Instructor's Manual
to accompany

Construction Planning and Scheduling

Fourth Edition

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Table of Contents

Chapter 1: Introduction

Learning Objectives

At the completion of this chapter, the student should be able to:

- Explain the differences between planning and scheduling.
- Describe the advantages and disadvantages of using bar charts for scheduling a construction project.
- Compare bar charts and precedence diagrams as used in the construction industry.
- Outline the reasons for using planning and scheduling in construction.

Instructional Hints

- Spend time on the history and evolution of planning and scheduling.
- Bring magazine articles that highlight the impact of planning and scheduling on the successful completion of a construction project.

Activities

- Invite a construction manager from a medium-sized construction company to your class to share two concrete examples that illustrate the importance of planning and scheduling on construction projects.

Chapter 1
Review Questions

1. Describe the disadvantages of scheduling a project with the use of bar charts.

   Answer: Traditional bar charts do not show the interrelationships between activities, as they show only the timescale of when each activity is to occur. This makes it difficult to add activities that were left out in the original schedule. As a result, complex projects do not lend themselves to scheduling. Even if a project is scheduled successfully with a bar chart, updating the schedule can be very cumbersome. The impact of changes is difficult to show with bar charts.

   Note: The above answer is given purely as a response to the traditional use of bar charts. With the use of computers, a project can be scheduled as a precedence network and with a keystroke the bar chart of the project is displayed. In addition, the bar chart can generally be displayed with the dependencies between activities also shown. Thus, the disadvantages noted above do not apply to most conventional computer scheduling software packages.

2. Explain why the use of bar charts is popular in the construction industry.

   Answer: The popularity of bar charts lies in the ease of conveying scheduling information. While a schedule network requires considerable study to understand, the bar chart can generally be comprehended by anyone, including foremen, workers, architects, owners, etc. There is little confusion in the information that is conveyed.

3. Why is it often common to use bar charts and precedence diagrams to depict schedules on the same construction project?

   Answer: Bar charts are an ideal way to communicate with a universal audience. Bar charts are clear representations of when activities are to Occur. If projects were built as they were originally scheduled, there would be little need to use any other scheduling tools. Unfortunately, schedules are rarely exact portrayals of how projects are actually completed. Updating is almost always a scheduling requirement as some activities are delayed and others run ahead of schedule. Changes are also commonly made to projects and these must also be reflected in the schedule. Precedence diagrams are a convenient way of incorporating changes in the schedule and they are also a convenient way of updating the schedule.

   Also, since most scheduling software easily toggles between precedence diagrams and bar charts, it is very convenient to use the format of the schedule that is most applicable at the time. As a result, it is easy to use bar charts for one purpose and quickly convert the schedule to a precedence diagram for another purpose.

4. What is the difference between planning and scheduling?

Answer: Planning is essentially the determination of what tasks must be performed. Schedules provide a time frame in which the tasks or activities are to take place. Planning can be considered to be similar to a list of activities that must be performed, similar to a “to do” list. Scheduling would consist of putting those “to do” items on a calendar.

5. Compare bar charts and precedence diagrams in terms of the ease with which activities can be added to the schedule.

   Answer: It is only on the complex schedules that this issue is a particular concern. For example, if a schedule consists of 100 activities, it may be difficult to add an activity to a bar chart and still accurately anticipate the impact of the change on the entire schedule. With the use of a precedence diagram, the insertion of an activity is a relatively simple matter. Each activity must generally have at least one predecessor and at least one successor. With the precedence diagram, the logic is more readily apparent and incorporating a new activity is a simple matter.

Chapter 2: Developing a Network Model

Learning Objectives

At the completion of this chapter, the student should be able to:

- Identify the steps in building a network model.
- Differentiate between an arrow diagram and a precedence diagram.
- Differentiate between an activity and an event.
- Give types and examples of different types of constraints that might impact a scheduling network.
- Draw a simple precedence diagram for a basic construction activity.
- Calculate start/finish times and float values; identify the critical path.

Instructional Hints

- Help the students understand the importance of completing the fundamental steps of manually developing the network model, even though most of them will be utilizing computerized scheduling methods.
- Emphasize with the students that the quality and accuracy of the network model determines its effectiveness as a scheduling tool.

Activities

- Bring in an example of a real-life construction activity from a local company, and build a network model by following the fundamental steps outlined in the chapter. Apply the known constraints, calculate start/finish times, and float values. Identify the critical path/s. Compare the network diagram with the one developed by the construction company.

Chapter 2
Review Questions

1. What is the difference between an activity and an event?

   Answer: An activity is a task or function that consumes time and perhaps other resources. An event consumes no resources, especially no time. An event can be considered to represent a point in time or the representation of the status of a project at a particular instant, e.g., dried in.

2. What are examples of two different types of constraints that might have an adverse impact on a scheduling network?

   Answer: One serious resource constraint (labor constraint) that is hampering many construction projects today is the shortage of skilled workers. Various types of material constraints might also exist. For example, the total amount of ready-mix concrete that might be available for a project on a given day might be seriously impacted by the capacity of the ready-mix supplier. An equipment constraint may also exist, e.g., the firm might want to complete the project with the use of a single crane. A safety constraint might consist of unseasonably hot or cold weather.

3. What is the fundamental difference between an arrow diagram and a precedence diagram?

   Answer: Arrow diagrams depict activities as arrows while precedence diagrams depict activities as nodes. Because of the fundamental difference in the methods of graphically preparing the diagrams, precedence diagrams are generally considered to be easier to develop and understand. While both types of diagrams depict essentially the same information, arrow diagrams may be more complex to develop as dummy activities (artificial activities that consume no time or other resources but are necessary to show proper relationships between activities) may be required to show proper logic. There are no dummy activities required in a precedence diagram. Also, events are automatically included in arrow diagrams, but they must be specifically added in precedence diagrams.

4. Why should many of the constraints be imposed on a network after the basic logic network has been completed, rather than incorporating them as the network is being developed?

   Answer: It may be advisable to develop an unconstrained scheduling network in order to begin the scheduling analysis with an ideal case. As constraints are imposed in successive iterations, the scheduler will have a fuller appreciation of the impact that specific constraints have on the project duration. As these project extensions are recognized, it will be easier to isolate the impact of specific constraints. If these constraints are recognized early in the scheduling effort, it might be tempting to automatically incorporate them in the original schedule and thereby limit or reduce

scheduling flexibility, increase project duration generally add to project cost, and confuse the scheduling logic.

5. Describe two different network schedules that might be generated for the same project. Explain why.

   Answer: The schedules that might be developed on a project will generally differ in the level of detail that is represented. The master schedule might/show activities in a more generic sense as these would be utilized by upper managers in a firm to quickly grasp the general status of a project as it pertains to the schedule. For Communication purposes, the network schedule might be converted to a bar chart. Another network schedule might be utilized to schedule the tasks of specific crews. This might be appropriately shown with a network diagram. While the level of detail may not necessarily show every task that must be performed on a given day, there must be sufficient detail to permit field personnel to begin to understand the general scheduling objectives at a particular point in time on a project.

6. What is an example of a procurement activity that might be a valuable inclusion in a network? Conversely, what is an example of a procurement activity that has little merit for inclusion in a network?

   Answer: Major pieces of equipment that are to be incorporated in a project are often included on schedules. This is especially true of equipment (or materials) that have a long lead time associated with their fabrication and delivery. Any items that are in short supply or that cannot be readily obtained should be considered for inclusion in the procurement activities on a schedule. When materials or equipment are particularly expensive, their inclusion may also be desirable so that the cash flow impact can be more fully evaluated.

   Examples of procurement activity items that are often included in schedules include elevators in a multi-story structures, specially-fabricated hoists, electrical switch gear, custom tiles, large electrical motors, etc. Procurement activities that may not be warranted for inclusion in the schedule include those related to stock purchases and small items that might be readily available. For example, the purchase of 16 penny nails for a small wood frame structure would generally not be included in the network schedule.

7. Why is the initial schedule to be viewed as a best guess of how a project will be constructed rather than a definitive statement about how it will be done and when it will be completed?

   Answer: The initial schedule is very similar to the estimate prepared by the contractor. When the estimate is prepared, predictions will be made about how much given items will cost. If the estimates are prepared judiciously, some items may actually cost more but other items will cost less. The end result is that things average out. The schedule is prepared with the same expectation, with some activities taking longer that originally scheduled and others being completed in a shorter time.

An obvious variable that is impossible to predict with complete accuracy is the weather. On sitework activities, an estimate might be made that the clearing will be completed on a particular project in 12 working days. Perhaps an allowance was included in the time estimate for rain. If no rain occurs, it might be possible to complete the activity in 8 days. Of course, if very heavy rains plague the project for two weeks, the project duration might extend to 20 days or more.

8. Describe potential users of a construction schedule.

   Answer: Any party involved in the construction process in any way is a potential user of the schedule. The most obvious individuals would be the supervisory personnel on the construction site (foremen and superintendents) who would use the information to communicate with their crews and also with subcontractors. Subcontractors might be regular users of the schedules because of their need to know when their services will be required on site. Major vendors will also want to know the project status in order to plan their material deliveries.

   Top managers of the construction firm and representatives of the facility owner would also be regular users of the schedule, although their interest will be of a more generic nature to monitor the general status of the project. Sureties and financial lenders may similarly want to have a general idea of how the project is progressing.

9. Give an example of a safety constraint that might be imposed in a schedule.

   Answer: Weather can impact safety in a variety of ways. For example, in hot climates it may be advisable to not perform work. If the temperature is 110° F it may not be safe for workers to be applying asphalt. On such days, work might be schedule to start as early in the day that workers can safely see what they are doing. If the temperature is below freezing and there is some rain, it will be unsafe for workers to be putting up roof decking on a sloped roof

   When overhead work is performed, such a placing concrete on the 10th floor of an office building, work might be stopped on the ground in the area over which the concrete bucket will be swung. On roadwork, work might be stopped during the rush hours (assuming very heavy and possibly fast traffic) to reduce the risks for the construction workers.

10. Describe factors that might impact the level of detail used in a schedule.

    Answer: Perhaps the primary factor is the end user of the schedule. If the user of the schedule will use the schedule to monitor performance, less detail will be required than when the schedule is used to plan work activities. Where there are many users, it is a function of the maximum amount of detail that will be required or expected by one of the users. In some instances, the contract will dictate the level of detail that is to be used.

Other factors that might impact the schedule detail include project complexity, number of subcontractors, and how much the schedule will be used to plan the work.

Chapter 3: Precedence Diagrams

Learning Objectives

At the completion of this chapter, the student should be able to:

- Explain the basic elements of a precedence network.
- Describe the various types of activity relationships.
- Compute the values of various start/finish times, total and free float.
- Explain how this information can be used to make various types of management decisions.

Instructional Hints

- Instructors who plan to lecture on arrow diagrams should consider jumping to Chapter 16 after the first two chapters are covered.
- Explain the fundamentals of precedence diagrams clearly.

Activities

- Solve at least three types of problems from the back of the chapter, with participation from the students. A suggested sequence would be #1, 3 and 4.