Chapter 7

Time and Schedule Management

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Chapter 7

Time and Schedule Management

7.1 Introduction

Time is a resource that is constantly in use and, once spent, cannot be recovered. While there may be an endless supply of days, they are delivered at a constant rate and cannot be compressed or expanded. Additional time, if any is available, can only be bought by giving up something else. Time is also money. Resources, especially people, cannot be used over time without paying for them. Because we all use the same time line, projects must conform to the schedule needs of the bigger picture if they are to be of any value. New fighter aircraft are only valuable if they are delivered early enough to provide air superiority, before the enemy can field a better aircraft. Time and schedule management is absolutely essential for project success. Running out of time, like running out of money, will bring your project to a halt.

Cost, schedule, scope, and quality are four attributes of all development projects. The project manager can at best control any three of these four attributes. If the capabilities and performance (scope), development cost, and quality are defined, schedule is pre-determined. When schedule is fixed, one or more of the other three attributes must become variables that change to meet schedule requirements. Each of the attributes is bounded and none can have a zero value. Software cannot be produced in less than a minimum time depending on size, complexity, and environment. Project scope must include a minimum set of capabilities. Projects that stay within predicted schedule are the exception, not the rule. A project manager who can control schedule while achieving performance, quality, and cost goals has learned the secrets of proper planning and execution.

The first step in controlling a schedule is “knowing” what the schedule is. Three other primary factors are also essential to schedule control: managing project costs, system scope, and quality. In general, if system capabilities, project costs, and product quality are well defined and controlled, the schedule can be realistically predicted using appropriate estimating methods, and then followed. While schedules slip out of control for a number of reasons, foremost among those reasons are: (1) the schedule was significantly under-estimated, and (2) the scope (size) increased during development. Success is easier to achieve when scope, costs, and quality are known up front and controlled. Schedule is used to monitor project performance, but it must be remembered that management of the project determines schedule and not vice versa.

Managing time and schedule involves determining what needs to be done, in what order, estimating how long it will take, scheduling tasks to coincide with resource availability, tracking project progress with respect to the schedule, and taking preventive or corrective action when the project begins to deviate from the schedule. It is a logical step in planning a project, and runs throughout the project. It can be viewed as a separate discipline in its own right, apart from project management. Some project managers work with a scheduler assistant whose sole purpose is to coordinate, document, and monitor the project schedule.

This chapter summarizes the process of schedule development and control, as well as providing an overview of methods and tools used in the process.

7.2 Process Description

The time management process consists of the five activities shown in Figure 7-1. The first four are project schedule preparation steps and are usually performed during the planning phase. The last activity involves monitoring and tracking the project performance with respect to the schedule, and implementing corrective actions when schedule performance varies significantly from the planned schedule. The schedule control activity is performed throughout the remainder of the project.

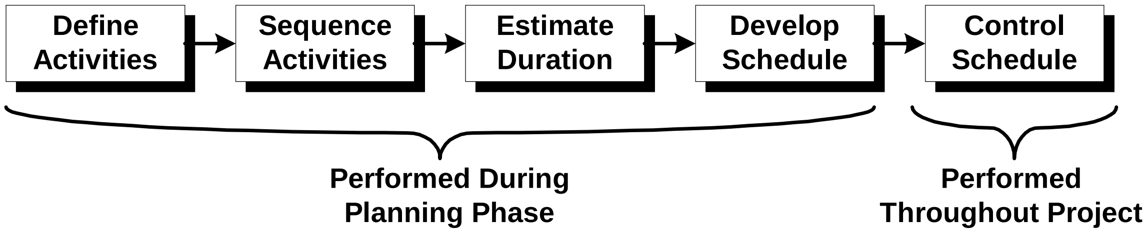

Figure 7-1 Time Management Process [1]

Schedule development is illustrated in greater detail in the example in Figure 7-2. In the first step, all those activities needed to accomplish the project goals are identified and defined. In this simplified example there are only eight activities. The second step involves determining which activities must be performed before others and sequencing them to match this dependence. In the next step the duration of each activity is estimated. Finally, the activities are put into a time frame, properly sequenced, with parallel activities matching the availability of resources and manpower. When this is done there will be a single string of dependent activities which will collectively have the longest duration. This string is called the *critical path*. All other activities depend on this sequence of activities. If an activity on the critical path is delayed, the project is delayed and the schedule lengthened. Identifying the critical path and monitoring its activities are essential to successful schedule control. Each of these process steps is explained in greater detail in the following paragraphs, along with schedule control.

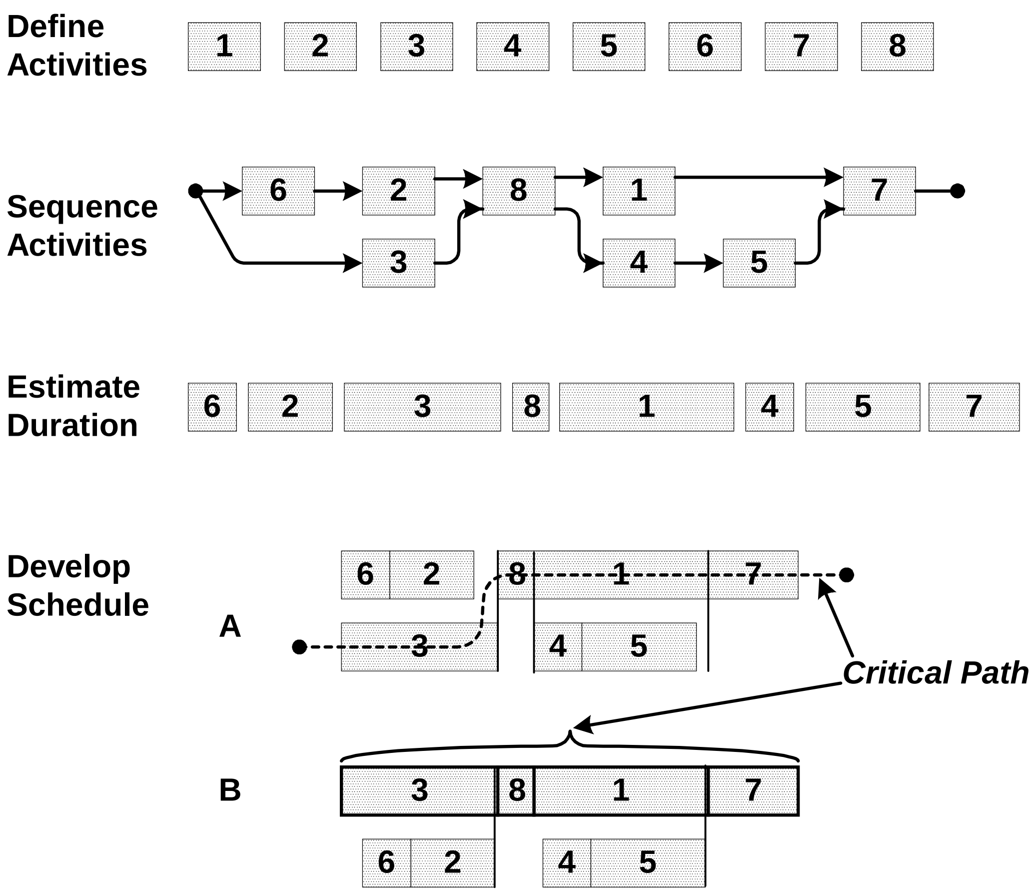

Figure 7-2 Schedule Development Overview

7.2.1 Activity Definition

Activity definition is the process of identifying all the activities needed to produce the project deliverables defined in the Work Breakdown Structure (WBS). (The WBS is discussed in Chapter 3, Section 3.2.1.3.) Deliverables should have appropriate and sufficient activities associated with them to accomplish all project objectives. [1]

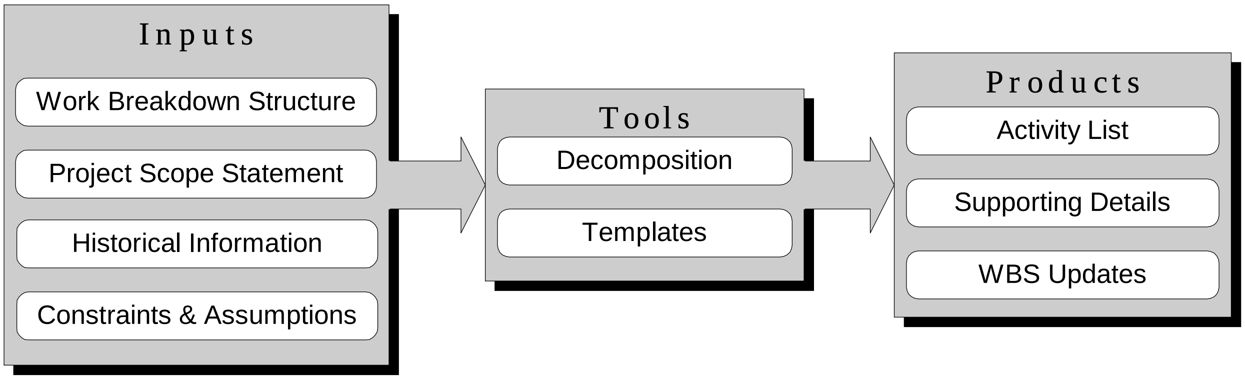

Figure 7-3 Activity Definition Elements [1]

Figure 7-3 lists the various elements associated with activity definition. The primary input is the WBS. Other inputs include the project scope statement to ensure all activities fall within project scope, historical information from previous projects to see how it was done in the past, and any constraints or assumptions affecting project activities.

Activity definition tools include decomposition and templates. Decomposition is the process of dividing and subdividing tasks into smaller, more manageable components. Remember, activity definition decomposition is dealing with activities and not with deliverables. Templates are prepared, often from previous project activity lists, to ensure all necessary information is documented. They should include blanks for such things as needed skills, hours of effort, materials, risks, deliverables, etc. [1]

The primary product of activity definition is the activity list, describing each activity to be performed. The activity list is accompanied by detailed information on how the activities were defined, e.g. the decomposition method used, etc. In addition to creating the activity list, the intense scrutiny of the WBS by the project team usually illuminates inconsistencies or omissions in the WBS, leading to updates to the WBS.

7.2.2 Activity Sequencing

Activity sequencing is the process of determining dependencies between activities. Each activity is analyzed to determine what other activities must be performed before it can begin. The result is a network of activity chains like that shown in Figure 7-4. There various forms of these networks and collectively they are called *Project Network Diagrams*.

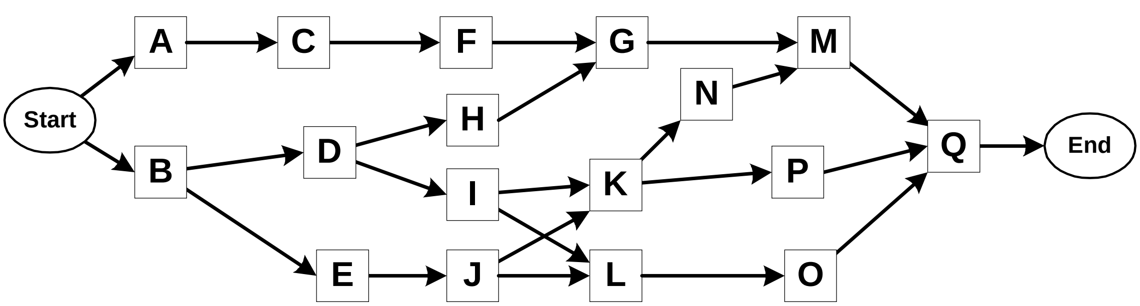

Figure 7-4 Activity Network Diagram (Precedence Diagramming Method)

The elements of the sequencing process are shown in Figure 7-5. The primary input is the activity list developed during activity definition. These are the activities that must be sequenced. The project product definition, lists of dependencies, and expected projected milestones are used to ensure the sequencing process takes all issues and requirements into consideration. Dependencies include the following types: [1]

- Mandatory dependencies – physical limitations, flow of work, and obvious sequences of events. Often called hard logic.
- Discretionary dependencies – defined and documented by the project team, best practices, and preferred logic.
- External dependencies – relationships of the project with external (to the project) activities. An example would be flight-testing an avionics upgrade. It is dependent upon the availability of aircraft, pilots, weather, etc.

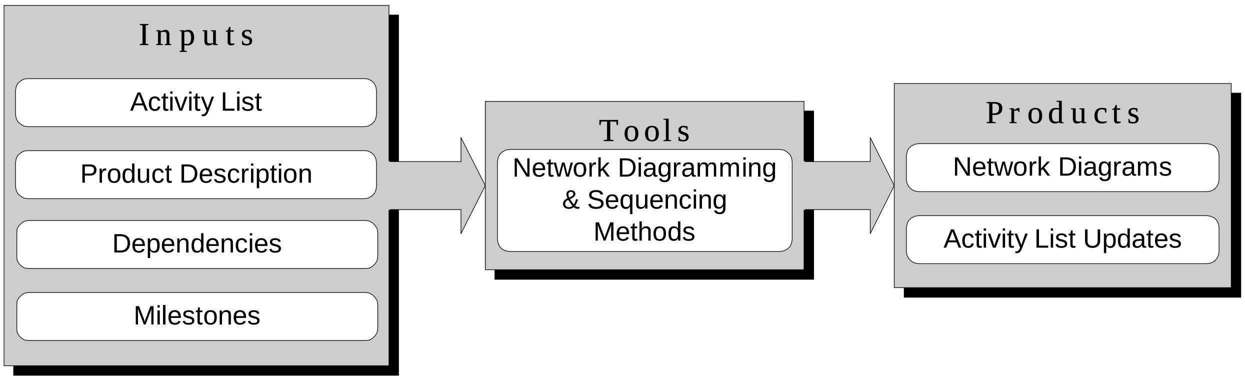

Figure 7-5 Activity Definition Elements [1]

Various methods have been developed for activity sequencing. Two of the most common are the Precedence Diagramming Method (PDM), also known as Activity-on-Node (AON), and the Arrow Diagramming Method (ADM). AON is implemented in most project management software but can be also be performed manually. The diagram uses boxes to represent activities and arrows to represent dependencies, similar to Figure 7-4. It is based on four types of precedence relationships: [1]

- Finish-to-start – the successor activity cannot start until the predecessor activity has finished. This is the most common relationship.
- Finish-to-finish – the successor cannot finish work until the predecessor has finished.
- Start-to-start – the successor cannot start work until the predecessor has started.
- Start-to-finish - the successor cannot finish work until the predecessor has started.

ADM, also known as Activity-on-Arrow (AOA), uses arrows to represent activities, and uses nodes to show dependencies between the activities, as shown in Figure 7-6. Only finish-to-start dependencies are used for ADM.

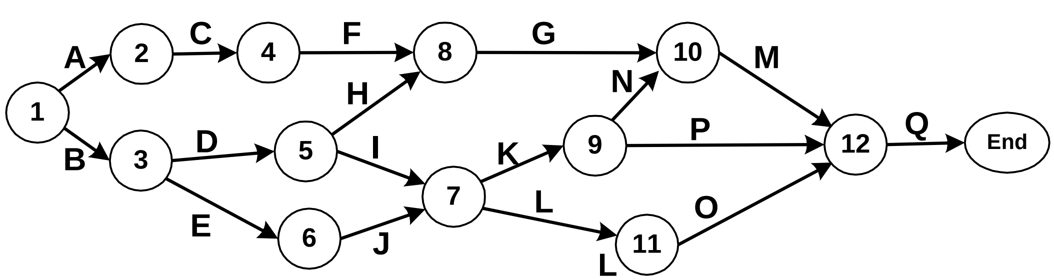

Figure 7-6 Activity Network Diagram (Arrow Diagramming Method)

Neither PDM nor ADM allow loops or conditional branches (if-then-else). If that type of diagramming is needed, *conditional diagramming* methods can be used. Two examples are Graphical Evaluation and Review Technique (GERT) and System Dynamics models. [1] More on diagramming methods can be found in 7.5, Resources.

7.2.3 Estimating Activity Duration

With activities defined and sequenced, the next step in developing a schedule is estimating the duration of each activity. The elements of this activity are shown in Figure 7-7 and include various inputs, tools and outputs.

When estimating, the activity list is used to provide details on each activity and to ensure all activities are estimated. A knowledge of how an activity can and should be performed, and what is required to do it is essential. Estimators must know about resource capabilities and availability, along with project constraints (funding, people, etc.), and assumptions. Some activities' durations can be shortened by putting more people to work on them, where others cannot. Nine women can't produce a baby in one month. Even if nine people can accomplish a task in less time, there may not be nine people available to do it, or it may be cost prohibitive. One of the greatest helps to estimating duration is historical information from previous projects. Seeing what actually happened in the past can be a good reality check for current estimates. Risks can have a significant impact on activity duration and may be looked at as either threats or opportunities. [1]

7.2.3.1 Expert Judgment and Analogous Estimating

The tools used in estimating are varied and are all likely to be used on the same project. Some activities can best be estimated using one method, some another. *Expert judgment* involves the use of people who have an expert understanding of the activity and are guided by historical information. In *analogous estimating*, also known as top-down estimating, a previous similar activity is used as a model for estimating future duration. It is a form of expert judgment and requires that the previous activity be truly similar to be accurate.

7.2.3.2 Quantitative Estimating

Quantitative estimating involves determining the quantity of work to be accomplished for each activity. This could include writing a certain number of lines of code, designing a certain numbers of circuit boards with specific levels of complexity, processing a specific number of pages, producing a specific quantity of engineering drawings, etc. A unit-rate, the rate of time to accomplish a unit of work, is divided into the quantity to produce a duration for the specific activity. Unit rates are derived from historical data or from industry standards or models. In addition to the specific duration estimates, reserve time should be added to provide a buffer against contingencies which may arise from realized risks.

Using this method for software estimating requires the development environment (people, development system, process), as well as product scope and application, to be essentially identical to the projects used to produce the unit rate. Humans tend to develop software estimates that are optimistic: that is, success-oriented. Care must be taken to assure that the estimates are realistic and within organization historical data bounds.

7.2.3.3 Parametric Estimating

Parametric estimating uses mathematical models, cost estimating relationships (CERs) and rules of thumb to realistically estimate software activity schedules. CERs are relationships between schedule, cost and product size (scope) to arrive at realistic schedules. Parametric models are derived from historic data and allow the estimator to incorporate environment and product information, as well as project constraints, into the activity characteristics. Parametric estimating is usually easier and faster than quantitative methods, but the method is only accurate if the correct model or CER is used in the appropriate manner.

7.2.3.4 Computer Tools

Computer tools are used extensively, especially with parametric estimating, to assist in schedule or activity duration estimating. The tools range from simple spreadsheets to project management software for specialized system, hardware, and software schedule estimates. Computer tools speed the estimation process, reduce the incidence of errors caused by optimism and calculation, and allow for consideration of process alternatives. Widely used hardware estimating tools include Price-H and SEER-H. Widely used software estimating tools include COCOMO II, Price-S, Sage, SEER-SEM, and SLIM. More information about these tools can be found in section 7.5, Resources.

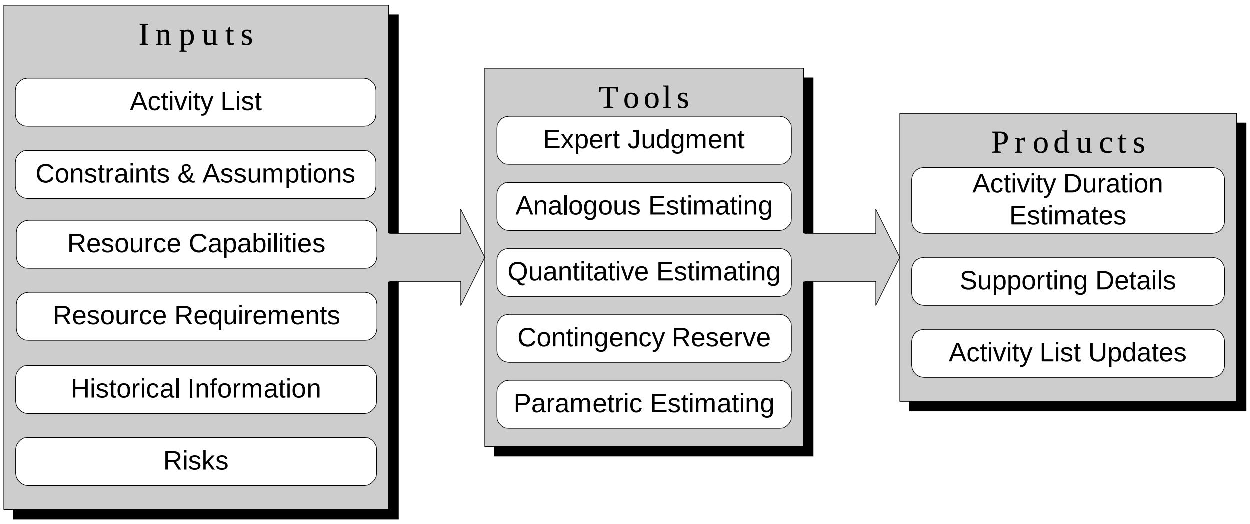

Figure 7-7 Activity Duration Estimation Elements [1]

The output from activity duration estimating includes the estimates themselves, and details explaining the estimation methods used and reasons for choosing them. After working with each activity in greater detail, there will probably be changes to the activity list.

7.2.4 Schedule Development

7.2.4.1 Inputs

The schedule development process combines the activity sequence from the project network diagrams with the duration estimates to build chains of activities, the basis for the project schedule. This is usually done with the help of project management software to ensure calculations are correct and keep track of all activities. Most project management software will also produce charts to help visualize, track, and control the project schedule. Another thing they do is force the user to provide essential project information and follow good project planning processes.

If activity sequence and duration were all that was necessary, the job would fairly simple. Far more is needed to develop a schedule. The resources needed to perform the work, and the capabilities and availability of resources, including skilled people, materials, equipment, tools, facilities, etc. have a major impact on when activities can start and which can run simultaneously. Other significant inputs to schedule development are the project constraints, assumptions, and the calendar. Holidays, weekends, and vacations must be considered. Lead and lag times of materials and equipment must be built into the schedule. For example, some electronic parts are long lead items and must be ordered weeks or even months before they are delivered. New equipment will probably need to be inspected, installed and tested, necessitating a lag time between delivery and actual availability for use. Necessary training time for personnel must be considered. Activity attributes such as when, where, or how the activity must be performed will affect the schedule. If something cannot be performed in cold weather or if it must be performed at a specific location, the scheduler will need to consider the seasons or include transportation time. As always, project risks must be figured into the schedule. These inputs to schedule development are shown in Figure 7-8.

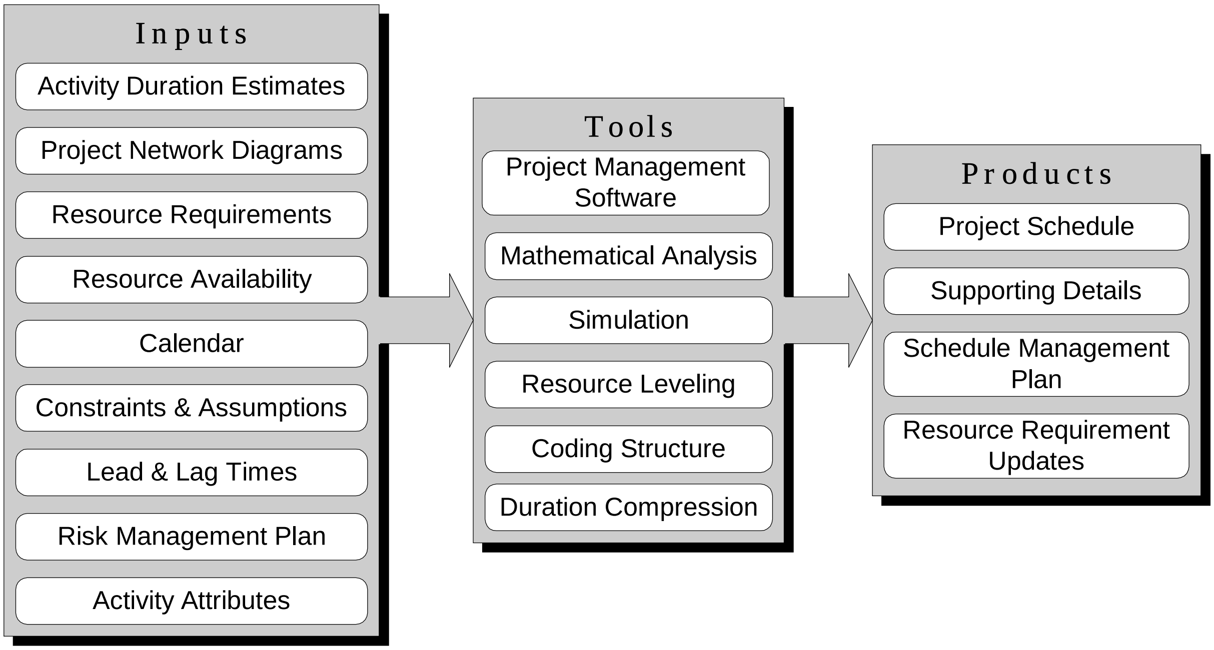

Figure 7-8 Schedule Development Elements [1]

7.2.4.2 Tools

The most important tool for schedule development is common sense. *Project management software* can take the drudgery out of schedule development. The better packages can guide users in gathering and properly using pertinent information. However, to fully utilize the capabilities of the software, the user should be properly trained, have an understanding of project management processes and techniques, and exercise his or her common sense.

Beyond good software, there exists a host of techniques and methods to help build an efficient, optimized schedule. One of the more widely used scheduling tools is *mathematical analysis*, which consists of calculating the range of possible start and stop dates for each activity. This shows when activities could theoretically start and how long they could take to accomplish. To this indefinite schedule must be added resource capabilities and availability, as well as the other considerations and constraints listed as schedule inputs in Figure 7-8. This additional information allows the schedulers to finalize activity start and stop dates. Once this is complete, the chain of dependent activities which has the longest total duration is identified and designated as the *critical path*. Any activity along this path that starts late or takes longer than planned lengthens the whole project schedule. The most commonly used implementations of mathematical analysis are *Critical Path Method (CPM)*, *Program Evaluation and Review Technique (PERT)*, and *Graphical Evaluation and Review Technique (GERT)*.

Other tools may be used instead of, or in concert with, the above-mentioned mathematical analyses. The following categories are worth mentioning: [1]

- *Simulation* – Performing computer simulations of the schedule, and what-if analyses to determine the best schedule.
- *Resource Leveling* – Basing or adjusting the schedule to desired or expected levels of manpower and/or other resources.
- *Coding Structure* – Method of coding or labeling activities to indicate attributes which may be used in grouping or sorting the activities into more logical or useful sequences.
- *Duration Compression* – Methods of determining ways to shorten the schedule without reducing the project scope.

7.2.4.3 Products

The primary output of the scheduling effort is the project schedule. This includes planned start and finish dates for each activity and usually consists of a top-level summary, or *master schedule*, and a more detailed version. Schedules may be presented in a tabular format but most people prefer some type of graphical format because it makes it easier to see and understand the overall picture. Project network diagrams with the dates added may be used to show program logic and the critical path. Another type of schedule chart is the bar chart also known as the Gantt chart. Activity start, finish, and duration are represented as bars on time graph background, shown in Figure 7-9.

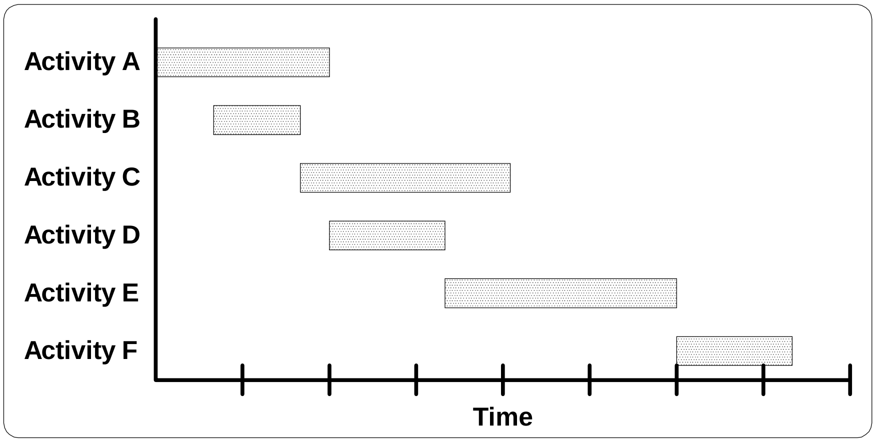

Figure 7-9 Example Gantt Chart

A third type of schedule chart is the milestone chart. This chart lists project milestones on the left and their planned and actual completion dates on a time graph background, shown in Figure 7-10. The various types of charts have different levels of details and are meant for different audiences.

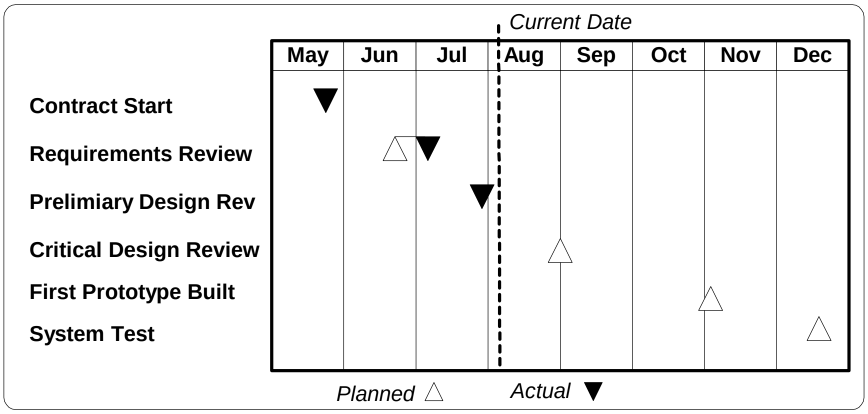

Figure 7-10 Example Milestone Chart

The other essential product of schedule development is the *Schedule Management Plan*. This plan describes the process to be used to track the schedule and identifies what will be measured and tracked to determine whether the actual performance is following the planned schedule. It also defines how the schedule will be updated and changes may be made. This plan may be formal or informal, detailed or top-level, according to the needs of the project.

The two other outputs of the schedule development process are the perennial supporting details, how the schedule was developed and why those methods were used, and updates to the resource requirements. Now that the schedule is fixed on the calendar, there will need to be a final coordination between the schedule and available resources. Until this is finalized, the schedule is tentative.

7.2.5 Schedule Control

The primary method of schedule control is to compare actual schedule performance reports with the planned schedule and take corrective action when there is a danger of falling behind schedule along the critical path. The inputs to the schedule control process are shown in Figure 7-11. In addition to the project schedule, the schedule management plan, and regular performance reports, there will probably be change requests. For example, someone may request an extension on the duration of a particular activity because ordered parts will not be delivered in time to complete the activity on schedule. If the extension does not impact the critical path, it may be sufficient to just allow the extension and watch the situation closely. If it does impact the critical path, corrective action must be taken to get the parts earlier, make up for the lost time by compressing other activity on the critical path, or lengthening the project schedule.

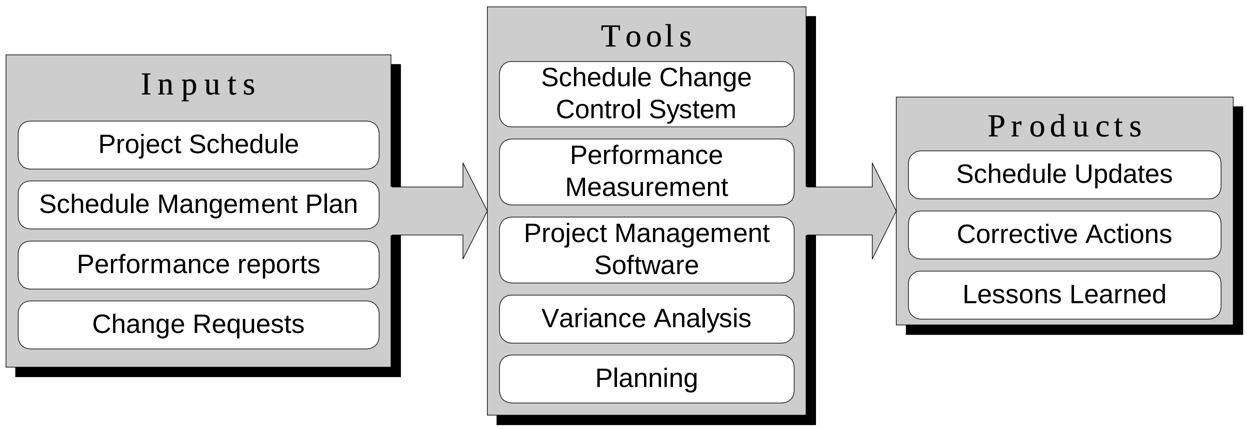

Figure 7-11 Schedule Control Elements [1]

Controlling the schedule requires careful, constant monitoring of the project status. Anything that can impact the schedule, slow down, or postpone an activity must be watched. This includes changes in requirements. A change in scope will usually require changes in budget and in schedule. Specific areas to monitor for each activity are:

Before the Activity

- Preparatory actions: permissions, paperwork, clearances, etc.
- Equipment deliveries and setup
- Long-lead material acquisitions
- Availability of manpower and other resources

During the Activity

- Actual progress of the activity – Talk doesn't count
- How much of the activity is left to be accomplished
- Activity milestones, if applicable
- Any problems that may slow or postpone work, whether technical, budgetary, resources, etc.
- Other projects competing for your resources

Regular performance reports of progress, problems, risks, and plans for upcoming and ongoing activities will provide the oversight necessary to track schedule performance. Informal monitoring, outside the briefing room, among the team leaders and workers will provide insight to events and issues that may become problems down the road. The sooner a potential problem can be detected the easier it is to avoid it or reduce its effects. Bringing project schedule back on track usually involves sacrifices in the other project attributes, quality and scope. Increasing project resources invariably decreases the possibility of schedule improvement, as stated in Brooks' Law: "*Adding manpower to a late software project makes it later.*" [3]

When actual progress deviates from the planned schedule *variance analysis* is used to determine how much difference there is and what impact the variance will have. If tasks are not on the critical path, there should be some flexibility in when they are performed. This range of time for their performance is called *float* time. The amount of float a particular activity has will, to a large extent, determine your response to schedule variance for that activity. Critical path activities have no float. The schedule change control system, defined in the schedule management plan, should provide a standard process and guidelines for dealing with schedule impacts and changes. When threatened with schedule impacts, i.e. if float time is running out or if a critical path activity is delayed, you will have to carefully evaluate your resources and use creativity to solve or get around the problem. Remember, pilots aren't in trouble unless they run out of airspeed, altitude, and ideas at the same time. The following methods are often used to deal with schedule problems.

Reserve Hopefully, you've reserved some time for just such occasions and can use some now. *Star Trek's* Scotty asked how he could keep his reputation as a miracle worker if he didn't tell people things would take longer than he thought.

Substitution While waiting for unforeseen delays, do other tasks or parts of tasks that can be done now.

Preparation Prepare everything for this and follow on activities so that startup and transition times can be reduced.

Miracles Consult with your experts to see if there is a way to catch up by working faster and smarter, or improving the process.

Manpower Sometimes putting more people on a task is a viable way to speed it up. If additional manpower can be found they may be able to overcome a delay. However, adding manpower is usually not a good solution (See Brooks' Law). Don't forget the additional budget costs you may incur, or the time needed to come up to speed on the project, or the initial additional delay caused by diverting project personnel to bring added personnel up to speed.

Overtime Nights, weekends, and holidays can sometimes be used to overcome a delay. However, this method does not come without high costs in morale, quality, etc. Use this method sparingly.

Diligent monitoring, creative problem solving, being proactive instead of reactive, and carefully preparing the schedule in the first place go a long way toward keeping the project on schedule. There will always be unforeseen events and problems because of chance, inexperience, or incomplete information. For those problems that cannot be solved within the bounds of the current schedule, extension of the schedule will be necessary. "Slipping" the schedule is also a method of dealing with project time problems and is not necessarily catastrophic event. However, continually asking for more time, like continually asking for more money, will quickly diminish support for the project and confidence in the project manager.

The outputs of the project control process will be schedule updates and, corrective actions, and lessons which can be applied later in the current project and on future projects.

7.3 Time and Schedule Checklist

This checklist is provided as to assist you in Time and Schedule Management. Consider your answers carefully to determine whether you need to carefully examine the situation and take action.

7.3.1 Preparing for Schedule Development

- ❑ 1. Have you identified an experienced, knowledgeable team to develop the schedule?
- ❑ 2. Has a process to develop the project schedule been defined and documented?
- ❑ 3. Are all time and date requirements for the project known and documented? (What is needed when?)
- ❑ 4. Are there unreasonable time constraints for the project?
- ❑ 5. Are resource capabilities and availability known?
- ❑ 6. Do you have the project constraints, assumptions, and risk plan documented?
- ❑ 7. Do all deliverables listed in the WBS have adequate and appropriate activities identified to produce them?
- ❑ 8. Have you chosen an appropriate project management software package, and are you experienced or have you been trained in using it?

- ❑ 9. Is historical duration data available for project activities?

7.3.2 Schedule Development

- ❑ 10. Have you identified appropriate methods and models for estimating activity duration?
- ❑ 11. Have all activities been sequenced by putting them into an activity network and indicating the dependencies between them?
- ❑ 12. Have durations been estimated for all activities?
- ❑ 13. Have the activity durations been reviewed by people experienced in those activities?
- ❑ 14. Has the critical path been identified?
- ❑ 15. Has float time been documented for all activities not on the critical path?
- ❑ 16. When developing the schedule, are you using resource leveling and remembering holidays, vacations, and sick time?
- ❑ 17. Have you developed and documented a reality-based schedule?
- ❑ 18. Have you built a time reserve into your schedule for contingencies and unforeseen events?
- ❑ 19. Has your schedule been entered into a program management software package?

7.3.3 Schedule Control

- ❑ 20. Have you developed and documented a schedule management plan?
- ❑ 21. Do you know how, what, when, why, and how much to monitor for schedule control?
- ❑ 22. Are you being proactive vs. reactive in your approach to schedule control by looking ahead and asking what could go wrong?
- ❑ 23. Do you have a schedule change process documented and implemented?
- ❑ 24. Are you monitoring all preparatory actions, acquisitions, deliveries, and resources for each activity to make sure they are all complete and ready when it is time to begin the activity?
- ❑ 25. Are you using experienced people to make and review schedule progress reports?
- ❑ 26. Have the various groups and individuals been given sufficient levels of responsibility, accountability, and authority to perform their tasks? Have they agreed to their assigned roles?
- ❑ 27. Are you employing regular formal and informal schedule monitoring and progress reports
- ❑ 28. Are you constantly aware of project milestones and your schedule progress?
- ❑ 29. Are you solving schedule problems by being creative and using common sense vs. extending the schedule?
- ❑ 30. Are you documenting your progress, problems, issues, solutions, and lessons learned?

7.4 References

[1] *Guide to the Project Management Body of Knowledge, A,* Chapter 6, Project Management Institute, 2000. Download complete PMBOK 1996 or PMBOK 2000 preview at: www.hunu.edu.cn/pmrc/download.htm

[2] *NASA Systems Engineering Handbook*, Chapter 4, June 1995. Download PDF version at: http://ldcm.gsfc.nasa.gov/library/library.htm

[3] Brooks, F. P., Jr., *Mythical Man-Month: Essays on Software Engineering*, (Reading, MA: Addison Wesley, Inc.), 1975, p 25.

7.5 Resources

Builders Net, Critical Path Method (CPM) tutorial: www.buildersnet.org/cpmtutor/

Critical Path Method Tutor, U.S. Army. Copy files: ftp://www.buildersnet.org/CPMTeach/

Guide to the Project Management Body of Knowledge, A, Chapter 6, Project Management Institute, 2000.

Crosstalk Magazine: www.stsc.hill.af.mil/crosstalk/

- "Quantitative Software Management - Software Cost and Schedule Estimation": www.stsc.hill.af.mil/crosstalk/1996/oct/xt96d10h.asp
- "Applying Management Reserve to Software Project Management": www.stsc.hill.af.mil/crosstalk/1999/mar/lipke.asp
- "Project Scheduling According to Dr. Goldratt": www.stsc.hill.af.mil/crosstalk/2001/jan/perkins.asp
- "Metrics Tools: Effort and Schedule": www.stsc.hill.af.mil/crosstalk/1995/mar/metrics.asp
- "Project Recovery … It Can Be Done": www.stsc.hill.af.mil/crosstalk/2002/jan/lipke.asp
- "New Air Force Software Metrics Policy": www.stsc.hill.af.mil/crosstalk/1994/apr/xt94d04a.asp

Illinois Institute of Technology, Construction Planning and Scheduling class notes.

Gantt Chart notes: www.iit.edu/~jshi/courses/CAE471_L2.PDF

Critical Path Method Schedules notes: www.iit.edu/~jshi/courses/CAE471_L3.PDF

Arrow Diagramming Method notes: www.iit.edu/~jshi/courses/CAE471_L4.PDF

Precedence Diagramming Method notes: www.iit.edu/~jshi/courses/CAE471_L5.PDF

Resource Allocation notes: www.iit.edu/~jshi/courses/CAE471_L7.PDF

Time – Cost Tradeoff notes: www.iit.edu/~jshi/courses/CAE471_L8.PDF

Learning Factory, MS Project scheduling tutorial: http://lfserver.lf.psu.edu/lf/msproject/over.htm

Manchester Metropolitan University, Scheduling tutorial: www.doc.mmu.ac.uk/online/SAD/T04/projman.htm

Smartdraw scheduling tutorials: www.smartdraw.com/resources/centers/gantt/resources.htm

Software Estimating Tools and Methods:

- Constructive Cost Model (COCOMO II), information and software, University of Southern California, Center for Software Engineering: http://sunset.usc.edu/research/COCOMOII/index.html
- Price-H, information and software: www.pricesystems.com
- Sage, information and software: www.seisage.com
- SEER-H, information and software: www.galorath.com
- SLIM, information: www.jsc.nasa.gov/bu2/PCEHHTML/pceh.htm , www.qsm.com/THRU_PUT.pdf , www.qsm-uk.com/course.pdf

Software Technology Support Center Course: *Life Cycle Software Project Management*, Estimation, earned value, etc., 9 October 2001.

Univ. of Minnesota, Tutorial on scheduling, Gantt charts: www.me.umn.edu/courses/me4054/assignments/gantt.html