AACE INTERNATIONAL RECOMMENDED PRACTICE

49R-06

IDENTIFYING THE CRITICAL PATH

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AACE® International Recommended Practice No. 49R-06

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TCM Framework: 7.2 – Schedule Planning and Development
9.2 – Progress and Performance Measurement
10.1 – Project Performance Assessment
10.2 – Forecasting

March 5, 2010

Note: As AACE International Recommended Practices evolve over time, please refer to www.aacei.org for the latest revisions.

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Disclaimer: The opinions expressed by the authors and contributors to this recommended practice are their own and do not necessarily reflect those of their employers, unless otherwise stated.

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INTRODUCTION

Purpose

This recommended practice (RP) for *Identifying the Critical Path* is intended to serve as a guideline and a resource, not to establish a standard. As a recommended practice of AACE International it provides guidelines for the project scheduler when reviewing a network schedule to be able to determine the critical path and to understand the limitations and assumptions involved in a critical path assessment. Such a determination is a part of the total cost management (TCM) project planning, scheduling forecasting, and change management processes.

Overview

This RP focuses on the types of prospective analyses performed in real-time while the project is underway, the advantages and the limitations of each in identifying the critical path of network schedules. The identification of the critical path and understanding what calculations and settings went into making that identification is a critical first-step in the schedule analysis process. Other recommended practices discuss analysis of schedule trends and the issues involved with plan changes intended to modify the critical path.

The work breakdown structure (WBS) is used to break down (or decompose) a project into all component activities necessary to deliver a complete and functional project for the stakeholders. The critical path method (CPM) is used to apply logic to determine sequencing of those activities to form an activity "network," and then mathematically determine activity timing. The mathematical calculation determines the earliest time that an activity can start in a calculated "forward pass" through the network. The latest time that an activity can start is determined by calculating the network in a "backward pass."

There are various accepted methods for determining the critical path. This RP describes four such CPM methods and explains the calculations used in these methods. It assumes a working understanding of the CPM calculation process.

This RP also discusses the analysis of the output of a CPM calculation. There is no absolute standard or definition of "proper" CPM calculation procedure or a list of required or optional rule extensions. No professional organization or standards testing bureau currently evaluates, certifies or validates CPM software algorithms or procedures. Identifying the critical path requires an understanding of the methods and algorithms used by the various software platforms in producing the CPM calculations.

Different CPM software products can produce different calculation results when applied to the same schedule. A project scheduler must understand the differences and nuances of the software tools they will most often encounter and be prepared to account for the same in their analysis. In addition, different CPM calculation options from the same CPM software can produce different results for the same schedule logic. This RP provides an analysis of the output and identifies the strengths and weaknesses of the processes used to obtain those results.

This RP acknowledges that identification of the critical path is likely made via various software products. Specific software is identified in this RP in order to qualify these methods and algorithms. In the interests of accuracy, only those platforms where the authors have expert knowledge are cited here. This does not constitute a recommendation of any particular company or software product. References to other software platforms may be added to this RP as they become available.

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RECOMMENDED PRACTICE

Critical Path Analysis

The critical path is defined as the longest logical path through the CPM network and consists of those activities that determine the shortest time for project completion. Activities within this or list form a series (or sequence) of logically connected activities that is called the critical path. A delay to the start or completion of any activity in this critical path results in a delay to project completion, assuming that this path consists of a continuous sequence of activities without an overriding date constraint or multiple calendars.

Normally, there is only one critical path though a network schedule. There may be multiple critical paths through a schedule. Multiple critical paths may occur due to different paths having exactly the same overall duration. Constrained milestones (perhaps reflecting contractual requirements) may cause different paths to be critical at the same time. Individual schedules (each with their own critical path) may be combined into a master schedule that has a different critical path. In the case of a master schedule, there are both individual schedule critical paths as well as a larger program critical path. Project schedule specifications should define the legal interpretation of each type.

Another type of critical path is called a "resource critical path." As there are rarely unlimited resources available to the project team the constraint of limited resources often strongly influences the critical path calculation. Therefore, in addition to the standard CPM calculations and logical connections, there is an additional, implied constraint of limited resources. In a resource critical path, after CPM network calculations have been made activities are further delayed, interrupted, or accelerated to reduce the overall daily unit resource requirement to some predetermined resource limit. This may be accomplished by adding preferential (or soft) logic, by manual or automatic resource leveling, or just by the physical resource limits imposed or utilized on the project without prior planning. While many aspects of standard critical path analysis are pertinent to resource critical path analysis, this RP does not further address the subject of a resource critical path. This RP does not address schedules that contain settings that force the activity durations to be calculated by resource availability, as in resource-driven schedules.

Successful project schedulers must determine and communicate activities that are critical, as well as those that are near-critical (see later discussion in "Near-Critical Activities/Paths"), in a CPM schedule. Management by exception[1] processes dictate that project management should devote more attention to maintaining the required production level for activities on the critical path than for other activities further removed from criticality. Further, recognition that duration estimates are not absolute and susceptible to variation requires that a critical path analysis should also include the review of near-critical paths. Both of these topics are addressed in more detail later.

The list of critical path activities often changes from schedule update to schedule update as activity status is revised and the schedule is recalculated. Any activity associated with the CPM schedule that is delayed long enough can eventually become critical, regardless of its original status.

There are several accepted methods for determining the critical path. The four most frequently used methods include the following,

1. Lowest Total Float – The activities with the lowest total float (sometimes abbreviated as "TF") values may be considered critical path activities. This calculated value may be a positive number, zero, or even a negative number.

2. Negative Total Float – Using this classification method, any activity that has negative float is considered critical, even if other activities have a lower negative float value. Under this classification, if an activity is contributing to late project completion then it is worthy of inclusion on the critical path list regardless of its

direct contribution to delayed project completion. Another way of framing this concept is to say that any work is understood to be critical if it scheduled to be completed after the date required for a timely project completion.

3. Longest Path – The concept and term, "longest path" has existed since the beginning of formal CPM theory. Commercial implementation of this process into a defined algorithm has only recently been made and is recommended for projects that use multiple calendars and activity constraints.

4. The longest path calculation begins by identifying the activities that have an early finish equal to the latest calculated early finish for the project and then identifies all driving relationships for these activities and traces them back to the project start date. This special calculation scheme is currently only instituted in Primavera scheduling software products. When discussing the theory of longest path, we will use the phrase using lower-case letters. When describing the Primavera software feature called, "Longest Path," we will use upper-case to distinguish the implementation from the theory.

5. Longest Path Value Method - The principle of longest path value differs from the approach used by Primavera in that, instead of just noting activity inclusion or exclusion from the longest path, a numerical value is calculated for each activity that describes the degree of longest path not like float describes the degree of criticality. Other principles are also enforced that will be described below.

While very similar, the terms "TF critical path" and "longest path" are used in slightly different contexts. The purpose and major use for longest path is to describe the shortest path to finishing the work necessary to complete the project. Acceleration or deceleration of work on the longest path activities will have an effect on project completion. In contrast, if external project constraints and/or contractual issues involved in the use of constraints are applied, they will influence direction of the critical path through the project schedule. The critical path defines project priorities and displays the complexities involved with late completion throughout the project, especially when multiple milestones are involved. In short, longest path describes the work sequence with the greatest total duration. The critical path can be used to perform the same function but also incorporates other project restrictions that may or may not be related to project completion.

There are exceptions caused by constraints to each of these calculation methods and technical issues that result from using any of these critical path analysis methods in various software tools. This RP will discuss each method in detail.

Lowest Total Float

The lowest total float method identifies the critical path activities as activities that have the lowest float value in the schedule. For the purposes of this RP, "float" is synonymous with "total float." Activity float is computed by subtracting its early finish from its late finish, or by subtracting its early start from its late start[2]. Sometimes float values for a sequence of activities will vary depending upon which float computation method is used.

Solely using float to define the critical path is often confusing because the use of constraints, calendars, and sequencing methods often results in the logical chain of critical path activities not all having the same float value. Sequential activities may be affected or activities with logical relationships on the critical path may have different float values for the following reasons:

- Date and float constraints
- Activity calendars
- Lag calendars
- Interruptible activities
- Hammock, level of effort, WBS, and other types of summary activities