COMPUTER SCIENCE AND INFORMATION TECHNOLOGY RMIT University

Software Engineering Project Management

Chapter 10: Resourcing in Project Management

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Learning objectives text.

Course Materials

Online Course Material

Please select a subtopic to view its contents.

Additional Materials

There are no additional materials available at this time.

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COMPUTER SCIENCE AND INFORMATION TECHNOLOGY RMIT University

Software Engineering Project Management

Chapter 10: Resourcing in Project Management

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Resourcing in Project Management

Learning outcomes

- Upon completion of this lecture you should be able to:
  - understand the concepts of resource leveling and resource loading in project scenario
  - understand basics of budgeting in a project

Expediting a Project (Assumptions)

1. Smaller problem to avoid unnecessary arithmetic
2. Problem set in a deterministic world
3. All estimates of task duration are based on normal (or standard) resource loadings

Expediting a Project (Approaches)

1. The critical path method
2. Fast-tracking a project Project expediting in practice
   a. Opportunities before the project begins
   b. Opportunities when the project is underway

The Critical Path Method

- Normal duration estimates
- Normal costs
- Crash duration estimates
- Crash costs
- Crash cost per day

Notes on Crashing

- Important to make sure the resources required to crash the project are available
- Technology may be used to crash an activity
  - Using Ditch Witch to dig a trench rather than adding more workers
- May have to expedite tasks not on critical path to make resources available to other projects
- Some tasks cannot be crashed

How to Crash

- Start with the normal schedule
- Select activities to crash, one at a time
  1. Focus on the critical path(s)
  2. Select least expensive activity to crash
- Calculate slope information on activities to crash

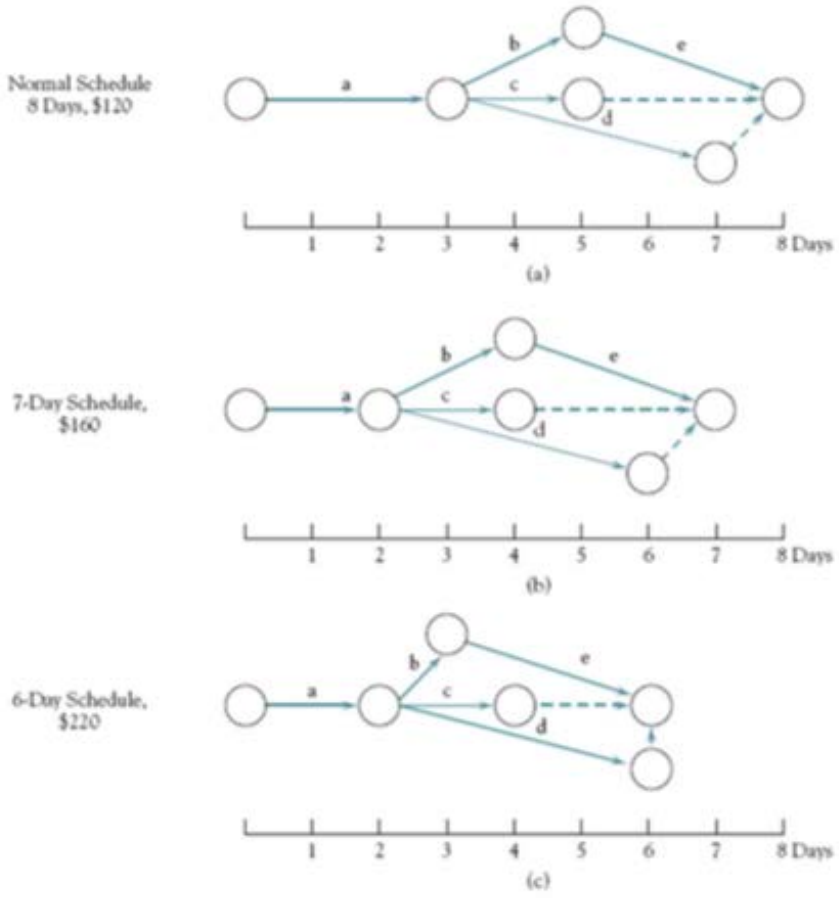
Slope = (crash time - normal time) / (crash cost - normal cost)

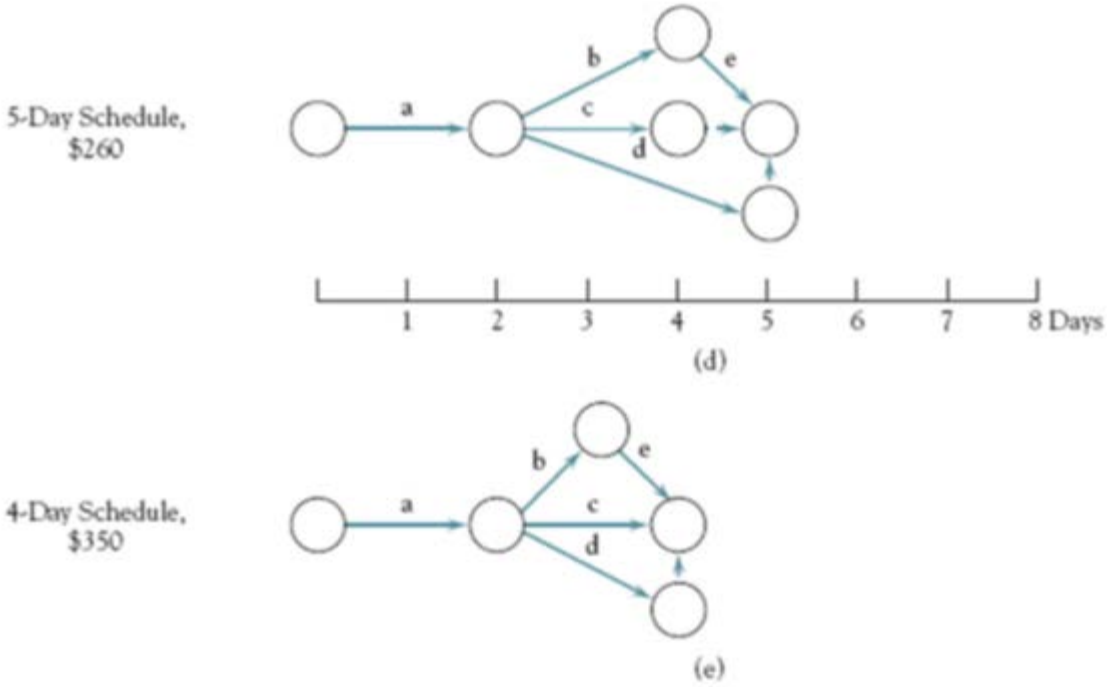
An Example of a Normal/Crash Project

Activity	Precedence	Duration, Days (norm/crash)	Cost (norm/crash)	Slope ($/day)
a	—	3, 2	$ 40, 80	40/ − 1 = − 40
b	a	2, 1	20, 80	60/ − 1 = − 60
c	a	2, 2	20, 20	—
d*	a	4, 1	30, 120	90/ − 3 = − 30
e**	b	3, 1	10, 80	− 70 (2 days)

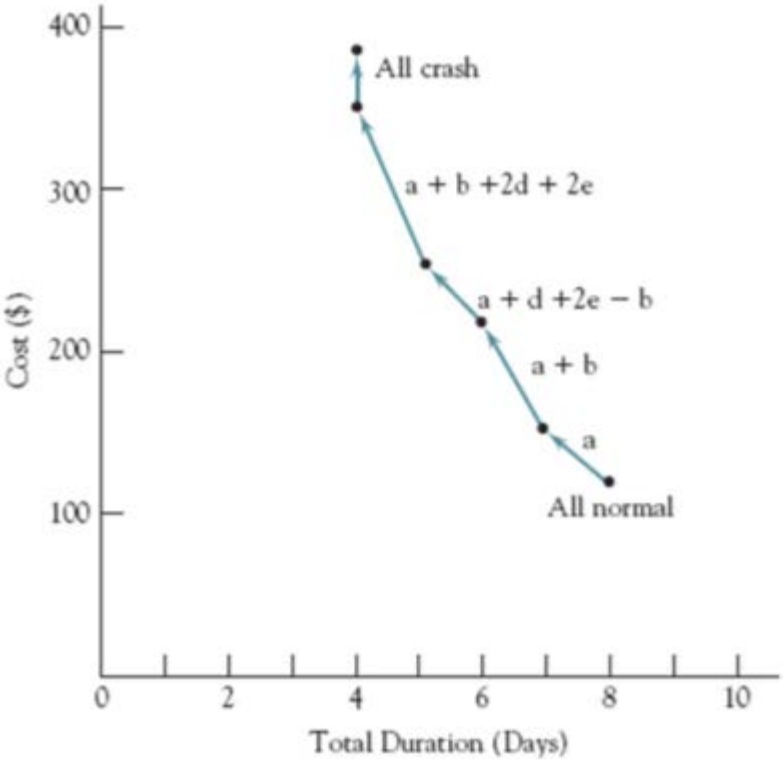
*Partial crashing allowed
**Partial crashing not allowed

A PERT/CPM Example of Crashing a Project, AOA Network





CPM Crash Cost- Duration History



Fast-Tracking a Project

- An expediting technique in which one phase of the project is started before preceding phases are completed
- Used in the construction industry when the building phase is started before the design and planning phases are complete
- This technique is particularly appropriate when large proportion of work is routine

Project Expediting in Practice

1. Project manager may know ahead of time that this project is time-critical and needs to be finished as early as possible
2. Project manager may during project that it needs to be finished earlier
3. Something delays the project and time needs to be made up

Opportunities Before the Project Begins

- Most projects have one time estimate
- Many projects have a project “buffer”
- A project time contingency may be added as well ! Can monitor key activities closely
- May order long-lead time items early

Opportunities When the Project Is Underway

- Focus on critical path
- Use contingency time
- Pull resources from less critical activities
- Move buffers to more critical activities
- May skip less critical steps
- May postpone activities involving non-core members ! Move activities to post-project phase
- May run activities in parallel or use weekends
- Pressuring team to work faster
- Get additional resources for overtime or more people ! May reduce scope
- May wait and see
-

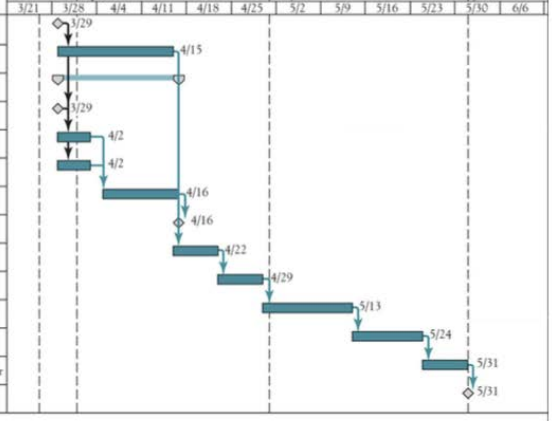
Resource Loading

- Refers to the amounts of specific resources that are scheduled for use on specific activities or projects at specific time
- It is usually presented in the form of a list or table
- Will see using short documentary DVD example

Project Plan and Gantt Chart for Production of a Short Documentary Film

Producing a Documentary Film
A. J. Lucas

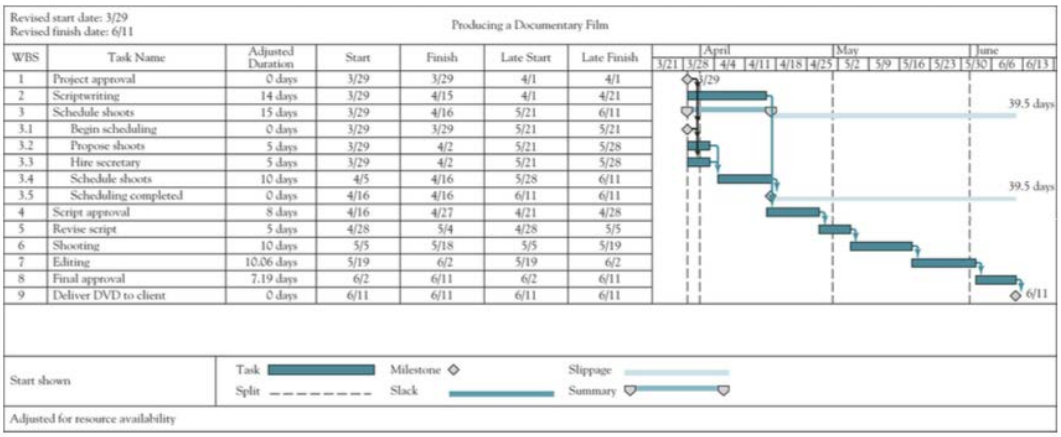
WBS	Task Name	Duration	Resource Names
1	Project approval	0 days	
2	Scriptwriting	14 days	Scriptwriter
3	Schedule shoots	15 days	
3.1	Begin scheduling	0 days	
3.2	Propose shoots	5 days	Scriptwriter, Producer, Client
3.3	Hire secretary	5 days	Producer
3.4	Schedule shoots	10 days	Secretary
3.5	Scheduling completed	0 days	
4	Script approval	5 days	Producer, Client
5	Revise script	5 days	Scriptwriter, Producer
6	Shooting	10 days	Editor, Production Staff
7	Editing	7 days	Editor, Editing staff, Editing room
8	Final approval	5 days	Producer, Client, Editing room, Editor
9	Deliver DVD to client	0 days	



Start date: 3/29
Finish date: 5/31

Task Milestone Summary

Gantt Chart for DVD Project, Adjusted for Client Availability

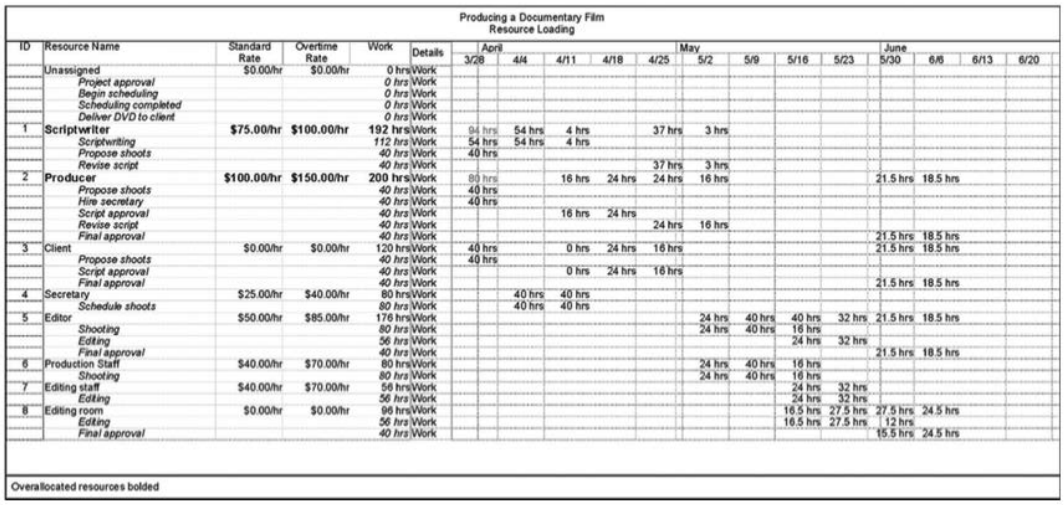


Revised start date: 3/29
Revised finish date: 6/11

Producing a Documentary Film

WBS	Task Name	Adjusted Duration	Start	Finish	Late Start	Late Finish
1	Project approval	0 days	3/29	3/29	4/1	4/1
2	Scriptwriting	14 days	3/29	4/15	4/1	4/21
3	Schedule shoots	15 days	3/29	4/16	5/21	6/11
3.1	Begin scheduling	0 days	3/29	3/29	5/21	5/21
3.2	Propose shoots	5 days	3/29	4/2	5/21	5/28
3.3	Hire secretary	5 days	3/29	4/2	5/21	5/28
3.4	Schedule shoots	10 days	4/5	4/16	5/28	6/11
3.5	Scheduling completed	0 days	4/16	4/16	6/11	6/11
4	Script approval	8 days	4/16	4/27	4/21	4/28
5	Revise script	5 days	4/28	5/4	4/28	5/5
6	Shooting	10 days	5/5	5/18	5/5	5/19
7	Editing	10.06 days	5/19	6/2	5/19	6/2
8	Final approval	7.19 days	6/2	6/11	6/2	6/11
9	Deliver DVD to client	0 days	6/11	6/11	6/11	6/11

Resource Loading Chart for DVD Production



Producing a Documentary Film
Resource Loading

ID	Resource Name	Standard Rate	Overtime Rate	Work	Details	April 3/28	4/4	4/11	4/18	4/25	May 5/2	5/9	5/16	5/23	June 5/30	6/6	6/13	6/20
	Unassigned	$0.00/hr	$0.00/hr	0 hrs	Work													
	Project approval			*0 hrs*	Work													
	Begin scheduling			*0 hrs*	Work													
	Scheduling completed			*0 hrs*	Work													
	Deliver DVD to client			*0 hrs*	Work													
1	**Scriptwriter**	**$75.00/hr**	**$100.00/hr**	**192 hrs**	Work	94 hrs	54 hrs	4 hrs		37 hrs	3 hrs							
	Scriptwriting			*112 hrs*	Work	54 hrs	54 hrs	4 hrs										
	Propose shoots			*40 hrs*	Work	40 hrs												
	Revise script			*40 hrs*	Work					37 hrs	3 hrs							
2	**Producer**	**$100.00/hr**	**$150.00/hr**	**200 hrs**	Work	80 hrs		16 hrs	24 hrs	24 hrs	16 hrs				21.5 hrs	18.5 hrs		
	Propose shoots			*40 hrs*	Work	40 hrs												
	Hire secretary			*40 hrs*	Work	40 hrs												
	Script approval			*40 hrs*	Work			16 hrs	24 hrs									
	Revise script			*40 hrs*	Work					24 hrs	16 hrs							
	Final approval			*40 hrs*	Work										21.5 hrs	18.5 hrs		
3	Client	$0.00/hr	$0.00/hr	120 hrs	Work	40 hrs		0 hrs	24 hrs	16 hrs					21.5 hrs	18.5 hrs		
	Propose shoots			*40 hrs*	Work	40 hrs												
	Script approval			*40 hrs*	Work			0 hrs	24 hrs	16 hrs								
	Final approval			*40 hrs*	Work										21.5 hrs	18.5 hrs		
4	Secretary	$25.00/hr	$40.00/hr	80 hrs	Work		40 hrs	40 hrs										
	Schedule shoots			*80 hrs*	Work		40 hrs	40 hrs										
5	Editor	$50.00/hr	$85.00/hr	176 hrs	Work						24 hrs	40 hrs	40 hrs	32 hrs	21.5 hrs	18.5 hrs		
	Shooting			*80 hrs*	Work						24 hrs	40 hrs	16 hrs					
	Editing			*56 hrs*	Work								24 hrs	32 hrs				
	Final approval			*40 hrs*	Work										21.5 hrs	18.5 hrs		
6	Production Staff	$40.00/hr	$70.00/hr	80 hrs	Work						24 hrs	40 hrs	16 hrs					
	Shooting			*80 hrs*	Work						24 hrs	40 hrs	16 hrs					
7	Editing staff	$40.00/hr	$70.00/hr	56 hrs	Work								24 hrs	32 hrs				
	Editing			*56 hrs*	Work								24 hrs	32 hrs				
8	Editing room	$0.00/hr	$0.00/hr	96 hrs	Work								16.5 hrs	27.5 hrs	27.5 hrs	24.5 hrs		
	Editing			*56 hrs*	Work								16.5 hrs	27.5 hrs	12 hrs			
	Final approval			*40 hrs*	Work										15.5 hrs	24.5 hrs		

Overallocated resources bolded

Resource Loading Issues

- Most project management software assumes that any resource assigned to an activity will work on that activity 100 percent of the time available
  - Can be resolved by allocating a specific percentage of time to project
- It is easy to over utilise human resources
  - Overtime is expensive

Resource Leveling

- To perform resource leveling, software will move activities so that resources do not exceed their capacity
  - Using available slack first
  - Extending project duration where using slack doesnot work
- Project manager may not try to level all resources
- A working schedule may require more resources
- A more-or-less steady state demand for human resources is highly desirable

Resource Loading/Leveling and Uncertainty

- Holidays, vacations, sick days can reduce human resource availability
- Not all required facilities and equipment will be available when needed
- There may be change orders
- All of these must be factored into plans

Project Completion Time Statistics Based on Simulation

	Scenario 1	Scenario 2	Scenario 3
Average	50.4	51.9	53.4
Std. Dev.	7.1	6.3	5.3
Max.	69.4	72.7	69.3
Min.	30.1	36.1	39.3
Median	50.0	51.8	53.1

Analysis

- This example clearly demonstrates how the commonly made assumption of known activity times in practice can lead to quite unrealistic project deadlines
- The results would have been even more dramatic had the activities required some common resources
- Similarly, the results would have been more dramatic and realistic had a nonsymmetrical distribution been used to model the activity times

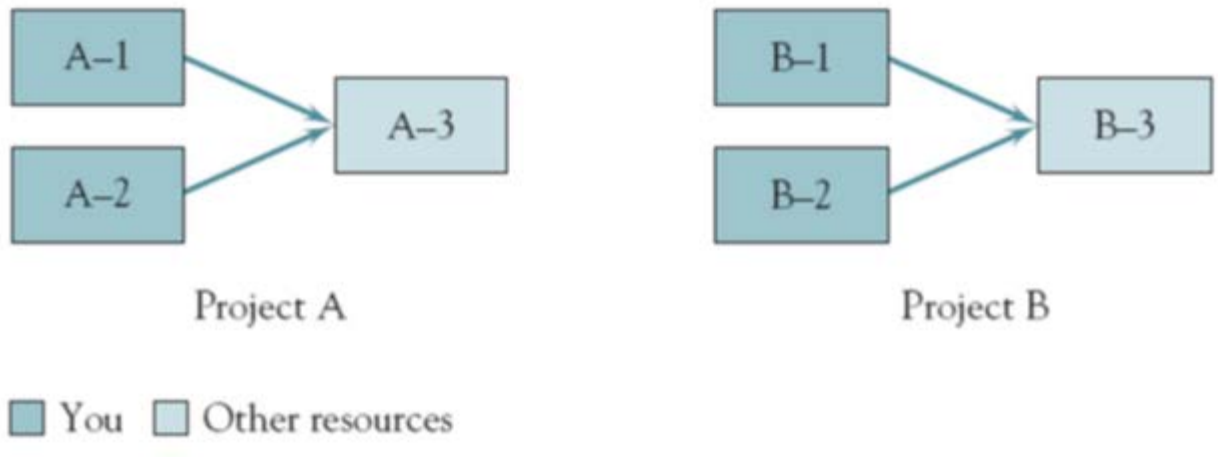
Estimating Task Times

- Workers often pad time estimates
- Inflated time estimates tend to create even more problems
- When workers finish a padded activity early, they often do not let management know they are done yet
- Worse, workers may perceive they have plenty of time to complete the task and therefore delay starting the task
    1. "Goldratt refers to this as the student syndrome

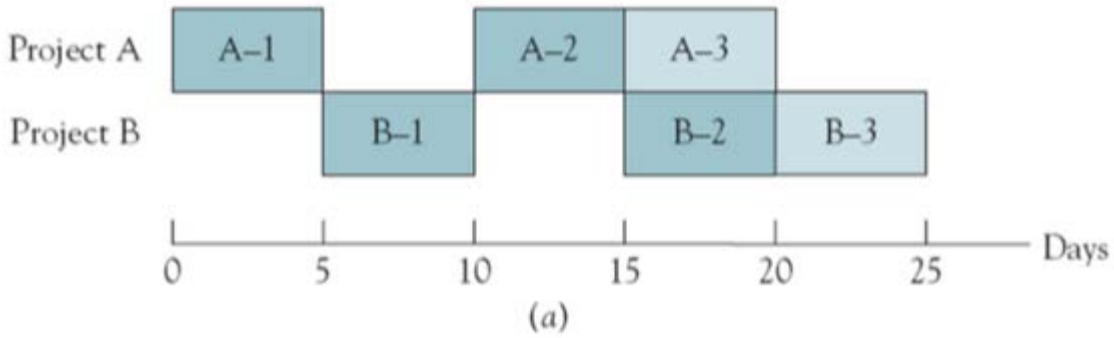
Multitasking

- Multitasking is assigning team members to multiple projects and having them allocate their time across these projects
- There is typically a penalty or cost associated with switching from working on one project to another

Sample Project with Multitasking



Alternative Gantt Charts for Projects A and B



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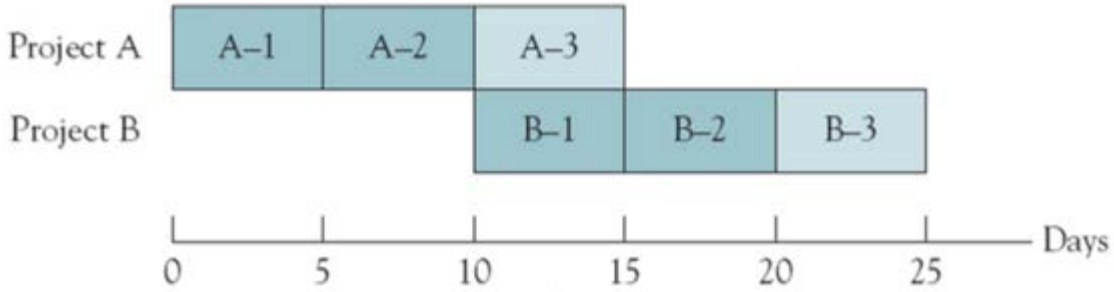


Common Chain of Events

1. Assuming that activity times are known and that the paths are independent leads to underestimating the actual amount of time needed
2. Because the time is underestimated, project team members tend to inflate their time estimates
3. Inflated time estimates lead to work filling available time, workers not reporting that a task has been completed early
4. An important caveat then becomes that safety time is usually visible to project workers and is often misused
5. Misused safety time results in missed deadlines and milestones
6. Hidden safety time further complicates the task of prioritizing project activities
7. The lack of clear priorities likely results in poor multitasking
8. Task durations increase as a result of poor multitasking
9. Uneven demand on resources may also occur as a result of poor multitasking
10. In an effort to utilize all resources fully, more projects will be undertaken to make sure that no resources are underutilized
11. Adding more projects further increases poormultitasking

Resolving These Problems

- Goldratt suggests that the key to resolving this is to schedule the start of new projects based on the availability of bottleneck resources
- He further suggests that time buffers be created between the bottleneck resource and the resources that feed it
- He also suggests reducing the amount of safety time added to individual tasks and then adding some fraction of the safety time reduced back into the system as safety buffer for the entire project

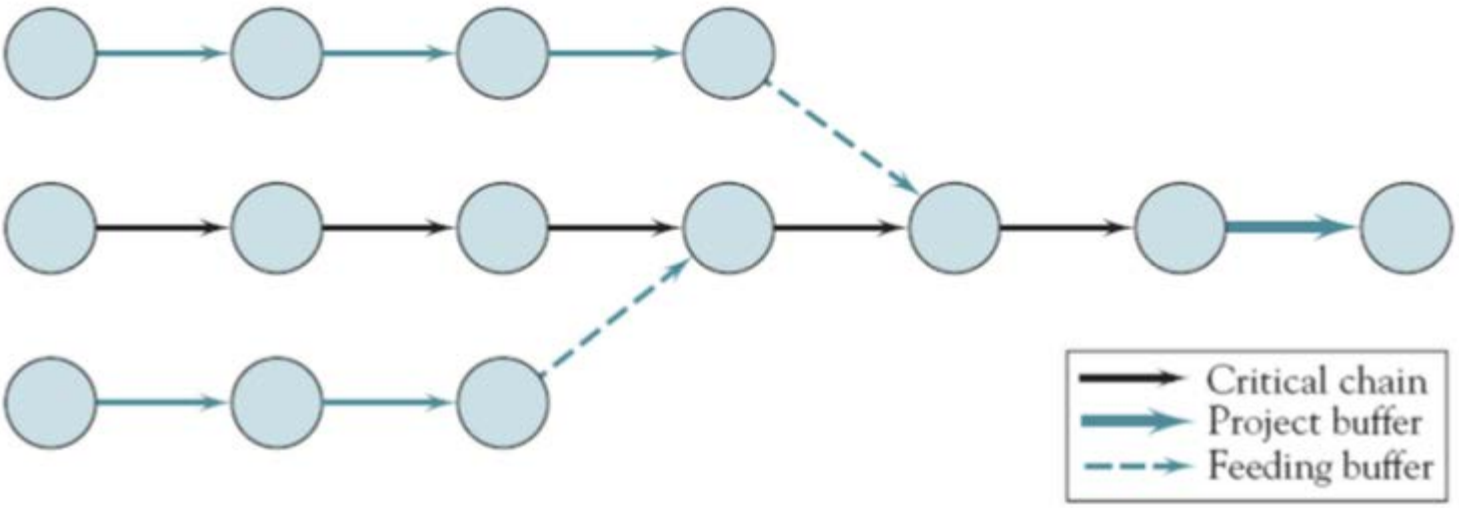
The Critical Chain

- Another limitation is the dependency between resources and tasks is often ignored
- Using traditional approaches, A1-C1 is the critical path
- What if A1 and A2 are not independent
- Then page A1-C1 increases to 22 days

Addressing Problem

- Need to consider both precedence relationships and resource dependencies
- Goldratt proposes thinking in terms of the longest chain of consecutively dependent tasks where such dependencies can arise
    - Referred to as critical chain
- There are two potential sources that can delay the project
    1. Delay in the tasks that make up the critical chain
    2. Delay in activity feeding the critical chain that results in delay of the critical chain

Project and Feeder Buffers



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COMPUTER SCIENCE AND INFORMATION TECHNOLOGY RMIT University

Software Engineering Project Management

Chapter 10: Budgeting

Up | Site Map

Introduction

- A budget must be developed in order to obtain the needed resources
- A budget is a plan for allocating organisational resources to the project activities
- A budget ties the project to the organisation's aims and objectives through organisational policy
- A budget acts as a tool for upper management to monitor and guide the project

Methods of Budgeting

- Budgeting is forecasting what resources the project will require, what quantities of each will be needed, when they will be needed, and how much they will cost
- Most businesses employ experienced estimators who can forecast resource usage very well
- Budgeting a project is more difficult than budgeting more routine activities

Budgeting Problems

- Project are unique activities
- No history to aid estimators
- Projects may be multi-year with cost escalations
  - Changes in technology, materials, prices
- Organization tradition impacts project budgeting
- How overhead and indirect costs are charged
  - Specific legal issues
  - Accounting idiosyncrasies
- Project managers see costs differently than accountants
  - Accounts treat costs linearly

Top-Down Budgeting

- Based on collective judgments and experiences of top and middle managers
- Overall project cost estimated by estimating the costs of major tasks
- Advantages
  - Accuracy of estimating overall budget
  - Errors in funding small tasks need not be individually identified
- Disadvantage
  - Allows budget to be controlled by people who play little role in designing and doing the work required by the project

Bottom-Up Budgeting

- Work breakdown structure (WBS) identifies elemental tasks
- Those responsible for executing these tasks estimate resource requirements
- Advantage
  - More accurate in the detailed tasks
- Disadvantage
  - Risk of overlooking tasks

Cost Estimating

- Details of the process of estimating costs

- Some dangers of arbitrary cuts in the budget
- Difference between activity budgeting and program budgeting
-

Work Element Costing

- Determine resource requirements and then costs for each task
  - Fixed costs
  - Labor time and labor rate
  - Equipment time and equipment rate " Overhead
  - General, sales, and administrative
- Full cost budget is used by accounting to estimate the profit of the project
- Project manager may also construct a budget of direct costs
  - This provides information required to manage the project without being confounded with costs over which he has no control

The Impact of Budget Cuts

- Top-down budgets are usually lower than bottom-up budgets
  1. Job always looks easier, faster, and cheaper to the manager
  2. Managers are usually optimistic
  3. Subordinates are usually pessimistic
- To resolve difference...
  1. Subordinate explains the reality of the task
  2. Both parties search for efficiencies
  3. Resolving remaining difference depends on the type of project

Activity Versus Program Budgeting

- Activity oriented budgeting are based on historical data accumulated through an activity- based accounting system
  - Expenses assigned to basic budget lines "Lines are aggregated and reported by units
  - With program budgets, each project is divided by task and time period allows for aggregation across projects
  - Budget reports are shown both aggregated and disaggregated by regular operations
  - Each project has its own budget

Typical Monthly Budget for a Real Estate Project (Partial)

	Current			
	Actual	Budget	Variance	Pct.
Corporate—Income Statement				
Revenue				
8430 Management fees	.00	.00	.00	.0
8491 Prtnsp. reimb.—property mgmt.	7,410.00	6,222.00	1,188.00	119.0
8492 Prtnsp. reimb.—owner acquisition	.00	3,750.00	3,750.00—	.0
8493 Prtnsp. reimb.—rehab	.00	.00	.00	.0
8494 Other income	.00	.00	.00	.0
8495 Reimbursements—others	.00	.00	.00	.0
Total revenue	7,410.00	9,972.00	2,562.00—	74.3
Operating expenses				
Payroll & P/R benefits				
8511 Salaries	29,425.75	34,583.00	5,157.25	85.0
8512 Payroll taxes	1,789.88	3,458.00	1,668.12	51.7
8513 Group ins. & med. reimb.	1,407.45	1,040.00	387.45—	135.3
8515 Workers' compensation	43.04	43.00	.04—	100.0
8516 Staff apartments	.00	.00	.00	.0
8517 Bonus	.00	.00	.00	.0
Total payroll & P/R benefits	32,668.12	39,124.00	6,457.88	83.5
Travel & entertainment expenses				
8512 Travel	456.65	300.00	156.65—	152.2
8522 Promotion, entertainment & gift	69.52	500.00	430.48	13.9
8523 Auto	1,295.90	1,729.00	433.10	75.0
Total travel & entertainment exp.	1,822.07	2,529.00	706.93	72.1
Professional fees				
8531 Legal fees	419.00	50.00	369.00—	838.0
8532 Accounting fees	289.00	.00	289.00—	.0
8534 Temporary help	234.58	200.00	34.58—	117.2

Project Budget by Task and Month

Task	Start Node (I)	End Node (J)	Estimate (£)	Monthly Budget (£) 1	2	3	4	5	6	7	8
A	1	2	7000	5600	1400						
B	2	3	9000		3857	5143					
C	2	4	10000		3750	5000	1250				
D	2	5	6000		3600	2400					
E	3	7	12000				4800	4800	2400		
F	4	7	3000				3000				
G	5	6	9000			2571	5143	1286			
H	6	7	5000					3750	1250		
I	7	8	8000						2667	5333	
J	8	9	6000								6000
			75000	5600	12,607	15,114	14,193	9836	6317	5333	6000

Improving Estimates and Forecasts

- Forms
- Learning curves
- Tracking signals

Forms

- A form for project resource needs might include:
  - People – managers, technical and non-technical
  - Money
  - Materials – facilities, equipment, tools, space
  - Special services
- And might identify:
  - Person to contact
  - When needed
  - How many/much needed
  - Whether available

Form for Gathering Data on Project Resource Needs

Project name_____
Date_____
Task number_____

RESOURCES NEEDED

Resources	Person to Contact	How Many/ Much Needed	When Needed	Check (√) If Available
People: Managers, Supervisors				
Professional & Technical				
Nontechnical				
Money				
Materials: Facilities				
Equipment				
Tools				
Power				
Space				
Special Services: Research & Test				
Typing/clerical				
Reproduction				
Others				

Learning Curves

- Humans learn when they repeat a task
- It has been found that unit performance improves by a
- fixed percent each time total production doubles
- Each time the output doubles, the worker hours per unit decrease by a fixed percentage of their previous value
  - This percentage is called the learning rate

Learning Curves

- $T_n = T_1 n^r$

where...

- T_n = the time required to complete the n^{th} unit
- T_1 = the time required to complete the first unit
- r = log(learning rate)/log(2)

Tracking Signals

- Random error: there is a roughly equal chance that estimates are above or below the true value
  - Random errors cancel out
- Bias: if the over/under chances are not equal or the over/under errors are not the same size
- A tracking signal number can reveal if there is a systematic bias in cost and other estimates
  - And whether the bias is positive or negative
- By observing their own errors a project manager can learn to make unbiased estimates

Tracking Signal Calculation

	A	B	C	D	E	F	G
1	This is a template for improving one's estimating skills.						
2							
3	MAR = Sum[|(At / Et)−1|] / n						
4	Tracking Signal = Sum[(At / Et)−1] / MAR						
5							Tracking
6	Period	Estimate	Actual	$(A_t / E_t) - 1$	$\|(A_t / E_t) - 1\|$	MAR	Signal
7	1	155	163	.052	.052		
8	2	242	240	−.008	.008	0.030	1.448
9	3	46	67	.457	.457	0.172	2.904
10	4	69	78	.130	.130	0.162	3.898
11	5	75	71	−.053	.053	0.140	4.120
12	6	344	423	.230	.230	0.155	5.205
13	7	56	49	.125	.125	0.151	4.523
14	8	128	157	.227	.227	0.160	5.670
15							
16	Total			.908	1.281		
17							
18	Formulas:						
19	Cell D7	=(C7/B7)−1 {copy to cells D8:D14}					
20	Cell D7	=(ABS)D7 {copy to cells E8:E14}					
21	Cell F8	=SUM(E$7:E8)/COUNT(E$7:E8) {copy to cells F9:F14}					
22	Cell G8	=SUM(D$7:D8)/F8 {copy to cellsG9:G14}					
23	Cell D16	=SUM(D7:D14) {copy to cells E16}					

Other Factors Influencing the Success of a Project

- Changes in resource prices
  - Estimate rate of price change individually for inputs that have significant impact on costs
- Waste and spoilage
- Team member turnover costs
- Using "mythical man-months"
- Organisation climate
- Just bad luck

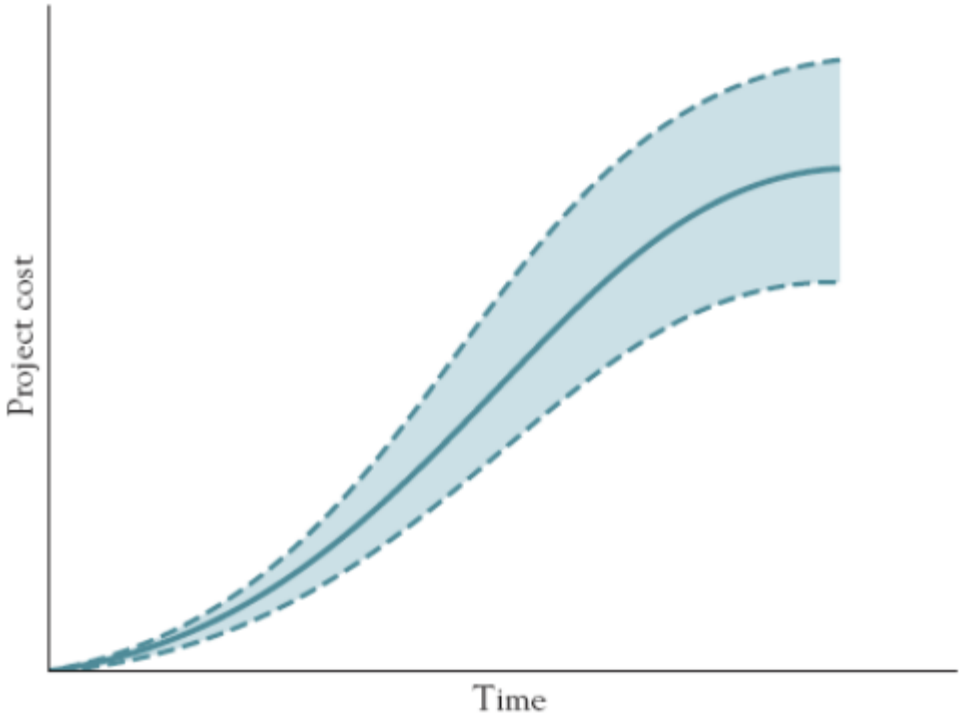
Budget Uncertainty and Project Risk Management

- Budget is an estimate made under uncertainty
- Risk pervades all elements of a project
- Risk is particularly an issue with performance, schedule, and budgets

Budget Uncertainty

Prices may escalate
- Different resources may be required ! Project may take more or less time
  - Impacts indirect costs

Estimate of Project Costs with Uncertainty Shown



Three Basic Causes for Change in Projects and Their Budgets

1. Errors made by cost estimator as to how to achieve tasks.
2. New knowledge about the nature of the performance goal or setting.
3. A mandate...a new law or standard

Handling Changes

- Accept a negative change and take a loss
  - Least preferred way
- Prepare ahead of time by including provisions for such change in contract
  - Best approach
- More difficult are those resulting from misunderstood assumptions, technological uncertainty, and mandates
  - State assumptions and note that if they change, project will have to be adjusted
- Mandates are the most difficult to accommodate
  - Divide project into shorter segments and contract sequentially

Revising Budgets

1. If the changes are confined to early elements of the project and will not impact the rest of the project, then the new budget is the old budget plus the changes
2. For change that impacts rest of project, the new budget id the accumulated costs to date plus the previous estimates of the rest of the budget multiplied by some correction factor for the systemic change
3. For change to impact specific elements of remaining project tasks, new budget is the actual costs to date plus the expected costs for the remaining project tasks

Project Risk Simulation with Crystal Ball

- A mathematical model of the situation is constructed
- A simulation is run to determine the model's outcomes under various scenarios
- The model is run repeatedly
- Outputs of the model are used to construct statistical distributions of items of interest "Risk profiles of the outcome
- Risk profiles can be considered by the manager when considering a decision

References

1. Prescribed textbook: Project Management in Practice, 5th Ed.- Wiley Inc.

Lesson Number 10

- Resource Based Scheduling affects project planning
- Keep your projects under budget

Acknowledgement: Youtube video's copyright is held by the Youtube website and the owner, it has been cited for educational purposes.

Suggested Reading

- Chapter 4: Budgeting the Project - Pages 112-130
- Chapter 6: Allocating resources to the project - Pages 200-235

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