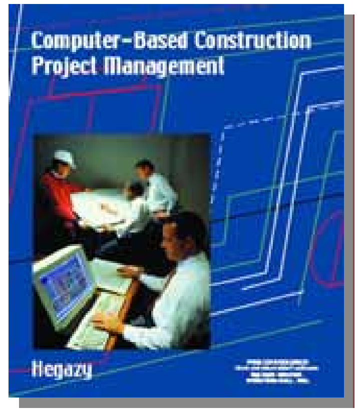
The Easiest Way to Get More Jobs and Manage Them Well

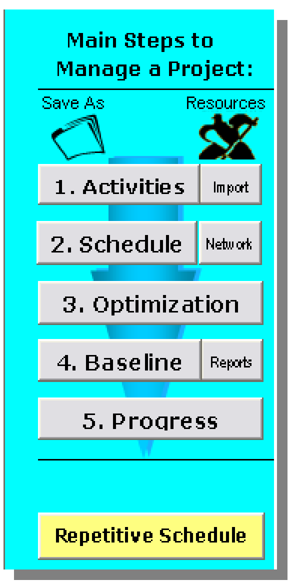
Important background material on EasyPlan and basic Project Management concepts are in the article at the end of this manaual.



Detailed concepts can be found in the textbook shown.

Using EasyPlan:

Simply follow the options in this menu one-by-one.



Switch between Excel's own menu and EasyPlan's Toolbar

Features:

Project Planning Features:

1. Organized resource bank.
2. Not one … but three estimates/activity.
3. Cost optimization to meet deadline.
4. Cash flow analysis to estimate interest charges.
5. Repetitive scheduling features.
6. Analysis of competitors to estimate markup.
7. Price fine-tuning through unbalancing.
8. Extensive reports & charts.

Project Control Features:

9. Site layout optimization.
10. Simple records of site events, including delays.
11. Cost-effective corrective actions.
12. Earned-Value Control, with time & cost indices.
13. Full Delay Analysis.
14. Import & Export to Microsoft Project software.

Limitations:

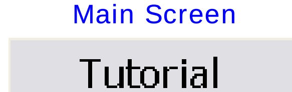
- Activity relations are limited to finish-to-start, with a limit of three predecessors and three successors per activity.
- Project is limited to 211 working days (about 9 months) because of Excel limited columns.

Important Setup Note:

1. **Activate Excel**
2. Change macro security level to **low** (Tools – Macro – Security)
3. Close Excel

Online Training Exercises:

Main Screen



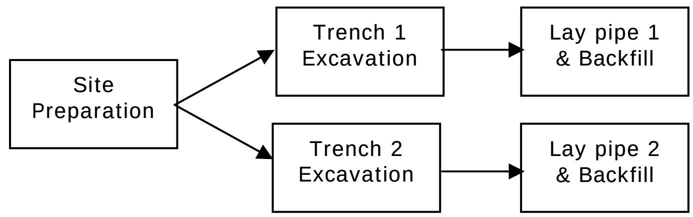
Download projects, solve, and check your score.

- You are involved in a small trenching project for a section length of 200 meters. Work will start Jan. 16, 2006 under the following contract information:

- Deadline is 8 days; Penalty for late completion = $5,000/day, Bonus for early completion = $1000/day.
- Indirect cost = $50/day; Contractor's markup = 10%; Reporting period = every 2 days; Interest rate is 1% per period; Owner's holdback = 5% (payable at end); and Workers (L1) availability limit is 4 / day.

The contractor's team studied the drawings, specifications, and other contract documents, then did some planning tasks that resulted in dividing the project into 5 work packages (activities). Optional estimates per activity were identified as shown in the following table. Activity relationships are also shown. Some other identified information is as follows:

Network for the activities of a single unit (200-meter section)



No.	Description	Depends on	Estimate 1 Cost	Estimate 1 Duration	Estimate 1 Workers	Estimate 2 Cost	Estimate 2 Duration	Estimate 2 Workers	Estimate 3 Cost	Estimate 3 Duration	Estimate 3 Workers
1	Site Preparation	---	$5,000	4.0	3.0	$7,000	2.0	3.0			
2	Trench 1 Excavation	1	$5,000	4.0	3.0				$10,000	2.0	2.0
3	Trench 2 Excavation	1	$5,000	4.0	2.0	$6,000	3.0	2.0	$7,000	2.0	2.0
4	Lay Pipe 1 & Backfill	2	$5,000	4.0	3.0	$5,000	2.0	2.0	$7,000	1.0	2.0
5	Lay Pipe 2 & Backfill	3	$5,000	4.0	3.0	$8,000	3.0	2.0	$9,000	2.0	2.0

Requirements: Enter the project data into EasyPlan. Determine the optimum execution plan that meets both the **deadline and resource limits**, with minimum cost.

Step-By-Step Solution

- Activate **EasyPlan.xls** from the directory in which it was installed.

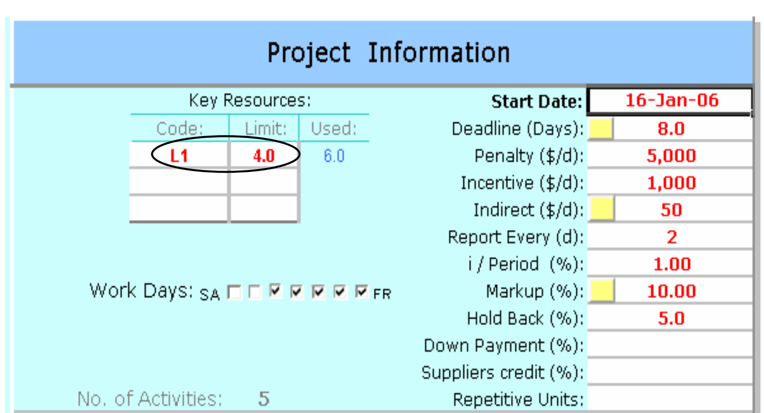
- Use 

to rename the project to a new name of your choice.
Always save the file to EasyPlan's directory to access all the help features.

General Information

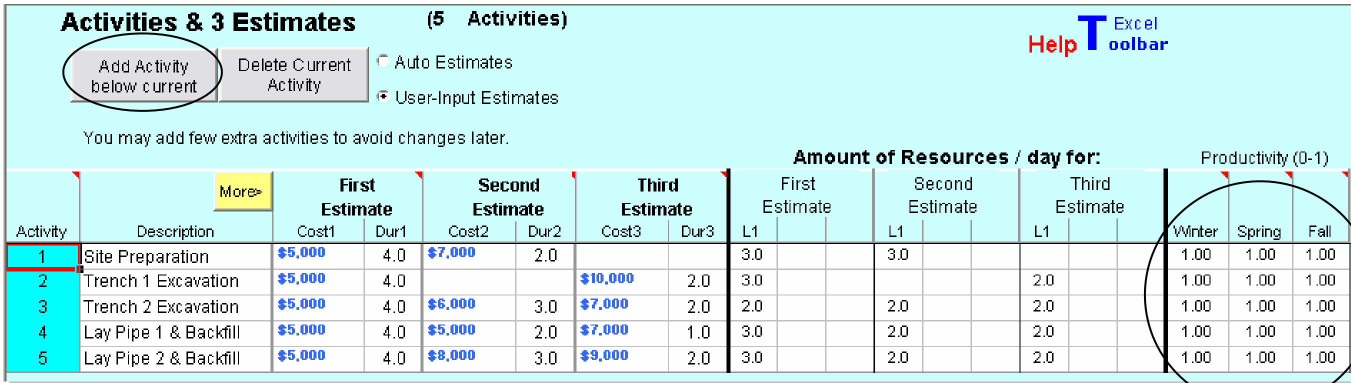
- In the **"Main Screen"**, input the general data for the project and the constraints you have:

- Start date;
- Working days;
- The key resource (L1) and its daily limit
- Project deadline duration;
- Penalty & incentive amounts; and
- Other contract provisions as shown.



Step 1: Specify the Activities

- Use the "Activities" button **1. Activities** to proceed to the activities sheet. Add / delete activities as necessary and specify the activities' estimates, as shown below:



Activity	Description	First Estimate Cost1	Dur1	Second Estimate Cost2	Dur2	Third Estimate Cost3	Dur3	First Estimate L1	Second Estimate L1	Third Estimate L1	Winter	Spring	Fall
1	Site Preparation	$5,000	4.0	$7,000	2.0			3.0	3.0		1.00	1.00	1.00
2	Trench 1 Excavation	$5,000	4.0			$10,000	2.0	3.0		2.0	1.00	1.00	1.00
3	Trench 2 Excavation	$5,000	4.0	$6,000	3.0	$7,000	2.0	2.0	2.0	2.0	1.00	1.00	1.00
4	Lay Pipe 1 & Backfill	$5,000	4.0	$5,000	2.0	$7,000	1.0	3.0	2.0	2.0	1.00	1.00	1.00
5	Lay Pipe 2 & Backfill	$5,000	4.0	$8,000	3.0	$9,000	2.0	3.0	2.0	2.0	1.00	1.00	1.00

We arrange our estimates so that Estimate1 is the cheapest, & Estimate3 is the most expensive but fastest.

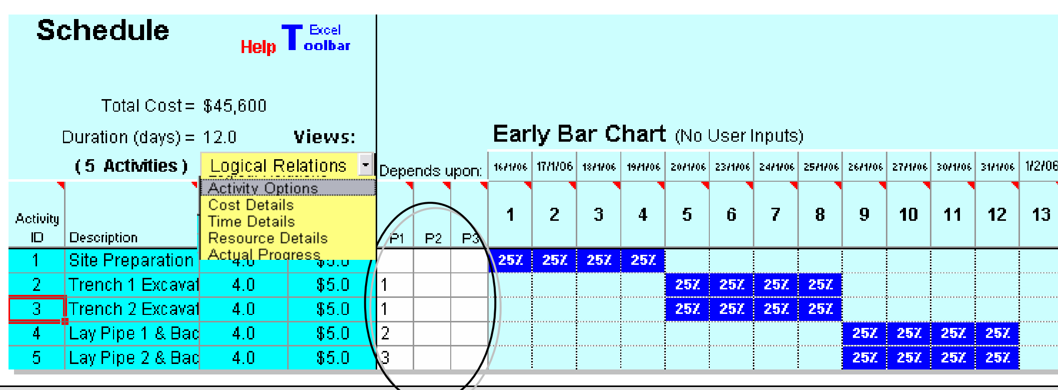
Seasonal productivity factors to consider the effect of construction during winter or under unfavorable working conditions.

NOTES:

- You may specify activities by importing a Microsoft Project file, using the "Import" button **Import**. Once the project activities are imported, a message appears to notify you of successful import.
- Once done adding new activities and specifying their estimate data, return to the **Main Screen** from the top toolbar **Main Screen**.
- If you click on the "**More >**" button in the Activities sheet **More>**, you can put additional information about the activities supervisors, area in the project, and contract item.

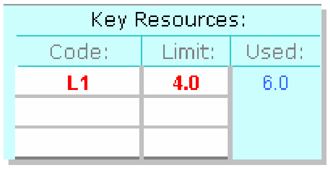
Step 2: Specify Work Sequence & Schedule Details

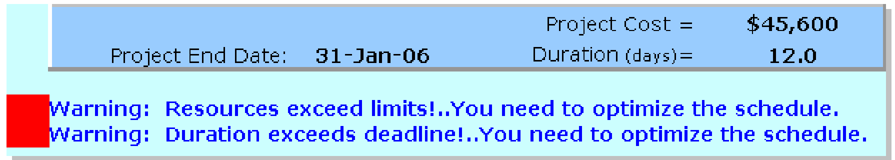
- Use the "Schedule" button **2. Schedule** **Network** to access the schedule sheet to enter the IDs of three predecessors to each activity, as shown below. Automatically, project duration becomes 12 days (4 days beyond the deadline), with a cost of $45,600 as shown at the top of the schedule sheet. Notice that all activities use their cheapest estimate.



- When we return to the Main Screen 

Return to the Main Screen., we notice that we not only exceed the deadline but also we need to use six of the L1 resource i.e., two more than available.





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We can now look at the network diagram.

Step 3: Optimize the Schedule

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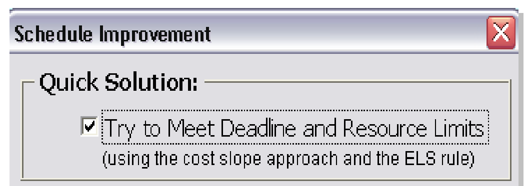
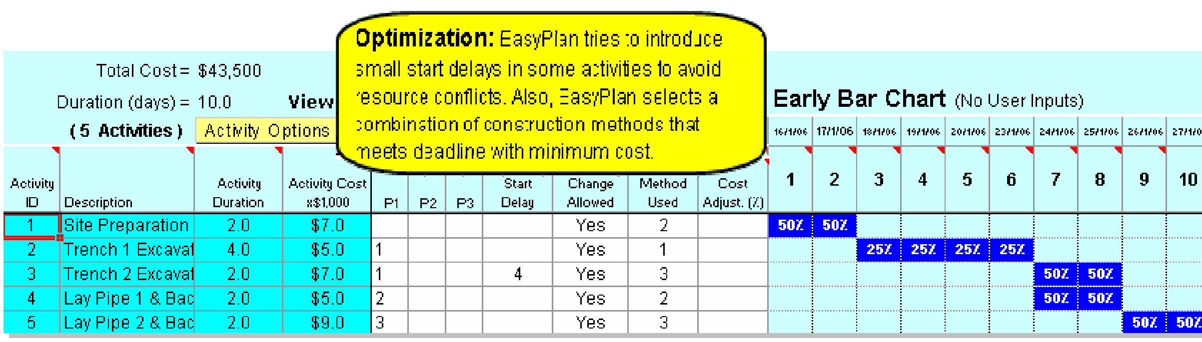
With our options put into the software, EasyPlan can help us decide the cheapest combination of work options that meets all project constraints (i.e., deadline and a limit of 4 L1 resources).



- Let's first try to use a simple heuristic approach, as shown in the option shown. Accordingly, the result shows an improved schedule of 10 days that meets the resource limits.



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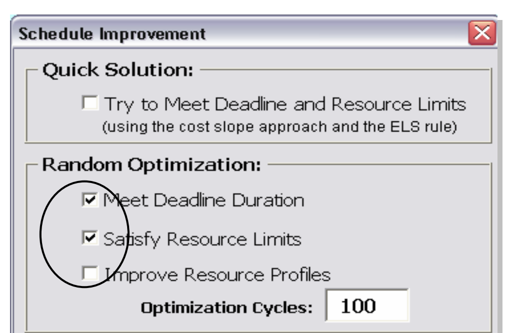
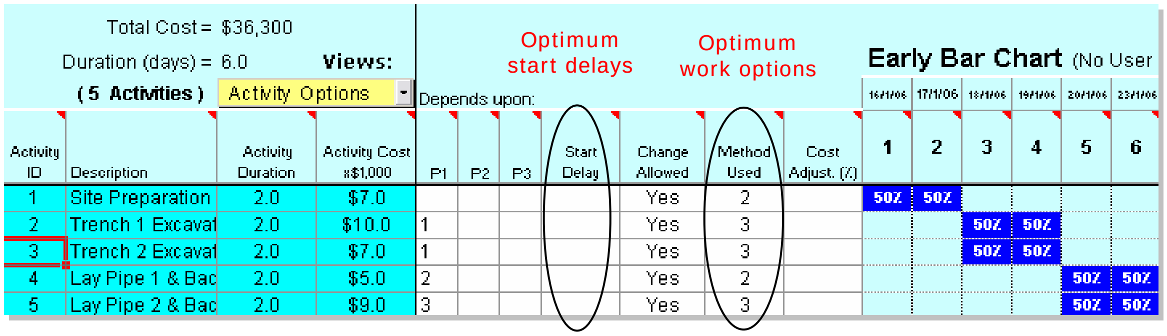
Since we do not meet the deadline, let's do the optimization again and use the random optimization approach, as shown. Let's choose the two objectives selected, and then specify the number of cycles.

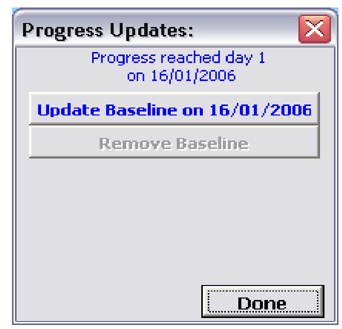


Due to the nature of the random process, different trials may reach to a different near-optimum solution



- At the end of optimization, the result shows an optimum schedule of **6 days and $36,300** (meets both the deadline and the resource limits). The schedule shows the best work methods (estimates) and any start delays that satisfy our objectives with minimum cost.
- It is possible to run the optimization more than once, even with larger number of cycles (thousands for large projects) until a satisfactory solution is obtained.

Step 4: Save the Baseline



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Once you determine a schedule that meets deadline and resource limits, it is time to save this schedule as a **Baseline** for the project so that can be used for progress evaluation.

Step 5: Progress Control

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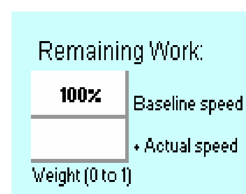
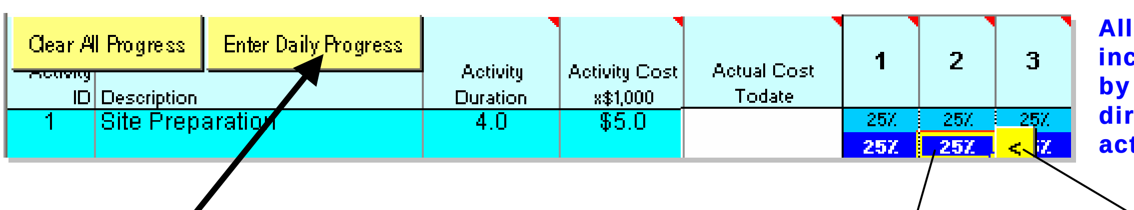
Recording, monitoring and controlling actual progress is one key benefit of Easyplan. We access that from the Project Toolbar menu.



- In EasyPlan, if an activity is progressing, then its remaining work can proceed either: (a) Based on baseline speed (default); or (b) Based on actual speed. In EasyPlan, you can decide on the way remaining work is calculated, as shown.
- You can then enter the daily progress in three ways as follows:



All progress events including delays made by all parties are directly entered on the actual bar chart.

Enter Data

Click on the "**Enter Daily Progress**" button and EasyPlan will present a form to ask you about the events that took place on a daily basis.

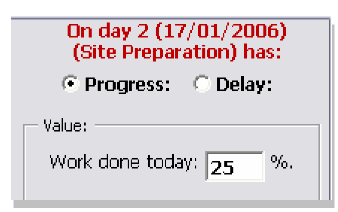
Edit / Modify

Select cell & **directly edit**:

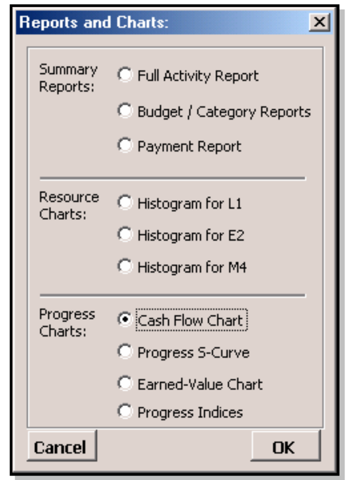
- A value from 0 to 1.0, say 0.5 to represent 50% progress;
- Letter **O** for owner delay;
- Letter **C** for contractor delay;
- **C+O** if both; or
- Letter **N** for third-party delay.

Edit / Modify

Select cell & **click yellow button** to show form.

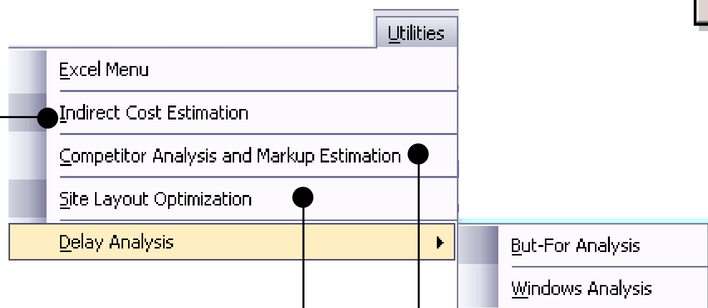


Step 6: Reports & Charts



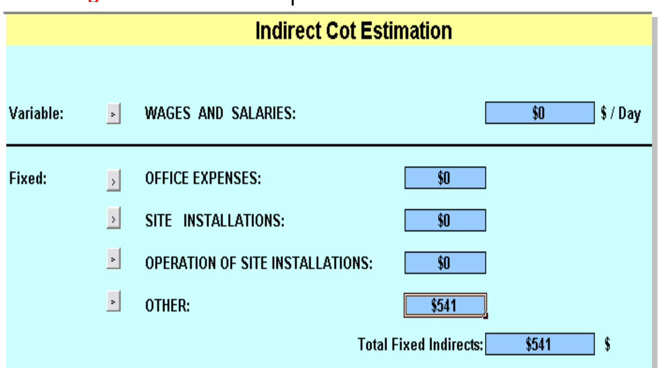
- EasyPlan has various reports and charts that are useful both before and after start of construction. One of these is a Cash Flow chart that facilitates your financing decisions. Similarly, you can view a bid proposal report and resource profiles.
- For project control purposes, EasyPlan has several reports and charts to support you in identifying project status, actual versus planned progress, corrective actions, and payment reports.

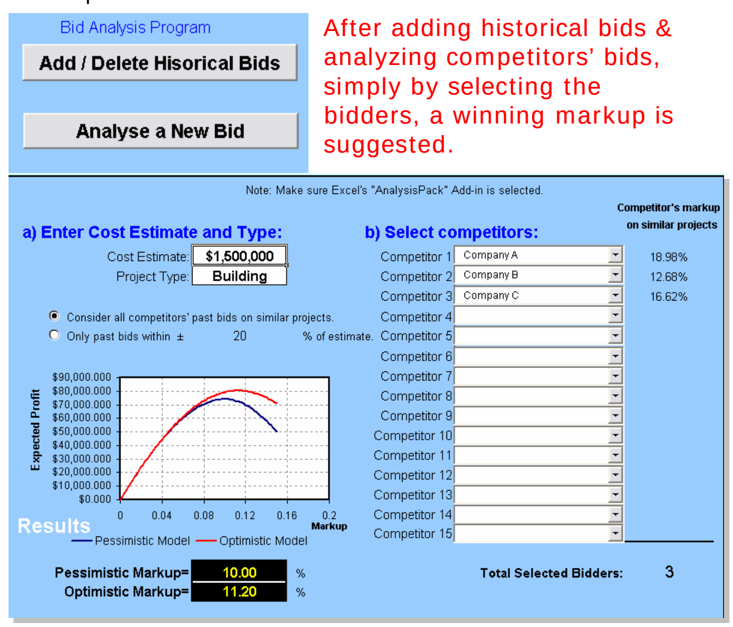
EasyPlan Utilities



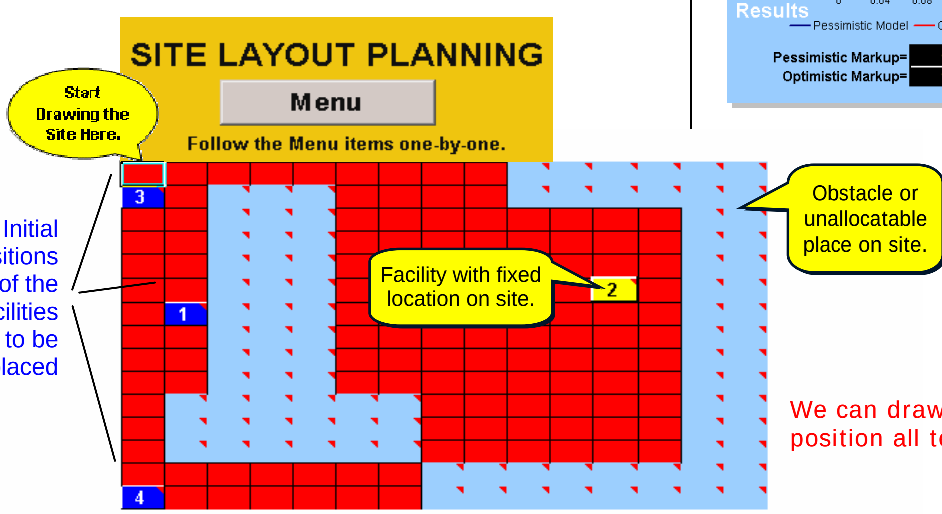
Delay analysis compares progress against baseline to allocate delay responsibility

Many indirect cost categories.





After adding historical bids & analyzing competitors' bids, simply by selecting the bidders, a winning markup is suggested.



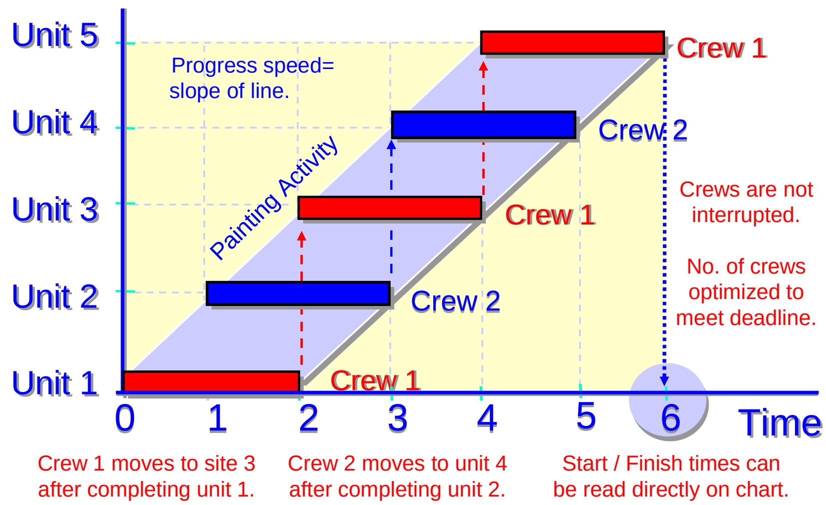
We can draw the site and optimally position all temporary facilities.

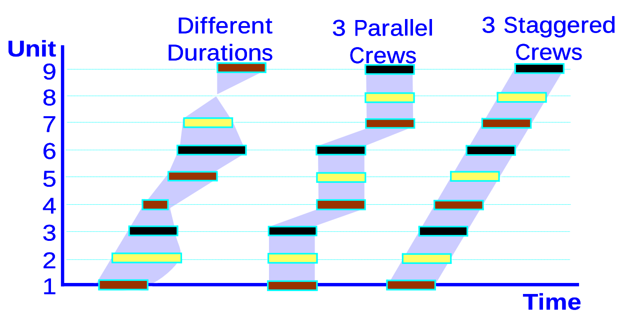
Assume for the same **trenching project**, your company is involved in not only a single section of 200 meters, but a full stretch of two kilometers (i.e., 10 repetitive units of the standard section). This is the same as dealing with multiple housing projects or any other repetitive operations.

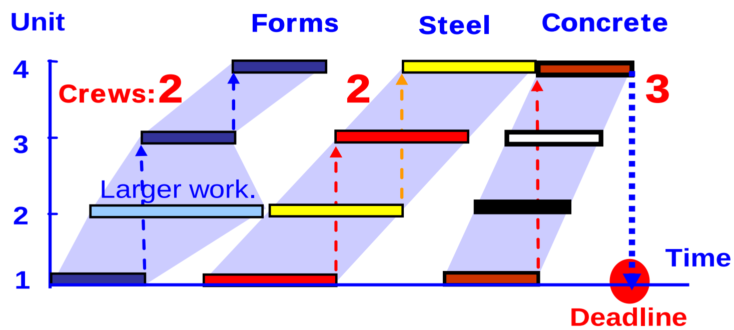
EasyPlan has made repetitive scheduling simple and straightforward. In addition, it helps you determine the necessary crews and their detailed work assignment so that to meet deadlines in the cheapest manner. One advantage is to schedule crews to work continuously without interruption, to develop a learning momentum.

One example of a repetitive schedule is shown below of two crews working in one activity (e.g., painting) along five units. Crews are color coded. Notice the vertical axis is the unit number.

Other figures of repetitive schedules are shown below with various ways to schedule crews.

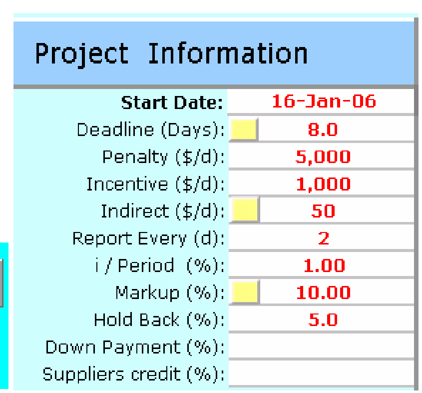






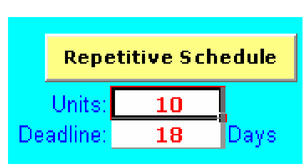
Let's now apply the repetitive scheduling feature to our example. Despite the fact that we took 8 days to complete one unit, let's assume we have only **18 days to complete all the 10 sections** (units). All activities and estimates data are the same in this case. One constraint is that you **cannot provide more than four crews for any activity**. Also, **Sections 1 and 10 do not require "Site Preparation" work**.

- In the Main Screen, let's specify number of unit = 10, and a deadline of 18 days. Then, we proceed to the "Repetitive Schedule" button.



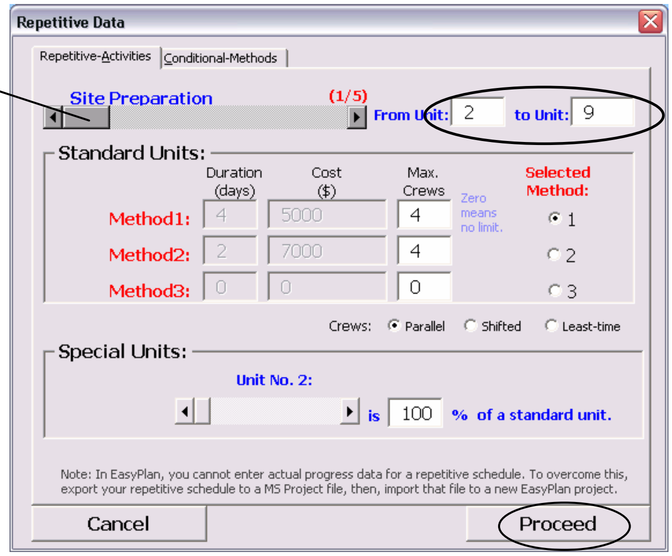
Important Note: The repetitive schedule is available when actual progress is NOT entered (i.e., for planning only). To clear actual progress, use the following buttons:

5. Progress then Clear All Progress



- The repetitive Scheduling screen shows the activities estimates and allows you to set a limit on the number of crews that each activity has. Also, it allows us to specify any special units that has smaller or larger durations and costs than all others. We then click "**Proceed**".

Select and setup the repetitive activities one-by-one.

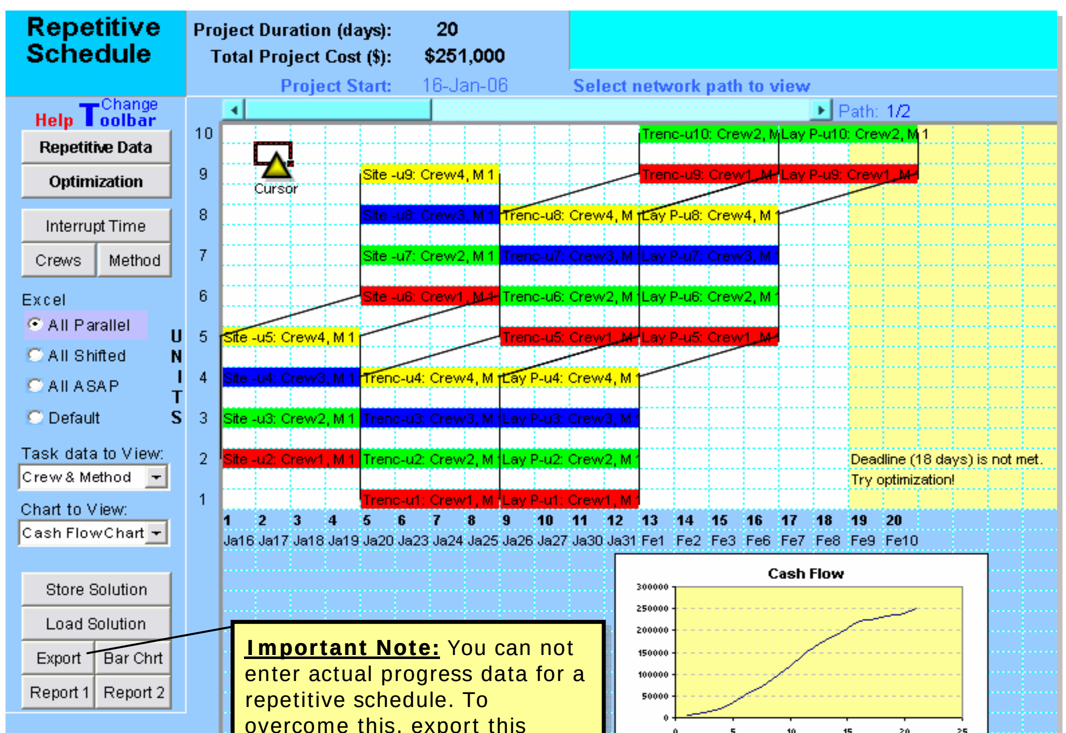


Site Preparation in units 2 to 9 only

3 estimates for standard units and maximum available crews set to 4

If any of the units is not standard, you can set its duration & cost here

- Once we finish data entry, let's view the schedule. Notice the project is **20 days** with a total cost of $251,000.
- **Can you meet the 18 day deadline?**



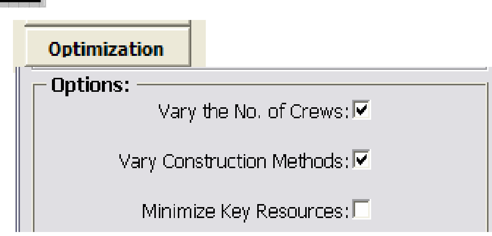
Various options to organize the crews and manually improve the schedule

Save & Re-Load a desired solution

Various detailed reports.

Important Note: You can not enter actual progress data for a repetitive schedule. To overcome this, export this schedule to a MS Project file, then, re-import the file to a new EasyPlan project (Main Screen).

- It's time to optimize. In this case, the program will find for us which activities need more crews and which activities need a speedy construction method.
- After the optimization, various reports can be generated to communicate the final plan to site personnel.



EasyPlan: A Computer Game for Simplified Project Management

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Abstract: Construction is largely perceived as an experience-based industry. Many industry professionals, therefore, are often sceptical about investing in structured project management. In this paper, project management concepts are explained in a simplified manner to increase awareness about the feasibility and possibility of using project management to meet project challenges. A case study game is used to clearly describe the interactions among planning, estimating, scheduling, cash flow analysis, and project control. The descriptions in the paper claim to be simple enough for individuals without much knowledge on formal project management. Furthermore, the paper presents a simple software program, EasyPlan, for web-based project management training. EasyPlan users can download a case study, solve it using the system features, and then check the solution through the system's online checker. In essence, the game approach to project management training presented in this paper Increases the awareness of project participants about their roles in bringing success to projects.

Introduction

While the construction industry includes many large companies, statistics indicate that over two-thirds of construction firms have less than five employees (Halpin and Woodhead 1998). The majority of these small firms are specialist sub-contractors working with the general contractor. This category of firms experiences the highest level of business failures, as reported in a survey by Russell and Radtke (1991). The survey identified the factors that contribute to failure include underbidding, insufficient cash flow, external difficulties, and the lack of experience to estimate and monitor costs. These factors, in essence, indicate lack of efficient project management.

Despite of its importance, project management is not typically considered a concern of senior executives until some crisis awakens their interest (Thomas et al. 2001). Full awareness of project management concepts and their potential benefits is also not common knowledge, particularly in construction where most knowledge is believed to be experience–based. Despite the efforts or professional organizations and commercial software, to many construction professionals, particularly trades and small contractors, project management and available tools are applicable only to large firms and do not extend beyond creating a neat schedule to satisfy contract requirements. Thus, real savings in time and money are believed to be found only in actual construction rather than in applying any structured procedures or tools. Based on this discussion, existing training and educational avenues on project management have done little to reach the largest sector of construction professionals in small firms and specialty contractors who are actually doing the majority of construction work.

Traditionally, project management concepts are taught at the university/college levels in a manner that is more theoretical and lacks project-level experience. This type of education will not suit the majority of construction professionals. Many pioneering efforts have therefore attempted to improve the manner by which project management is taught. At the university level, case study based learning (e.g., Russell and Udaipurwala 2005) and web-based games (e.g., Fan and Froese 2005) are examples of these efforts. At the organizational level, more design and construction firms are elevating company training, employee development, and adult learning into a top corporate priority (Rubin and powers 2005).

Targeting the small construction players who are often overlooked in existing systems and tools, this paper takes an intuitive and effortless approach to project management training. A game-like case study is used to clearly describe the interactions among the essential project management functions of planning, estimating, scheduling, cash flow analysis, and project control. The case study approach is simple enough for individuals without much knowledge on formal project management and helps them appreciate its benefits. A simple software program, EasyPlan, is also presented to provide practitioners and educators with a simple tool for web-based training and help them exercise full control over the planning and execution of projects. The program can be freely downloaded from the author's site: www.civil.uwaterloo.ca/tarek for educational and training use.

Essential Project Management Concepts

A project manager's job is to "get the job done". This means doing the work on time, within budget, and according to quality. These three objectives (Figure 1, Hegazy 2002) need to be clearly conveyed, focused upon, and reinforced by all project participants at all project stages. To help in meeting these three objectives, particularly when a project is exposed to time, cost, and resource constraints, various project management concepts can be used. These concepts are presented next, in the order they are likely to be used on projects.

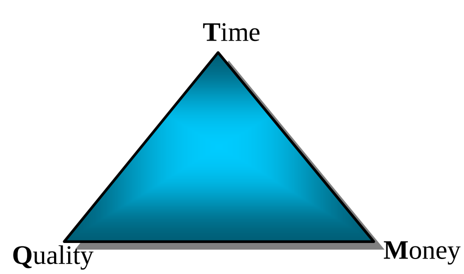


Fig 1: Project Management Objectives

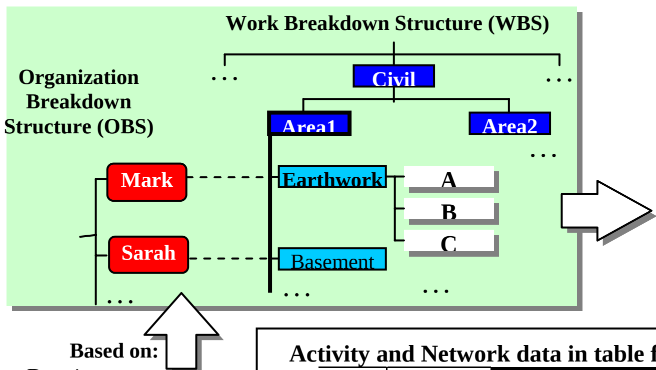
Planning the Work

Planning a project (for bidding or execution) is like solving a jig-saw puzzle by: (1) getting all the pieces and not omitting a single one; and (2) placing the pieces logically together to create the full scene. Construction planning is no different and requires the same two steps: (1) defining a complete list of all the work activities; and (2) arranging the activities in various ways to suit project needs.

Activities can be directly defined by takeoff from drawings and contract documents, looking for hidden items experienced in past projects, consulting with templates and checklists, and getting feedback from all parties. The more exhaustive the list is, the less surprises are expected during execution. Once the list is established, it is arranged according to the different project areas, systems, and supervisory levels, to create a hierarchy called the Work Breakdown Structure (Figure 2a) that is linked to the organization structure.

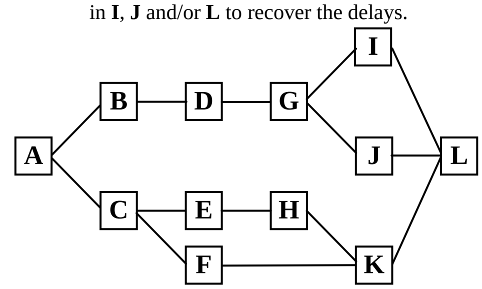
(a) Defining Project Activities

Categorizing the activities according to project areas and supervisory levels helps in accumulating the costs, resources, and performance data for each category.



(b) Drawing a Network Diagram (Logic)

The network below shows a project of 12 activities with their logical sequence. If **G** is delayed, then, it is clear from the network that we need to put extra resource only in **I**, **J** and/or **L** to recover the delays.



Based on:

- Drawings
- Specifications
- Previous Projects
- Templates
- Check Lists
- Brain Storming
- Company Structure
- Supervisors
- Accounting Needs
- Project Areas

Activity and Network data in table format

No.	Activity	WBS			OBS	Depends on (see network)		
		Area	Type	System				
1	A	Area1	Earthwork	Civil	Mark	---	---	---
2	B	Area1	Earthwork	Civil	Mark	1	---	---
3	C	Area1	Earthwork	Civil	Mark	1	---	---
4	D	---	---	---	---	2	---	---
.	.	---	---	---	---	.	.	.
.	.	---	---	---	---	.	.	.
		---	---	---	---			.
11	K	---	---	---	---	6	8	---
12	L	---	---	---	---	9	10	11

Fig. 2: The Two Facets of Planning

The same activity list also needs to be arranged visually according to the execution sequence of activities to create a network diagram, as shown in Figure 2b. The diagram shows for each activity, such as (G) that it can only start after the finish of (D), and when it finishes, activities (I) and (J) can immediately start. The benefit of the network is not only to help planners calculate project duration and cost but also to define suitable corrective actions during execution. At the end of planning, it is possible to put all decisions in a simple table as shown in Figure 2.

Estimating Activities' Time and Cost

With the activities defined, good project management requires solid cost, duration, and resource estimates for the activities. Bad estimates are a leading source of project failure. Estimating the direct costs of activities can be simple and adequately detailed as shown in Figure 3, where the activities of the project are considered one at a time. First, the resources to use in the activity are defined with their daily rate ($/day) and daily production (P, from previous work). Then, the duration can be easily calculated by dividing the quantity over the production rate P and the cost is calculated by multiplying the duration by the daily rate.

As explained, the production rate of crews in previous jobs is the basis for cost and time calculations. Companies, as such, find it a worthwhile investment to keep track of their crews (combination of labor and equipment) and their production rates in previous jobs. With this information stored in the company's database, estimating becomes a direct use of a simple equation (Eq. 1), where (Q) is the quantity of work and (f) is a productivity modifier (0 to 1.0) for unfavorable work conditions (e.g., 0.7 means 70% productivity).

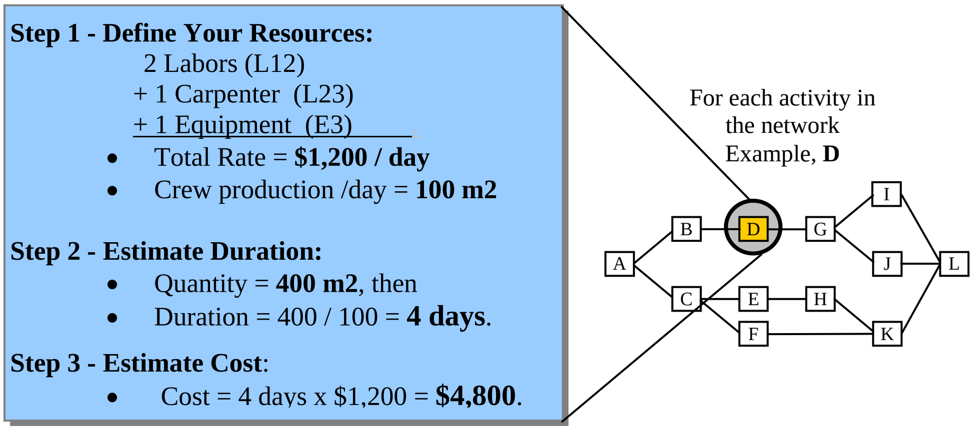


Fig. 3: Basics of Estimating

$$Duration = \frac{Q}{P.F} \text{ (days)}; \qquad Cost = Duration \text{ x } \$/day \qquad (1)$$

One important option during estimating is to develop more than one estimate for each activity. These estimates (three are reasonable) can be received, for example, from different subcontractors and vary from cheap and slow to fast and expensive. Using a more productive crew and/or an overtime strategy are also viable options, where cost becomes higher but execution time is shorter. The selection of which of these estimates to use in each activity can be decided later based on whether the project has a strict deadline and/or resource limits. It is noted that, added to the direct costs estimated as explained, project indirect cost can be estimated as a cost per day to cover project related overhead costs and a portion of the general overhead costs (Hegazy 2002).

Project Scheduling

Once planning and estimating are performed, the network of activities becomes available along with the activities' optional estimates of resources, durations, and costs. Yet, however, the total project duration is not known. Also, since real-life projects involve hundreds of activities, it is important to identify the most critical ones so that extra care can be given to them. Scheduling, as such, adds a time dimension to the planning process, which is very important for managing resource mobilization, delivery of materials, and the timing of all activities.

Scheduling calculations follow a systematic approach called the Critical Path Method (CPM), which is described in many references (e.g., Hegazy 2002; Halphin and Woodhead 1998). The results of scheduling can be presented legibly in the form of a bar chart, which is clear and understandable to all the project parties. Figure 4a shows a bar chart that corresponds to a small network of five activities, where the activities, their relations, and their durations are assumed to have resulted from planning and estimating exercises. The bar chart in Figure 4a preserves the logical relationships and shows all activities starting at their earliest time (the bar chart is called Early bar chart). Because activities B, C, and D are parallel, the two short activities (B and C) will have float times (as shown in Figure 4a), which are periods of permissible changes to these activities. When activities B and C are delayed to the end of their float, as in Figure 4b, a Late bar chart results. Also, looking at the bar chart, the activities that do not have floats (A, D, and E) have no permissible changes and, as such, are called critical activities. These critical activities form a continuous path from the start to the end of the project, called the critical path, which is the longest path in the network that dictates the project duration (i.e., length = 3+6+5 =14 days = project

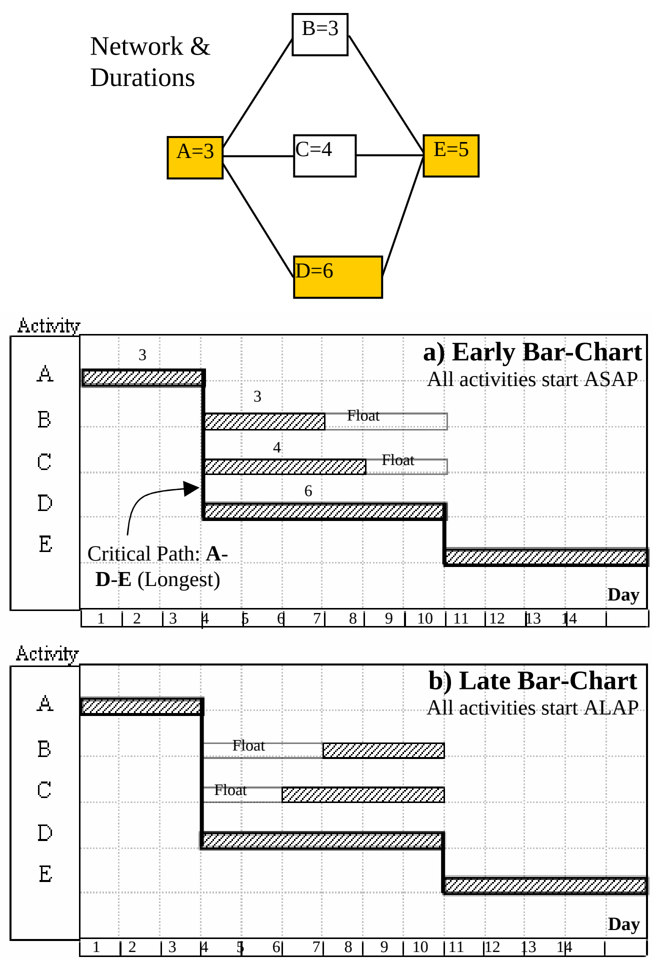


Fig. 4: Early and Late Bar Charts

duration). The bar chart, as shown, is simple to read and can be used to accumulate total daily resources and / or costs. One additional benefit of the bar chart is to use it on site to plot the actual progress of activities versus their schedule.

Improving the Schedule

Once a schedule bar chart is determined, it is important to check the feasibility of this schedule from three practical points of views: the fluctuation in resource demands; the proper allocation of limited resources; and the shortening the project duration to meet a given deadline or to speed the execution. These three aspects may require some modifications to the schedule, as discussed below.

a) Reducing Resource Hiring and Firing

One important consideration is the variability of resource needs from day to day. The left side of Figure 5, for example, shows an early bar chart with the amount of a certain resource (e.g., carpenter) shown on the activities' bars. Adding up the number of daily carpenters results in the required daily amount written below the figure, indicating an inconvenient hiring and firing (two carpenters are hired for the first two days, then three in days 3 and 4, then firing two to use only one in days 5 and 6, etc.). The solution of this problem follows a simple resource smoothing process. A quick look at the bar chart shows that activities B, C and D are running in parallel, thus creating a high demand on days 3 and 4. Because activities B and C have floats, it is also possible to visualize that if one of them is shifted to the right, it is possible to have a constant resource need of 2 per day as written below the right side chart of Figure 5. This resource smoothing is very beneficial particularly for rented equipment that needs to be efficiently used in all days. In essence, the strategy is to introduce appropriate delays to some of the non-critical activities that have floats (delays from their original start times, called start delays), so that the project duration is unaffected. This strategy is shown in the values in the start-delay column of Figure 5.

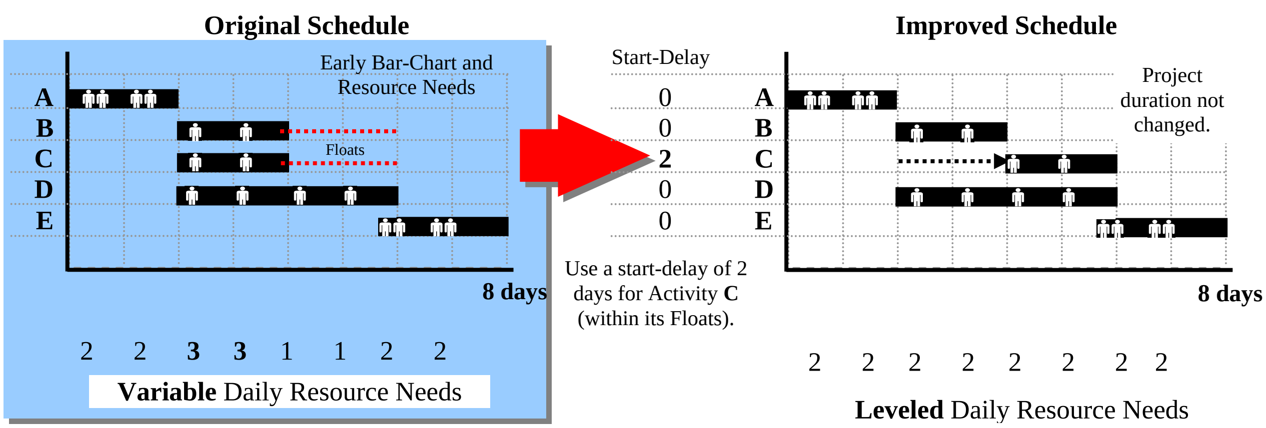


Fig. 5: Smoothing Resource Demands

b) Allocating Limited Resources

Another important aspect in the practicality of a schedule is to consider the impact of shortages in the project's resources. Consider, for example, that the project in Figure 6 has a limit of 2 skilled workers per day. The resource needs are shown on the bars, indicating a total daily need (written below the chart) that exceeds the availability limits on days 3 and 4, because three activities B, C and D are running in parallel on these days. Trying to introduce start delays to some activities within their floats does not help. In this situation, some activities (either critical or non-critical) will have to be delayed beyond their floats, thus affecting the project duration. One solution for the situation in Figure 6 is shown in the right side of the figure, where the project had to be delayed from 8 to 10 days. Similar to resource smoothing, the solution is represented by the values in the start-delay column. It is noted that while only one resource is considered in Figs. 6, but the solution approach remains the same in the case of multiple resources shortages. Also, because it is possible to have more than one solution to this problem (by changing the values in the start-delay column), it is highly desirable to identify the solution that has the least impact on project duration.

c) Reducing Project Duration

Time is a killer constraint. In today's business environment, there is tremendous pressure to deliver goods, services, and projects at breakneck speed. Assume, for example that the same project in Figure 6, which has been extended to 10 days due to resource limits, has a strict deadline of 9 days. Then, a reasonable strategy to meet the deadline is to check the individual activities and use a faster method of execution that can save project time, even at increased cost. This strategy is called Time-Cost Trade-Off (TCT) or project crashing, and benefits from the optional estimates made at the estimating stage. For example, one solution to the project in Figure 6 is to use a fast execution method (three days) for activity (D). Because it is possible to have more than one solution (by crashing other activities from a cheap and slow method to a fast and expensive method), it is highly desirable to identify the solution that meets the deadline with least cost. Details on formal approaches for TCT can be found in Hegazy (2002).

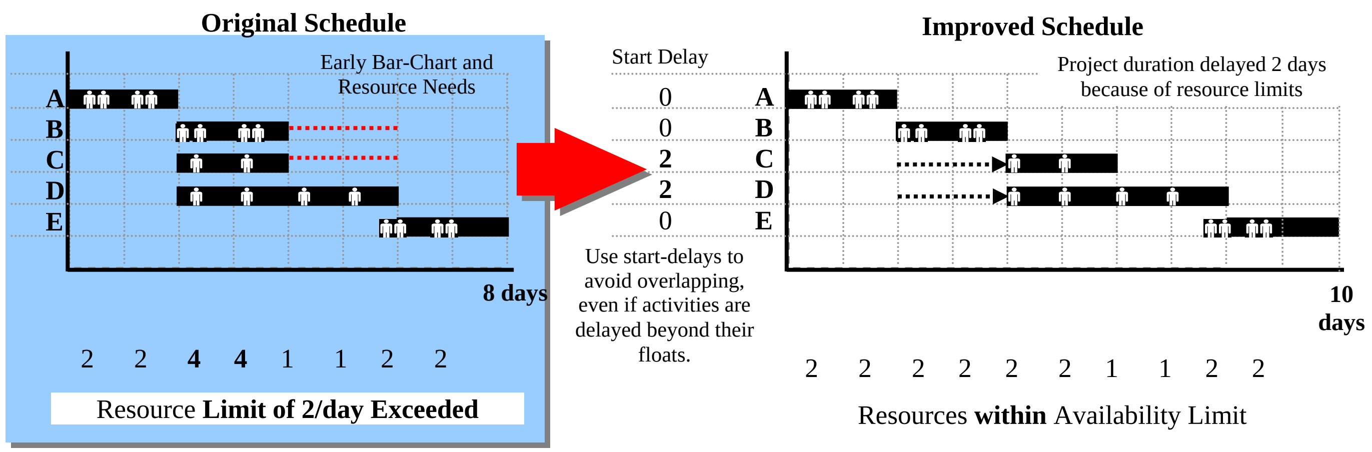


Fig. 6: Allocating Limited Resource

Analyzing the Project Cash-Flow

Project professionals today must function as business people. Cash flow analysis, therefore, helps contractors in managing the financial end of projects. It helps contractors define the expected expense and income profiles, as well as the applicable financing charges. This helps contractors identify the charges that need to be built into the project price so that it is not cut from the expected profit. Cash flow analysis involves drawing the two curves in Figure 7: the cumulative expense curve (based on the project bar chart and activities' costs) which often has an S-shape; and the income profile of the periodical payments received for doing the work (the ladder shape). The difference between the two curves represents the area of financing on which interest is charged. From this figure, financing charges can be reduced by getting the expenses lower (through cheaper costs and/or credit from suppliers), and/or by getting the income profile higher (e.g., receiving a down payment). Details on the cash flow calculation can be found in Hegazy (2002).

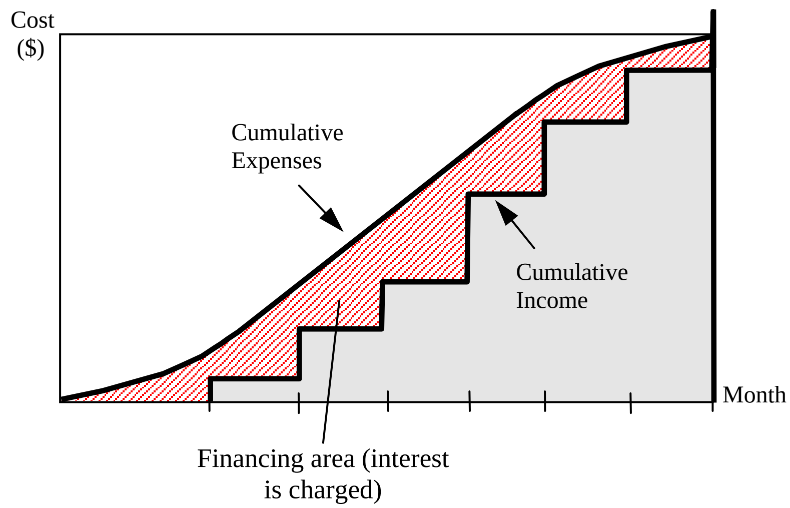


Fig. 7: Project Cash Flow Chart

Scheduling Repetitive Projects

Many construction projects involve repetitive activities, and as such, require special consideration. Repetitive projects include multiple typical units (e.g., housing projects) or geometric linear sections (highways, pipelines, floors, etc.). A bar chart, in this case, is expected to be very lengthy and will not legibly show the project details. A new type of chart is therefore needed, as shown in Figure 8a, which is a relationship between time and units. The figure shows a schedule for one activity along five repetitive units with two color-coded crews being employed. Each crew moves to a new unit once it completes work on a previous one, thus ensuring that crew-work continuity is maintained. Figure 8b also shows a schedule for three sequential activities and the crews employed to meet a given deadline. As shown in Figure 8b, the resource movement among the units is clear and the activities' progress speeds are represented by the slopes of their lines. These details are not possible to show in a network diagram or a bar chart. One variation of the schedule in Figure 8b is when the units have different geographical locations (such as the case of infrastructure maintenance programs involving multiple schools, bridges etc.). Advanced scheduling and cost optimization models for such projects are discussed in Hegazy (2006).

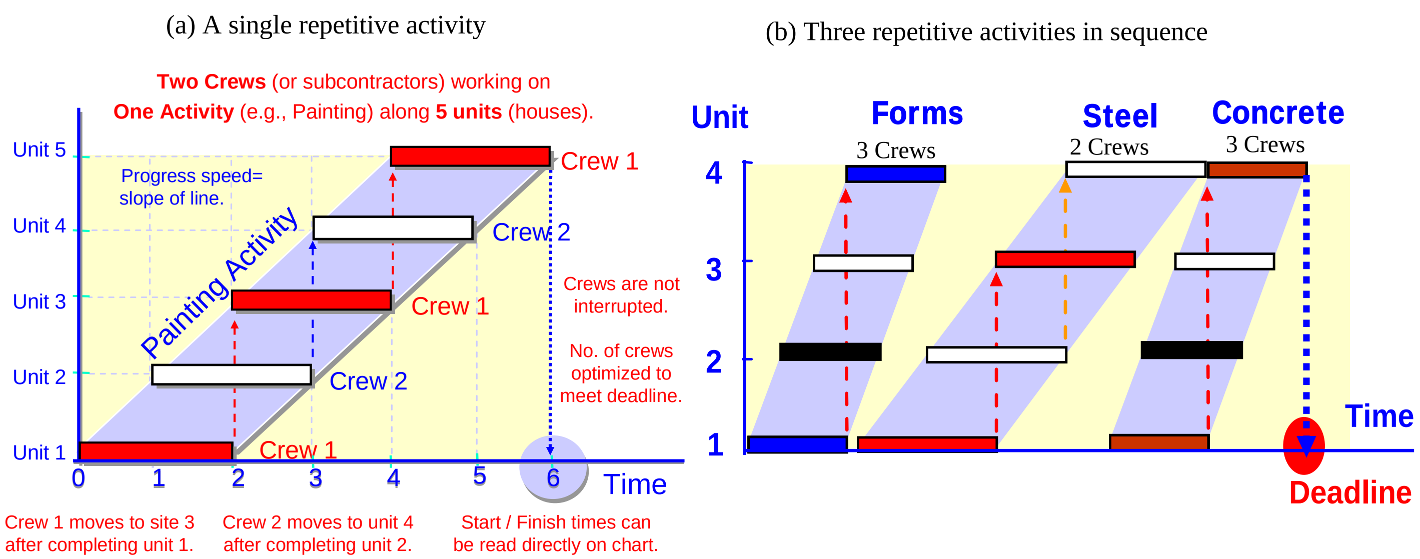


Fig. 8: Example Repetitive Schedule

Project Tracking and Control

While most of the concepts presented so far are useful at the pre-execution stage, project control becomes essential at the execution stage to make sure the perceived benefits are achieved. Project control involves essential functions, including: recording of all progress events; comparing planned versus actual progress; determining progress payments; managing changes and updates; deciding corrective actions; productivity assessment; and documenting the lessons learned. All these function are easy to do given the daily progress is accurately and fully recorded. The key step in this process, as such, is to simplify the recording of site events using a bar chart, as shown in Figure 9. Each activity in the figure has two bars, the top bar is the planned progress, which is indicated as daily percentages (i.e., a duration of two days makes the daily progress 50%). The activity bottom bar, on the other hand, records the actual events that were experienced during execution. The "Foundation" activity, for example, immediately followed the completion of "Excavation". It progressed at 25% per day for the first two days (slower than the 50% planned) then completed the remaining 50% in one day. This representation makes it easy to record and view all site events that facilitate the calculation of project status, delay responsibility, and time/cost performance. In general, however, added to a simple project management tool, project execution can be successful given the following guidelines are followed: (1) Keep the work site organized; (2) Monitor your trades by placing more importance on following the predecessors not on an exact start date; (3) give incentives for starting early and finishing early; (4) submit timely and accurate invoices; (5) Keep all parties informed of progress all the time; and (5) Document all progress and associated costs.

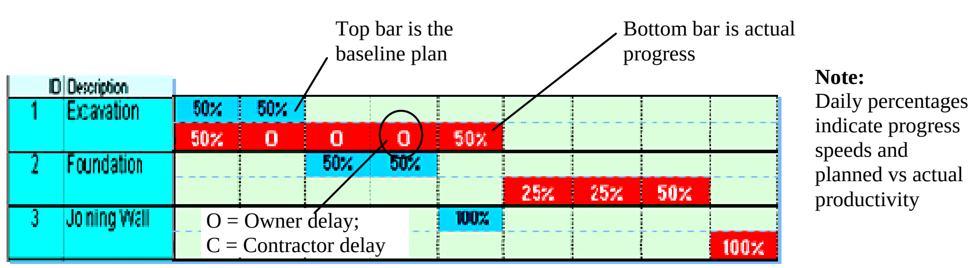


Fig. 9: Simple Bar Chart for Progress Recording

As discussed, Figures 1 to 8 become a simple set of quick reminders of the essential project management concepts that need to be common knowledge among all parties.

Simplified Project Management: A Case Study

Real-life projects are often exposed to multiple constraints and challenges. To demonstrate a simple and intuitive approach to managing projects, a small but comprehensive case study is considered (Figure 10). The left side of the figure shows four work activities and their sequence (activity A is followed by B and C who run in parallel, then are followed by D). Each activity has up to three construction methods, each with its associated cost and duration, as shown in the figure. The resource need of each activity is also written on top of it. In this simple case study, a 10-day deadline and a resource limit of 2/day are strict constraints. The part to the right of the figure shows the two essential decisions that need to be taken: (a) an index to the method selected (among the three estimates of each activity) that satisfy the deadline; and (b) the start-delay time that avoids having the activities running in parallel and using more resources than available. Based on these decisions, a bar chart of the project schedule needs to be drawn.

Deadline is 10 days; Resource Limit = 2 / day; & Penalty for delay = $2,000/day

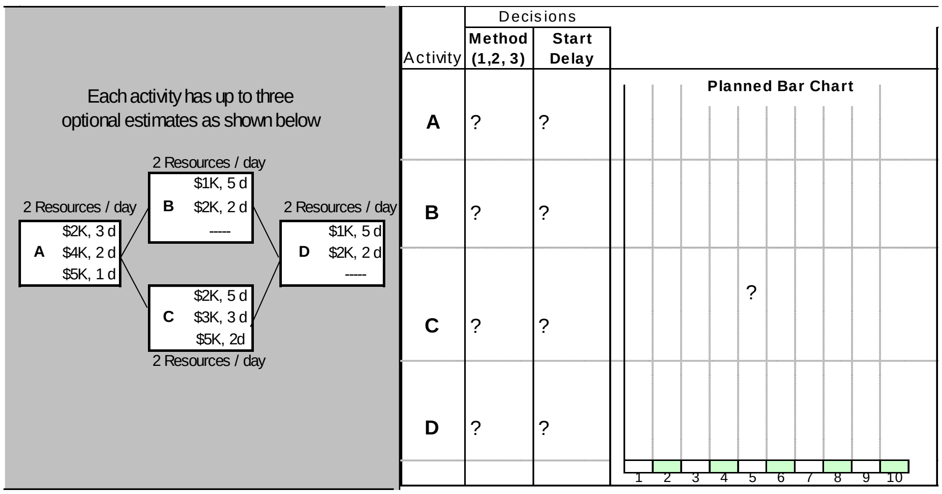


Fig. 10. Case study data.

A quick look at this project reveals that: Activities B and C run in parallel and will require 4 resources per day (limit is 2); and Using the cheapest method (estimate 1) for each activity, project duration becomes 13 days (unacceptable) with a high total cost of $12K ($6K direct activities' cost + $6K penalty).

As such, making proper decisions for this small case study is not as simple as it seems. It is possibly to manually experiment with various decisions to try meeting the constraints. For example, using a faster method for activity D brings project duration to within the deadline but still does not resolve the resource problem. Because of the simplicity of this example, it is possible, after some trials, to determine the cheapest solution as shown in the right side of Figure 11, showing a plan with 10-day project duration (meets deadline) with all the activities scheduled so that the resource limit is not exceeded.

It is important to note that Figures 10 and 11 embody all the functions of planning, estimating, scheduling, resource management, budgeting, project constraints, decision implications, etc. Once enough knowledge is gathered about the project activities, the logical sequence, and optional estimates, the decision that faces contractors is to decide on a realistic and cost-effective plan that meets project constraints. Such a plan enables contractors not only submit more competitive bids but also face little surprises during execution. As shown in the case study, all the interrelated project management decisions have been summarized and simplified into the two decision columns shown in the figures: one column concerns the necessary execution method for each activity (i.e., how fast & costly) to respect a given deadline, while the second provides the necessary tweaking to the start time of each activity to avoid resource problems. These two activity decisions, as such, represent key focus areas during the planning and execution phases of a project. During execution, for example, if a project is expected to be delayed, then a suitable corrective action is to decide on modified values for the two decisions (i.e., more speedy methods to some activities and/or some start-time adjustments). Based on the case study, Figures 10 and 11 represent a template for setting other training exercises to trades, contractors, educators, and students, even without being introduced to the formal project management concepts.

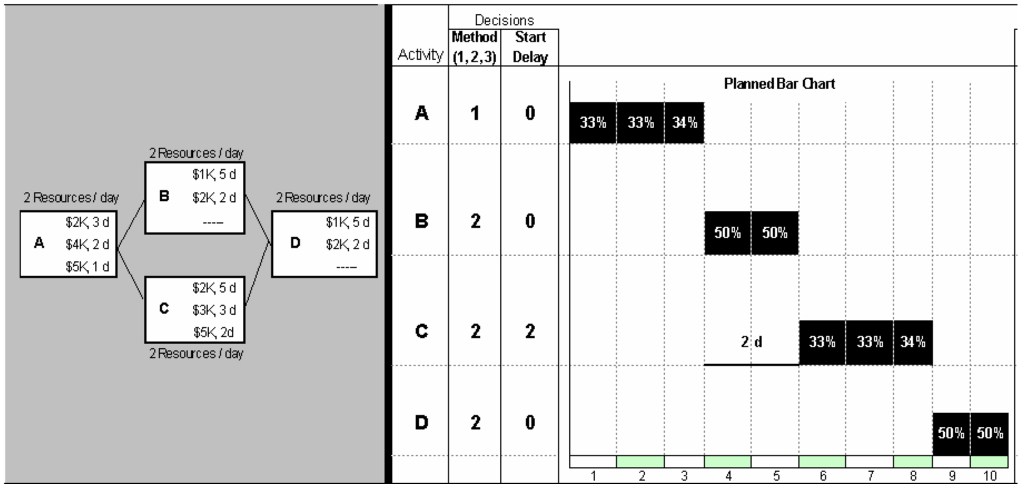


Fig. 11. Details of the best solution.

EasyPlan Program

As seen in the case study, a four-activity network required some effort to manually solve it. Any real-life project, therefore, requires a reasonable degree of automation to facilitate speedy decisions. In consistency with the simplified explanation of the project management concepts of this paper, a computer program, EasyPlan, has been developed. The program has simple steps to be followed one-by one, as shown in Figure 12. The program has almost all the functions needed by a small contractor to manage a project, including unique features to manage a simple depository of resources, allow optional estimates to be specified, automatically optimize the schedule, analyze the project cash flow, schedule repetitive units, analyze the bidding behavior of competitors to properly estimate markup, optimize the site layout, record actual progress and work interruptions, perform delay analysis, and produce extensive reports (e.g., automated bid proposal) and a variety of charts (e.g., cash flow).

Another interesting feature of EasyPlan is its link to a web-based depository of case studies for users to download, solve, and check the solution to get a score. This feature is particularly useful for students, computer workshops, and training purposes. To demonstrate EasyPlan's features and training benefits, one of the web-based case studies will be used for demonstration. First, the case study is selected from the available list (Figure 12) and the project statement is then downloaded (Figure 13).

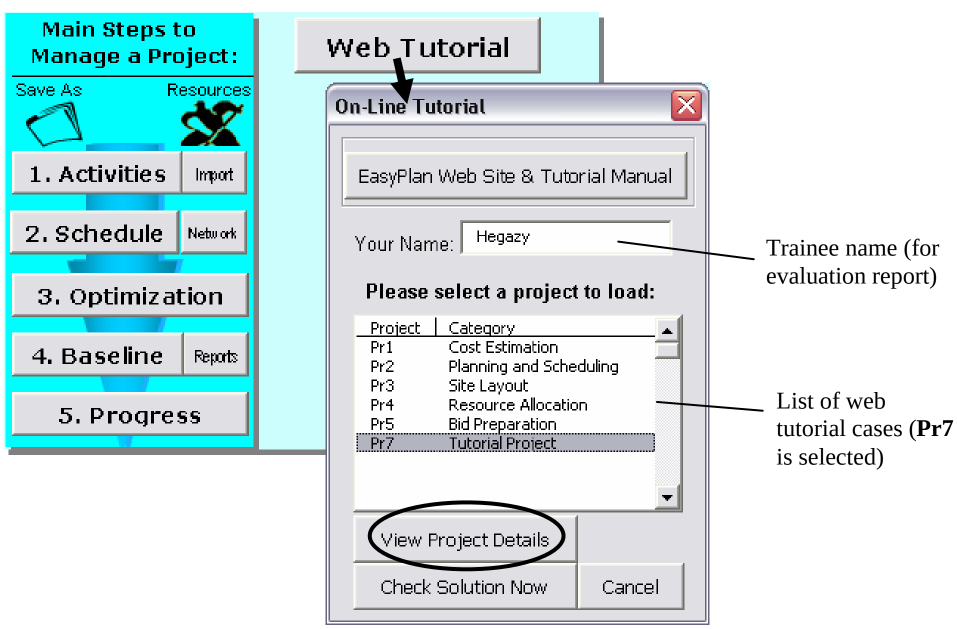


Fig. 12. EasyPlan's main screen and training mode.

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

Activity	Dependents	Description	Estimate no. 1		Estimate no. 2		Estimate no. 3	
			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	------	------	------	------

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 and interest rate is 1% per period; Markup is 10% and owner retention is 5%.

Requirements:
Determine the optimum execution plan. **Check your solution.**

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

- 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 and 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, and the final as-built schedule.
c) Experiment with contractor versus owner acceleration on delay analysis results.

Fig. 13. Downloaded training case.

As shown in the case study statement of Figure 13, the project involves a game-like challenge of trying to meet a group of constraints related to deadline and resource limits in the cheapest way. In EasyPlan, the step-by-step solution procedure is simple and the user can easily investigate many what-if scenarios, with all calculations being kept hidden in the background. The simple solution procedure followed in solving this case study is shown in Figures 14 to 19.

Project Summary Information

Key Resources:	Limit:	Used:		
L5	4.0		Deadline (Days):	14.0
			Penalty ($/d):	5,000
			Incentive ($/d):	1,000
			Indirect ($/d):	300
			Report Every (d):	3
Start Date:	1-Jan-04		i / Period (%):	1.00
Work Days: SA ☐ ☐ ☑ ☑ ☑ ☑ ☑ FR			Markup (%):	10.00
			Hold Back (%):	5.0
No. of Activities: #DIV/0!			Down Payment (%):	
Largest Overdraft ($): #DIV/0!			Suppliers credit (%):	
No. of Activities: 12			Other Info.:	

Fig. 14: Step 1- Entering the project general information.

Activity	Description	First Estimate Cost1	First Estimate Dur1	Second Estimate Cost2	Second Estimate Dur2	Third Estimate Cost3	Third Estimate Dur3	Resources/day L5			Productivity (0-1) Winter	Spring	Fall
1	Excavation	$2,000	2.0	$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

Fig. 15: Step 2- Specifying the project activities and their optional estimates.

Decision 1: Start delays that avoid having many activities running in parallel and using many resources.

Decision 2: Index to one of the three optional estimates (**1, 2,** or **3**) for each activity.

Total Cost = $44,800
Duration (days) = 16.0
(12 Activities) Views: Activity Options

Early Bar Chart (No User Inputs)

Activity ID	Description	Activity Duration	Activity Cost x$1,000	Depends upon: P1	P2	P3	Start Delay	Method Used	1 (1/1/04)	2 (2/1/04)	3 (5/1/04)	4 (6/1/04)	5 (7/1/04)	6 (8/1/04)	7 (9/1/04)	8 (12/1/04)	9 (13/1/04)
1	Excavation	2.0	$2.0					1	50%	50%							
2	Foundation	2.0	$2.0	1				1			50%	50%					
3	Joining Wall	1.0	$1.0	2				1					100%				
4	House Walls	4.0	$4.0	3				1						25%	25%	25%	25%
5	House Roof	3.0	$3.0	4				1									
6	Select Finishes	1.0	$1.0					1	100%								
7	Interior Finishes	3.0	$3.0	6	5			1									
8	Clean Up	1.0	$1.0	7	12			1									
9	Fab. Garage Doors	6.0	$6.0					1	17%	17%	17%	17%	17%	17%			
10	Garage Walls	3.0	$3.0	3				1						33%	33%	33%	
11	Garage Roof	2.0	$2.0	10				1									50%
12	Garage Doors	2.0	$2.0	11	9			1									

Fig. 16: Step 3- Specifying logical relationships among activities.

Once the case study data is entered as shown in Figures 14 to 16, and the activities' methods are set tentatively to the cheapest option (index 1 for all activities as shown in Figure 16), the project duration becomes 16 days (2 days beyond the deadline), with a cost of $44,800, as shown at the top of Figure 16. The schedule also not only exceeds the deadline but also requires the use of six of the L5 resource (two more than available).

To decide on a schedule that satisfies the project constraints, the user may manually change the values in the two decision columns of Figure 16. As an alternative to the manual process, the optimization feature of EasyPlan can be activated, as shown in Figure 17. Optimization is automated based on the objectives specified by the user. After the specified optimization cycles have elapsed, where EasyPlan attempts many random values for the variables, a solution is determined. The resulting optimum schedule (Figure 18) meets the deadline (14 days) and uses only 4 or the L5 resource (same as the available limit). The total project cost is $39,200. The schedule selects the proper values for the work methods (estimates) and some start delays that satisfy our objectives with minimum cost. It is noted that the optimization may be carried out more than once, even with larger number of cycles, until a satisfactory solution is obtained.

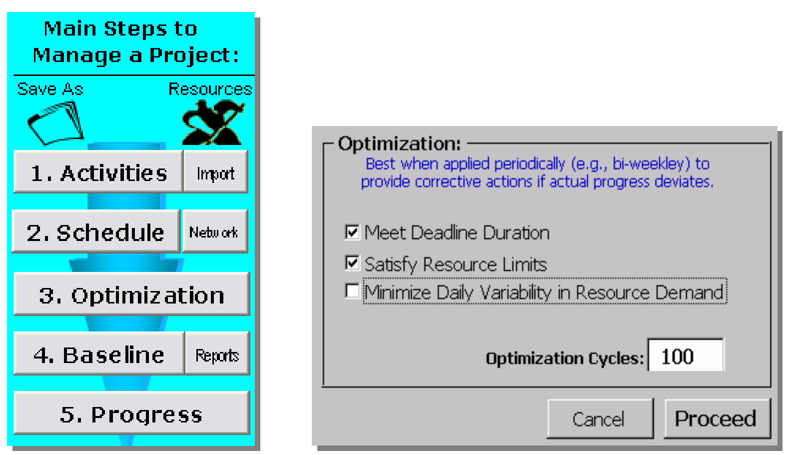


Fig. 17: Step 4- Optimizing the schedule.

Total Cost = $39,200
Duration (days) = 14.0
(12 Activities) Views: Activity Options

Early Bar Chart (No User Inputs)

Activity ID	Description	Activity Duration	Activity Cost x$1,000	Start Delay	Method Used	1 (1/1/04)	2 (2/1/04)	3 (5/1/04)	4 (6/1/04)	5 (7/1/04)	6 (8/1/04)	7 (9/1/04)	8 (12/1/04)	9 (13/1/04)	10 (14/1/04)	11 (15/1/04)	12 (16/1/04)	13 (19/1/04)	14 (20/1/04)
1	Excavation	2.0	$2.0		1	50%	50%												
2	Foundation	2.0	$2.0		1			50%	50%										
3	Joining Wall	1.0	$1.0		1					100%									
4	House Walls	4.0	$4.0		1						25%	25%	25%	25%					
5	House Roof	2.0	$5.0		2										50%	50%			
6	Select Finishes	1.0	$1.0		1	100%													
7	Interior Finishes	2.0	$4.0		2												50%	50%	
8	Clean Up	1.0	$1.0		1														100%
9	Fab. Garage Doors	6.0	$6.0	1	1		17%	17%	17%	17%	17%	17%							
10	Garage Walls	2.0	$5.0	2	2								50%	50%					
11	Garage Roof	2.0	$2.0		1										50%	50%			
12	Garage Doors	2.0	$2.0		1												50%	50%	

Fig. 18: Step 5- The resulting optimum schedule.

Once a satisfactory schedule is obtained, it the quality of the solution can be checked for this training case study using the "Web Tutorial" feature shown earlier in Figure 12. The solution checker gives a score for all the steps made and checks for errors in the general data, the resources, the estimates, the activity relationships, and also the resulting schedule. For example, if a solution that meets the deadline but violates the resource limits is checked, then a report is generated as shown in Figure 19, with a score of 80 %. It should be noted that the solution in Figure 18 gives a 100% score.

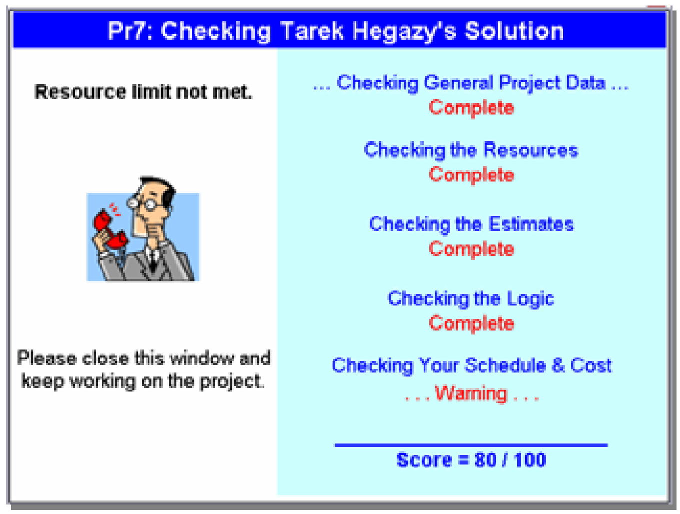


Fig. 19: Step 6 – Solution check report.

With the optimized schedule being satisfactory, it was saved as a baseline for progress evaluation. To continue using EasyPlan for progress recording and project control, the actual data for the first 12 days of the project (in the case study statement of Figure 13) were entered as shown in Figure 20.

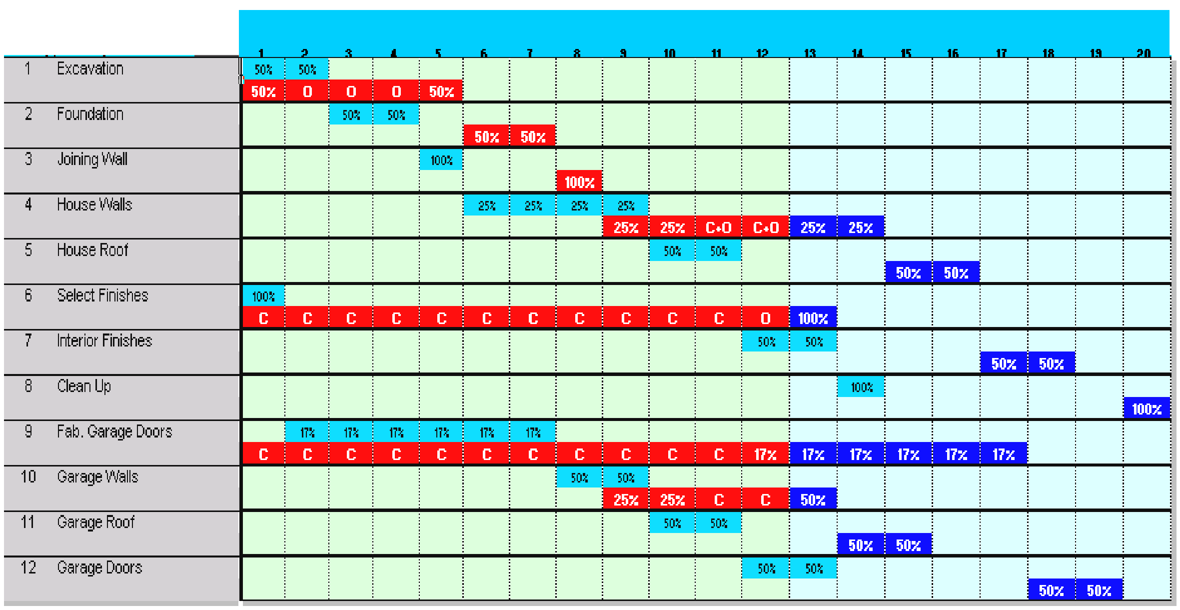


Fig. 20: Actual versus planned progress.

Figure 20 shows two bars for each activity: the top being the baseline, and the bottom being the actual progress. It is noted that both the planned and the actual progress are recorded as daily percentages shown on their respective cells. This is one of the basic advantages of EasyPlan to legibly show whether actual progress is slower or faster than planned. Also, in this legible representation, the reasons for work interruptions are shown as comments on the cells ("o" means owner interruption; "c" means contractor interruption; and "c+o" means both).

With the specified actual progress, the project is now 6 days longer than the deadline (projected duration is 20 days as shown in Figure 20). One way to bring the project back within the deadline is to re-optimize the schedule and determine the cheapest corrective action needed. Accordingly, the remaining part of the project was adjusted and the projected completion became 18 days (shorter by 2-days than the previous one). If we need to meet the strict 14-day deadline, we may change the estimates of some activities to reflect new technology, more productive equipment, or more experienced crew. Then, we re-optimize the project using these better project options. Also, to identify the responsibility for the project delay, we may activate the "Delay Analysis" feature of EasyPlan.

Concluding Remarks

This paper used a simple case study approach, which is more like a game challenge, to train practitioners on the interactions among planning, estimating, scheduling, cash flow analysis, and project control. The benefits of using this simple training approach include: appreciation of project management and its benefits, better planning and execution of projects, cost and time savings, better utilization of resources, and speedy corrective actions. The paper also presented a simple computer program, EasyPlan, for integrated project management. EasyPlan's features include several web-based case studies. During training, users download a case study, solve it using the software features, and then check the solution through the online checker. EasyPlan is easy-to-use and its simplified presentation suits educational and professional users to effortlessly train on integrated project management concepts and experiment with a variety of what-if scenarios. In essence, the game approach to project management training presented in this paper mainly targets the small players who are often overlooked in existing systems and tools. Increasing the awareness of those players about their roles in bringing success to projects is perceived to cause substantial productivity improvements to projects and to the whole industry.

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