Critical path is a term used in the field of project management to define a sequence of tasks in a project wherein none of the tasks can be delayed without affecting the final project end date. The sequence of tasks making up the critical path starts with the first task in the project, and follows through to the last task in the project. In effect, the timely completion of each task in the sequence is critical to the timely completion of the project.

Knowing the critical path on a project, the project manager can apply additional management techniques to the tasks in the critical path sequence to reduce the risk of delays in the completion of those tasks and the overall project schedule. Critical path is, therefore, a risk management technique.

History of the Critical Path Technique
The critical path concept evolved during the late 1950s on large defense research projects in the United States of America. Meredith and Mantel (336-7) present two different project scheduling methods developing the concept of a critical path at the same time:

- **Critical Path Method.** The Critical Path Method (CPM) was developed by DuPont Inc. for use on construction-type projects with fixed project end dates. CPM's main strength is the data it provides for making cost vs. schedule tradeoff decisions. Today, the CPM is the most widely used method for determining and managing the critical path on projects, and is used in all industries.

- **Program Evaluation and Review Technique.** This method, known by the acronym PERT, was developed in 1958 by the consulting firm Booz-Allen Hamilton and the defense contractor Lockheed Corporation for use on the Polaris missile/submarine project. PERT uses probabilistic methods to assess the likelihood that a project will finish by a given date.

Duncan (1996) promotes both the CPM and PERT techniques for determining the critical path on a project. His *Guide to the Project Management Body of Knowledge* (PMBOK Guide) published by the Project Management Institute, has become a *de facto* baseline standard for project management knowledge and competency assessments. Duncan describes the critical path techniques as being tools that are “applicable to most projects most of the time, and that there is widespread consensus about their value and usefulness” (1).
Determining the Critical Path in a Project

The critical path identifies the sequence of tasks in which no single task can be delayed without affecting the completion date of the sequence: in other words, a sequence with no buffer (also called “float”). Figure 1 shows a traditional task network diagram wherein the boxes represent tasks to be completed on a project. The arrows connecting the boxes show the order in which the tasks must be completed. For example, task B cannot start until task A has finished; this dependency is shown with the arrow connecting the two tasks. Task D has two arrows coming in to it; this means that both of the linked tasks (B and C) must be complete before task D can start. The number in parentheses below each box represents the number of days required to complete the task. A quick look at this network diagram shows that there are three sequences of tasks (“paths”) that need to be completed: the sequence A-B-D-E, the sequence A-C-D-E, and the sequence A-C-E.

We can calculate the sequence with the longest duration by adding the numbers in parentheses in each sequence. Figure 2 shows the calculations for the duration of each sequence in the network. The sequence A-B-D-E has the longest duration at nine days, making it the critical path. This means that any delay in a task in this sequence will increase the total duration of the sequence and delay the final project end date. On the other hand, if task C were delayed such that its actual duration were now two days, task D would not have to start any later because it is also dependent upon task B which would have not yet completed. Task C, therefore, is not on the critical path.

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Calculation</th>
<th>Sequence Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-B-D-E</td>
<td>1+3+4+1</td>
<td>9 days</td>
</tr>
<tr>
<td>A-C-D-E</td>
<td>1+1+4+1</td>
<td>7 days</td>
</tr>
<tr>
<td>A-C-E</td>
<td>1+1+1</td>
<td>3 days</td>
</tr>
</tbody>
</table>

Figure 1: A sample project task network.

Figure 2: Calculating sequence durations.
Limitations of the Critical Path Techniques

When a project manager provides extra attention to tasks on the critical path, it is easy to lose sight of the risks inherent in the other tasks in the project. For example, the completion of a task not on the critical path could be delayed so that its duration becomes long enough to change the critical path of the project. Using our project task network above, if the completion of task C required four days (instead of one day), the task sequence A-C-D-E would be lengthened to a total of ten days, making the sequence the new critical path on the project. Project managers should watch for schedule risks in these non-critical tasks.

Another limitation of the critical path technique is that it highlights tasks at greatest risk for causing schedule delays, but it does not identify the source of the schedule risks. Alternate methods, such as the Critical Resource Path technique identified by Aguanno (2002) calculate alternate critical paths that factor in the risks caused by dependence on unique or constrained resources.

An Alternate Approach to Critical Path Techniques

Other approaches to determining and managing schedule risk have emerged in recent years. For example, Goldratt developed the Critical Chain Method (1997) based upon his Theory of Constraints (1990) that addresses the problems of constrained scheduling and process optimization. Goldratt's Critical Chain Method provides a practical means of scheduling project task sequences (taking into account the common constraint of relatively finite resource availability) to minimize risk in the project delivery schedule. Patrick (1999 and 2001) has refined the practical implementation of Goldratt's method and is a driving force behind its growing adoption in the corporate world.

Why Use the Critical Path Techniques?

While there are significant limitations in using the critical path for schedule risk management, the critical path techniques provide a quick means of determining the task sequence that is likely the source of the greatest schedule risk in the project. Widespread adoption of the techniques, and their support in most project scheduling software packages, have lead to a growing understanding and acceptance of critical path as a schedule risk management technique among executives. Critical path is a tool all project managers should have in their toolbox.

Works Cited

About the Author

As a Certified Senior Project Manager, Kevin Aguanno specializes in managing complex software development projects. He has been managing consulting, integration, and software development projects in various industries since 1990.

Mr. Aguanno is certified by the Project Management Institute (PMI), and is a member of both PMI and the Association for Project Management (APM) in the United Kingdom.

Mr. Aguanno is the editor of Inside Project Management, an element-K journal, and has written several books. His articles appear regularly in various professional journals, and he speaks internationally on project-management related issues.

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