

Teaching Strategies

- The two vignettes in this chapter reinforce the need have good relationships with customers and potential customers. Relationships help with winning contracts and making sure that the best team members are available for projects. **(See Premium Deck for Slides.)**
- In the first vignette, Palmaz Scientific, Inc. has worked to create a high quality project team that works to generate innovative solutions to accelerate healing and increase patient well-being.
- The second vignette portrays the complexity of project and program management and suggests possible solutions to the problems that arise from limited resources.
- Good project management utilizes techniques that work in complex situations. The solution to a project problem can be as simple as a spreadsheet. Solutions are not always complex.
- Resource leveling is an important concept discussed in this chapter.
 - Ask the students why it is important to consider resources when planning and managing a project.
 - Will the amount of available resources affect the completion date? If you had 2 experienced people building a house, would it take as long as if you had 10 experienced people building a house? What would happen if you started with 10 and half of them quit?
- See **premium deck for slides** corresponding to the Appendix.

Optional Supplemental Activities

- Have students read the real-world vignettes and discuss them
- Have students read the chapter and answer all of the Reinforce Your Learning questions and the questions at the end of the chapter. **(See Premium Deck for Slides.)**
- Have students manually solve the resource leveling and resource-limited scheduling presented in this chapter then solve the problems in Microsoft Project.
- Examine the Association for Project Management website with the class and explore the resources.

- Have students determine what resources would be best for junior-level project managers versus for more senior-level management.

Chapter Concepts

- Taking resource constraints into account when developing a network diagram
- Determining the resource requirements plan for a project
- Leveling the use of resources within the required time frame of the project
- Determining the shortest project schedule with the limited resources available

Chapter Concepts

- Considering how to best utilize limited resources adds another dimension to planning and scheduling.
 - It is necessary to estimate the types and quantities of resources required to perform each activity.
 - These resources can include people, materials, equipment, tools, or facilities.
 - A resource requirements plan illustrates the expected utilization of resources by time period during the time span of the project.
- In many projects, several activities may require the same resources at the same time.
 - There may not be sufficient resources available to satisfy all demands.
 - These activities compete for the use of the same resources.
- If sufficient resources are not available when required, some activities may have to be delayed until a later time when more resources are available.
- Resource availability can constrain the project schedule.
- They can also be a constraint on completing the project within budget if it is determined that additional resources are needed to complete the project by its required completion time.

This chapter covers several approaches to incorporating resource considerations into the project plan and schedule. Based on the information in this chapter, students will become familiar with:

- Taking resource constraints into account when developing a network diagram
- Determining the resource requirements plan for a project

- Leveling the use of resources within the required time frame of the project
- Determining the shortest project schedule with the limited resources available

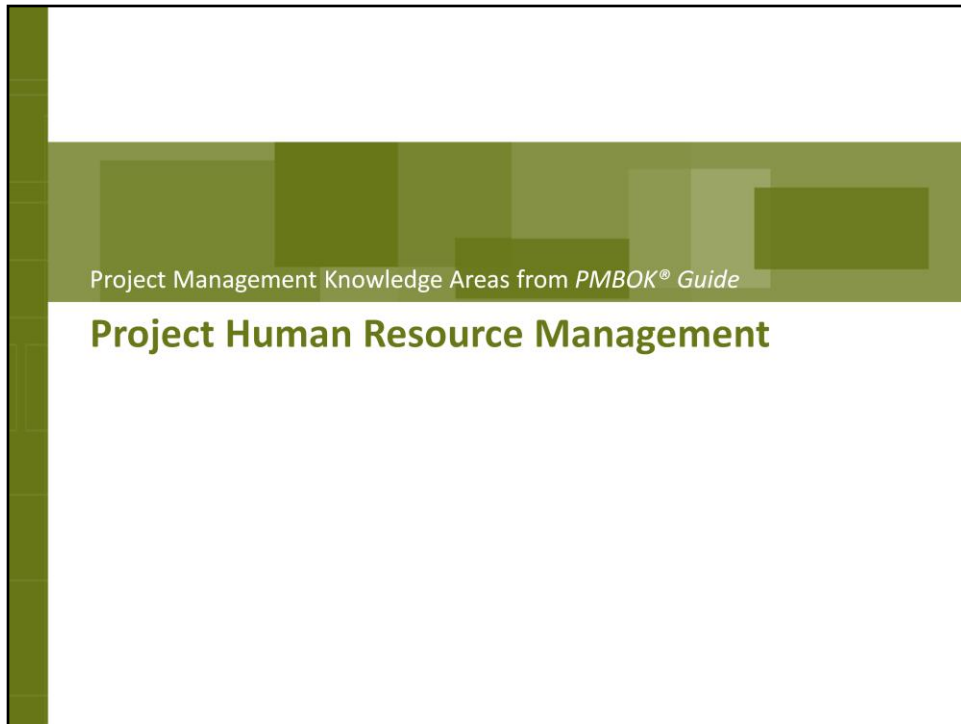
Learning Outcomes

- Create a network diagram that takes resource constraints into account
- Prepare a resource requirements plan
- Explain resource leveling
- Discuss resource-limited scheduling

Learning Outcomes


After studying this chapter, the student should be able to:

- Create a network diagram that takes resource constraints into account
- Prepare a resource requirements plan
- Explain resource leveling
- Discuss resource-limited scheduling



Project Management Knowledge Areas from PMBOK® Guide

Concepts in this chapter support the following Project Management Knowledge Areas of the *PMI Guide to the Project Management Body of Knowledge (PMBOK® Guide)*:
Project Human Resource Management



\$3 Million Emerging Technology Fund Investment in Palmaz Scientific, Inc.

Background	Why Funded
<ul style="list-style-type: none">■ A 17-member panel reviews proposals for Texas Emerging Technology Fund■ Palmaz Scientific, Inc. was funded■ Projects that accelerate healing and improve patient well-being■ Apply nanotechnologies for medical devices; required a team of executives, physicians, scientists, and engineers■ Uses project management for research and development and taking products to market	<ul style="list-style-type: none">■ Proven management team■ Innovative technology■ The project team works together in an innovation incubator■ Projects apply new techniques and materials to solve new problems■ Resources and creative teams have taken ideas to commercial applications

Vignette A: \$3 Million Emerging Technology Fund Investment in Palmaz Scientific, Inc.

- The 17-member panel of the South Texas Regional Center for Innovation and Commercialization reviewed proposals for innovations in advanced technology commercial enterprises. Palmaz Scientific, Inc. was announced as one of the funding recipients.
 - Palmaz has a proven management team of executives, physicians, scientists, and engineers
 - It creates innovative technology developed by an experienced management team
- The project team works together in an innovation incubator.
- Projects apply new techniques and materials to solve new problems.
 - Resources and creative teams have taken ideas to commercial applications to accelerate healing and increase patient well-being.
- One man may have been inspired to develop the solution; but it took an entire team to make it to a reality.
- The Palmaz team continues to work together to help improve the quality of life through project management of research and development projects and taking those projects to commercial applications.



Allocating Resources in Multi-Project Programs: Lessons Learned from the Trenches (DoD)

Resource Allocation Problems

- Failure to determine true program capacity when managing multiple projects at a time (project portfolio)
- Project-tracking system that did not support program-level time tracking, only project-level tracking
- Only summary reports were made by project managers for resource pools
- Critical paths were calculated on individual projects only

Solutions

- Determine supply and demand of project resources
- Use of an integrated enterprise-resource planning system to track interproject requirements for resources
- Examination of task requirements and tracking to avoid unnecessary resource conflicts
- Critical path analysis tool was implemented

Vignette B: Allocating Resources in Multi-Project Programs: Lessons Learned from the Trenches

- Department of Defense project managers simultaneously manage multiple projects, or a portfolio of projects.
 - The same resource is assigned to multiple projects
- The DOD has highly complex project management issues without a sufficient project-tracking system in place.
- It requires resource management techniques that are effective and can identify key resource conflicts and priorities.
- A software requirements analyst was assigned to work 200 hours within a five-week period of performance and reported that he could complete the tasks for the two deliverables in the planned timeframe.
 - During his work, the software requirements analyst faced numerous delays, lack of material resources to complete the tasks on time, and an increased number of stakeholders with whom he met.
 - Other resources were not available when he needed them.
- The first task took four weeks to complete, when it was scheduled to take one week and for a deliverable that was to take 120 total hours.
- The developer team could not start development until the functional requirements were defined.
- The development team task duration was 12 weeks, but was only scheduled to take 5 weeks— following the tasks completed by the software requirements analyst
 - The development team discovered they could reduce their 12 week task to 3 weeks
- The project manager reported that the project was operating on time, even though the first task took an extra 3 weeks.
- Other resource constraints occurred, yet the project manager calculated a six-week slack in the project to account for problems and slowdowns.
- Changes were implemented to solve the resource allocation problem.
- A problem was the project-tracking system that did not support program-level time tracking, only project-level tracking
 - The solution involved using an integrated enterprise-resource planning system to track inter-project requirements for resources
- Another problem was that summary reports were made by project managers for resource pools.
 - The solution was to examine task requirements and tracking to avoid unnecessary resource conflicts.
- Part of the slowdown came from calculating critical paths on an individual project basis.
 - The solution involved implementing a critical path analysis tool that looked at all the projects together. This helps project managers to describe tasks in sufficient detail for the system to assess the conflicts between projects and develop risk mitigation strategies.
- Project and program management is expected to continue to increase in complexity and lead to more challenging multi-project situations and inter- and intra-project resource management requirements

Technical-Constrained Planning

- Serial relationship – performed in that sequence

FIGURE 6.1 Technically Constrained Activity Sequence



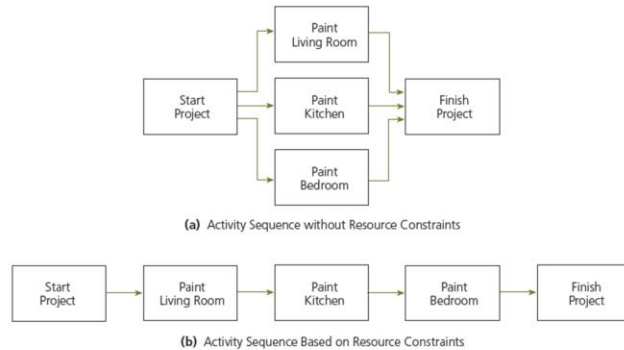
Technical-Constrained Planning

- Network diagrams illustrate the technical constraints between and among activities.
 - Activities are drawn in a serial relationship because, from a technical standpoint, they must be performed in that sequence.
- This figure depicts three house-building activities that must be completed serially.
- In addition to showing the technical constraints among activities, the network logic can also take into account resource constraints. The sequence of activities in a figure such as the one on this slide reflects the availability of a limited quantity of resources.

Resource-Constrained Planning

- Available resources allow for concurrent tasks

FIGURE 6.2 Resource-constrained Planning



- Limited resource availability constrains project

Resource-Constrained Planning

- Here you can see two figures that help to illustrate how resource availability allows for tasks to be conducted concurrently.
- The figure on the top depicts three activities that could be performed concurrently because there is no technical reason why the start of any one of these activities should depend on the completion of any other one.
- The figure on the bottom shows what happens when human resources are limited, such as when there is only one person available to do all the painting.
 - There is no way that one person can do multiple jobs at the same time.
- A network diagram helps to illustrate potential resource allocation problems.

Resource Requirements Plan

- Illustrates the expected resource use by time period
- Indicate the amounts and types of resources needed to perform each activity

FIGURE 6.3 Estimated Resource Requirements for Consumer Market Study Project

NAME	ACTIVITIES	WORK DAYS	PERIOD
Susan	1, 2, 3, 4, 8	40	0 to 40
Steve	5, 6, 9	8	38 to 53
Andy	7, 10	17	38 to 55
Jim	11, 12, 13	25	103 to 128
		90	0 to 128

Resource Requirements Plan

- A resource requirements plan illustrates the expected utilization of resources by time period across the time span of the project.
- It is necessary to indicate the amounts and types of resources needed to perform each activity.
- This figure depicts the estimated resource requirements for the consumer market study project.
- Although the project takes 128 days, the amount of work days is 90 days— this is too few days to complete the project as it is currently laid out.

Example Painting Project: Resource Requirements

FIGURE 6.4 Required Resources for Painting Project

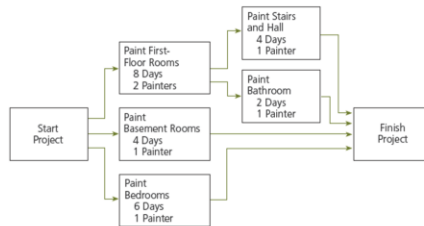
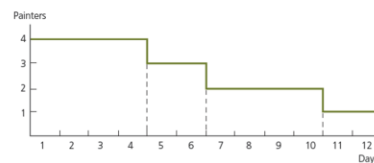


FIGURE 6.5 Resource Requirements Plan for Painting Project

	1	2	3	4	5	6	7	8	9	10	11	12	Painter Days
First-Floor Rooms (2 Painters)													16
Stairs & Hall (1 Painter)													4
Bathroom (1 Painter)													2
Basement Rooms (1 Painter)													4
Bedrooms (1 Painter)													6
Day	1	2	3	4	5	6	7	8	9	10	11	12	
Painters	4	4	4	4	3	3	2	2	2	2	1	1	32

ASAP Schedule!

FIGURE 6.6 Resource Utilization for Painters



Example Painting Project: Resource Requirements

- The resource profile for painters is illustrated in the network diagram on the left in this slide, Figure 6.4.
 - It clearly shows how painters are being utilized unevenly.
- The top figure on the right, figure 6.5, depicts the resource *requirements* for the painters based on the network diagram in Figure 6.4.
- Figure 6.6, which is on the lower right, depicts the resource *utilization* of the painters based on the network diagram in Figure 6.4.
 - You can see that the pattern is uneven.
- Sometimes it is preferable to have a more uniform, or level, application of resources.
 - This helps to avoid having to pay workers overtime or to pay for time when work is not being performed.
- Resource utilization charts based on each activity's *earliest* start time are said to be based on an as-soon-as-possible (ASAP) schedule.
- Resource utilization charts based on each activity's *latest* start time are said to be based on an as-late-as-possible (ALAP) schedule.

Resource Leveling

- Minimize resource requirement fluctuations
- Resources applied as **uniformly as possible**
- Must keep project schedule **within required time**
- Delay start of noncritical activities
- Use positive slack
- Project management information systems assist
- If delay beyond slack and on critical path, project will be delayed beyond required completion time

Resource Leveling

- *Resource leveling, or smoothing*, is a method for developing a schedule that attempts to minimize the fluctuations in requirements for resources.
- This method seeks to apply resources as uniformly as possible, without extending the project schedule beyond the required completion time.
- The start of noncritical activities are delayed beyond their earliest start times (but not beyond their latest start times) in order to maintain a uniform level of required resources.
 - Activities can be delayed only to the point where all their positive slack is used up. Any further delays would cause the project to extend beyond the project completion time.
- Generating a resource-leveled schedule and resource requirements graphs and tables can be highly complex.
 - Project management information systems can assist with the challenge.

How to level the painting project?

FIGURE 6.5 Resource Requirements Plan for Painting Project

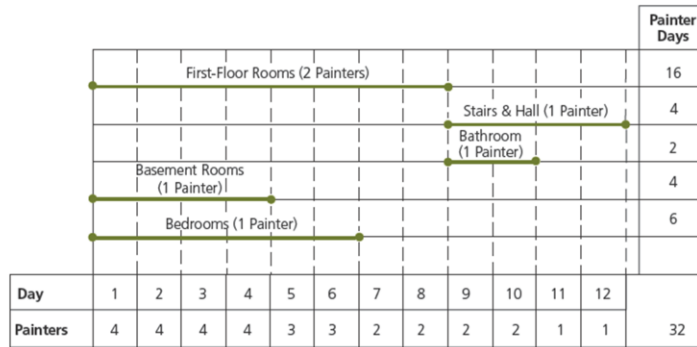


FIGURE 6.5 Resource Requirements Plan for Painting Project

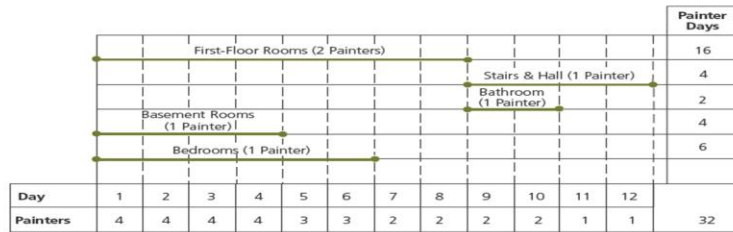


FIGURE 6.7 Resource-levelled Requirements Plan for Painting Project

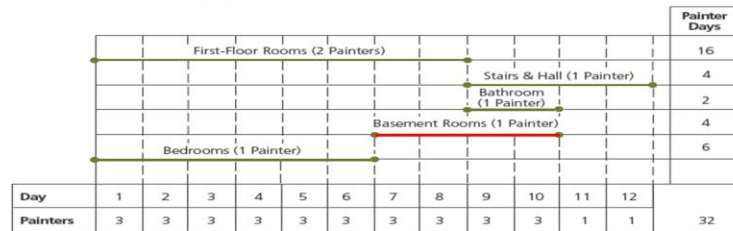
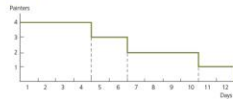
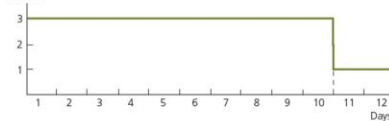


FIGURE 6.8 Resource-levelled Utilization for Painters

FIGURE 6.5 Resource Utilization for Painters



Painters



Days

- In the painters example, resource utilization can be leveled.
 - “Bathroom” could be delayed up to 2 days.
 - “Basement Rooms” could be delayed up to 8 days.
 - “Bedrooms” could be delayed up to 6 days.
 - All of this can be done without extending the project completion time.
- Two alternative actions could be taken to assist in resource leveling:
 - Alternative 1. Delay the activity with the most positive slack—“Basement Rooms” (+8 days slack)—by 6 days so that it will start after “Bedrooms” is finished.
 - Figures 6.7 and 6.8, the middle and bottom figures on the right side of the slide, depict the resource-levelled requirements plan for the painting project and the resource leveled utilization for the painters with alternative 1.
 - Alternative 2. Delay “Bedrooms” so that it will start on day 4, after “Basement Rooms” is completed.

Resource-Limited Scheduling

- Develop shortest schedule
- Not exceed fixed available resources
- Extend the project completion time if necessary
- Give activities with the least slack first priority
- Delay lower priority activities

Resource-Limited Scheduling

- Resource-limited scheduling is a method for developing the shortest schedule when the number or amount of available resources is fixed and cannot be increased.
 - This method will extend the project completion time if necessary in order to keep within the resource limits.
- When several activities need the same limited resource at the same time, the activities with the least slack have first priority.
 - The lower priority activities get delayed, but the delaying of activities may delay the project.

Example Painting Project: Limited Resources

■ Limit of two painters

FIGURE 6.9 Effect of Limited Resource Availability

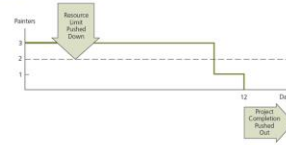
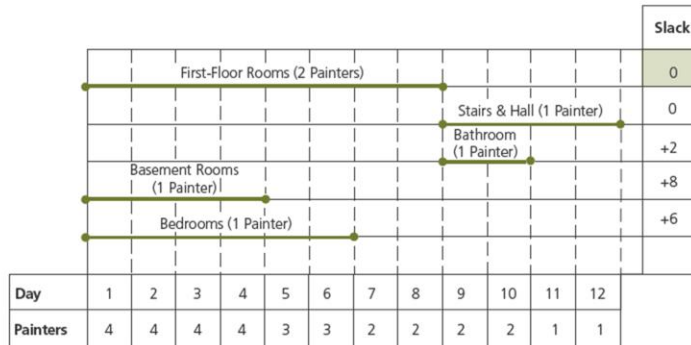


FIGURE 6.10 Resource Requirements Plan for Painting Project



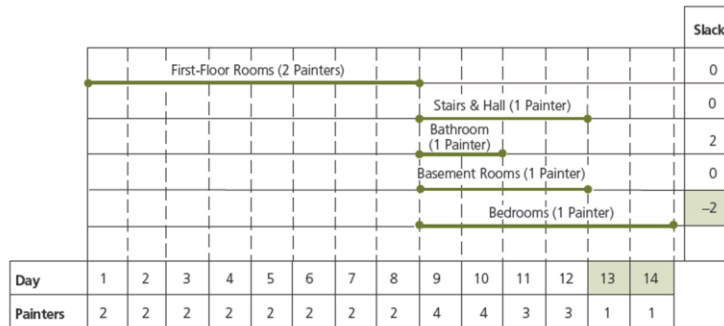
Example Painting Project: Limited Resources

- The resource availability figure on the top illustrates what would happen if only a limited number of painters—two—were available to finish the painting project.
- The larger figure, the resource requirements plan, on the bottom shows that the three activities require a total of four painters to be performed the quickest.

Example Painting Project: First Resource Allocation

- “First Floor Rooms” has a slack of 0
- Other tasks are delayed

FIGURE 6.11 First Resource Allocation



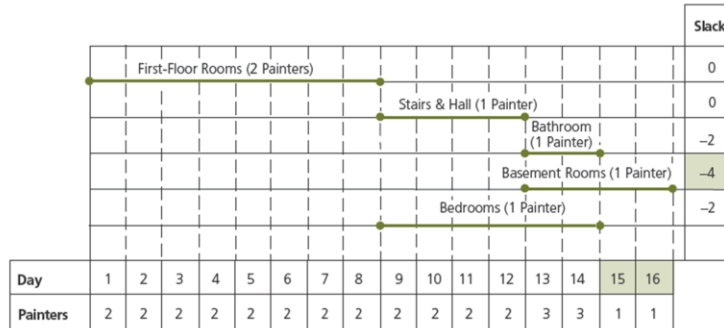
Example Painting Project: First Resource Allocation

- Let's take a look at how the completion date for each activity changes when the job finishes with four painters instead of two.
- Because “First Floor Rooms” has a slack of 0, the two painters will be allocated to the first floor rooms and will continue to be assigned to that activity until it is finished.
- This first resource allocation is shown in the figure on this slide, with the project completion extending from day 12 to day 14.

Example Painting Project: Second Resource Allocation

- Begin “Stairs & Hall” and “Bedrooms”
- Need to address limit for days 13 and 14

FIGURE 6.12 Second Resource Allocation



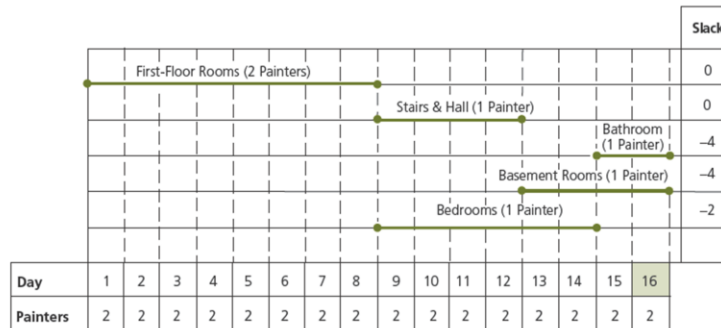
Example Painting Project: Second Resource Allocation

- The second resource allocation is shown in this figure.
- If the job only has two painters from start to finish, you can see that the project completion date goes from day 14 to day 16.

Example Painting Project: Third Resource Allocation

- Delay “Bathroom” to days 15 and 16
- Project delayed by 4 days

FIGURE 6.13 Third Resource Allocation



Example Painting Project: Third Resource Allocation

- The third resource allocation is shown in this figure, with the project completion date remaining at day 16.
- This completion date is satisfactory, even with the resource constraint of only two painters when four would be ideal.

Resource Requirements For Information Systems Development

- Five basic required resources
 - People, hardware, software, data, and network resources
- The more accurate the resource assessment, the more likely the project can be completed on time
- Most common problem – **Overallocation**
 - Resources assigned to multiple tasks at same time
 - Conflict results in lengthening the time

Resource Requirements For Information Systems Development

- There are five basic required resources for IS development.
 - People, hardware, software, data, and network resources
- The more accurate and detailed the resource assessment is, the more likely the project can be completed on time.
- Overallocation of resources is the most common problem in project management.
 - It happens when resources are assigned to multiple tasks at same time.
 - The conflict results in lengthening the time needed to complete the project.

Project Management Information Systems

- Handle resource considerations within a project
- Create and maintain a list of resources
- Store availability, rate, and costs for resources
- Assign resources and calculate cost
- Assign calendar to record availability
- Resolve overallocations for best solution

Project Management Information Systems

- Project management information systems provide excellent features for handling resource considerations within a project.
- Most systems allow you to create and maintain a list of resources that can be accessed for all the tasks associated with a project.
 - The list typically allows you to store the resource name, maximum quantity of units available, standard and overtime rates, and costs.
- Because the expenses for resources can be accrued at different times throughout a project, most systems allow you to create charges for a resource at the beginning of its use, at fixed intervals, or at the end of the project.
- Each resource can also be assigned a calendar to display its availability over a specified period of time.
- Resource overallocations can be resolved either manually, or with automatic processes wherein the information system determines the best solution and whether the project can be delayed to solve the overallocation.

Critical Success Factors

- **Resources can constrain the project schedule** because the quantities of various types of resources available to perform the project activities may be limited.
- It is necessary **to estimate the types and quantities** of resources required to perform each activity.
- If sufficient resources are not available when required, some activities **may have to be delayed** until a later time when resources become available to perform the activities.
- **Resource leveling**, or smoothing, is a method for developing a schedule that attempts to minimize the fluctuations in requirements for resources. It levels the resources so that they are **applied as uniformly as possible** without extending the project schedule beyond its required completion time.
- **Resource-limited scheduling** is a method for developing the shortest schedule when the quantity of resources is fixed. It **will extend the project** completion time if necessary.

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Summary

- The consideration of resources adds another dimension to planning and scheduling; resources can constrain a project.
- Resources can include people, materials, equipment, tools, facilities, and other crucial elements to a project.
- A resource requirements plan illustrates the expected utilization of resources by time period during the time span of the project.
- Resource leveling, or smoothing, is a method for developing a schedule that attempts to minimize the fluctuations in requirements for resources when the project completion time is fixed.
- Resource-limited scheduling is a method for developing the shortest schedule when the quantity of available resources is fixed, and may extend the project completion time in order to keep within the resource limits.

Summary

- The consideration of resources *adds another dimension* to planning and scheduling; resources can constrain a project.
- Resources can include *people, materials, equipment, tools, facilities*, and other crucial elements to a project.
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- Resource leveling, or smoothing, is a method for developing a schedule that attempts to *minimize the fluctuations* in requirements for resources when the project completion time is fixed.
- Resource-limited scheduling is a method for developing the shortest schedule when the *quantity of available resources is fixed*, and may extend the project completion time in order to keep within the resource limits.