Chapter 1

Introduction

Like estimating, construction scheduling has been covered in other books dedicated solely to that topic. But scheduling by itself, without integrating preconstruction planning and controls during construction, is an incomplete construction management (CM) study. The schedule is a project management (PM) tool just as is the estimate; and time management is just as important to project success as is cost management. The key to effective time management is to carefully *plan* the work to be performed, develop a realistic construction *schedule*, and then *control* or manage the performance of the work. People often use the terms *planning* and *scheduling* together. Planning is the up-front work which makes the schedule feasible. Planning is a process and the schedule is the result. The schedule is a logical arrangement of activities in order of occurrence, with prerequisites, and charted with a timeline. And the control element is the implementation of those plans during physical construction of a project. Planning, scheduling, and control are therefore the three major sections and focus of this book.

Schedules are important tools for all members of the owner and design and construction teams. Proper planning of the project and the schedule, with input from the relevant personnel such as the general contractor's (GC's) project superintendent and major subcontractors, are keys to developing a useful construction management tool. Schedule development begins with proper planning, which considers many variables such as deliveries, logical workflow, manpower, and equipment availabilities. There are many different types of schedules, each of which has a use on a construction project. Some of the major ones include:

- Summary schedule, may also be the contract schedule;
- Detailed schedule, may be the contract schedule;
- Three-week look-ahead schedules;
- Specialty schedules which include those focused on one area of the building or phase or on just one subcontractor;
- Pull planning schedules, which are part of lean construction;
- Expediting and submittal schedules and others.

1.1 SCHEDULERS

Who draws schedules and who uses schedules? Hopefully after reading the book you will have a thorough understanding of this topic. This chapter provides just a brief introduction.

First, some members of the built environment use the terms *scheduling* and *project management* as though they are the same, but PM as presented in this book involves much more than scheduling. A PM may be the scheduler on his or her particular project, but a person who schedules by profession, be they a home office specialist or a scheduling consultant, would not typically also be a project manager. For many the "scheduler" is the one in charge of creating the schedule, such as a superintendent or project manager, but for others the scheduler is a computer technician, sometimes without extensive construction field experience. A valuable scheduler oftentimes is one with a mix of construction field knowledge and technical skills.

Different contractors will establish the role of the scheduler in a variety of fashions. A scheduler can be assigned to the home office as a staff scheduler and he or she either prepares all the project schedules (for a small to mid-sized contractor) or supports the project manager and superintendent with creating their own schedules. Or a large project may have its own full-time scheduler. If there is not someone in-house, then an outside consultant/specialist may be hired, or a project engineer or assistant superintendent may be the project scheduler. A retired superintendent working as a consultant, teamed with a construction management graduate, is an excellent example of a scheduler as shown in this first example. The problem with either the PM or superintendent also taking full responsibility for the schedule maintenance on a large project is that the effort may be all-consuming, as will be shown in another example further on in the book. An industry partner from a national construction firm who was interviewed when researching this book indicated, "The scheduling process requires teamwork and does not rely on an isolated home office individual. The ideal scheduler must have a background in construction, particularly with field expertise."

Example 1.1

One of the area's most highly acclaimed superintendents retired, but he wanted to keep himself busy and had always enjoyed drawing schedules by hand. Another competing GC hired him as their scheduling vice president and he would come into the office one or two days a week and assist field superintendents with their schedules. He would review the drawings first, then sit down with the field superintendent and a large sheet of butcher paper and scratch the schedule out, with lots of loop lines and plenty of erasures, but somehow it all got down on paper. The field superintendents were happy to work with the scheduler as they all appreciated his experience and insights. He would have a young CM graduate formalize the schedule and transform it into a useful communication tool. During the course of construction, he was on call if a superintendent needed support, but he generally left jobsite controls, including schedule control, to the field supervisors.

1.2 SCHEDULE TYPES

Schedules take on a lot of different formats, and similar to planning, there is no one exact form the contract schedule should follow. Many project managers and schedulers have their personal preferences. Most schedules fall into one of two standard formats: Bar charts and network diagrams. Bar charts relate activities to a calendar, but generally show little to no relationship among the activities. Network diagrams show the relationship among the activities, and may or may not be time-scaled on a calendar. Two diagramming techniques are used to represent network schedules. The first is known as the arrow diagramming method (ADM), in which arrows connect the individual activities and nodes depict events. The other is known as the precedence diagramming method (PDM), in which the activities are represented by nodes and arrows depict relationships between activities. Arrow diagramming method was the original form of *critical path* schedules but PDM has basically replaced ADM today. Network diagram schedules are also customarily referred to as critical path schedules. The critical path is the longest path through the schedule and determines the overall project duration. Any delay in any activity on the critical path results in a delay in the completion of the project. All are good systems and may be appropriate in different applications.

The schedule is a tool to help build the construction project and is used in a variety of fashions, as exhibited in this second example. Schedules can also be prepared for different presentations depending upon the anticipated use. Detailed discussions of all the following schedule types are elaborated on in Chapter 7. There are many other types of schedules and scheduling theories than presented in this book, each with an entirely separate glossary of terms and lists of abbreviations. A few of these other scheduling concepts are introduced in this book as well, but a more detailed analysis will be left for a more advanced book geared for the professional schedule consultant. This focus is on the scheduling tools typically utilized in the field by construction contractors. Many of these useful scheduling tools are described here.

Example 1.2

Schedules are intended to be tools to help build a project. A developer, who was also his own contractor, was a very capable builder and creative but did not have the patience or interest to draw formal schedules. Instead he used two whiteboards in the jobsite trailer – one for this month and one for the next month. This was an effective communication tool for the foremen and subcontractors on his current apartment project. But this type of schedule was not sufficient for the bank or his investment partners. The developer hired a scheduling consultant who prepared good detailed schedules to present to the bank each month with the monthly pay request draw, but he never hung them in the trailer nor shared them with subcontractors or the design team. This schedule was also a tool, but not the tool that it might have been, given more attention.

- *Contract schedules*, also known as formal schedules: These schedules will be provided to the client at the beginning and throughout the project delivery as required by the contract special conditions.
- *Summary schedules*: These schedules are often used for presentations or proposals or management reporting. They are similar to the milestone bar chart illustrated in Figure 1.1 for the case study project. A more detailed summary schedule is included in Chapter 7.
- *Detailed schedules*: These schedules are posted on the walls of meeting rooms or in the jobsite trailer, or at least they used to be. Now many are kept electronically on the computer screen as discussed in a couple of boxed-in examples presented further on in the book. These schedules are marked up with comments and progress. Detailed schedules may also serve as submittals for contract schedule requirements. A complete detailed schedule for the case study project is included on the book's companion website. Portions of this detailed schedule are used as figures and examples throughout the book.
- *Short-interval look-ahead schedules*: These schedules focus on short-term field activities. They should be developed by each superintendent or foreman and each subcontractor each week. These schedules can be in two-, three-, or four-week increments, depending on the job and level of activity. Some contractors simply print the next three weeks' worth of activities from the electronic master schedule without any additional detail or input from the superintendent, which is not as effective. Short-interval schedules may also be referred to as trade schedules in that each subcontractor prepares their own. These schedules are valuable for pretask planning, similar to pull schedules discussed further on. Figure 1.2 shows an example of the initial three-week schedule from the case study project and additional examples are included throughout the book. The schedule format is not as important as its author and content.
- *Mini-schedules*, *area schedules*, and *system schedules*: These schedules are intended to allow additional detail for certain portions of the work that could not be adequately represented in the detailed project schedule and have longer durations than the short-interval schedule. A system schedule for the case study's roofing subcontractor's scope is also included on the companion website.
- *Pull schedules*: These schedules are one of the major lean construction tools being adapted from production industries. They are prepared by the *last planners*, typically the foremen and superintendents responsible for accomplishing the work. Pull planning schedules are discussed in lieu of schedules in Chapter 5.
- *Other schedules*: There may be many other specialized schedules on the project that include submittal, buyout or procurement, delivery, start-up, as-built, and close-out schedules. Estimate or bid schedules are utilized to prepare the original quote and may be included with the bid. Many of these are discussed in other chapters in this book.

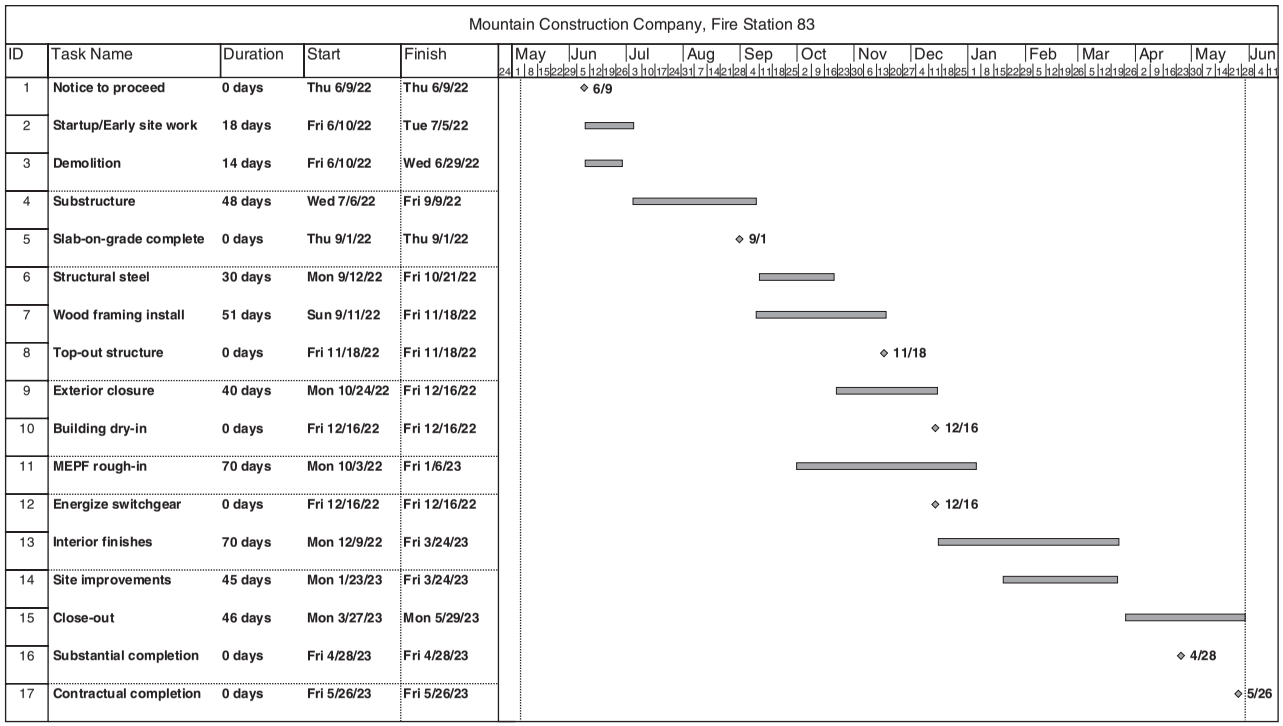


Figure 1.1 Milestone summary schedule

Mountain Construction Co.

Short-interval schedule

Project: Fire Station 83, Pasco, WA — Date: 6/6/2022

Superintendent: Ralph Henry — Sheet: 1 of 1

June

No.	Activity description:	S	S	6	7	8	9	10	S	S	13	14	15	16	17	S	S	20	21	22	23	24	S	S	Comments
1	Notice to proceed						X																		Original in office
2	Deliver office trailers							X																	
3	Install silt fence							X			X	X													
4	Surveyor:	**Site and bldg corners**									**Layout utilities**							**Building gridlines/setbacks**							
5	Locate utilities							X			X	X													Public utility co.
6	Install temp power												X	X	X			X	X						
7	Deliver sanikan							X																	
8	Clear and grub site												X	X											
9	Pre-con meeting with city											X													
10	Mobilize demolition sub											X													Demo permit ready?
11	Demo existing structure												X	X											
12	Geo approve import sample										X	X	X	X	X			X	X						Expedite!
13	Site utilities																	X	X	X	X	>			Post demo
14	Rebar shop drawings										X	X	X	X	X			X	X	X	X				Expedite!
15	Deliver rebar																					X			
16	Structural excavation																					>			Tues, 6/28
17	Begin foundations																					>			6-Jul

Figure 1.2 Three-week schedule

1.3 INTRODUCTION TO THE BOOK

Construction has its own unique set of abbreviations and acronyms. An extensive list of all of the abbreviations used in this book, and several other industry standards, is included at the front of the book. Over 80 figures and tables that help to explain concepts are included in the book. Many of these are connected to the book's primary case study, as discussed further on in this chapter. Lists of these illustrations are also included in the front material.

The book is organized into four major parts, beginning with this first part, "Introductory Topics." In addition to this chapter. which defines the scheduler and introduces several types of schedules, all of which will be expanded on throughout the book, this first chapter outlines the layout of the book and introduces the reader to the case study. The second chapter includes the many introductory topics that form the foundation for any CM discussion, especially scheduling.

Part II, "Planning," explains the creative part of scheduling, the *planning* phase. Many preconstruction plans are developed by a contractor before construction commences. Planning involves breaking the work down into identifiable and measurable work tasks, often referred to as work packages. These tasks, or activities, are then arranged in a logical order, resolving the question "What precedes what?" How one activity relates to another is known, in scheduling terms, as relationships or restraints, and these are incorporated into the logic plan. Other planning considerations include sustainability, lean practices, and a thorough review of proposed contract language.

Very few contractors have professional "planners." This upfront work may be performed by a scheduling expert, but input from the builders, such as the PM and superintendent, are vital to the preparation of a successful plan. Without a good plan, schedules are rarely viable construction tools, as reflected in this quote from a former contractor-employer:

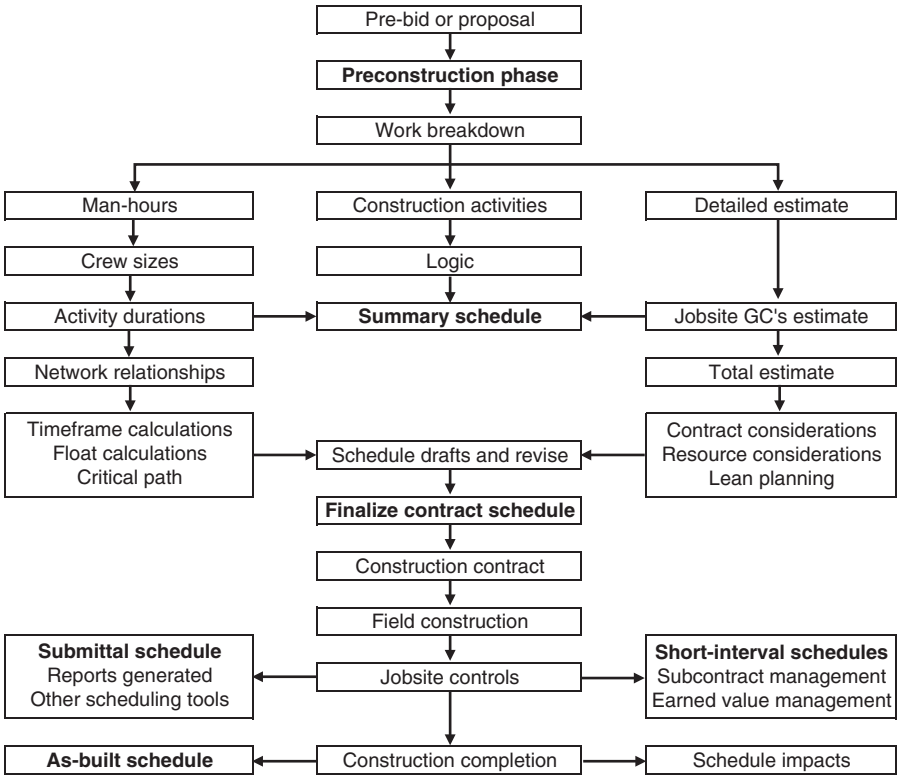
We never have time to build it right,
But we always seem to have time to build it over.

Scheduling is the second phase, which involves adding durations to activities and a timeframe and milestone dates, or constraint dates to the logic diagram and plotting out a schedule document. Many calculations are performed today by scheduling software that highlights the *critical path* of the project, or those activities that must be completed either on time or earlier or they will cause delays for the entire project. Activities which are not deemed to be critical have float. The scheduling effort encompasses many topics that are included in Part III, "Scheduling," including resource planning and technology tools. As discussed previously, the person who transformed the plan into the schedule is the scheduler and that role may be performed by a home office specialist or a field supervisor.

After the contractor is done preparing the plan and has incorporated it into a schedule document, then construction commences and it is time to make sure that the work is performed according to the plan. Some may call this "monitoring" or "recording" but *controlling* the schedule is the common nomenclature and Part IV, "Project Controls," includes many construction management control topics and tools. In addition to schedule control, this fourth section of the book includes earned value management, subcontract management, and schedule impacts, including construction claims. The actual progress of the work is measured and compared against the schedule. If there are deviations, then an adjustment to the plan is necessary which often results in a revised schedule. There are many members of the jobsite team involved with controls, including the project manager, superintendent, cost and schedule engineers, foremen, and project engineers.

Figure 1.3 is a flowchart of many of the planning, scheduling, and control activities that are discussed throughout this book. There are other subsequent flowcharts that are subsets and expand on various portions of this initial chart. Essentially Figure 1.3 is a plan for the book. A full-size copy of this figure is included on the book's website and the reader may wish to print out a copy of that flowchart to use as their bookmark.

Just as construction documents (and books) are full of abbreviations, there are also unique words and terms in the built environment industry. An extensive glossary of scheduling and construction management terms encompassing all of those introduced in the body of this book, as well as many other common built environment terms, are included as an appendix. Several other publications were drawn on while researching these topics, many of which are referenced in the book, and a list of these books is included as an appendix that the scheduling student or construction professional might find useful for their personal library.



Note: Additional detail is added in Flowcharts 4.1, 9.1, and 14.1.

Figure 1.3 Planning, scheduling, and control flowchart

As discussed next, the book has one substantial project that is threaded throughout many of the figures and discussions. Over 35 other examples from actual construction projects are set in boxed features and discussed in the book; two of them were included in this chapter. These boxed examples connect with the relative chapter topic and are from the author's firsthand experiences, some of them successful and some not so, but all offer good learning opportunities. In addition, five short case studies have been borrowed from *101 Case Studies in Construction Management* that are directly connected with scheduling and they are also included at the back of the book as an appendix. These short cases are presented in a different format than the book's primary case study. The five *101 Case Studies* bring up problems that have occurred on various projects and lead the reader into a "Who done it?" scenario without any one exact correct answer.

1.4 INTRODUCTION TO THE CASE STUDY

The Fire Station 83 Project is a new single-story fire station constructed in Pasco, Washington. The building comprises 10,612 square feet and consists of a variety of spaces including: Four drive-through vehicle bays, sleeping rooms and living space for the crew, an exercise facility, kitchen, offices, and several areas to support fire-fighting operations, including cleaning and decontamination rooms, mechanical and electrical rooms, and a vehicle maintenance shop.

The building's structure is a combination of wood and steel framing supported by cast-in-place concrete spread and continuous footings with a concrete slab-on-grade. Important structural components include a thickened eight-inch thick slab-on-grade throughout the vehicle bay and 22-foot tall structural steel columns to support the vehicle bay's steel roof joists. Exterior enclosure components include metal wall, roof, and soffit panels; aluminum-framed storefront glass; fiberglass and vision-control glazing; and phenolic wood panels. Construction of the site includes clear and grub, excavation, permanent site utilities, concrete and asphalt pavement, curbs and sidewalks, site structures, and landscaping.

A rendering of the building, which was included with the bid documents, is shown in Figure 1.4. The building's owner is the City of Pasco and the architect was TCA Architecture, Planning, and Design of Seattle, Washington. We appreciate Pasco and TCA for allowing the use of their project as the book's primary case study. The project was competitively bid at a little over $4.7 million and took just under a year to build.

The drawings and specifications for the actual project are included on the companion website. A list of all of the website support documents is included in the book's front material. Several examples of schedules and estimates and other background information are threaded throughout the book as figures and tables. These documents connect the major topics of planning, scheduling, and construction management controls together. Many of the applied exercises in the book are also related

Photo courtesy of TCA Architecture, Planning, and Design

Figure 1.4 Case study rendering

to this case study. Additional detailed backup including a complete schedule, detailed estimate, and site logistics plan are also included on the companion website. Although this is a real project that is used in this book as a great example to discuss scheduling, all of the figures and tables in the book have been re-created for educational purposes. The fictional general contractor utilized for the case study in this book is Mountain Construction Company (MCC). A traditional GC organization was assumed for this project. Any connection with actual companies or individuals who participated in the construction project is coincidental. It is also assumed the preconstruction manager working for Mountain Construction prepared the bid estimate and detailed and summary schedules, and then transitioned into the role of jobsite PM for the duration of construction. A few examples for an additional negotiated project are also included as figures in the book.

1.5 SUMMARY

This is not a book about how to become a professional scheduling consultant; rather the focus is on developing planning, scheduling, and control tools for the construction management student and the industry professional's (project manager and superintendent's) tool box. Planning is a proposal to act. Scheduling involves creation of a written document to carry out the plan, essentially adding timeframes and durations to the original plan. Controlling is monitoring the schedule and making adjustments as necessary so that the original plan is accomplished. The importance of proper planning is critical to production of a schedule communication tool that can be managed in the field.

Many people involved in real estate development, including designers and builders, prepare schedules. The book's focus is on the scheduler for the construction contractor. This person may be a home-office staff specialist, outside consultant, or field supervisor. There are many different types of construction schedules and scheduling tools, from summary to detailed schedules and from short-interval foreman's schedules to as-built schedules. All of these tools are discussed in this book. The book's primary case study project is a $4.7 million fire station built in Pasco, Washington. The construction duration was 11 months. Many of the figures and exercises presented in the book connect with that project. In addition to the commercial fire station case study, schedule examples for residential and heavy civil projects and a specialty contractor schedule are also included on the companion website.

1.6 REVIEW QUESTIONS

1. Have you ever worked as a scheduler or with a scheduler?
2. Looking at the list of types of people or companies presented earlier who might be schedulers, which would be the best fit for these situations:

A. Small GC that does residential remodel work
B. Mid-size GC that builds work in the $5 to $50 million range
C. National CM with 1,000 management employees
D. Public utility company
E. Attorney who represents contractors in legal disputes

3. Why did the field supervisors trust the scheduler in Example 1.1 maybe more than they would an outside consultant? There are a couple of reasons.
4. Was either of the schedules described in Example 1.2 an effective construction management tool? Could one of them have replaced the other? Could a third schedule have replaced them both?