Project Planning and Control Methods

Lecture #7-P2

Schedule Constraints (Resources)

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Outline

- Project resources
- Resource allocation
- Resource leveling
 - Resource leveling Technique
 - Resource Leveling MSP
- Resource over-allocation
- Resource calendar constraint
- □ MSP (more features)

Project resources

- We need resources to carry out different activities. There are three main resource types used in projects:
 - People (engineer, labor, operator)
 - Equipment (loader, crane, truck)
 - Material (steel, concrete, asphalt)
- Material-type resources are *expendable* resources, i.e., they are depleted during activity execution (e.g., use of concrete during "pouring foundation concrete" activity).
- People-type and equipment-type resources are *non-expendable* resources, i.e., they are busy when participating in an activity execution and become available for other activities after that. E.g., use of shovel and shovel operator for "digging the ditch" activity.
- Several resources might be used to carry out an activity (e.g., to install a steel column we need steel column, iron workers, crane and crane operator).

Resource allocation

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- Resource allocation (or resource loading) is the assignment of the resources required to each activity, in the required amount and timing.
- When we first estimate an activity duration, to be able to estimate the duration, we automatically assign normal number of resources required to each activity. This is basically the initial resource allocation.
- Example: Remember our "prepare foundation form work" example in *lecture 5* when we first estimated the activities, all durations came with number of resources
 required, we have allocated resources by mentioning resources for each activity:
 - 1) Extract foundation sizes from drawings (1 engineer, 1 day)
 - 2) Order form sheets (1 purchaser, 0.5 day)
 - 3) Hire two form-workers for the job(1 HR-person, 1 day)
 - 4) Size form sheets (2 form-worker, 2 day)
 - 5) Install form sheets in place (2 form-worker, 4 days)

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- Fluctuations in number of some (not all) of project resources over the course of the project are undesirable. For these resources we are trying to level their number over the time.
 - **Note:** Resource leveling is the case for most (not all!) people and equipment resource types (or non-expendable resources) but not for material resource type (or expendable resources)! (*why? see the justification in below!*)
- Every time we are forced to increase/ decrease number of our resources (i.e., hire/ fire our workers or set up / pack up our equipment) for the project we are imposing some costs to the project. Some examples of these additional costs are:
 - Time spent by HR person for hiring/ firing workers
 - Low performance of the new workers
 - Time spent by procurement person to sign rental/ purchase contract
 - Time spent for picking up/ dropping off and install/ uninstall the equipment



Project managers also whish to cut the resource peaks! Why?

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- Example 1: Following resource charts represent resource distribution over course of a project before and after resource leveling. Total number of resources per time unit in both schedules is 42. However, we are expecting less cost in the leveled schedule since project will have no cost regarding resource fluctuations!



Question: In reality is a completely leveled schedule possible?

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Example 1 (cont'd):

For calculating resource fluctuations in resource chart we need to sum up the amount of all ups and downs of the resource level!



Question: How can we reduce resource fluctuations (or level the resources) in a project?

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- Resource leveling has different types according to different types of project constraints. Resource leveling we are discussing here is for projects with *unlimited* resources and *limited* duration (the duration calculated in CPM).
 - **Note:** A project might have different types of resources (with different expertise or applications). Leveling different types of resources are done separately (e.g., welders, painters, cranes, etc. need to be leveled separately); most important resources are leveled the latest! **Why?**
- To be able to level the resources we need to adjust activities start (or finish) time in a way that resource fluctuations are reduced.



Question: For doing resource leveling on our schedule what type of activities we need to shift? (critical or non-critical) (easy question!!!!)

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Example 2: We are trying to level the project schedule presented in resource aggregate (or resource load) table in below by moving activities start time:

							V	Vor	king	g Da	у		
WBS	Predecessor	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	2	2	2	2	2				
2	1SS	1	4	3	2	2							
3	2	3	6	3			3	3	3	3			
4	2	3	8	5			2	2					
5	1,2	1	1	0						2	2	2	
6	5	1	1	0									1
	Sum		-		4	4	7	7	5	5	2	2	1

Resource fluctuations= 0+3+0+2+0+3+0+1=9

Example 2 (cont'd):

Moving activity 4 forward: **Resource fluctuations=** 0+1+0+0+0+1+0+3=5

	2	122	Т	4	3	Z	Z							
	3	2	3	6	З			3	З	З	3			
5	4	2	3	8	5							2	2	
	5	1,2	1	1	0						2	2	2	
	6	5	1	1	0									1
		Sum				4	4	5	5	5	5	4	4	1
								V	Vor	king	g Da	у		
	WBS	Predecessor	ES	LS	Slack	1	2	3	4	5	6	7	8	9
	1		1	1	0	2	2	2	2	2				
	2	1SS	1	4	3	2	2							
	3	2	3	6	3					3	3	3	3	
5	4	2	3	8	5			2	2					
	5	1,2	1	1	0						2	2	2	
	6	5	1	1	0									1

WBS Predecessor ES LS Slack

Working Day

Moving activity 3 forward: **Resource fluctuations=** 0+0+0+1+0+0+4=5

Example 3 (cont'd):

Moving activity 3 to ultimate forward:

Resource fluctuations= 0+0+0+2+3+0+0+1=6

							V	Vor	king	g Da	у		
WBS	Predecessor	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	2	2	2	2	2				
2	1SS	1	4	3	2	2							
3	2	3	6	3						3	3	3	3
4	2	3	8	5			2	2					
5	1,2	1	1	0						2	2	2	
6	5	1	1	0									1
	Sum				4	4	4	4	2	5	5	5	4

							V	Vor	king	g Da	у		
WBS	Predecessor	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	2	2	2	2	2				
2	1SS	1	4	3		2	2						
3	2	3	6	3						3	3	3	3
4	2	3	8	5				2	2				
5	1,2	1	1	0						2	2	2	
6	5	1	1	0									1
	Sum				2	4	4	4	4	5	5	5	4

Moving activity 3 to ultimate Forward and activity 2 and 4 1 step forward:

Resource fluctuations= 2+0+0+0+1+0+0+1=**4**

- To find the best possible resource distribution in a project's schedule, there is no way other than comparing resource fluctuations in all possible activity combinations in the project and picking the combination that has the minimum resource fluctuation!
- For a real world project schedules (e.g., with more than 100s or even1000s of activities), we are going to have a considerable number (e.g., 100s or 1000s) of non-critical activities which are candidates for changing their start time. Many of them have slack time of more than 1 which adds to the number of possible activity combinations.
- Example 3: A project schedule has total130 activities (30 of them on the critical path and 100 are non-critical). Average slack time for non-critical activities is 3 days. Total combination of activities will be in the order of:

3^100= 5.2 * 10^47

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- Example 3 (cont'd): If we suppose just 1 simple calculation is required for calculating every schedule combination (!!!!) and the computer can handle 10 billion (10^10) calculations in a second. Total calculation time for finding the best possible activity combination is:

5.2 * 10^47 / 10^10 = 5.2 * 10^37 seconds = 1.6 * 10^30 years (!!!!!!)

(I))Resource leveling problems are considered computationally complex problem (so call non-deterministic polynomial time hard or NP-Hard). For real scale projects there is no way that we can guarantee optimum answer for the problem.

To address resource the leveling concern there are heuristic and meta-heuristic methods developed with the main purpose of converging toward the optimum answer!

In class exercise 1

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Try to find the most leveled schedule for the project schedule presented in

resource aggregate (or resource load) table in below:

							V	Vor	king	g Da	у		
WBS	Predecessor	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	1	1	1	1	1	1	1	1	1
2	1SS	1	4	3	1	1							
3	2	3	6	3			2	2	2	2			
4	2	3	8	5			3	3					
	Sum				2	2	6	6	3	3	1	1	1

- **Definition:** Resource moment (torque):
 - A resource moment at the specified time of i with the resource number of Yi about the time axis is:

$$\frac{1}{2}(Y_i)^2$$

 Total schedule moment (M) for a resource is calculated:

$$M = \frac{1}{2} \sum_{i} (Y_i)^2$$



Resource chart of a schedule

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- Minimum Moment Technique (MMT) for resource leveling (Harris 1978) is a widely used heuristic method for resource leveling we will discuss here!
 - Dr. Harris has based minimum moment technique up on the fact that with the constant total number of resource-time unit (e.g., worker-day, man-hour) (ΣYi=A) the more leveled the schedule the less resource moment value will be resulted.
 - **Example 5**: Calculate the resource moment for the resource charts presented below:



Harris, R. I. (1978). Precedence and arrow networking techniques for construction, Wiley, New York.

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- MMT consists of two cycles: forward cycle and backward cycle. These two cycles are run consecutively up until we could not see any progresses in none of cycles. The main steps of the MMT are as follows:
 - 1) Start with the forward cycle, where you go to the *last* non-critical activity in the schedule (with the latest start).

								W	orking [Day			
WBS	Predec	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	1	1	1	1	1	1	1	1	1
2	1SS	1	4	3	2	2							
3	2	3	7	4			3	3	3				
4	2	3	6	3			2	2					
5	4	5	8	3					3	3			
		1	Total re	sources	3	3	6	6	7	4	1	1	1

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2) Shift the activity forward within its slack time (make sure no dependency rule is broken). Calculate total moment of different possible shifts.

								W	orking	g Day			
WBS	Predecessor	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	1	1	1	1	1	1	1	1	1
2	1SS	1	4	3	2	2							
3	2	3	7	4			3	3	3				
4	2	3	6	3			2	2					
5	4	5	8	3					3	3			
	Total resou	irce	s		3	3	6	6	7	4	1	1	1
	Moment			79	4.5	4.5	18	18	24.5	8	0.5	0.5	0.5

								W	orking	g Day			
WBS	Predecessor	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	1	1	1	1	1	1	1	1	1
2	1SS	1	4	3	2	2							
3	2	3	7	4			3	3	3				
4	2	3	6	3			2	2					
5	4	5	8	3						3	3		
	Total resou	irce	s		3	3	6	6	4	4	4	1	1
	Moment			70	4.5	4.5	18	18	8	8	8	0.5	0.5



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2) Shift the activity forward within its slack time (make sure no dependency rule is broken). Calculate total moment of different possible shifts.

								W	orking	g Day			
WBS	Predecessor	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	1	1	1	1	1	1	1	1	1
2	1SS	1	4	3	2	2							
3	2	3	7	4			3	3	3				
4	2	3	6	3			2	2					
5	4	5	8	3							3	3	
	Total resou	irce	S		3	3	6	6	4	1	4	4	1
	Moment			70	4.5	4.5	18	18	8	0.5	8	8	0.5



								W	orking	g Day			
WBS	Predecessor	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	1	1	1	1	1	1	1	1	1
2	1SS	1	4	3	2	2							
3	2	3	7	4			3	3	3				
4	2	3	6	3			2	2					
5	4	5	8	3								3	3
	Total resou	ırce	s		3	3	6	6	4	1	1	4	4
	Moment			70	4.5	4.5	18	18	8	0.5	0.5	8	8



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- 3) Shift the activity to the location with minimum total moment
 - **Note:** If several activity shifts result in similar total moment choose the shift with the latest start date!

								W	orking	g Day			
WBS	Predecessor	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	1	1	1	1	1	1	1	1	1
2	1SS	1	4	3	2	2							
3	2	3	7	4			3	3	3				
4	2	3	6	3			2	2					
5	4	5	8	3								3	3
	Total resou	irce	S		3	3	6	6	4	1	1	4	4
	Moment			70	4.5	4.5	18	18	8	0.5	0.5	8	8

The shift with the minimum total moment and the latest start is selected and set as new updated schedule!

- 4) Continue steps 2 and 3 for all activities from last to the first non-critical activities
- 5) Start backward cycle from the first non-critical activity
- 6) Shift the activity backward within its slack time (make sure no dependency rule is broken). Calculate total moment of different possible shifts.
- 7) In the backward cycle the activity to the location with the minimum total moment.
 Note: In case that you have several locations with equal minimum total moments, move the activity to the location with the *latest* start!
- 8) Continue steps 6 and 7 for all activities from first to the last non-critical activities
- 9) Continue steps 1 through 8 until there is no improvement achieved after two (i.e., one forward and one backward) cycles.

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Simplified MMT Calculations: To speed up the calculation of the moment

changes. Dr. Harris has introduced a shortcut method as follows. Suppose:

- The activity requires R number of resources
- The duration of the activity is t
- You have shifted the activity by S time units

- X1, X2, ... are number of resources in the days in which total number of resources reduced (by R) (prior to the shift)

-W1, W2, ... are number of resources in the days in which total number of resources increased (by R) (prior to the shift)

-m is number of days with resource increase which is equal to minimum of S and t

The change made in the moment (M1-M0) can be calculated as in below:

$$M_1 - M_0 = \Delta M = \frac{1}{2} \sum_{i}^{m} (X_i - R)^2 + \frac{1}{2} \sum_{i}^{m} (W_i + R)^2 - \frac{1}{2} \sum_{i}^{m} (X_i)^2 - \frac{1}{2} \sum_{i}^{m} (W_i)^2$$

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Example 6:

- R=Number of resources for activity 5 = 3 resources
- t= Duration of activity 5 = 2 days s= acitivity shift= 3 days

X1=7; X2=4 (resources) W1=1; W2=1 (resources)

m=number days with resource increase =Min(t,s)=2

								W	orking	g Day			
WBS	Predecessor	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	1	1	1	1	1	1	1	1	1
2	1SS	1	4	3	2	2							
3	2	3	7	4			3	3	3				
4	2	3	6	3			2	2					
5	4	5	8	3					3	3			
	Total resou	irce	s		3	3	6	6	7	4	1	1	1
	Moment			79	4.5	4.5	18	18	X1	X2	<u>).</u> !	W1	W2

								W	orking	g Day			
WBS	Predecessor	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	1	1	1	1	1	1	1	1	1
2	1SS	1	4	3	2	2							
3	2	3	7	4			3	3	3				
4	2	3	6	3			2	2			-		
5	4	5	8	3								3	3
	Total resou	ırce	s		3	3	6	6	4	1	1	4	4
	Moment			70	4.5 4.5 18 18 8 0.5 0.5 8 8								

M1-M0= $1/2^{(7-3)^2+(4-3)^2+(1+3)^2+(1+3)^2-7^2-4^2-1^2} = -9$ (So move it!!!)

Simplified MMT Calculations (cont'd):

By simplifying this equation we have:

 $\Delta M = R(-\Sigma X i + \Sigma W i + mR)$

In this calculations we are not interested in the actual value of the moment or even ΔM . What is important in MMT is the direction of changes (positive or negative). The fact is a decrease in ΔM represents a positive shift or an improvement and an increase in ΔM represents a negative shift or a decline. To make the sign (+ and -) of the formula more consistent with our purpose we define the Improvement Factor (or IF) as the negative value of ΔM . Since R is a positive constant value within the activity we are going to remove R factor from the formula. The simplified formula will become: IF= ($\Sigma Xi - \Sigma Wi - mR$)

Note: In the simplified method you need to follow the same steps discussed for *MMT*, but just replace total moment with IF!

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- Example 7: Follow MMT to level the project schedule presented in resource aggregate (or resource load) table in below:

								W	orking [Day			
WBS	Predeo	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	1	1	1	1	1	1	1	1	1
2	1SS	1	4	3	2	2							
3	2	3	7	4			3	3	3				
4	2	3	6	3			2	2					
5	4	5	8	3					3	3			
		1	Total re	sources	3	3	6	6	7	4	1	1	1

- Start from Activity 5 and forward cycle
- Activity 5 can shifted 1, 2 or 3 days. The IF result for each is:

IF1= 7-1-1*3=3; IF2=(7+4)-(1+1)-2*3=3; IF3=(7+4)-(1+1)-2*3=3

Since all IFs are in the same value we are going to shift activity by 3 days

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Example 7 (cont'd):

								We	orking D	Day			
WBS	Predeo	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	1	1	1	1	1	1	1	1	1
2	1SS	1	4	3	2	2							
3	2	3	7	4			3	3	3				
4	2	3	6	3			2	2					
5	4	5	8	3								3	3
		7	otal res	sources	3	3	6	6	4	1	1	4	4

Continue with activity 4 which can be shifted 1, 2 or 3 days. The IF result for each is:

IF1=6-4-2=0; IF2=(6+6)-(4+1)-2*2=3; IF3=(6+6)-(1+1)-2*2=6

IF3 shows the maximum improvement

								W	orking [Day			
WBS	Predeo	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	1	1	1	1	1	1	1	1	1
2	1SS	1	4	3	2	2							
3	2	3	7	4			3	3	3				
4	2	3	6	3						2	2		
5	4	5	8	3								3	3
		7	otal res	sources	3 3 4 4 4 3 3 4 4								

Example 7 (cont'd):

Continue with activity 3 which can be shifted 1, 2, 3 or 4 days. The IF result for each is:

IF1=4-3-3=-2; IF2=(4+4)-(3+3)-2*3=-4; IF3=(4+4+4)-(3+3+4)-3*3=-7;

 $\mathsf{IF4} = = (4+4+4) - (3+4+4) - 3^*3 = -8$

No improvement will be made by shifting activity 3

- Continue with activity 2. But it can be shifted forward since its FS dependency with activity 3 will be violated.
- Continue with backward cycle.
- Activity 2 do not have any backward move!
- Activity 3 do not have any backward move!
- Activity 4 has 3 backward shifts, 1, 2 and 3 days. The IF result for each is: IF1=3-4-2=-3; IF2=(3+3)-(4+4)-2*2=-6; IF3==(3+3)-(4+4)-2*2=-6; No improvement will be made by shifting activity 4
- Activity 5 do not have any backward move!

Example 7 (cont'd):

- Continue with forward cycle from activity 5
- Activity 5 do not have any forward move!
- Activity 4 do not have any forward move!
- Activity 3 has 3 forward shifts, 1, 2, 3 and 4 days. The IF result for each is: IF1=4-3-3=-2; IF2=(4+4)-(3+3)-2*3=-4; IF3=(4+4+4)-(3+3+4)-3*3=-7; IF4==(4+4+4)-(3+4+4)-3*3=-8

No improvement will be made by shifting activity 3

- Activity 2 do not have any forward move!
- We are going to stop at this stage since we had 2 consecutive cycles with no improvement. The final leveled schedule is:

								W	orking [Day			
WBS	Predeo	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	1	1	1	1	1	1	1	1	1
2	1SS	1	4	3	2	2							
3	2	3	7	4			3	3	3				
4	2	3	6	3						2	2		
5	4	5	8	3								3	3
		7	Total res	sources	3	3	4	4	4	3	3	4	4

Example 7 (cont'd):





In class exercise 2

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Follow simplified MMT method to level the project schedule presented in below:

							V	Vor	king	g Da	у		
WBS	Predecessor	ES	LS	Slack	1	2	3	4	5	6	7	8	9
1		1	1	0	1	1	1	1	1	1	1	1	1
2	1SS	1	4	3	1	1							
3	2	3	6	3			2	2	2	2			
4	2	3	8	5			3	3					
	Sum				2	2	6	6	3	3	1	1	1

Resource leveling - MSP

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Priority: In MSP activities with lower priorities are first on the line to be delayed!

□Before	Task Information
resource	General Predecessors Resources Advanced Notes Custom Fields Name: Order form sheets required Duration: 1 day The Estimated
leveling	Percent complete: 0%
make sure	Schedule Mode: Manually Scheduled
about the	Dates
priority of	<u>Start:</u> Sun 07/04/13 ▼ <u>Finish:</u> Sun 07/04/13 ▼
activities in	Display on Timeline
Task	Rollup
information>	
General:	
	Help OK Cancel

Resource leveling- MSP



Resource leveling – MSP



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- Example 8: Remember initial schedule we developed for our "prepare foundation form work" in *lecture 5* using CPM method.
 - 1) Extract foundation sizes from drawings (1 engineer, 1 day)
 - 2) Order form sheets (1 purchaser, 0.5 day)
 - 3) Hire two form-workers for the job(1 HR-person, 1 day)
 - 4) Size form sheets (2 form-worker, 2 day)
 - 5) Install form sheets in place (2 form-worker, 4 days)



Example 8 (cont'd):

Schedule in MSP:

Task Name 👻	Duratior 🚽	Start 👻	Finish 👻	Predecessors 💂	Resource 🗸 Names
Prepare foundation form work	9 days	Sat 15/11/14	Tue 25/11/14		
Extract foundation sizes from drawings	1 day	Sat 15/11/14	Sat 15/11/14		Eng
Order form sheets required	1 day	Sun 16/11/14	Sun 16/11/14	1	Pu
Hire two form-workers for the job	1 day	Sat 15/11/14	Sat 15/11/14		HR
Size the form-sheets	2 days	Wed 19/11/14	Sat 22/11/14	3FS+3 days,2	FW[200%]
Install form-sheets in place	4 days	Sat 22/11/14	Tue 25/11/14	4SS+1 day	FW[200%]

Question: What if we have a limited number of form-workers of 3 available for the job (e.g., there are maximum of 3 form-workers available in the area)?

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Example 8 (cont'd): To answer this question we are going to use resourceaggregation or resource-loading table to show daily summation of resources required to complete activities on each day.

				١	Nork	ing Da	ay			
WBS	Description	1	2	3*	4*	5	6	7	8	9
3.1.1	Extract foundation sizes from drawings	1Eng								
3.1.2	Order form sheets required		1Pu							
3.1.3	Hire two form-workers for the job	1HR								
3.1.4	Size the form-sheets					2FW	2Fw			
3.1.5	Install form-sheets in place						2Fw	2Fw	2Fw	2Fw
	Total resources	1Eng, 1HR	1Pu			2FW	4FW	2FW	2FW	2FW
*Days	3 and 4 are working days in which no activ	vity can be o	carrie	d ou	t					

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Example 8 (cont'd): To answer this question we are going to use resourceaggregation or resource-loading table to show daily summation of resources required to complete activities on each day.

				١	Nork	ing D	ау				
WBS	Description	1	2	3*	4*	5	6	7	8	9	
3.1.1	Extract foundation sizes from drawings	1Eng									
3.1.2	Order form sheets required		1Pu								
3.1.3	Hire two form-workers for the job	1HR									
3.1.4	Size the form-sheets					2FW	2Fw				
3.1.5	Install form-sheets in place						2Fw	2Fw	2Fw	2Fw	
	Total resources	1Eng, 1HR	1Pu			2FW	4FW	2 FW	2FW	2FW	
*Days	Days 3 and 4 are working days in which no activity can be carried out										

 In day 6 total number form-workers reaches 4FW which is a resource overallocation (one more than maximum form-worker availability of 3).

day increase in the project duration (from 9 days to 10 days)!

42

Example 8 (cont'd): By shifting "install form-sheets in place" activity one day a head, we can eliminate this resource constraint violation! This shift results in 1

					V	Vorkir	ig Day				
WBS	Description	1	2	3*	4*	5	6	7	8	9	10
3.1.1	Extract foundation sizes from drawings	1Eng									
3.1.2	Order form sheets required		1Pu								
3.1.3	Hire two form-workers for the job	1HR									
3.1.4	Size the form-sheets					2FW	2Fw				
3.1.5	Install form-sheets in place							2Fw	2Fw	2Fw	2Fw
	Total resources	1Eng, 1HR	1Pu			2FW	2FW	2FW	2FW	2FW	2FW
*Days	s 3 and 4 are working days in which no act	ivity can be	e carri	ed o	ut						

) To eliminate resource over-allocation we need to shift the violator activity and all of its direct and indirect successor-activities forward until the maximum resource violation (resource over-allocation) is eliminated! However there is no guarantee that the total duration of the project will stay untouched!

- Depending on the location of the activities involved (on the critical path or off the critical path) and the activity slack, maximum resource constraint might increase or not increase the project duration!
- Recognizing and eliminating maximum resource constraint violation is a capability within project scheduling computer programs!

WBS 🚽	6	Task Name	•	Duratic 🚽	Start 👻	Finish 👻	Predecessors 💂	Resource 🗸 Names
1		Extract foundation sizes fro	om drawings	1 day	Sat 15/11/14	Sat 15/11/14		Eng
2		Order form sheets re 🛒	Fix in Task	Inspecto	or.	n 16/11/14	1	Pu
3	\frown	Hire two form-worke	Tax III Table	mopeen		t 15/11/14		HR
4	İ	Size the form-sheets 💐	Reschedule	e to Ava	ilable Date	t 22/11/14	3FS+3 days,2	FW[200%]
5	🎟 i	Install form-sheets in	Ignore Pro	hlems fo	r This Task	e 25/11/14	4SS+1 day	FW[200%]
	\smile		ignore more		1 11113 103K			

<u>C</u>ut Cell

Highlighting over-allocated activities and the rescheduling option in M.S. Project software

WBS -	0	Task Name 👻	Duratior 🗸	Start 👻	Finish 👻	Predecessors 💂	Resource 🚽 Names
0		Prepare foundation form work	10 days	Sat 15/11/14	Wed 26/11/14		
1		Extract foundation sizes from drawings	1 day	Sat 15/11/14	Sat 15/11/14		Eng
2		Order form sheets required	1 day	Sun 16/11/14	Sun 16/11/14	1	Pu
3	\frown	Hire two form-workers for the job	1 day	Sat 15/11/14	Sat 15/11/14		HR
4		Size the form-sheets	2 days	Wed 19/11/14	Sat 22/11/14	3FS+3 days,2	FW[200%]
5		Install form-sheets in place	4 days	Sun 23/11/14	Wed 26/11/14	4SS+1 day	FW[200%]



Question: Talking about resource over-allocation which types of resources are

usually involved (people, equipment, or material)?

- Resource over-allocation is the issue with non-expendable (or reusable)
 resources, i.e., people and equipment types!
- We need to have enough material resources to be able to do the project. No matter how (i.e., in what sequence) we are allocating the materials to the activities, no over-allocation will happen with the material resources!
- In this perspective, reusability of the people and equipment resource types adds to the complexity of their planning.
- In some cases resource over-allocation problems can get very complicated

- In a project different resources might be available with different working time (calendars) :
 - Hauling trucks can enter the city from 11pm to 5am due to traffic regulation. Therefore
 Hauling the tunneling mucks out of the city by hauling trucks is limited to 11pm to 5am.
 - Mill delivers 10-inch HSS sections after 6 months from order.
 - External certified NDT inspector is available one day a month.
 - Foreign consulting company works Monday through Friday
- If initial schedule violates resource working time constraints we need to update the schedule accordingly by applying these constraints to all related activities and recalculating the schedule!

47

Example 9: in our "prepare foundation form work" example suppose that HR person is in vacation until Aban 27th, 1393 (Nov 18th, 2014).

Initial schedule is:

WBS 🚽	0	Task Name 👻	Duratic 🚽	Start 🗸	Finish 👻	Predecessors 💂	Resource 🕌 Names
1		Extract foundation sizes from drawings	1 day	Sat 15/11/14	Sat 15/11/14		Eng
2		Order form sheets required	1 day	Sun 16/11/14	Sun 16/11/14	1	Pu
3		Hire two form-workers for the job	1 day	Sat 15/11/14	Sat 15/11/14		HR
4	ŧ.	Size the form-sheets	2 days	Wed 19/11/14	Sat 22/11/14	3FS+3 days,2	FW[200%]
5	III 🛉	Install form-sheets in place	4 days	Sat 22/11/14	Tue 25/11/14	4SS+1 day	FW[200%]

"Hire two form-workers for the job" (3.1.3) is the only activity requiring the HR-person to be carried out. In the initial schedule it starts from Aban 24th,1393 (Nov 15th, 2014) which violates the HR-person calendar constraint. We need to recalculate the schedule to address this constraint.

48

Example 9 (cont'd): previous CPM calculations resulted in:



HR- person calendar constraint can be reflected on the AON network by adding a

3-day lag for the start of activity 3.1.3



49

Example 9 (cont'd): previous CPM calculations resulted in:



50

Example 9 (cont'd): previous CPM calculations resulted in:



51

Example 9 (cont'd): previous CPM calculations resulted in:



52

 Setting calendar constraints for activities and resources and incorporating them in the project scheduling is one of the prevalent features offered by project scheduling programs.

₽ 🛃 🤊 ▾ (ལ ▾ ╤		Gantt Chart Tools	7_93-S1-PPCM-L07-P2_FormWork_ResourceOverAllocation_3.mpp - Microsoft Project (P	roduct Activation Fa
File Task Fesource	Project View Ad Task Information	robat Format		Notes
Gantt Chart + View Clipboard	General Predecessors <u>N</u> ame: Hire two form Constrain task	workers for the job	Notes Custom Fields Duration: 1 day	Add t
Information or	Deadline:	NA	-	
Dbl-click on a	Constraint type:	Start No Earlier Than As Late As Possible	Constraint da <u>t</u> e: Tue 18/11/14	
task to pop-up	Task type:	As Soon As Possible Finish No Earlier Than	Effort driven	
task	C <u>a</u> lendar: WBS code:	Finish No Later Than Must Finish On	Scheduling ignores resource calendars	
information	Earned <u>v</u> alue metho	Start No Earlier Than		
form! Many	Mark task as milesto	ne		
additional info				
can be added!	Help		OK Cancel	

Example 9 (cont'd): project's duration increases from 9 working days and 2 nonworking days (initially from Nov 15 to Nov 25) to 12 working days and 4 nonworking (from Nov 15 to Nov 30) days!

WBS 🗸	0	Task Name 👻	Duratior 🚽	Start 👻	Finish 👻	Predecessors 💂	Resource 🗸 Names
0		Prepare foundation form work	12 days	Sat 15/11/14	Sun 30/11/14		
1		Extract foundation sizes from drawings	1 day	Sat 15/11/14	Sat 15/11/14		Eng
2		Order form sheets required	1 day	Sun 16/11/14	Sun 16/11/14	1	Pu
3		Hire two form-workers for the job	1 day	Tue 18/11/14	Tue 18/11/14		HR
4		Size the form-sheets	2 days	Mon 24/11/14	Tue 25/11/14	3FS+3 days,2	FW[200%]
5		Install form-sheets in place	4 days	Tue 25/11/14	Sun 30/11/14	4SS+1 day	FW[200%]



MSP – Specific resource calendar

8

 More flexible method for setting resource constraint is to customize a resource through resource information! You can then specify a customize calendar for a resource!

P J	I I → I → Fa k Resource	Proj ct View	Acrobat Format	7_93-S1-PPCM-L07-P2_FormWork_ResourceOverAll Image: Contract of the second s
Team Planner • Re View	Assign Resource Su esources Pool - Re Assignments	ubstitute esources Insert	Information Notes Details Properties	Level Level Level All Level
1	Change Working Time Resource calendar for 'FW' Base calendar: Standard	:	6	✓ Max. ✓ Std. Rate ✓ Ovt. Rate 100% \$20.00/hr \$0.00
4	Legend: Working Nonworking 31 Edited working hours On this calendar: 31 Exception day 31 Nondefault work week Exceptions Work Weeks	Click on a day to see its <u>w</u> November 2014 <u>S M T W Th</u> 2 3 4 5 6 9 10 11 12 13 16 17 18 19 20 23 24 25 26 27 30 a a a a	F S 1 1 7 8 14 15 21 22 28 29 29 20	orking. Is: F
Kesource Shee	Name		Start Finish	Details Delete Change Working Time Delete OK Cancel

MSP-Time crashing

55

 Task duration is automatically changed by increasing/ decreasing resources after the first resource setting!

	Task Name 💂	Predecessor 🚽	Duratic 🚽	Resource Names	Ŧ
1	Extract foundation sizes from drawings		1 day	Eng	
2	Order form sheets required	1	1 day	Pu	
3	Hire two form-workers for the job		2 days	HR	
4	Size the form-sheets	3FS+3 days,2	1 day	FW[200%]	
5	Install form-sheets in place	4SS+1 day	2 days	FW[200%]	
	, L		1	1	

	Task Name 💂	Predecessor 🖕	Duratic 🚽	Resource 🚽
1	Extract foundation sizes from drawings		1 day	Eng
2	Order form sheets required	1	0.5 days	Pu[200%]
3	Hire two form-workers for the job		2 days	HR
4	Size the form-sheets	3FS+3 days,2	1 day	FW[200%]
5	Install form-sheets in place	4SS+1 day	2 days	FW[200%]

MSP-format- critical tasks

56

Critical tasks are shown red if you select critical tasks on the format menu!



MSP-format- project summary task

57

Project summary task is added as a the project title with WBS 0 to aggregate the results!



MSP-Schedule baseline

58



OK

Help

Set as Default

Cancel

Help

Set as Default

Cancel

OK

MSP-Schedule baseline

	WB 🚽	Task Name 👻	Duratic 🚽	Baseline 🚽 🚽	Baseline 🚽 🚽	Start 🔶	Finish 🚽
1	3.1.1	Extract foundation sizes from drawings	1 day	NA	NA	Sat 06/04/13	Sat 06/04/13
2	3.1.2	Order form sheets required	1 day	NA	NA	Sun 07/04/13	Sun 07/04/13
3	3.1.3	Hire two form-workers for the job	1 day	NA	NA	Sat 06/04/13	Sat 06/04/13
4	3.1.4	Size the form-sheets	2 days	NA	NA	Wed 10/04/13	Sat 13/04/13
5	3.1.5	Install form-sheets in place	4 days	NA	NA	Mon 15/04/13	Sat 20/04/13



	WB-	Task Name 👻	Duratic 🚽	Baseline 🖕	Baseline 🖕	Start 🚽 🚽	Finish 🚽 💂
1	3.1.1	Extract foundation sizes from drawings	1 day	Sat 06/04/13	Sat 06/04/13	Sat 06/04/13	Sat 06/04/13
2	3.1.2	Order form sheets required	1 day	Sun 07/04/13	Sun 07/04/13	Sun 07/04/13	Sun 07/04/13
3	3.1.3	Hire two form-workers for the job	1 day	Sat 06/04/13	Sat 06/04/13	Sat 06/04/13	Sat 06/04/13
4	3.1.4	Size the form-sheets	2 days	Wed 10/04/13	Sat 13/04/13	Wed 10/04/13	Sat 13/04/13
5	3.1.5	Install form-sheets in place	4 days	Mon 15/04/13	Sat 20/04/13	Mon 15/04/18	Sat 20/04/13

MSP - Split the view

1 ¹ Three-story Office Building 24 days Mon 0201000 Thu 280401 2 ¹ General Conditions 17 days Mon 0201000 Thu 280401 3 Receive notice to proceed: 3 days G.C. General Management(.GC. General Management			0	Task Name 👻	Duration 🚽	Resource Names 🚽	Start 🚽	Finish 🚽 P	0/2 Jan '00 0/9 Jan '00 16 Jan '00 1/23 Jan '00 30 Jan '00 0/6 Fet▲ SSM TW TFSSM TW TFSSM TW TFSSM TW TFSSM TW TFSSM TW TFSSM
2 - General Conditions 17 days Mon 030100 The 250100 3 - General Manage motice to proceed it 3 days 6.C. General Management, 6.C. General Management, 12% j. 4 - Sumt bord and insurance 2 days 6.C. Project Management, 12% j. - G.C. Project Management, 12% j. 5 - Prepare and submit project 2 days 6.C. Project Management, 6.C. General Management, 12% j. - G.C. Project Management, 12% j. - G.C. Project Management, 12% j. 7 - Ottain buiking permits 4 days 6.C. Project Management, 12% j. - G.C. Project Management, 12% j. - G.C. Project Management, 12% j. 9 - Submit broid days 6.C. Project Management, 12% j. - G.C. Project Management, 12% j. - G.C. Project Management, 12% j. 10 - Long Lead Procurement, 70 days - Ti 070100 Tu 130000 Tu 130000 - Submit shop drawings and 2 wis Stell Frection Contractor W wed 280100 Tu 080200 8 - Submit shop drawings and 2 wis Elevisor Contractor W wed 280100 Tu 080200 8 - Submit shop drawings and 2 wis Elevisor Contractor W wed 280100 - Submit shop drawings and 2 wis Elevisor Contractor W wed 280100 - Submit shop drawings and 2 wis Elevisor Contractor W wed 280100 - Submit shop drawings and 2 wis Elevisor Contractor W wed 28		1		 Three-story Office Building (76,000 square feet) 	344 days		Mon 03/01/00	Thu 26/04/01	
3 Receive notice to proceed a 3 days G.C. General Management 4 Submit bond and insurance 2 days G.C. Project Management 5 Propare and submit project 2 days G.C. Project Management 6 Propare and submit project 2 days G.C. Project Management 7 Obtain building permits 2 days G.C. Project Management 9 Submit project Management 7 (1000) G.C. Project Management 9 Submit project Management 7 (1000) G.C. Project Management 9 Submit project Management 7 (1000) G.C. Project Management 12 Submit shop drawings and 2 wks Store fright for drawings G.C. Project Management 14 Submit shop drawings and 2 wks Rofing Contractor M Wed 260100 Tue 060200 8 15 Submit shop drawings and 2 wks Rofing Contractor M Wed 260100 Tue 060200 8 15 Submit shop drawings and 2 wks Rofing Contractor M Wed 260100 Tue 060200 8 15 Submit shop drawings and 2 wks Rectific driven		2		General Conditions	17 days		Mon 03/01/00	Tue 25/01/00	
4 Summ bond and insurance 2 days G.C. Project Management(25%) 5 Prepare and slumt project 2 days G.C. Project Management(25%) 6 Prepare and slumt project 2 days G.C. Project Management(25%) 7 Obtain building permits 4 days G.C. Project Management(25%) 7 Obtain building permits 4 days G.C. Project Management(25%) 9 Summ trong training stop dra 2 wiss G.C. Project Management(25%) 10 E Long Lead Procurement 70 days Th 0.061000 Th 0.061000 7 11 Summ shop drawings and 2 wiss Stelle Treation Contractor 1 Wed 280100 The 0.080200 8 14 Summ shop drawings and 2 wiss Stelletract Contractor 1 Wed 280100 The 0.080200 8 14 Summ shop drawings and 2 wiss Declarator 1 Wed 280100 The 0.080200 8 14 Summ shop drawings and 2 wiss Declarator 1 Wed 280100 Wed 280100 15 Submt shond and maurance documents Qurator: 2 days Perevinue Neg		3		Receive notice to proceed a	3 days	G.C. General Manag	Mon 03/01/00	Wed 05/01/00	G.C. General Management
5 Prepare and submit project 2 days G. C. Project Management(25%), G. C. Project Management(15%), G. C. Projec		4	ŧ	Submit bond and insurance	2 days	G.C. Project Manage	Thu 06/01/00	Fri 07/01/00 3	G.C., Project Management, G.C. General Management [25%]
B Prepare and submit schedu 2 days C.C. General Management (10%), G.C. Project		5		Prepare and submit project	2 days	G.C. Project Manage	Mon 10/01/00	Tue 11/01/00 4	G.C. Project Management[25%],G.C. Scheduler
0 Obtain building permits 4 days G.C. Project Managee Thu 660100 Thu 10100 3 8 Submit perlimany shop dra 2 wiss G.C. Project Managee Thu 660100 Thu 050100 Thu 0501000 Thu 050100 Thu 0501000	art	6	ŧ	Prepare and submit schedu	2 days	G.C. General Manag	Wed 12/01/00	Thu 13/01/00 5	G.C. General Management[10%],G.C. Project Management
B Submit preliminary shop dra 2 wks G.C. Project Management[50%],G.C. 9 Submit monthly requests to 1 day Thu 0601100 Thu 0601100 10 — Long Lead Procurement 70 days Fri 07/0100 Thu 13/04000 11 Submit shop drawings and 2 wks Steel Erection Contractor N Wed 26/0100 Tue 08/02/00 & 12 Submit shop drawings and 2 wks Beel Erection Contractor N Wed 26/01/00 Tue 08/02/00 & 14 Submit shop drawings and 2 wks Beel Erection Contractor N Wed 26/01/00 Tue 08/02/00 & 15 Submit shop drawings and 2 wks Electric Contractor N Wed 26/01/00 Tue 08/02/00 & 15 Submit shop drawings and 2 wks Electric Contractor N Wed 26/01/00 Tue 08/02/00 & 15 Submit shop drawings and 2 wks Electric Contractor N Wed 26/01/00 Tue 08/02/00 & 16 Submit shop drawings and 2 wks Electric Contractor N Wed 26/01/00 Tue 08/02/00 & 16 Submit shop drawings and 2 wks Electric Contractor N Wed 26/01/00 Neextore 17 <td>ۍ ا</td> <td>7</td> <td>i</td> <td>Obtain building permits</td> <td>4 days</td> <td>G.C. Project Manage</td> <td>Thu 06/01/00</td> <td>Tue 11/01/00 3</td> <td>G.C. Project Management[50%],G.C. Procurement[50%]</td>	ۍ ا	7	i	Obtain building permits	4 days	G.C. Project Manage	Thu 06/01/00	Tue 11/01/00 3	G.C. Project Management[50%],G.C. Procurement[50%]
3 Submit monthly requests to 1 day Thu 06/01/00 Thu	antt	8	i	Submit preliminary shop dra	2 wks	G.C. Project Manage	Wed 12/01/00	Tue 25/01/00 7	G.C. Project Management[50%],G.C. I
10 Image: Constraint Shop drawings and 2 wiss Steel Erection Contra Fri 07/01/00 Thu 2001/00 9 11 Submit Shop drawings and 2 wiss Steel Erection Contra Fri 07/01/00 Thu 2001/00 9 12 Submit Shop drawings and 2 wiss Steel Erection Contractor / Wed 26/01/00 Tue 08/02/00 8 13 Submit Shop drawings and 2 wiss Elevator Contractor / Wed 26/01/00 Tue 08/02/00 8 14 Submit Shop drawings and 2 wiss Elevator Contractor / Wed 26/01/00 Tue 08/02/00 8 15 Submit Shop drawings and 2 wiss Elevator Contractor / Wed 26/01/00 Tue 08/02/00 8 15 Submit Shop drawings and 2 wiss Elevator Contractor / Wed 26/01/00 Tue 08/02/00 8 15 Submit Shop drawings and 2 wiss Elevator Contractor / Wed 26/01/00 Tue 08/02/00 8 15 Submit Shop drawings and 2 wiss Elevator Contractor / Med 26/01/00 Tue 08/02/00 8 15 Submit Shop drawings and 2 wiss Elevator Contractor / Med 26/01/00 Tue 08/02/00 8 16 Ord Previous Negat 17 Resource Name Work R/D Leveling Delay Scheduled Start Scheduled Finish 10 Resource Name Work R/D Leveling Delay Scheduled Start Scheduled Finish Fri 07/01/00 Fri 07/01/00 Fri 07/01/00 10 G.C. General Management 16h Od<	G	9	6	Submit monthly requests for	1 day		Thu 06/01/00	Thu 06/01/00 3	
11 Submit shop drawings and 2 wis Steel Erection Contractor Management 12 Submit shop drawings and 2 wis Roofing Contractor / Wed 26/01/00 Tue 08/02/00 8 13 Submit shop drawings and 2 wis Pletytain Contractor / Wed 26/01/00 Tue 08/02/00 8 14 Submit shop drawings and 2 wis Pletytain Contractor / Wed 26/01/00 Tue 08/02/00 8 15 Submit shop drawings and 2 wis Pletytain Contractor / Wed 26/01/00 Tue 08/02/00 8 15 Submit shop drawings and 2 wis Pletytain Contractor / Wed 26/01/00 Tue 08/02/00 8 15 Submit shop drawings and 2 wis Pletytain Contractor / Wed 26/01/00 Tue 08/02/00 8 16 Submit bond and insurance documents Quartson: 2 days Pletfort driven Manually Scheduled Previous Negt 10 Resource Name Work R/D Leveling Delay Scheduled Start Scheduled Finish No 2 G.C. Project Management JSh Od Od Thu 0		10	-	Long Lead Procurement	70 days		Fri 07/01/00	Thu 13/04/00	
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13 Submit shop drawings and 2 wks Elevator Contractor h Wed 26/01/00 Tue 08/02/00 8 14 Submit shop drawings and 2 wks Plumbing Contractor Wed 26/01/00 Tue 08/02/00 8 15 Submit shop drawings and 2 wks Electric Contractor M Wed 26/01/00 Tue 08/02/00 8 15 Submit shop drawings and 2 wks Electric Contractor M Wed 26/01/00 Tue 08/02/00 8 15 Submit bond and insurance documents Duration: 2 days Image: Fixed Units Next Start: Thu 06/01/00 Finigh: Fi 07/01/00 Task type: Fixed Units % Complete: 0% % 10 Resource Name Work R/D Leveling Delay Delay Scheduled Start Scheduled Start Scheduled Tinish 1 2 G.C. Project Management 16h Od Od Thu 06/01/00 Fin 07/01/00 Fin 07/01/00 1 G.C. General Management 4h Od Od Thu 06/01/00 Fin 07/01/00 Fin 07/01/00		12		Submit shop drawings and	2 wks	Roofing Contractor N	Wed 26/01/00	Tue 08/02/00 8	
14 Submit shop drawings and 2 wks Plumbing Contractor Wed 26/01/00 Tue 08/02/00 8 15 Submit shop drawings and 2 wks Electric Contractor M Wed 26/01/00 Tue 08/02/00 8 1 Submit bond and insurance documents Quartion: 2 days Image: Previous Next Start: Thu 06/01/00 Fri 07/01/00 Task type: Fixed Units % 6 complete: 0% image: 10 Resource Name Work R/D Leveling Delay Scheduled Start Scheduled Finish 2 G.C. Project Management 16h Od Od Thu 06/01/00 Fri 07/01/00 1 G.C. General Management 4h Od Od Thu 06/01/00 Fri 07/01/00		13		Submit shop drawings and	2 wks	Elevator Contractor I	Wed 26/01/00	Tue 08/02/00 8	
15 Submit shoo drawinos and 2 wks Electric Contractor M Wed 26/01/00 Tue 08/02/00 8 Name: Submit bond and insurance documents Duration: 2 days Image: Effort driven Manually Scheduled Previous Next Start: Thu 06/01/00 Image: Fri 07/01/00 Task type: Fixed Units % Complete: 0% Image: 0% Im		14		Submit shop drawings and	2 wks	Plumbing Contractor	Wed 26/01/00	Tue 08/02/00 8	
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Name: Submit bond and insurance documents Duration: 2 days Image: Complete instruction Next Start: Thu 06/01/00 Finigh: Fri 07/01/00 Task type: Fixed Units % Complete: 0% Image: Optimized Complete: 0% Image: Opticon Complete: 0% <		4						•	
Start: Thu 06/01/00 Finigh: Fri 07/01/00 Task type: Fixed Units % Complete: 0% © 1D Resource Name Work R/D Leveling Delay Delay Scheduled Start Scheduled Finish * 2 G.C. Project Management 16h Od Od Thu 06/01/00 Fri 07/01/00 * 1 G.C. General Management 4h Od Od Thu 06/01/00 Fri 07/01/00 *		Name	Subr	mit bond and insurance documents	uration: 2 da	vs 🚔 🗸 Effor	t driven Manual	v Scheduled	Previous
Start: Thu 06/01/00 Task type: Fixed Units % Complete: 0% 7 ID Resource Name Work R/D Leveling Delay Scheduled Start Scheduled Finish 2 G.C. Project Management 16h 0d 0d Thu 06/01/00 Fri 07/01/00 1 G.C. General Management 4h 0d 0d 0d Fri 07/01/00 10 G.C. General Management 4h 0d 0d Fri 07/01/00 </td <td></td> <td><u>H</u>anner</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>		<u>H</u> anner							
ID Resource Name Work R/D Leveling Delay Scheduled Start Scheduled Finish A 2 G.C. Project Management 16h 0d 0d Thu 06/01/00 Fri 07/01/00 Image: Comparison of the compar		St <u>a</u> rt:	Thu	06/01/00 ▼ Fini <u>s</u> h:	Fri 07/01/0	0 -	Task type: Fix	ed Units 🔻	% Complete: 0%
2 G.C. Project Management 16h 0d 0d Thu 06/01/00 Fri 07/01/00 1 G.C. General Management 4h 0d 0d Thu 06/01/00 Fri 07/01/00		ID	Reso	urce Name	Work	R/D Leveling	Delay Delay	Scheduled Sta	t Scheduled Finish
1 G.C. General Management 4h Od Od Thu 06/01/00		2	G.C.	Project Management	16h		0d 0d	Thu 06/0	/00 Fri 07/01/00
Task Fo	Ε	1	G.C.	General Management	4h		0d 0d	Thu 06/0	/00 Fri 07/01/00
	Ð								
	ask								
	-								

MSP- Calendar view

61



MSP- Detail Gantt

62

Critical tasks are shown red in the Detail Gantt view!



MSP – Network view

Steel Erection Start: Tue 25/04/00 ID: 47 Finish: Mon 26/06/00 Dur: 45 days Comp: 0%	
Form and Pour Concrete - Floors and Start: Tue 09/05/00 DD: 54 Finish: Mon 04/09/00 Dur: 85 days Comp: 0%	
□ <u>Carpentry Work</u> Start: Tue 05/09/00 ID: 77 Finish: Mon 25/09/00 Dur: 15 days Comp: 0%	Install exterior sheathing and metal st Start: Tue 05/09/0 ID: 78 Finish: Mon 25/09 Dur: 3 wks Res: Drywall Contractor
□ <u>Masonry Work</u> <u>Start: Tue 06/06/00 ID: 79</u> <u>Finish: Mon 06/11/00 Dur: 110 days</u> <u>Comp: 0%</u>	Install tile in toilet rooms Start: Wed 16/08/ ID: 80 Finish: Tue 12/09/ Dur: 4 wks Start: Wed 13/09/ ID: 84 Res: Plumbing Contractor
	Lay masonry at core, mechanical, and 1 Start: Tue 06/06/0 ID: 81 Finish: Mon 03/07 Dur: 4 wks Res: Masonry Contractor

MSP- Resource graph view

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Painting Contractor Overallocated: Allocated:

MSP - Team planner view

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Resource _	Unscheduled		07 Apr '13								14 A	pr'13					
Name	Tasks	F	S	S	M	Т	W	Т	F	S	S	Μ	Т	W	Т	F	S
Eng			E xt														
Pu				O r													
HR			Hire two f	for													
FW										Si z				Insta sheet	ll for ts in p	m- olace	

Assignment 6 – resource constraint

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preparation and foundation project won by Pardis-e Kish construction company:

		WBS	Task	Predecessor	Resource	Estimated Duration
	1	1	Site Grading and Utilities			
•	2	1-1	Clear and grub site		Dozer (2)	2w
nts site	3	1-2	Stone site access and temporary parking area	2	Dozer (1), Stone (10 truck bucker)	1w
ation	4	1-3	Rough grade site (cut and fill)	2	Dozer (1)	4w
allon	5	1-4	Install storm drainage	4	Excavator (1), Crane (1)	1w
	6	1-5	Install exterior fire line and building fire riser	4	Excavator (1), Crane (1)	3w
ation	7	1-6	Perform final site grading	4	Dozer (1)	1w
t won	8	1-7	Erect building batter boards and layout building	5SS+1w, 7	Crane (1), Installtion crew(1)	2w
dis-e	9	2	Foundations			
	10	2-1	Excavate foundations	8	Excavator (3)	2w
t'a	11	2-2	Excavate elevator pit	8	Excavator (1)	1w
uction	12	2-3	Form column piers and spread foundations	11	Form-Concrete crew (2)	2w
any:	13	2-4	Rough-in electric and plumbing in elevator	12	Electrical crew (2)	2w
	14	2-5	Form elevator pit walls	13	Form-Concrete crew (1)	2w
	15	2-6	Set reinforcing and anchor bolts	13FF+2w,14	Form-Concrete crew (1)	1w
	16	2-7	Pour column piers and foundations	15	Form-Concrete crew (1)	3w
	17	2-8	Pour concrete elevator walls	16	Form-Concrete crew (2)	1w
	18	2-9	Cure elevator wall concrete	17+1d	Labour (0.1)	2w
	19	2-10	Cure piers and foundations	18	Labour (0.1)	2w
	20	2-11	Strip wall forms	18	Form-Concrete crew (1)	1w
	21	2-12	Strip column piers and foundation forms	19	Form-Concrete crew (2)	2w
	22	2-13	Install pneumatic tube in elevator pit	21	Elevator crew (1)	1w
	23	2-14	Prepare and pour concrete floor in elevator pit	22,20	Form-Concrete crew (1)	1w

Assignment 6 – resource constraint

- Every working week is 5 working days (Saturday to Wednesday). The work starts from Azar 3rd.
- 1 –(Mark: 20%) Set up an MS Project file for the project and develop the initial schedule! (submit a separate MSP file for it.)
- 2 –(Mark: 50%) Follow Minimum Moment Technique steps for leveling "Form-Concrete crew" resources (NOT using MSP!)
- □ 3- (*Mark: 10%*) Use MSP's resource leveling feature to level all resources!
- 4- (Mark: 20%) Suppose we have maximum "Form-Concrete crew" of 2 (we can employ enough number of resources for the rest). Remove all over allocations, finalize the schedule and save it as the baseline!

Due date one week

