

COMPUTER WORKSHOP ON

CONSTRUCTION MANAGEMENT

Aug. 4 - 5, 2005

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OUTLINE

Aug. 4, 2005

Introduction to Project Management Project Management Concepts & Terminology Project Life Cycle Phases Planning Estimating Scheduling Resource Levelling Meeting deadlines Cash Flow Planning Microsoft Project Software EasyPlan Software Hands-on case studies

Aug. 5, 2005

Managing linear & repetitive infrastructure projects EasyPlan Exercises Project Control & Delay Analysis Progress recording Earned-value analysis Optimization of corrective actions Critical chain concept for project control Basics of delay analysis Hand-on case study Advanced IT Tools & Techniques Simulation Enterprise resource planning (ERP) Web Collaboration Hand-held devices 4-D visualization GIS

Guest Account at UW

Login in to the Nexus domain: User name = _____

Password = _____

All Files you need for the workshops are included in the directory "EasyPlan" on the **N**: drive of your UW machine.

Software Setup at Your Personal PC

- 1.

 Activate Excel
- 2. Change macro security level to **low** (Tools Macro Security)
- 3.
 □ Unselect having Excel help to appear on Excel start
- 4. 🗆 Close Excel
- 5.
 □ Activate Microsoft Project
- 6. Change macro security level to **low** (Tools Macro Security)
- 7. \Box Unselect having the help to appear on Microsoft Project start
- 8.
 □ Close Microsoft Project

Downloading EasyPlan:

- 9. Goto Dr. Hegazy's web site: <u>www.civil.uwaterloo.ca/tarek</u>
- 10.
 Goto My Free Educational Software
- 12. \Box Download the educational version of EasyPlan.
- 13. \Box If the downloaded file has ".ex_" extension, change it to ".exe".

Setup:

- 14. \Box Expand the software to a separate directory.
- 15. \Box Go to the "Setup" subdirectory and activate the "Setup.bat" file.
- 16.
 Access EasyPlan's directory and click on EasyPlan.xls





Project Management Concepts and Terminology

Project Life Cycle Phases

CONCEPT	DESIGN	- Didding Strategy & Markup Estimation - Cash flow analysis - Submit Bid BIDDING		Control - Commissioning	O & M
 Need Feasibility Project Definition Owner Approval 	A/E, CM, Owner - Conceptual Design - Owner Approval - Soil Reports - Preliminary Design - Detailed Design - Quantities - Work Documents - Select Project Contract Strategy	Bidders Prepare Bid Proposal + Baselines - Collect data (site, quantities, specs, resources, tasks, etc) - Planning - Time & Cost Estimation - Scheduling - Resource Management: Adjustments for Resource Constraints & Deadline - Bidding Strategy & Markup Estimation	Owner, CM - Evaluate Bids and Select General Contractor	Contractor - Start Construction - Detailed planning, estimating & resource management - Schedule Updating - Progress Evaluation Time Cost & Quality	O & M Staff - O & M - Demolition at end of service life
Owner, CM	A/E, CM, Owner	I			

Planning



Scheduling







Deadline = 10 days		Ī	Marku	- 10: - 10:		-	+					_					
Resource Limit = 2 ł	lay		Reten	tion =	5% (H	old bac	ž										
Indirect cost = \$100	lday			$ \uparrow $	\vdash	\vdash	+										
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Terms used	every	period	- 		-	-	-				S	Ë	sum=			Sum =	
- Cost= Esti	mate of	f direct	ts +	indire	acts.					S.Curve							
- Expenses	t= Cost ∩st + M	t, if su; arkin	* pplie	ers c∢ nst =	an giv Crist	6 Å	U Cre Mari	dit.	51 F 5								
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If everything	goes w	ell:							20-7		Dra	w the C	ash Flow Chart.	_			
- Expenses ·	t= Cost								* m v			at is the	effect of bid ur	nbalancing?			
- Income = E - Profit = Cos	Nudget xt*Marl	qD							0								
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Example Project: PR 7

Activity	Dependents	Description	Estima	te no. 1	Estima	te no. 2	Estima	te no. 3
Activity	Dependents	Description	Dur. (d)	Cost (\$)	Dur. (d)	Cost (\$)	Dur. (d)	Cost (\$)
1		Excavation	2	2,000			1	3,000
2	1	Foundation	2	2,000			1	3,000
3	2	Joining Wall	1	1,000				
4	3	House Walls	4	4,000	3	3,000	2	5,000
5	4	House Roof	3	3,000	2	5,000		
6		Select Finishes	1	1,000				
7	5,6	Interior Finishes	3	3,000	2	4,000		
8	7, 12	Clean Up	1	1,000				
9		Fab. Garage Doors	6	6,000	4	10,000	2	12,000
10	3	Garage Walls	3	3,000	2	5,000		
11	10	Garage Roof	2	2,000	1	3,000		
12	9, 11	Garage Doors	2	2,000				

The activities of a small project are shown in the following table.

Project Constraints:

- Deadline is 14 days; Indirect cost = \$300/day; Penalty = \$5,000/day; and Bonus = \$1000/day.
- Each activity uses 2 labors (L5) daily; and Resource limit is 4 L5 resources per day.
- A reporting period is 3 days; interest rate is 1% / period; Markup is 10%; & owner retention is 5%.

Requirements:

Enter the project data into EasyPlan. Determine the optimum execution plan that meets both the deadline and resource limits, with minimum cost. Use the Online Tutorial feature, load project 7, then **Check your solution using the On-Line solution Checker**.

Save the baseline plan and save your file. View the various reports. Examine the effect of mobilization payment on Cash Flow. Try unbalancing your bid and its effect on cash flow.

During actual progress, the following events were encountered during the first 12 days:

- Day 1: excavation progressed as planned and no other work was done.
- Day 2: the contractor encountered unexpected rock (an owner-related problem). Accordingly, Excavation was stopped until a new machine is procured. No other work was done on day 2.
- Days 3 and 4: the new excavation equipment did not arrive yet. No other work was done.
- Day 5: the new excavation equipment started working and all remaining excavation work was completed that day. No other work done.
- Days 6 and 7: Foundation work was started and completed.
- Day 8: work on the Joining Wall was started and completed.
- On each of days 9 & 10: 25% of the House Walls and 25% of the Garage Walls were completed.
- Day 11: both the owner and contractor caused the House Walls activity to stop. Also, the contractor did not have resources to work on the Garage Walls.
- Day 12: the problem due to both the owner and the contractor still caused the House Walls activity to stop. The contractor also still had a resource problem and could not proceed on the Garage Walls. On the same day, the owner wanted to take some time to change his selection of the interior finishes. In addition, the Fabrication of the Garage Doors activity is 17% done.
- Actual costs to day 12 are assumed to be \$5,000 for each of the started activities.

a) What is your optimum corrective action plan? Plot the project S-Curve and Earned-Value curve.b) Print the payment schedule, Cash Flow chart, resource histograms, & the as-built schedule.

Usinc

Log into your computer and Activate Microsoft

Browse the various features of Microsoft Proje

Let's now use Microsoft Project and try to se all the features we need to plan our project.

Setup

Once a new file is open, use the "Tools-Op menu item to start setting up the Microsoft Software.

Setup Default Options

With the "Schedule" tab, adjust default opti shown. Important ones are:

- Scheduling from start date; -
- Duration entered in days _
- Default task type is "Fixed Duration"

Click the Set as Default" button, then "OK".

g Microsof	t Project
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Project	
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	Work is entered in: Hours Default task type: Fixed Duration New tasks are effort driven Fixed Duration Autolink inserted or moved to Fixed Work Fixed Work Split in-progress tasks Tasks will always honor their constraint dates Show that tasks have estimated durations Set as Default
	Aug/5, 199 Aug 2 104 Laun 20, 109 Sep 5, 99 S S M T W T F S M T W T Zoom Change Working Time Change Working Time F S M T W T
For: Standard (F	Project Calendar)
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	Aug 15, 159 Aug 22, '99 Aug 29, '99 Sep 12, '99 Sep 12
Timescale	Nonworking Time
e	
Months	Label: 1, 2, 3, 4, (From Start) ✓ Use Eiscal Year Align: Left ✓ Ijck lines
Days •	Label: 1, 2, 3, 4, (From Start) ▼ ▼ Use Fiscal Year Align: Center ▼ Tick lines
65 🕂 %	☑ <u>S</u> cale separator

Setup Working Times

Use the right mouse button on the calendar and select "Change Working Time". Then, as shown, select the Saturday and Sunday columns and specify them as "Working Time". This gives us a 7-day working week. You may also specify any day as off or change the work hours on any day. Then, click "OK".

Major sca

Units:

Count:

Minor scal

Units:

Count: General Size:

Preview

Setup Time Scale

Use the right mouse button on the calendar and select "Time Scale". Set the major scale units as months labeled as shown. Also, set the Minor scale units as days labeled as shown.

Setup the Layout

Use the "*Format-Layout*" menu option to select how the bar chart will look like.



Input Project Activities

To input the activities of the project, let's enter their names one-by-one in the Sheet with their durations in the two columns shown.

Specifying Relationships

There are several ways to specify the relationships among the tasks

Move the divider bar until you see the "Predecessors" column. Then type the row numbers of the predecessors separated by commas and hit the ENTER key. A relationship will be inserted (arrow) and task 2 is made to follow task 1, as shown. If you double click the mouse on the relationship arrow, a window for specifying the relationship type and lag time appears. Another way is to drag from the middle of a task into another task, and a relationship will be inserted and predecessor ID is written into the "Predecessors" column.

	Task Name	Duration							2	
			-1	1	2	3	4	5	6	
1	Excavation	2 days								
2	Foundation	2 days								
3	Joining Wall	1 day			1					
4	House Walls	4 days								
5	House Roof	3 days								
6	Select Finishes	1 day								
7	Interior Finishes	3 days					1			
8	Clean Up	1 day								
9	Fab. Garage Doors	6 days								
10	Garage Walls	3 days								
11	Garage Roof	2 days								
12	Garage Doors	2 days				1				





The Schedule

Once relationships are entered and chart is formatted using "*Format-GanttChartWizard*", the following schedule

of 16 days will result.

	Teck Name	Duration	Start	Finish	Dredecessors						2											
	Tubic Nume	Daradon	orun	1 milori	110000033013	1	2	3	4	5	- 6	7	8	9	10	11	12	13	14	15	16	17
1	Excavation	2 days	Fri 11/26/04	Sat 11/27/04				1														
2	Foundation	2 days	Sun 11/28/04	Mon 11/29/04	1					1												
3	Joining Wall	1 day	Tue 11/30/04	Tue 11/30/04	2				1		h									ĺ		
4	House Walls	4 days	Wed 12/1/04	Sat 12/4/04	3										1							
5	House Roof	3 days	Sun 12/5/04	Tue 12/7/04	4													1				
6	Select Finishes	1 day	Fri 11/26/04	Fri 11/26/04																		
7	Interior Finishes	3 days	Wed 12/8/04	Fri 12/10/04	5,6																1	
8	Clean Up	1 day	Sat 12/11/04	Sat 12/11/04	7,12																	
9	Fab. Garage Doors	6 days	Fri 11/26/04	Wed 12/1/04																T		
10	Garage Walls	3 days	Wed 12/1/04	Fri 12/3/04	3						*			1								
11	Garage Roof	2 days	Sat 12/4/04	Sun 12/5/04	10											1						
12	Garage Doors	2 days	Mon 12/6/04	Tue 12/7/04	9,11																	
									:													

It is now possible to view many of the software's preset tables. Use the "*View-Table-Schedule*" menu option to show all schedule data, as shown here.

Viewing the Project Network

Now, you may view the project network. Notice that critical activities have bold borders. To specify what data to view in the box of each task use "*Format-Box Styles*" menu option. Experiment with this option.

Specifying Resources

Now, let's view the resource sheet and specify the resource categories and maximum available amount. Specify our (2 of L5).

Assign Resources to Tasks

From the Gantt chart, select each activity, push on the toolbar button shown and type the units as shown, then hit the "Assign" button and continue to next activity, and so on. Once finished,

you will notice that project duration is still 16 days.

Resource Graph

With resources and their limits specified, let's view the "*Resource Graph*". Notice the over-allocation in L5, indicating the need to perform resource allocation calculations to resolve this problem. After viewing, return to the Gantt chart.

Resource-Leveling Options

Now, use the "Tools-Resource Leveling" option.

Experiments:

Select the "Level only within available slack" Duration after leveling is: _____

UnSelect the "Level only within available slack" Duration after leveling is: _____

Change available L5 resources to 3, then Duration after leveling is: _____

Comments on Microsoft Project:

Costs? Deadline? Penalty? Incentive? Cash flow? Productivity Factors? Optimization?











EasyPlan

Unique Features:

1. Organized storage of your resources



Form crews, & store pre-defined hourly rates.

3. Powerful cost optimization



5. Competitor analysis & markup estimation



Summary O Full Activity Report

Category Reports : Report

alue Chart/ ; Indices

OK

Reports:

7. Extensive reports

Sum of TotalCost							<	C Budget / Category
Description 🔻	Contr. Item 🔻	Contr. Qu 🔻	ltem Uni 🔻	ContUC 🔻	Total			C Payment Report
Clean Up	ltem8	1.00	unit	\$1,000.0	\$1,000			
Excavation	ltem1	1.00	unit	\$2,000.0	\$2,000	Color d	de.	
Fab. Garage Doors	ltem9	1.00	unit	\$6,000.0	\$6,000	Charb	ule	Cash Flow Chart
Foundation	item2	1.00	unit	\$2,000.0	\$2,000	Charte	3.	C Histogram for L1
Garage Doors	ltem12	1.00	unit	\$2,000.0	\$2,000			- Histogrammor ET
Garage Roof	ltem11	1.00	unit	\$2,000.0	\$2,000			C Histogram for E3
Garage Walls	ltem10	1.00	unit	\$3,000.0	\$3,000			C Histogram for M1
House Roof	ltem5	1.00	unit	\$3,000.0	\$3,000			S histogram for Mr
House Walls	ltem4	1.00	unit	\$4,000.0	\$4,000	Dura		
Interior Finishes	ltem7	1.00	unit	\$3,000.0	\$3,000	Charb	855 5'	C Progress S-Curve
Joining Wall	ltem3	1.00	unit	\$1,000.0	\$1,000	Charc.	,	C Earned-Value Cha
Select Finishes	ltem6	1.00	unit	\$1,000.0	\$1,000			
Grand Total					\$30,000			Progress Indices
						Cance	9	
	Many	report	ts, ind	ludin	g			

automated bid proposal.

2. Not one ... but three estimates / activity

Activity	Description More>	7 First Esti	mate	2 Second Es	stimate	Third Est	3 imate
		Cost1	Dur1	Cost2	Dur2	Cost3	Dur3
1	Excavation	\$2,000	2.0	\$2,000	2.0	\$3,000	1.0
2	Foundation	\$2,000	2.0	\$2,000	2.0	\$3,000	1.0
3	Joining Wall	\$1,000	1.0	\$1,000	1.0	\$1,000	1.0
4	House Walls	\$4,000	4.0	\$3,000	3.0	\$5,000	2.0

3 options: from Cheap & Slow to Fast & Expensive

4. Cash flow analysis & indirect costs



6. Price unbalancing & fine-tuning



8. Most productive site layout



Projacs International www.ProjacsTraining.com



Progress directly recorded on Bar Chart

11. Earned-Value Control



Full range of time & cost indices to help monitor progress.

13. Import & Export

New Project 🕨 🕨		
Activities and Estimates	i	Save <u>A</u> s
		Load from MS Project file

10. Cost-effective corrective actions



Throughout execution, you may re-optimize the plan to meet your evolving constraints.

12. Full Delay Analysis



Innovative & accurate analysis to apportion delays among project parties and decide on fair compensation / extension.

Direct link to project management software such as Microsoft Project.

Resources

Main Screen |Project 🕶

Using EasyPlan

Simply, follow the options in main screen or the "Project" toolbar Menu one-by-one.





Specify the Activities

1. Activities Import

•

From EasyPlan' menu or toolbar, <u>*Project, Activities & Estimates*</u>, as shown here. Notice only a few activities exist with three estimates.

Δ

- Delete all but activity A (select each activity at a time, then push the "Delete Current Activity" button).
- We now need to add 11 new activities (total becomes 12) for our project.

We need to enter the data in all white cells.

Specify Activities' Optional Estimates

• Let's now enter the activities' data, including the time and cost of each estimate.

We can arrange our estimates so that Estimate1 is the cheapest work option, and Estimate3 is the more expensive but faster work option. Also, Estimate2 is somewhere in between.

Notice that each activity requires 2 of the L5 resource per day.

Add Activity below current	3 Estimates Delete Current Activity	(1 Activity) C Auto Estimates C User-Input Estimates	Note: You can add/delete activities only in this screen.
Ac He	tivities & Estim ow many activities b 1	ates o add?	OK Cancel

A	ctivities & 3 Est	timates		(12 Act	ivities)		_				
	Add Activity Dele below current You may add few extra a	ete Current Activity activities to a	C Aut C Use void cha	o Estimates er-Input Esti anges later.	: mates		He	Res	oolba ources/	a r day Pro	ductivity	(0-1)
	More>	Fir	st	Sec	ond	Thi	rd					
Activity	Description	Estin	Dur1	Estin Cost2	nate	Estim Cost3	Dur3	15		\&inter	Spring	Fall
1	Excavation	\$2,000	2.0	00012	Durz	\$3,000	1.0	2.0		1.00	1.00	1.00
2	Foundation	\$2,000	2.0			\$3,000	1.0	2.0		1.00	1.00	1.00
3	Joining Wall	\$1,000	1.0					2.0		1.00	1.00	1.00
4	House Walls \$4,000 4.0 \$3,000 3.0 \$5,000 2.0 2.0 1.00 1.00 1.00											
5	House Roof	\$3,000	3.0	\$5,000	2.0			2.0		1.00	1.00	1.00
6	Select Finishes	\$1,000	1.0					2.0		1.00	1.00	1.00
7	Interior Finishes	\$3,000	3.0	\$4,000	2.0			2.0		1.00	1.00	1.00
8	Clean Up	\$1,000	1.0					2.0		1.00	1.00	1.00
9	Fab. Garage Doors	\$6,000	6.0	\$10,000	4.0	\$12,000	2.0	2.0		1.00	1.00	1.00
10	Garage Walls	\$3,000	3.0	\$5,000	2.0			2.0		1.00	1.00	1.00
11	Garage Roof	\$2,000	2.0	\$3,000	1.0			2.0		1.00	1.00	1.00
12	Garage Doors	\$2,000	2.0					2.0		1.00	1.00	1.00

Notice also that if we change the seasonal productivity factors, we actually can consider for the effect of construction during winter or for a complex project, etc.

Notes:

•

1. Activities Import

An alternative way to specify the activities and their estimates is by **importing** a Microsoft Project file. In this project, we have a Microsoft Project file that comes with EasyPlan (**Tutorial.mpp**). Once the project activities are imported, a message appears to notify you of successful import (remember that MS Project allows us only one estimate). Remember to enter the complete data of the three estimates as shown earlier.

• Activity Description If you click on the "More" button in the Activities sheet, you can put additional information about the activities supervisors, area in the project, and contract item. These are beneficial to get specific report at different levels in the project. Assume all the house activities are Area1 (supervised by Mark) while the garage is Area2 (supervised by Sam). Enter the data in the white cells.

Activity		Contr.	ltern Lloit	Contr.	Desc.	Desc.	Super-
1	Excavation	1.00	unit	Item1	Area1	East	Mark
2	Foundation	1.00	unit	ltem2			
3	Joining Wall	1.00	unit	ltem3			



Optimize the Schedule

•

3. Optimization Straightforward. Let's choose the two objectives selected, then specify the number of cycles, then proceed.

Optimization:
✓ Meet Deadline Duration
✓ Satisfy Resource Limits
☐ Minimize Daily Variability in Resource Demand
Optimization Cycles: 100

The optimized schedule (below) **meets the deadline (14 days)** and uses 4 L5 resources (same as daily limit). Project cost is only **\$39,200**.

Can you get a better solution?

The resulting schedule (shown below) selects the proper values for the work methods (estimates) and some start delays that satisfy our objectives with minimum cost. We can run the optimization more than once, even with larger number of cycles until a satisfactory solution is obtained.



Save the Baseline

• **4.** Baseline **Perform** Once satisfied then save it as baseline ("*Project - Save/Update Baseline...*" toolbar option). In the form shown, click on the button shown.

Progress Updates:	X
Progress reached day 1 on 1/1/2004	
Update Baseline on 1/1/2004	\supset
Remove Current Baseline	
Done	

Project Reports

• EasyPlan has various reports and charts. One of these is a Cash Flow chart that facilitates your financing decisions. Similarly, you can view a bid proposal report and resource profiles.



Produce a report of all the costs of Area2.

Remember to save your file. We will use it in later exercises.

Notes:

 To estimate Mark Up, we may directly enter an estimated percentage (e.g., 10 %) in the main screen. Or, you may use EasyPlan's powerful bid analysis utility (Utilities Menu) that allows you to store past bids against key competitors and then suggests a markup strategy against them.



Specifying Auto-estimates based on resources:

Activities and Estimates

This button directs you to an alternative input screen for auto-estimate data



Delivery of Repetitive Projects (e.g., Infrastructure, High-rise, Highways)



Notes:

- The three crews employed in activity (A) have different work assignments.
- Each crew moves to a new unit as soon as it finishes with the previous one, without interruption.
- When a slower activity is to follow a faster activity (e.g., C follows B), bottleneck is at bottom.
- When a faster activity is to follow a slower activity (e.g., B follows A), bottleneck is at top.
- Changing the production rate (slope) of any activity changes project duration. Even speeding one task may prove to be harmful to the project; and
- A good scheduling strategy is to schedule the activities as parallel as possible to each other.

More Advanced Linear scheduling Model

Flexible features for scheduling the activities include: color-coded or pattern-coded crews; varying quantities; productivity impact; crew interruption time; crew staggering; crew work sequence; and activities' progress speeds (slopes of lines). It is noted that the schedule is efficiently arranged with crew work continuity maintained. Also, overlapping is avoided by simply showing the activities of each path in the work network separately. In addition:

- 1. Activities are not necessarily repeated at all sections.
- 2. Activities can proceed in an ascending or descending flow. This provides work flow flexibility and provides for a way to fast-track projects;
- 3. Each activity has up to 3 methods of construction (e.g., normal work, overtime, or subcontractor) with associated time, cost, and crew constraints. The model can then be used to select the proper combination of methods that meet the deadline, cost, and crew constraints;
- 4. Activities can have non-standard durations and costs at selected sections;
- 5. Work interruption (layoff period) can be specified by the user at any unit of any activity; and
- 6. Conditional methods of construction can be specified by the user.







Highway Example

A three-kilometer highway stretch is divided to ten sections for planning purposes. Each section is 300 meters. The cross section is shown below along with activities' details.

For the highway project, let's develop an optimum schedule considering different realistic options of crews and how they move among the ten stations. The data are as follows:

		Estim	ate 1	Estin	nate 2	Estim	ate 3
	Max.	Cost	Time	Cost	Time	Cost	Time
Activity	Crew	(\$)	(days)	(\$)	(days)	(\$)	(days)
	S						
1. Excavation	2	21,000	3	30,000	2		
2. Sub-base	2	7,800	2				
3. Base	3	72,000	10	80,000	8	100,000	5
4. Binder	1	30,000	1.2				
5. Asphalt	1	14,400	1				
6. Curbs	1	31,200	2	38,000	1		
7. Lighting	2	19,245	2	25,000	1		
8. Sidewalks	2	10,950	2				
9. Paint	1	198	0.2				

The logical relationships within each section are the same, but the deadline for finishing the whole highway is 30 days. Seasonal productivity factors are also as shown below.

- Programs-BAL DEMO.
- Go to the resource bank, view all sites, and change the productivity factors for the first four sites to: January 0.7, February 0.8 and March 0.9, and leave all others as 1.0s. In BAL main screen, activate the BAL-Schedule button to access MS Project. Use Project-Information to change project start data to Jan. 2, 2002. Use the BAL Schedule toolbar button, then the Project Data button. Change the deadline to March 25, 2002. Go to the Activities tab and scroll through the activities. Change the maximum number of crews for activity "Subbase" to 3. Save and proceed. Try to meet the deadline. Use optimization options. After every trial notice the arrangement of the sites, the number of crews used, and the method of construction used. Try manually to shift the sites that take long durations later in the order. Notice the time and cost. Best duration obtained is _____ days and minimum cost is _____

Example of BAL application

Project Control & Delay Analysis

Recording of **progress**? Activities and Project **Status**? Comparing **Planned vs Actual**? Progress Payments? Managing Changes? **Updating**? **Corrective Actions**? **Forecasting**? **Delay** Resposibility? Cost compensation? Productivity Assessment? Storing As-Built Details? Lessons Learned?

- Camcorders

- Time-Lapse Camera
- Minutes of meetings

MEASURING WORK PROGRESS (% Complete)

1 **Units Completed**

Agreed at the Outset of the Project

Repeated production of easily measured pieces of work.

Receive & Inspect	15
Setting Complete	35
Alignment Complete	50
Internals Installed	75
Testing Complete	90
Accepted by Owner	100

3

2

Start/Finish

Incremental Milestone

		V. Short	Short	Long
\$	Low	0, 100	50, 100	20, 100
Ψ	High	0, 100	20, 30, 100	20, 100

Lack of readily definable intermediate milestones

Cost Ratio _ Actual Cost (or hrs) of Work to Date 4

Forecast at Completion

Installation of Major Equipment

Duration

Weighed or Equivalent Units 5

Weighed or Equivalent Units Structural Steel Erection.	Scheduled	Actual

Weight cost/total	Subtask	Unit	(2) Total Quantity	(3) Equiv. Steel Tons	(4) Quan. to Date	(5) Earned Tons
0.02	Run Found. Bolts	Each	200	10.4	200	10.4
0.02	Shim	%	100	10.4	100	10.4
0.05	Shakeout	%	100	26	100	26
0.06	Columns	Each	84	31.2	74	27.5
0.11	Beams	Each	859	52	0	0
0.10	Cross Braces	Each	837	57.2	0	0
0.20	Gribs & Sagrods	Bay	38	104	0	0
0.09	Plumb	%	100	46.8	5	2.3
0.30	Connections	Each	977	156.0	74	3.9
0.05	Punch List	%	100	26	0	0
1.0	Steel	Ton		520		80.5

Earned Tons to Date (5) \pm Quantity to Date (4) x Rel. Wt (1) x Σ Equiv. Steel Tons (3)

Total Quantity (2)

% Complete $\pm \Sigma$ Earned Tons (5) / Σ Equiv. Steel Tons

Agenda for Success:

- Get Good Designers: Beware of Bargain Shopping;
- Watch Low Bids Carefully: Work at Cost Spells Trouble;
- Fail to Plan and you Plan to Fail;
- Keep the Work Site Organized;
- Monitor the Gaps;
- No Pay Causes Delay;
- Time = Money;
- Communication; and Documentation.

New Concept For Project Control (Critical Chain):

- Estimate with safety removed (50% chance);
- Incentive for early finish;
- Focus on predecessors' finish;
- Project buffer (50%);
- Simple monitoring of buffer penetration;
- Earned-Value for cost analysis.

Using Microsoft Project

- Open Microsoft Project and add four sequential tasks as shown below. Add the relationships.
- Save the Baseline (Tools Tracking Save Baseline).
- Activate the "Tracking Gantt" from the side bar. Notice the two bars per activity.
- Now, Use (View-Table-Tracking) to see the columns related to entering progress details.
- Add the percentage complete shown below for the tasks.
- Question: How to show Delays? Slow versus Fast Progress? Reasons for work stops?

Example Using EasyPlan

Load the file for the house and garage project (PR7) described earlier. Let's continue on the project.

During actual progress, the following events were encountered during the first 12 days:

- Day 1: excavation progressed as planned and no other work was done.
- Day 2: the contractor encountered unexpected rock (an owner-related problem). Accordingly, Excavation was stopped until a new machine is procured. No other work was done on day 2.
- Days 3 and 4: the new excavation equipment did not arrive yet. No other work was done.
- Day 5: the new excavation equipment started working and all remaining excavation work was completed that day. No other work done.
- Days 6 and 7: Foundation work was started and completed.
- Day 8: work on the Joining Wall was started and completed.
- On each of days 9 & 10: 25% of the House Walls and 25% of the Garage Walls were completed.
- Day 11: both the owner and contractor caused the House Walls activity to stop. Also, the contractor did not have resources to work on the Garage Walls.
- Day 12: the problem due to both the owner and the contractor still caused the House Walls activity to stop. The contractor also still had a resource problem and could not proceed on the Garage Walls. On the same day, the owner wanted to take some time to change his selection of the interior finishes. In addition, the Fabrication of the Garage Doors activity is 17% done.
- Actual costs to day 12 are assumed to be \$5,000 for each of the started activities.

a) What is your optimum corrective action plan? Plot the project S-Curve and Earned-Value curve.

b) Print the payment schedule, Cash Flow chart, resource histograms, & the as-built schedule.

Solution:

- Let's load the file, all the data are saved and the project meets our 14-day deadline.
- 4. Baseline Reports

Let's now save the baseline.

5. Progress Proceed to the progress screen. Notice that the dark bottom bars (expected or remaining schedule) is identical to the top baseline bars. We now need to enter the daily actual progress using the EnterDailyProgress button.

ва	seline vs Actual	–					Remaining	g Work:														
No	actual progress as of yet.	Help 🛛	oolbar				100%	Baseline speed	Aft	er savi	ng base	eline, e i	nter pr	ogress	s data i	in botto	m bar	s: (%, C	, O, N)			
Cos	st = \$39,200, Baseline \$ = \$39,	200						+ Actual speed														
	ution 44 Decelies 44						Weight (0 to	i)	R Sł	ow Re	maining	g Schee	dule									
Dui	ation = 14, Baseline = 14	Actual Pro	views:	I _					11104	24404	ENION	0.110.4	7/1/04	0.110.4	NUN	12/10/4	10/10/4	14,110,4	15,11,0,4	10,110,0	10,110,4	201
	(12 Activities)	Actual FIU	greas .	Dep	ends u	Jpon:			11104	211/04	01104	oriro4	71104	oriro4	311104	1211104	13FIF04	141104	ISPIR04	1011104	Iorir04	201
lear /	I Progress Enter DailyProgress		Activity Cost	P1	P2	P3	Selected	Actual Cost	1	2	3	4	5	6	7	8	9	10	11	12	13	1
1	Excavation	2.0	\$2.0		1.2	10	1	route	50%	50%												
2	Foundation	2.0	\$2.0	1			1		50%	50%	502	502										-
<u> </u>	1 oundation	2.0	02.0	1 C			1				50%	50%										
3	Joining Wall	1.0	\$1.0	2			1						100%									
4	House Walls	4.0	\$4.0	3			1						10074	25%	25%	25%	25%					
-	Heurop Doof	2.0	85.0				2							25%	25%	25%	25%	505	50%			
5	nouse Root	2.0	30.0	"			2											50%	50%			
6	Select Finishes	1.0	\$1.0				1		100%													
7	Interior Finishes	2.0	\$4.0	6	5		2		100%			1								50%	50%	
																				50%	50%	
8	Clean Up	1.0	\$1.0	7	12		1															10
9	Fab. Garage Doors	6.0	\$6.0				1			17%	17%	17%	17%	17%	17%							
40	Oerees Wells	- 2.0	85.0				2			17%	17%	17%	17%	17%	17%	FOR	101					
10	Garage wais	2.0	ao.u	3			2									50%	50%					
11	Garage Roof	2.0	\$2.0	10			1											50%	50%			1
12	Garage Doors	2.0	\$2.0	11	9		1											50%	50%	502	50%	
12	Garage Doors	2.0	92.0		1		L .													50%	50%	

Activity Progress: × On day 1 (01/01/2004) After entering all the data for the 12 days, the schedule will (Excavation) has: look as below with projected completion of 20 days. Make • Progress: • O Delay: sure that you record the reasons for the delays. Value: Work done today: 50 %. Owner-directed acceleration? No
 No
 C Yes Comment on progress, such Excavation important site details. OK 2 Foundation Delete all activity progress 3 Joining Wall 4 House Walls 25% 25% 5 House Roof 50% 50% 50% 6 Select Finishes 7 Interior Finishes 50% 50% 8 Clean Up 100% 9 Fab. Garage Doors 17% 17% 17% 17% 10 Garage Walls 11 Garage Roof 50% 50% 12 Garage Doors 50% 50%

- For corrective actions, you may reactivate the optimization feature of EasyPlan to determine an execution strategy that tries to recover the delays.

- For project control purposes, EasyPlan has a wide range of reports and charts to support you in identifying project status, actual versus planned progress, corrective actions, and payment reports. Two examples are the payment report and the project S-curve.

F	eports and	l Charts: 🔀	Payment Re	port						We specify 7the report
	Summary Reports:	C Full Activity Report C Budget / Category Reports	Pleip & Instructions	\$43,120	Period:	Erom day: 33.6%	1 \$14,501	To day:	12 \$14,501	period here.
		C Payment Report	Activity Description	Baseline Budget (\$)	Planned Progress (%)	Actual Progress (%)	\$Total Owing To End of Day 12	\$ Total Paid Before Day 1	\$ Payable Before Deductions	
	Resource Charts:	C Histogram for L5 C Histogram for 0	1 Excavation	\$2,464	100.0%	100.0%	\$2,464		\$2,464	
		C Histogram for 0	3 Joining Wall	\$1,232	100.0%	100.0%	\$1,232		\$1,282	Notice the
	Progress Charts:	Cash Flow Chart Progress S-Curve	4 House Walls 5 House Roof	\$4,928 \$6,160	100.0%	50.0%	\$2,464		\$2,464	actual versus
		C Earned-Value Chart	6 Select Finishes 7 Interior Finishes	\$1,232 \$4,928	100.0% 50.0%					planned progress
	Cancel		8 Clean Up 9 Fab. Garage Doors	\$1,232 \$7,392	100.0%	17.0%	\$1,257		\$1,257	for that period.

 Other reports include an S-Curve, an Earned-Value chart, and a chart for progress indices. View these reports for the case study project.

Example: In th the t	e sma wo da	ll exar ys dela	nple sł ay bey	nown b ond the	elow, d e deadl	can we line?	readil	y decid	le whic	h party	is responsible fo
l l		Date									
	Activity	1	2	3	4	5	6	7	8	9	
	Α	50%	50%	.							
	В			50%	50%	<u> </u>					
	С			50%	50%						
	D					33.33%	33.33%	33.33%			
As-Planned Bar Chart											
] [Activity	Date									
		1	2	3	4	5	6	7	8	9	
	A	50%	50%								
	В			50%	0	0	50%				
	с л			C	50%	50%			22.229/	22.229	
l								33.33%	33.33%	33.33%	
A	s-Built	BarC	nart		_				Actu	al complete	date
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- Using a But-Fo	or analy	sis, rem	noving c	ontracto	r delays	:					
	ar an ab	ala ran									
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0	,										
1											

Traditional delay analysis looks at several project intervals (windows or snapshots) and assesses how the critical path varies from each window to the other (but not within each window). When acceleration is not considered, the analysis may produce different results depending on the window size. This is illustrated in the small 2-activity example below. The two activities of this example are both critical. During execution, one-day acceleration occurred on the first day, thus causing a one-day acceleration float (with respect to the original deadline). The owner then caused a work stop on the third day, while the contractor caused a work stop on the fifth day. The net project delay is one day (6 days on the asbuilt versus 5 days on the as-planned).

	1	2	3	4	5	6
Δ	50%	50%				
<i>N</i>	100%	Acceleration		Plan		
в		Float	33%	33%	34%	Actual
D		20%	0	30%	С	50%
					Dea	dline

Advanced IT Tools & Techniques

Process Simulation

Computer simulation is a powerful tool for accurate modeling of real world construction systems to support planning, scheduling, and resource management. Over the years, several systems have been developed with various capabilities. Such tools are beneficial in modeling any cyclic process such as the erection of steel elements in the various floors of a high-rise building, or earth-moving operations in which trucks are loaded with material, sent to dump area, and returned in a queue for another loading. These processes can have a lot of variability in the timing of each step, probability of process breakdowns, and various possible resource combinations.

With traditional simulation tools, the process of developing a simulation model requires the user to be familiar with specific terminology and the modeling schematics of particular software, in addition to the ability to write proprietary computer code. This may not be suitable for many construction practitioners who are not familiar with the operational details needed for accurate simulation. Several researchers have, therefore, employed different ways to simplify the modeling process and to make it more attractive to practitioners.

One of the simple simulation tools available commercially that is remarkably easy to use is the Scitor Process software. It allows the user to draw a flowchart of any process, assign resources to the process steps, run the simulation, and then obtain various reports on productive times, idle times, and the production quantity produced at the various process steps. An example of a simple concrete placing operation is shown below.

Using any simulation tool brings substantial benefits. This includes proper estimation of production rates, analysis of the impact of various resource combinations on production, analysis of the impact of uncertainty on production, and analysis of various reengineering decisions.

Enterprise Resource Planning

With the turn of the millennium, many software vendors have put into the market project management software that is claimed to be usable by all parts of the "Enterprise". It ties scheduling, resource allocation, document management, timekeeping, financing, procurement, and reporting together into one integrated system. On the larger business community, such systems have been referred to as "ERP" or Enterprise Resource Planning systems. An Enterprise Resource Planning system is a packaged business software system that enables a company to manage the efficient and effective use of its resources (materials, plant, and equipment, etc). ERP systems have been used by large manufacturing, production, and larger corporations and they cost millions of dollars in its planning, customization, and training of users. Their objectives are:

- Automate and integrate the majority of an organization's business processes;
- Share common data and practices across the entire enterprise;
- Produce and access information in a real-time environment;
- Tie all departments of a corporation together and facilitate the transfer of information; and
- Increase productivity, achieve higher level of competitiveness, and ultimately attain larger market share and profit margins.

With the increase in number of corporations using ERP software, organizations are facing many challenges during the implementation, particularly with the large cultural changes required from users. In fact, the use of these systems is going through the second wave which follows the "Go Live" step in their implementing. In this second wave, the focus is on addressing whether the promised benefits are attainable, the systems' impact on users' ability to adapt, and how to optimize the benefits gained from using such systems.

In a recent consulting report published by Deloitte Consulting (http://www.dc.com), various worldwide ERP implementation were analyzed through a survey among 230 respondents in 85 global companies. The report "*ERP's Second Wave: Maximizing the Value of Enterprise Applications and Processes*" included a survey that was conducted between the summer of 1998 and spring of 1999. The ERP systems surveyed are **SAP**, **Oracle**, **Baan**, and **PeopleSoft**. Some of the findings in the report are shown in the figure below. According to this report, full benefits of ERP implementation can be achieved through the following practices:

- 1. Focus on capabilities and benefits, not just going live;
- 2. Implementation does not end by go-live. ERP requires continuous planning and management;
- 3. Companies should anticipate a temporary dip in performance after going live but substantial improvements will soon follow;
- 4. Achieve balanced people, process, and technology changes across all area;
- 5. Extend the ERP capabilities even further;
- 6. Teach the organization to use new capabilities;
- 7. Build and leverage process expertise;
- 8. Promote post-implementation commonalties; and
- 9. Assign clear ownership of benefits and define metrics and manage to them.

Project Collaboration on the Web

The examples on Web-enabled devices and software applications are plenty. From Cellular phones that can browse the World Wide Web to applications that can completely run from the remote server by the Web browser. Almost all the new versions of project management software such as MS Project and Primavera have web features. Other specialized software that provide web-based project management services have also become available. Examples include BidCom, Framework, and Meridian. A listing of these software systems is provided in the appendix. With the new hand-held gadgets and web-enabled software, site to head-office communication is much facilitated so that reports are transmitted on line and expert solutions are provided immediately to site professionals.

Before buying: do some search, visit service providers' sites, try demos, do a matrix, talk to users, look at financial performance, evaluate your own operations, test different procedures, & plan for the transition.

	Be Framework 1	ologie tems, Inc.	s, Inc. Inc.				
F	eatures:						
	aboration: Review Drawings Redline / Comment Archive versions Lock Review CADD models Review photos Review without applications Message Boards Real-time discussions Schedule meetings	Work Flow: Meeting minutes Manage Correspondence RFIs Transmittals Submittals Approvals Change Notification Job progress reporting Multi-project progress reporting			Budgeting / Procurement: Estimating / Budgeting Bid Solicitation Purchasing / Procurement Accounting Facilities management		
Com D D D	munication: Print Email Fax PDAs	Cost	t: Training fee Annual cost / Monthly cost /	project user	Big (0 0 0 0 0 0	Questions: Repetitive Projects? How to meet constraints? Crew planning? Optimization? Corrective Actions? New Engineering features?	

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	Electrical and Electronics	7	10	58	
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OTHER

Hand-held devices

4-D visualization

GIS

Workshop Evaluation						
Hands-On Computer Workshops						
work for an in Owner Contractory or			orgon	ization		
work for an : Owner; Contractor; or	organization.					
	Plea	ise circ	le your	answe	r	
		1 = L	ow / Di	sagree		
Question	5 = V. High/Strongly Agree					
How would you rate the overall quality of this workshop?	1	2	3	4	5	
Overall, how would you rate the instructor?	1	2	3	4	5	
The instructor is well prepared?	1	2	3	4	5	
The instructor answers questions carefully and completely?	1	2	3	4	5	
The instructor uses examples to make the materials understandable?	1	2	3	4	5	
The instructor stimulated interest in the course?	1	2	3	4	5	
The course material is interesting?	1	2	3	4	5	
The instructor makes participants comfortable about asking?	1	2	3	4	5	
The difficulty level of this serves was environmented for ma2	1	2	3	4	5	
The quality of the workshop potes are?	1	2	3	4	С 5	
I would recommend this course to others?	1	2	2	4	5	
Workshon cost is reasonable?	1	2	3	4	5	
Format and time of day is reasonable?	1	2	3	4	5	
Location is good?	1	2	3	4	5	
Is the workshop material useful for your work environment?	1	2	3	4	5	
ther comments & suggestions for other workshops:						