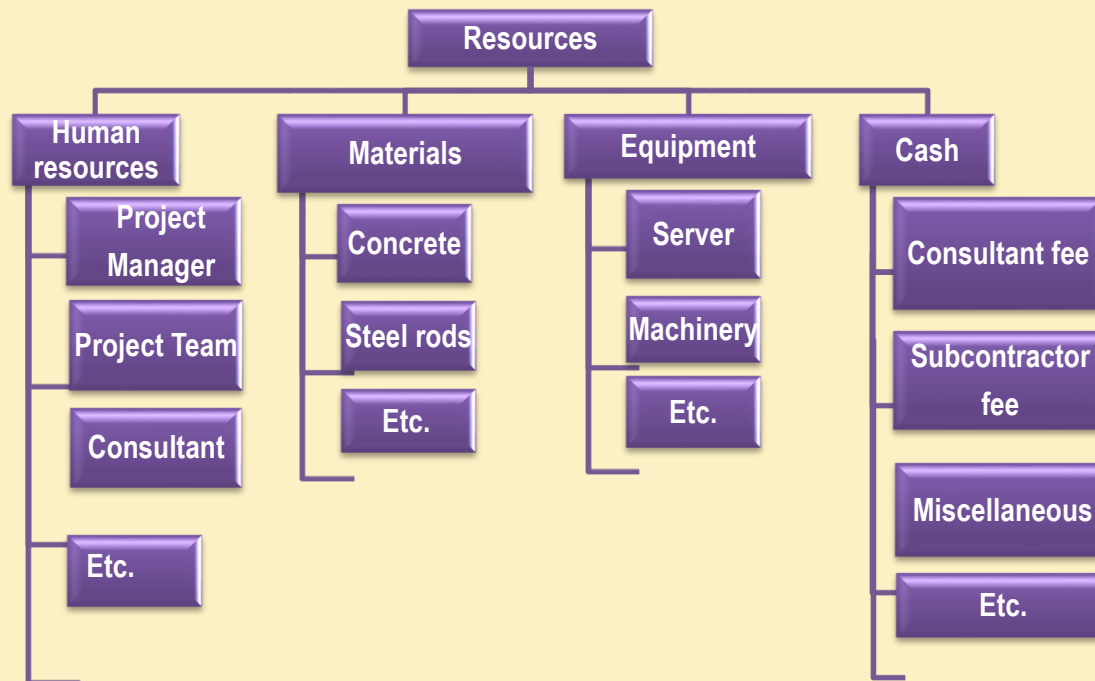
There are generally four resource categories on every project:

1. Human Resources
2. Materials
3. Equipment

 Can you think of an example of each type?

Resource Breakdown Structure

Resource breakdown structure - A hierarchical representation of resources by category and type (PMI, 2021, p. 187 and 247)



Resources – key questions to ask?

- Is the cost of each resource **time-based** or **fixed**?
- How easy is to determine the **cost accurately**?
- Has every project resource requirement been identified and quantified? **Nothing missed**?
- Are the projected costs **firm quotations** or **just estimated costs** that may change?
- Is there a need for **contingency**?
- Have we made **allowance for risks**?

Resource Optimization

- Two main types of schedules
 - Resource limited
 - **Time limited**

- **Resource Constrained** - Levelling, allowing end date to move
- **Time Constrained** – Smoothing, moving tasks
 - Splitting activities
 - Assigning replacement resources

Optimizing through Resource Levelling and Smoothing

- When you assign resources (staff) to a project it can often lead to **over allocation or staff conflict**
- For example **resource A is assigned to** an activity on **Project XYZ** on a day, for 8 hours. This resource is also allocated to **Project LMN** for 8 hours in a day
- Or resource A is assigned to work on multiple activities on a project occurring at the same time
- **How do we resolve this?**

Resource Levelling

- **Resource Levelling** can be applied to projects when there are ***Resource Constraints***.
- Resource Levelling forces the amount of work scheduled NOT to exceed the limits of the resources available.
- This results in either the activity durations being extended or entire activities being delayed to periods when the resource is available.
- NB. This often results in longer project durations.

Resource Levelling

- A technique in which start and finish dates are adjusted based on resource constraints with the goal of balancing demand for resources with the available supply
- This involves removing the over allocation of resources. **This can be done by:**
 - Delay certain task
 - Assign a different resource
 - Change task dependencies

Resource Smoothing

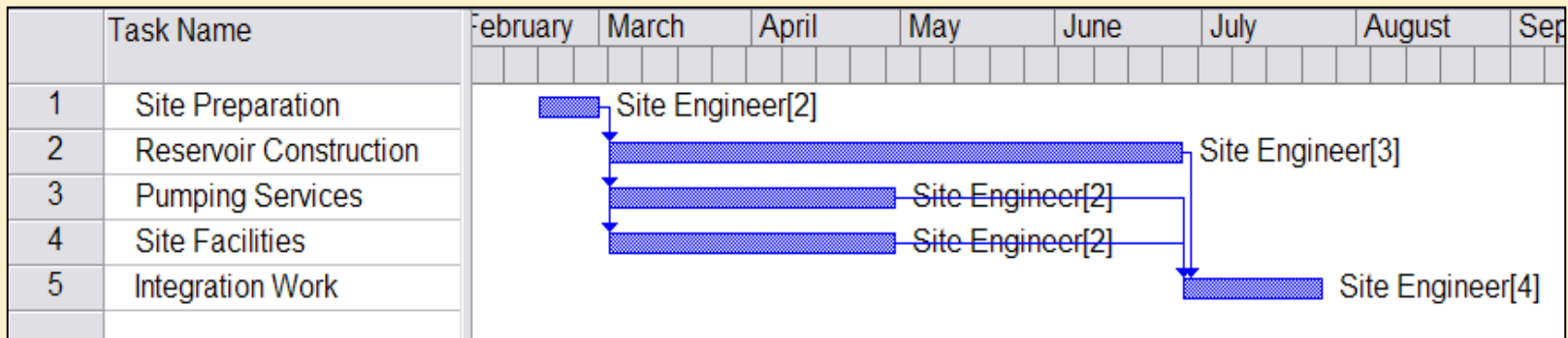
- **Smoothing** is the process applied to a project to ensure that resources are used as *efficiently* as possible.
- It involves **utilising float/slack** within the project or increasing or decreasing the resource required for specific activities
- So that peaks and troughs of the resource usage are 'smoothed out'.
- **NB. Smoothing does not affect the end date of the project duration**

Resource Smoothing

- Resource smoothing means the uniform distribution of resource allocation over the project
- Let's say that you have a resource working 30 hours this week, 10 hours next week, and 20 hours the week after next week.
- When you apply resource smoothing, the resource will work 20 hours this week, 20 hours next week, and 20 hours the week after. You see, the total amount of hours remains 60 hours, but is more uniformly distributed over the weeks.

Resource levelling or “smoothing” ??

- Consider the following simple construction project example:

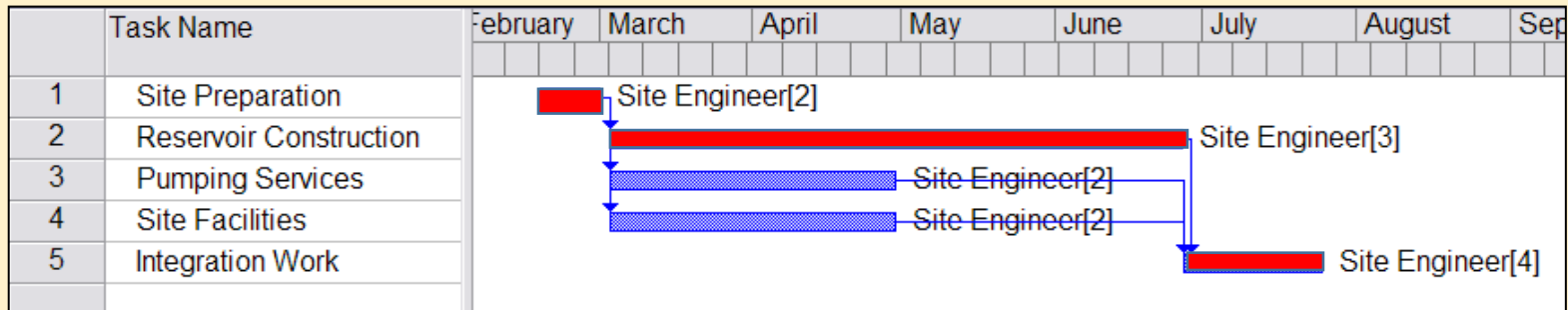


- 5 Site Engineer maximum allowed
- Note that Task 2 (16w) is twice as long as Tasks 3 and 4 (8 weeks).
- Task 1 is 2 weeks and Task 5 is 4 weeks

💬 What is the critical path?

Critical Path

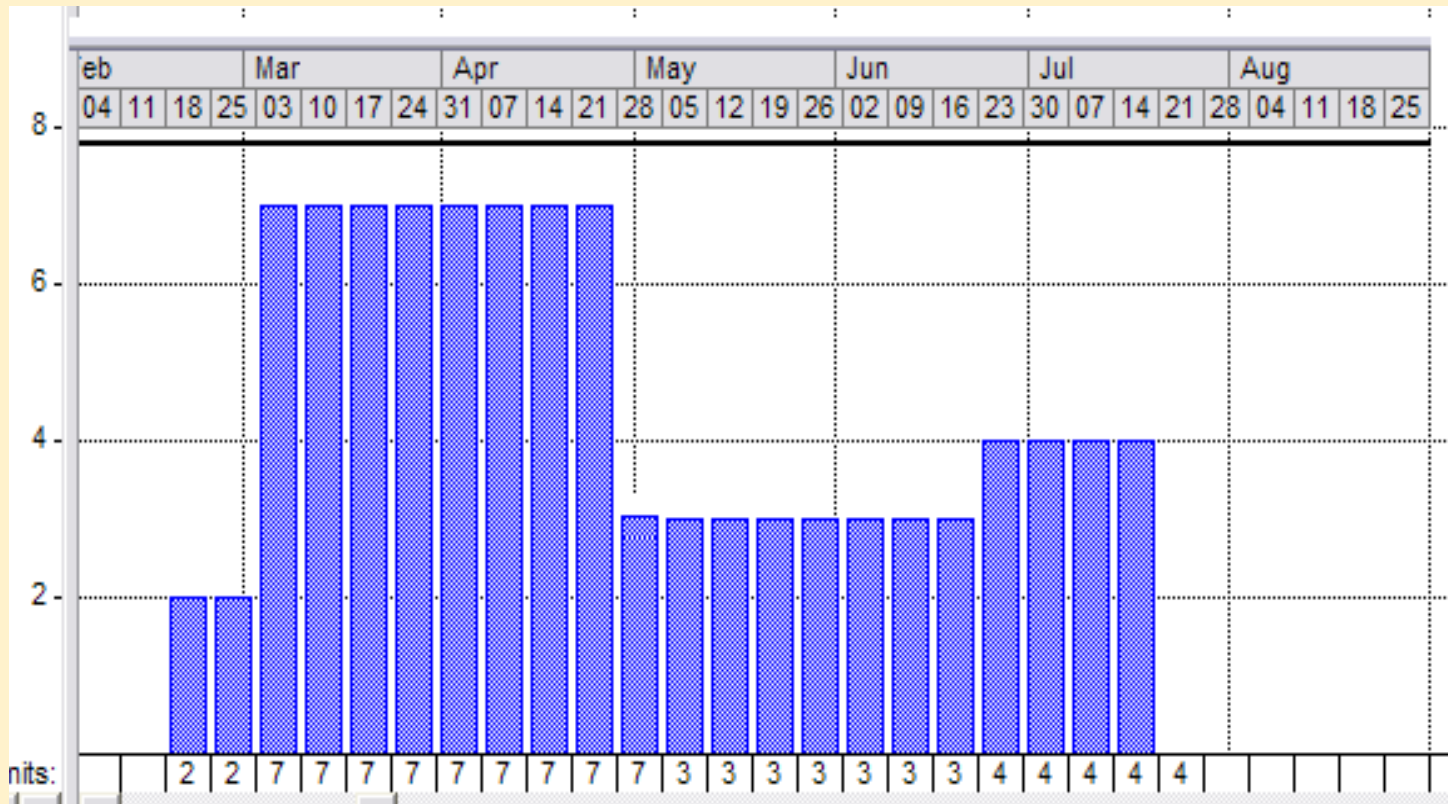
What is the critical path?



The resource histogram

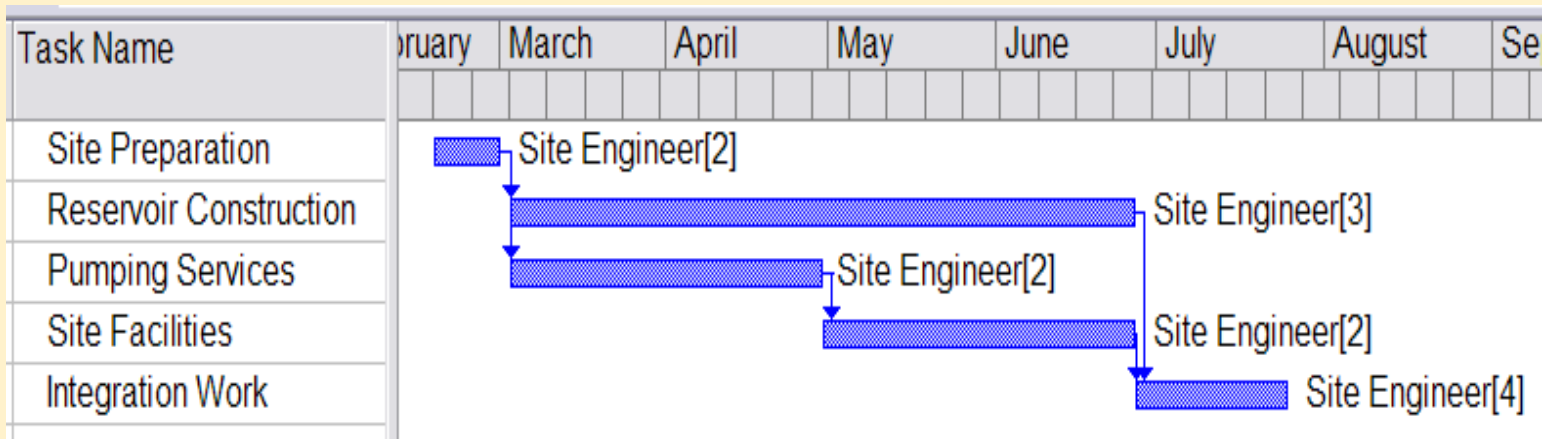
(based on the previous schedule)

What is this profile indicating? Any evidence of potential staffing problems?



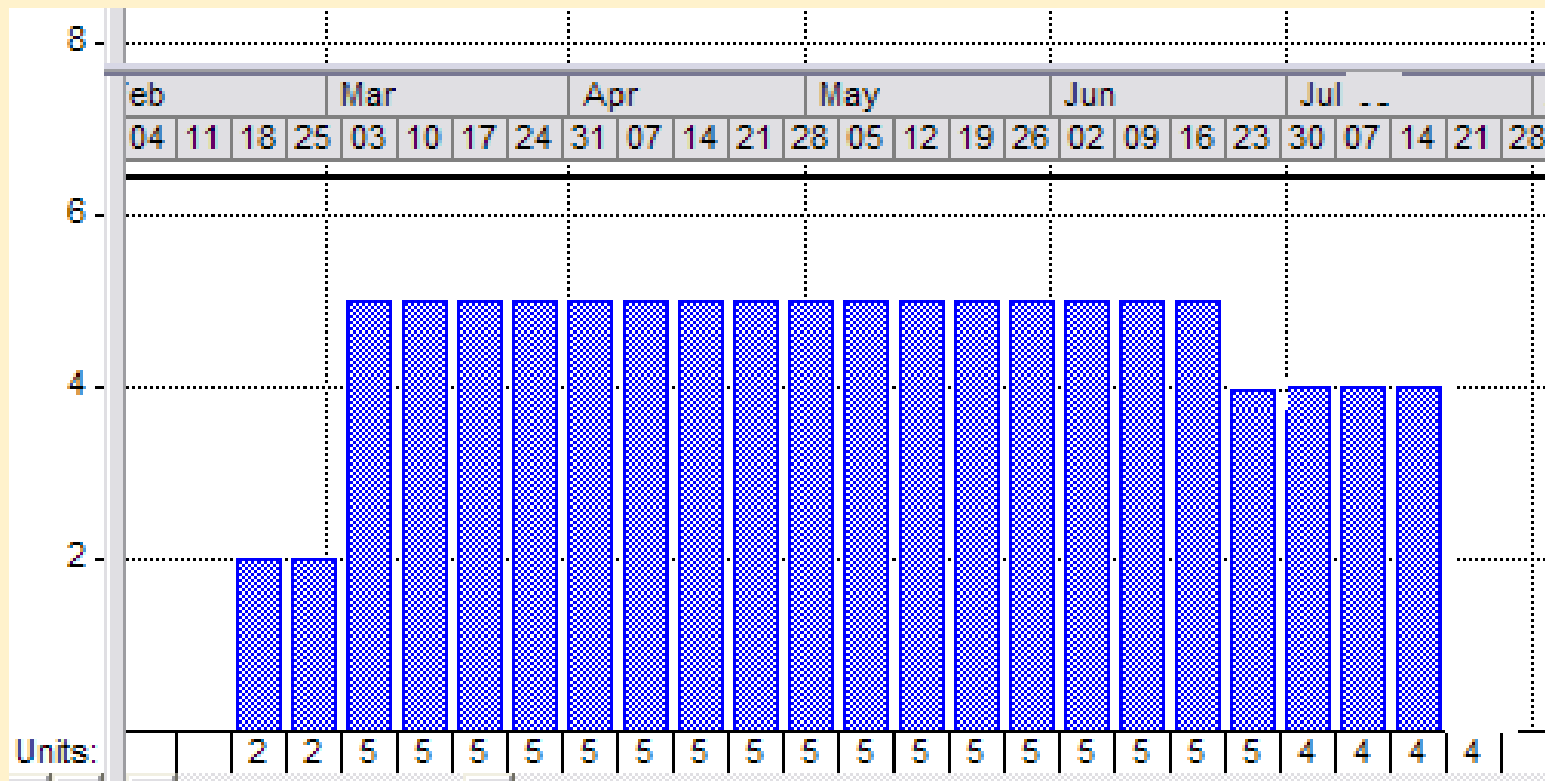
Resource Smoothing with permissible float

- Site Facilities now rescheduled to follow Pumping Services – no effect on overall project duration but a resourcing benefit



A smoother histogram

Resource profile for Site Engineers now much smoother - and easier to recruit/mobilise/manage

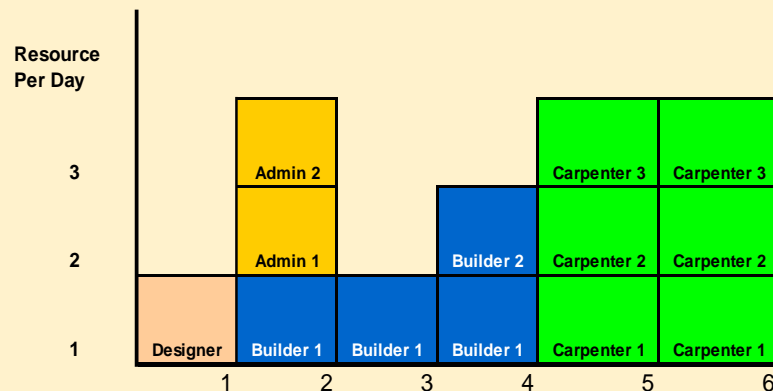


Activity- Resource Smoothing and Levelling

The Problems

1. Only one admin resource is available for the project and they are currently scheduled to do both Activity 3 and Activity 5 on Day 2 of the project.
 2. Only two carpenters work for the organisation so clearly there is an over demand on Activity 6.
- What actions can the Project Manager carry out to take these problems into consideration?

Activity	Description	Predecessor	Resource	Number	1	2	3	4	5	6
1	Design Warehouse	n/a	Des Designer	1	1					
2	Prepare Site	1	Bob Builder	1		1	1			
3	Order Concrete	1	Amanda Admin	1		1	=====			
4	Lay Concrete	2,3	Bob Builder	2				2		
5	Order Building Materials	1	Amanda Admin	1		1	=====	=====		
6	Build Warehouse	4,5	Chip Carpenter	3					3	3
Aggregated Total					1	3	1	2	3	3
Cumulative Total					1	4	5	7	10	13



Smoothing

- Smoothing out resources (duration not affected)
- Some free slack/float – activity 5 moved to day 3

Activity	Description	Resource	Number	1	2	3	4	5	6
1	Design Warehouse	Des Designer	1	1					
2	Prepare Site	Bob Builder	1		1	1			
3	Order Concrete	Amanda Admin	1		1	====			
4	Lay Concrete	Bob Builder	2				2		
5	Order Building Materials	Amanda Admin	1		1	1	====		
6	Build Warehouse	Chip Carpenter	3					3	3
		Aggregated Total		1	2	2	2	3	3

Resource	1	2	3	4	5	6 days
3		Admin				Carpenter 3
2		Admin	Admin	Builder 2	Carpenter 2	Carpenter 2
1	Designer	Builder 1	Builder 1	Builder 1	Carpenter 1	Carpenter 1

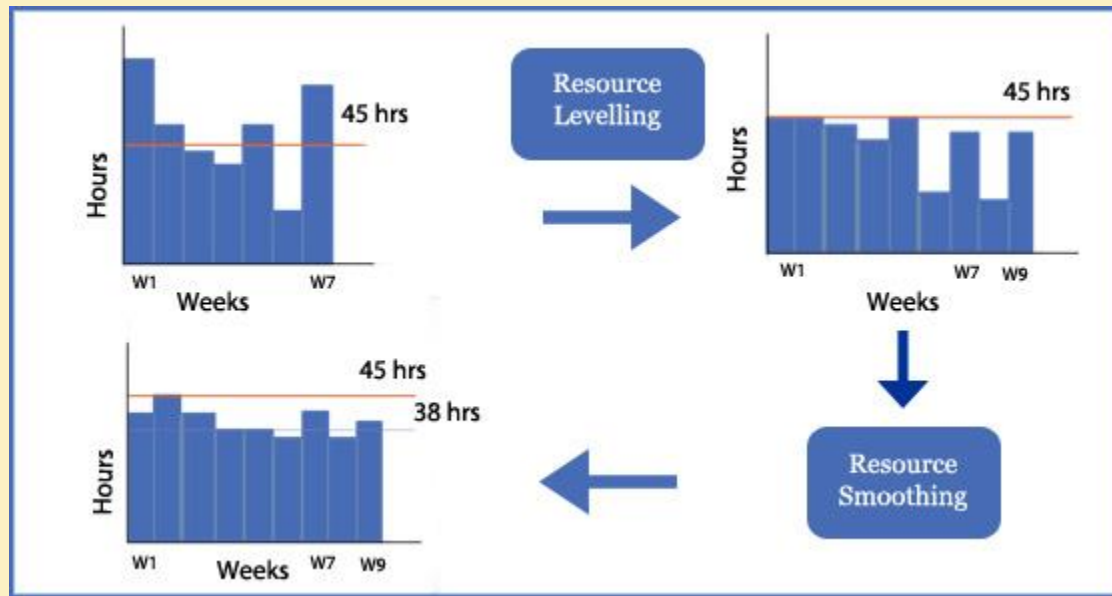
Levelling

- Levelling resources (duration may be affected)
- Resource limited – 2 Carpenters – extends the project time

Act.	Description	Resource	Number	1	2	3	4	5	6	7
1	Design Warehouse	Des Designer	1	1						
2	Prepare Site	Bob Builder	1		1	1				
3	Order Concrete	Amanda Admin	1		1	====				
4	Lay Concrete	Bob Builder	2				2			
5	Order Building Materials	Amanda Admin	1			1	====			
6	Build Warehouse	Chip Carpenter	3					2	2	2
		Aggregate		1	2	2	2	2	2	2

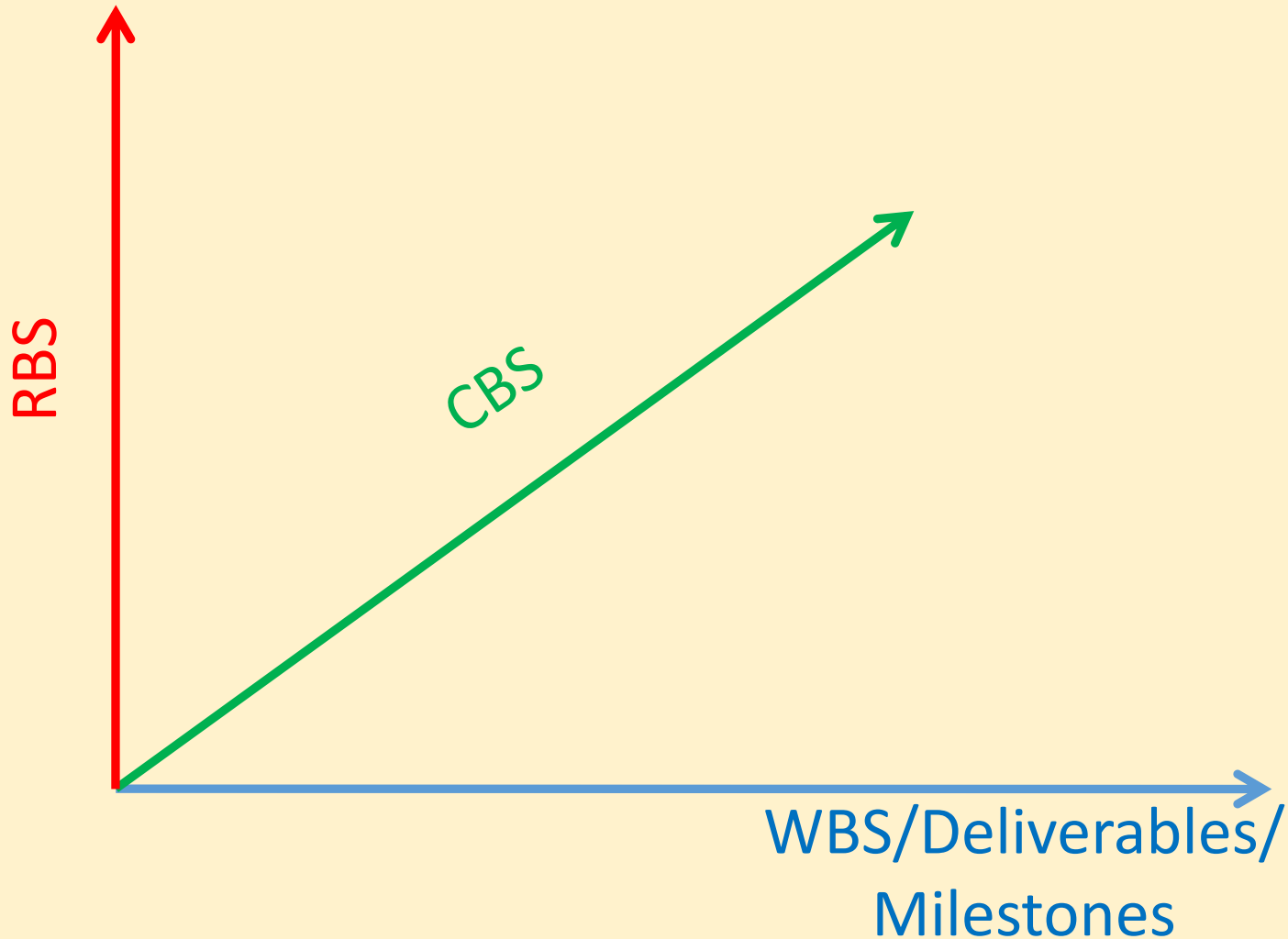
Resource	1	2	3	4	5	6	7 days
3						Carpenter 3	Carpenter 3
2		Admin	Admin	Builder 2	Carpenter 2	Carpenter 2	Carpenter 2
1	Designer	Builder 1	Builder 1	Builder 1	Carpenter 1	Carpenter 1	Carpenter 1
	1	2	3	4	5	6	7 days
						Old End Date	New EndDate

Summary-Levelling and Smoothing Scenario

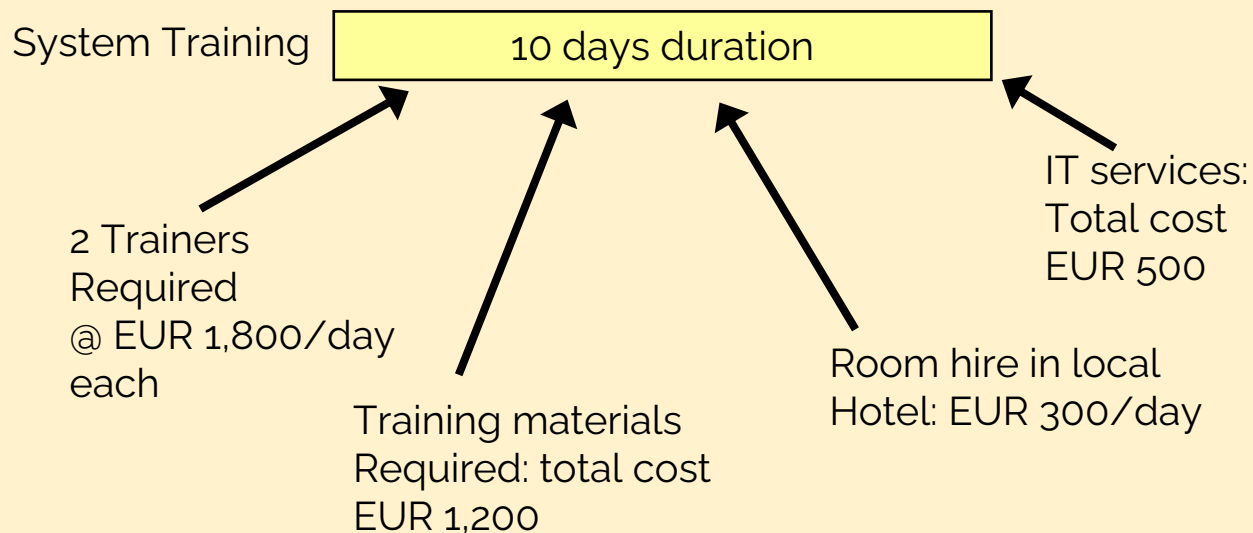


Costing

Cost Breakdown Structure (CBS)

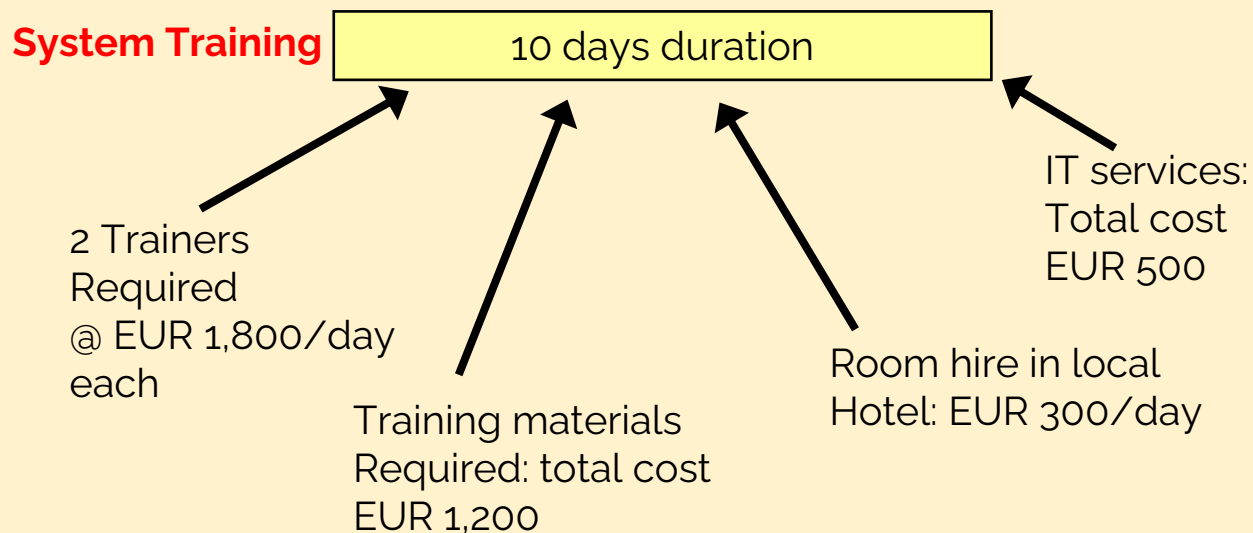


Simple single task example



What is the total budget cost in Euros for this task?

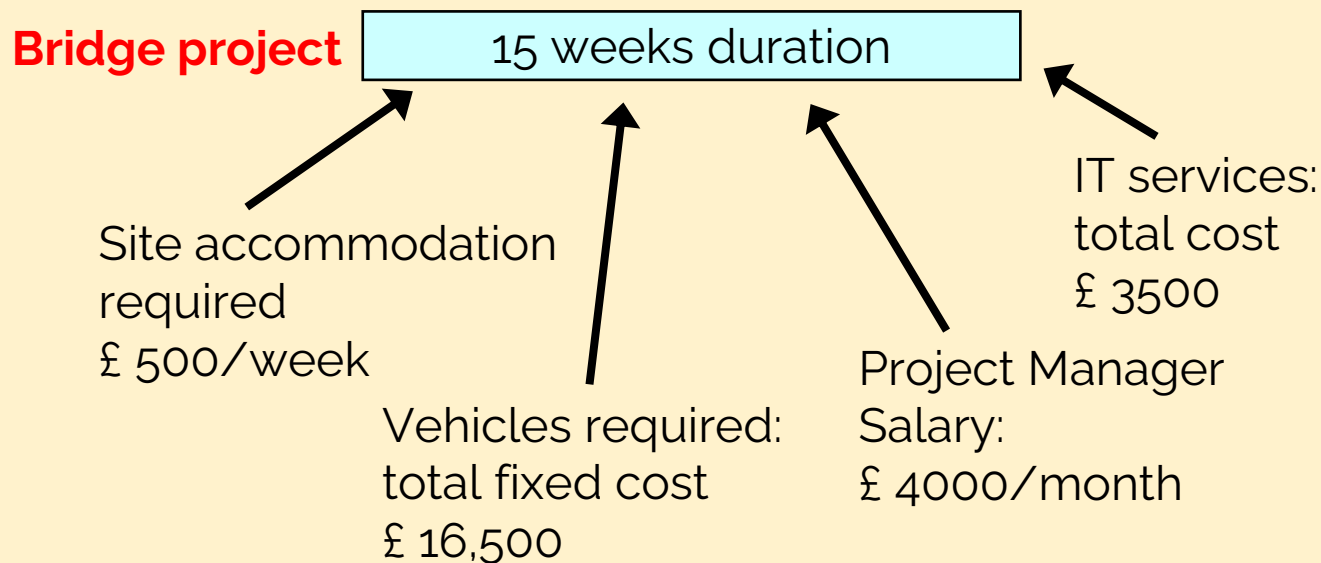
Answer: Simple single task example



What is the total budget cost in Euros for this task?

$$(2 * 1800 * 10) + 1200 + (300 * 10) + 500 = \text{€}40,700$$

Some costs are related to the overall project (not a single task)



What is the total budget cost for these resources?

Cost categories

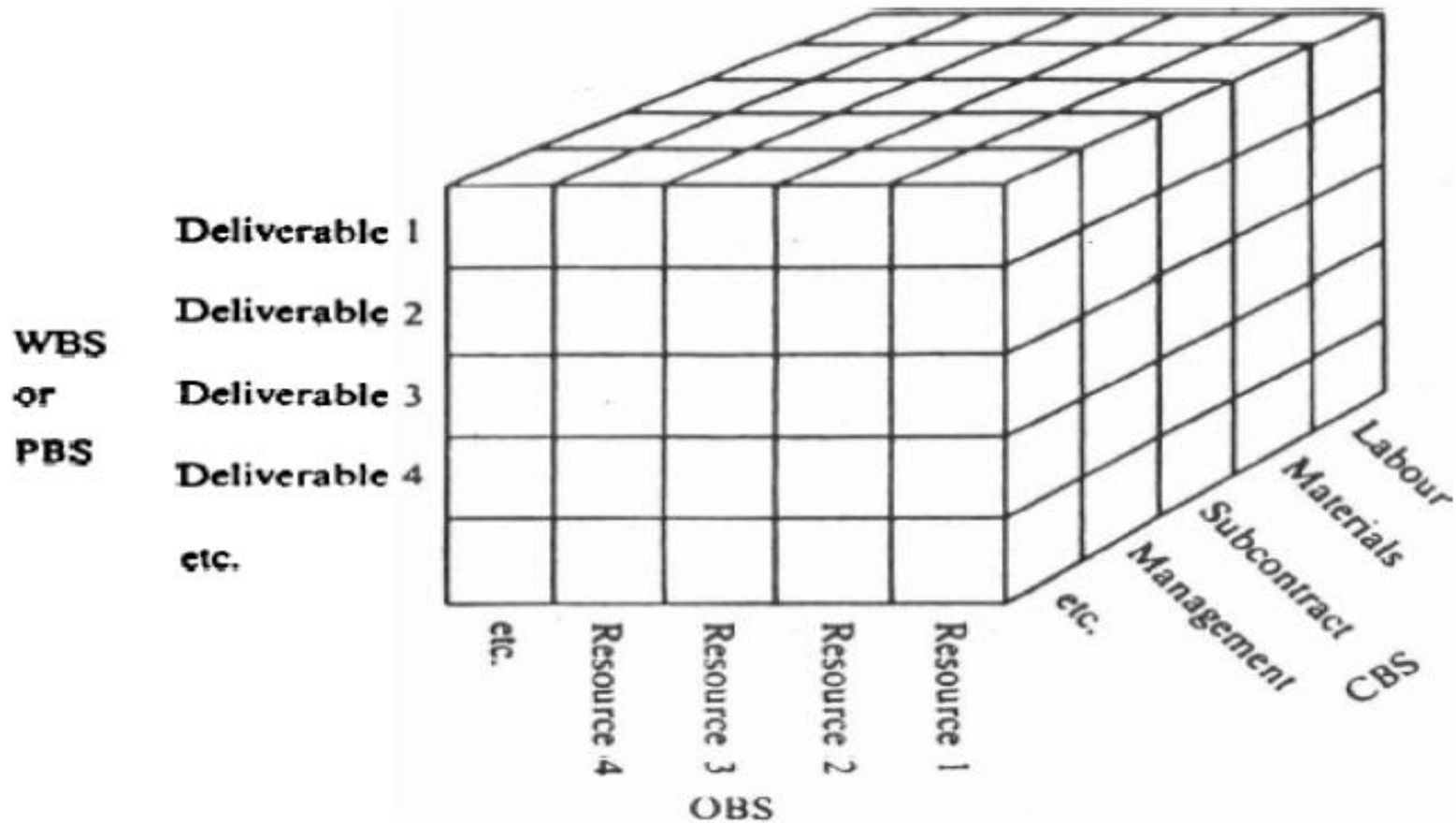
- **Time/Labour** – Direct input of labour into tasks
- **Materials** – consumables and other items using in the process
- **Capital Equipment** – the purchase of the means of providing the conversion process, or part of its cost, maintenance, running and depreciation offset against activities
- **Overheads** – provision of an office, financial and legal support, managers and non-direct staff
- **Contingency** – margin/allowance

(Maylor, 2017, pp. 178)

Turner (2009) Cost Elements

- Labour
- Materials
- Plant and Equipment
- Subcontract
- Management
- Overheads and Administration
- Fees and Taxation
- Inflation
- Contingency
- **Financing**

Cost Control Cube



Contingency

- Contingency reserves are **within the cost baseline** that is allocated for identified risks, which are accepted and for which contingent or mitigating responses are developed.
- Contingency reserves are often viewed as the part of the budget intended to address the “**known-unknowns**” that can affect a project.
- Contingency reserves can provide for a specific activity, for the whole project, or both.
- The contingency reserve may be **a percentage of the estimated cost**, a fixed number, or may be developed by using quantitative analysis methods.
- Contingency reserves are part of the cost baseline and the overall funding requirements for the project.

Management Reserves

- Management reserves are an amount of the project budget **withheld for management control purposes**
- It is reserved for **unforeseen work** that is within scope of the project.
- Management reserves are intended to **address the “unknown unknowns”** that can affect a project.
- The management reserve is **not included in the cost baseline** but is part of the overall project budget and funding requirements.
- When an amount of management reserves is used to fund unforeseen work, the amount of **management reserve used is added to the cost baseline**, thus requiring an approved change to the cost baseline.

- **Cost Estimate**

- The cost estimate is the cost of all work packages and is “rolled up” to the top level; this is the total cost of the project.

- **Cost Baseline**

- When you **add the contingency reserve** to the cost estimate, you get the cost baseline.

- **Cost Baseline = Cost Estimate + Contingency Reserve**

- Note that the project’s performance will be measured against the cost baseline.

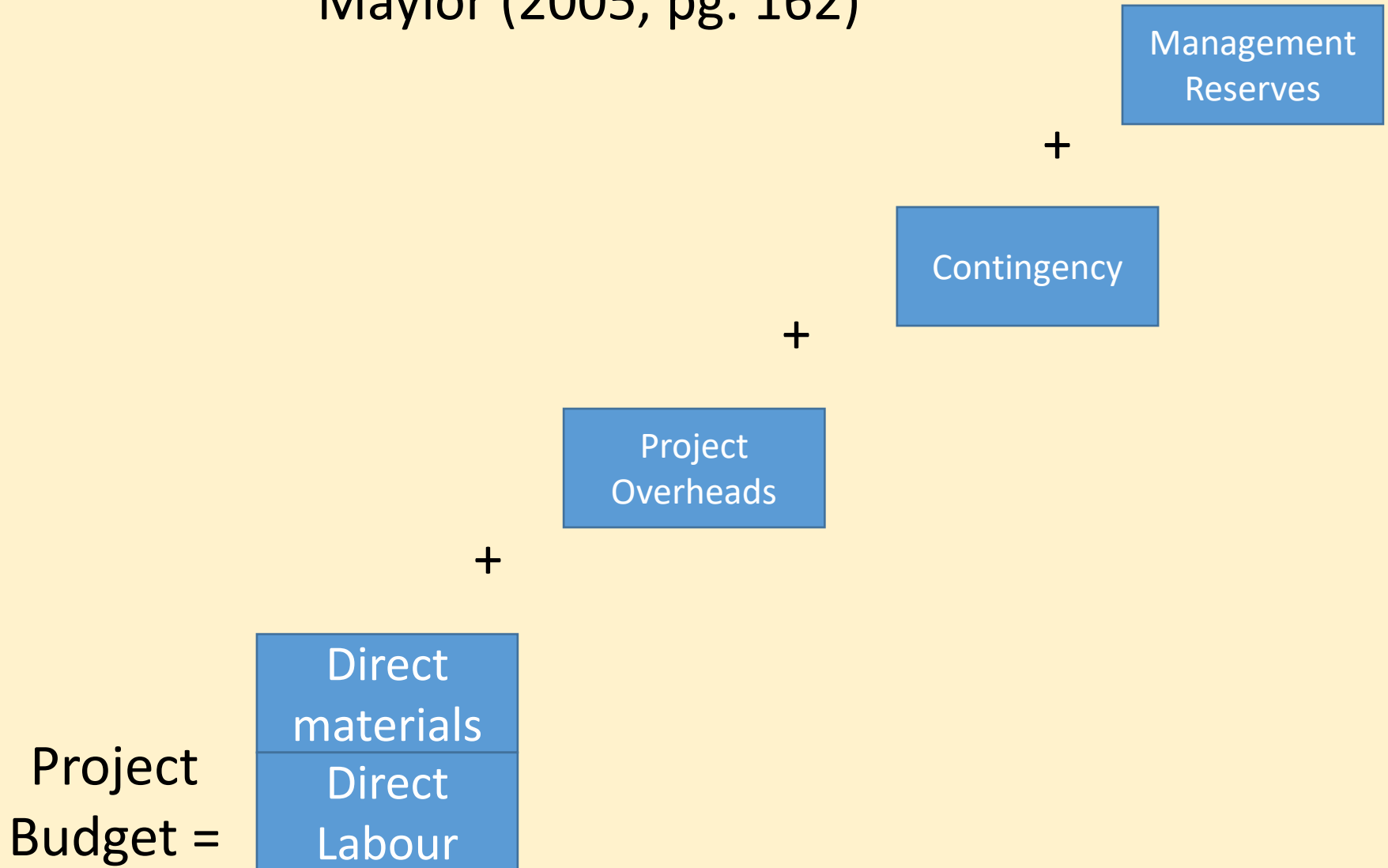
- **Project Budget**

- If you **add the management reserve** to the cost baseline, you will get the project budget.

- **Project Budget = Cost Baseline + Management Reserve**

Elements of Costs

Maylor (2005, pg. 162)



Above-the-line items	Direct (variable) costs	Direct labour	The wages and salaries of people employed on the project, for time that can be wholly and specifically attributed to the project. These times should be costed at the standard cost rates applicable to each grade of staff.
		Direct materials	Equipment, materials and bought-out services used specifically on the project.
		Direct expenses	Travel, accommodation and other costs chargeable specifically to the project. Can include the hiring of external consultants.
	Indirect (fixed) costs	Overhead costs	A portion of the costs of running the business, such as general management and accommodation. Usually calculated as a proportion of total direct costs. Not applicable if the project is itself charged as an overhead.
		Contingency sum	An addition, usually calculated as a small percentage of the above-the-line costs, in an attempt to compensate for estimating errors and omissions, unfunded project changes and other unexpected costs.
	Below-the-line items	Escalation	An addition to allow for costs that increase with time as a result of annual cost inflation. Particularly important for long-duration projects in times when national cost inflation rates are high.
Mark-up for profit		These two items apply only to projects sold to external clients. There are various ways in which they can be calculated and their levels are often judged according to the strength of the competition and what the market will stand. These are management decisions, not part of the cost estimating process. Such decisions are always more easy to make when there is confidence in the cost estimating accuracy.	
Selling price			
Provisional sums		The estimated costs of items that are not included in the quoted price which might have to be charged extra if the need for them is revealed as project work proceeds.	

Budget Formats- Vertical

Task	Resource	Duration (days)	Rate/day	Direct Labour Cost
Analysis of Cost Planning	C1	20	1,600.00	32,000.00
	C2	20	1,600.00	32,000.00
Detailed Analysis of the Effectiveness of Project Planning	C1	5	1,600.00	8,000.00
	C2	0		
Improvement of Project Planning Processes	C1	10	1,600.00	16,000.00
	C2	15	1,600.00	24,000.00
Detailed Description of Project Planning Metrics	C1	20	1,600.00	32,000.00
Selection of Project Planning Software	C1	30	1,600.00	48,000.00
	C2	20	1,600.00	32,000.00
Meeting with Supplier	C1	0	1,600.00	-
	C2	10	1,600.00	16,000.00
Discussion of Report with MD	C1	1	1,600.00	1,600.00
Writing of Final PMO Report	C2	10	1,600.00	16,000.00
Presentation of Final PMO Report	C1	1	1,600.00	1,600.00
				259,200.00
OTHER LABOUR COST				
S1			13,000.00	
S2			13,000.00	
SPO			21,000.00	
				47,000.00
TOTAL LABOUR COST				306,200.00
OVERHEADS				
Accomodation			11,700.00	
Travel			16,000.00	
Meetings			25,000.00	
				52,700.00
FIXED COST				
PC hardware			15,000.00	
Software			25,000.00	
Miscellaneous			8,000.00	
				48,000.00
Training Cost				50,000.00
Cost Estimate				763,100.00
Contingency 10%				76,310.00
Baseline Cost				839,410.00
Management Reserve				10,590.00
Project Budget				850,000.00