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Using Relationship Diagrams to Enhance the Critical Path Method of Project Scheduling

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Executive Overview

This white paper provides an overview of the Critical Path Method (CPM) for project scheduling and the history of its development. The implementation of the Relationship Diagramming Method (RDM) variant of CPM within Oracle's Primavera Risk Analysis (Release 8.2 or later) is illustrated, and the benefits of such an approach are highlighted. Primavera Risk Analysis is certified to be compliant with RDCPM, and it allows the user preparing a CPM to better model the real world. In addition, the user reviewing the CPM submitted by another can perform a more in-depth evaluation.

Introduction

The CPM for project planning is based on a mathematical algorithm for scheduling activities. It is an important tool for effectively managing projects ranging from construction to software development to engineering. To model a project using CPM, the following inputs are required:

- A list of all activities required to complete the project
- The duration of each activity
- The dependencies between activities

History of Project Scheduling Techniques

The original format for CPM, which was developed 50 years ago, was later renamed Arrow Diagramming Method (ADM). ADM is also known as Activity on Arrow, and both of these variants of CPM are distinct from the Precedence Diagramming Method (PDM) variant—also known as Activity-on-Node—which was first implemented in 1964. Another variant of the same era was the Program Evaluation and Review Technique (PERT), which the U.S. Navy developed to create the Polaris missile system. PERT focused on clearly defined milestones rather than the loosely defined activities between such milestones.

All three methodologies—ADM, PDM, and PERT—included weaknesses due to technology limitations. The original ADM and PERT methodologies were designed to operate on computers that lacked random access memory and were limited to linear access memory. Old cartoons illustrating computers with large reel-to-reel magnetic tape highlight the limitations that early software designers had to overcome. Similarly, PDM software was designed with fewer features. It stored less information and required less memory than theorists had initially envisioned. Many of these issues are rooted in this failure to record information known by the planner or scheduler.

The Relationship Diagramming Method Variant of Critical Path Method

In 2005, the construction industry manual *CPM in Construction Management* introduced RDCPM, the RDM variant of CPM.[1] RDCPM attempts to address the information-recording issues that plagued ADM, PDM, and PERT. Figure 1 shows the trademark that attests to the certification of proper use of RDCPM.

Figure 1. The trademark showing compliance to the RDM variant of CPM

[1] James O'Brien and Fredric Plotnick, *CPM in Construction Management,* 6th ed. (McGraw-Hill, 2005).

Just as CPM and PERT were distinguished from bar charts and milestone charts by the recording of additional information used to create those charts, RDM is also distinguished from the older versions of CPM and PERT by recording even more of that information. This information, as implemented by Primavera Risk Analysis, can be generally classified into several additional code fields:

- Reason/why codes and description fields
- Events and additional types of restraints between activities
- Relationship codes to further indicate the relationship between two activities

Reason/Why Codes and Description Fields

Reason/why codes provide additional description about why a restraint or link has been placed between two activities. This intelligent code can be entered based upon the thought process of the project team or calculated from other information about the activities. The code can also be used for additional calculations, such as better diagnostics for validation of plan logic, more-robust resource-leveling algorithms, acceleration or crashing studies, and other what-if scenarios. The reason/why code is supplemented by additional text fields that can contain descriptive information.

The reason/why code is supported in Primavera Risk Analysis (Release 8.2 or later) by clicking **Plan** > **Links** > **Link Categories** > **User Fields.** The default reason/why codes—or the link category codes in the Primavera Risk Analysis implementation—are "0" undesignated, "1" physical, "2" just-in-time, and "3" resource. Additional code designations, such as by individual resource, can be assigned from 4 through 255.

In the example in Figure 2, users augment the link category codes by entering descriptions such as "same crew" and "window wall affixed at edge of floor slabs." In the four text fields, users can enter additional descriptions or special coding assigned to the restraint or link between activities.

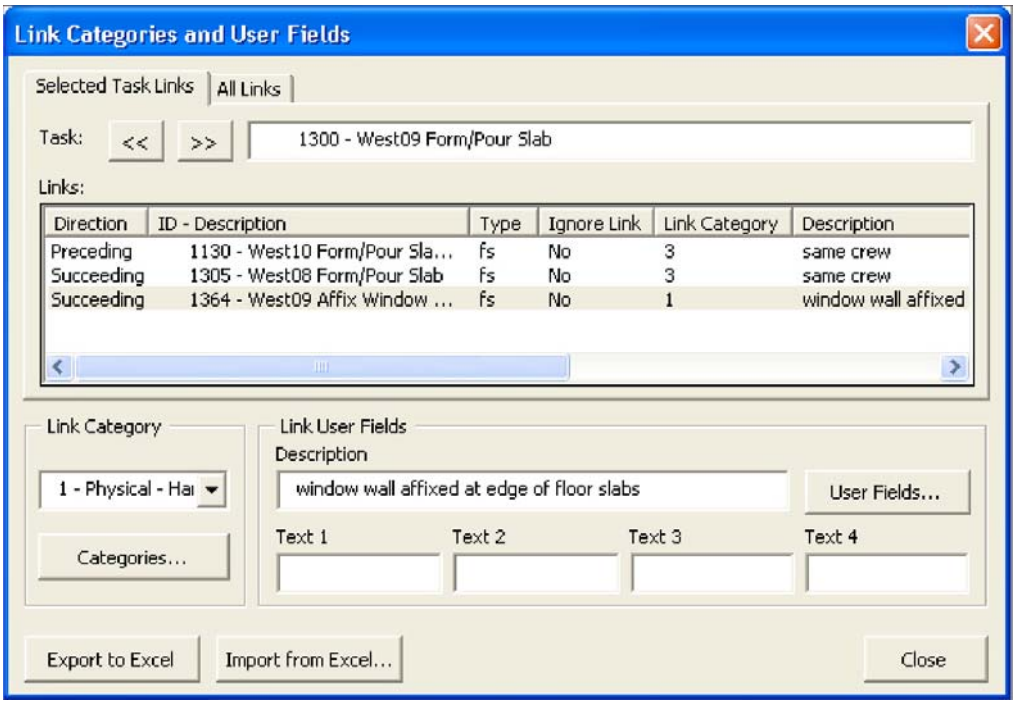

Figure 2. An example of link categories and user fields in Primavera Risk Analysis

Code Value 2: Just-in-Time

Code value 2 is reserved for a special type of link category: the just-in-time reason/why code. This code represents a physical relationship between activities that depend on the predecessor activity being completed just in time to support the early start of the successor activity. A typical use is between the end of a string of procurement activities (submit, approve, fabricate, and deliver) and a production activity (such as "rig/set the procured item to a foundation as soon as possible after the foundation is poured and cured"). Another example is a subcontractor being expected to deliver or install a just-in-time component to enable a continuous workflow for the prime contractor. The calculation of the just-in-time dates for an activity is similar to the calculation for the late dates. It starts at the last activity's late finish and flows toward the start of the project. The just-in-time finish and the start dates for each activity are the same as the late finish and start dates. However, at the link set to link category 2, the just-in-time finish of the predecessor activity to the link is set to the early start of its successor. Further processing continues as previously noted. Users of this feature might choose to display the late start and finish of the latest dates before causing delay to the project. Or they might choose to display the just-in-time start and finish of the latest dates before causing a disruption to the production crew's progress.

Events and Restraints Between Activities

Another hallmark of RDM is the re-establishment of the concept of *events,* which is generally lost in the transition from ADM and PERT to PDM. RDM has events at the beginning of an activity, at the end of an activity, and embedded within an activity whenever some portion of an activity must be completed before the start or finish of another activity. RDM also permits tags, descriptions, and user-defined codes to be assigned to these events. Because RDM handles events in this manner, users can record, for example, exactly what percentage of an activity is required to be complete before another can start.

Primavera Risk Analysis implements this RDM requirement by permitting activities to be split, placing the partial activity descriptions on the individual subtasks within the activity. RDM also permits the user to distinguish between the following two scenarios:

- Activity B will start 3 days after Activity A's 10-day process has begun—without regard to whether any progress was made on days two and three.
- Activity B will start only when 3 days—or 30 percent—of Activity A's 10-day process has been completed.

This is accomplished in Primavera Risk Analysis by the split activity function. To implement the first scenario, a traditional start-to-start restraint with a three-day delay might lead from the start of Activity A to the start of Activity B. To implement the second scenario, the RDM progressed-to-start restraint might lead from the end of a three-day subtask within Activity A—with zero delay—to the start of Activity B. Both uses will result in the same *initial* bar chart, but they will result in different *actual* bar charts if Activity A starts and stalls on day two.

Relationship Codes

Relationship codes allow users to program the computer to view the relationship between activities connected by a restraint or link. Users can then perform various diagnostic or global changes based upon such review.

For example, suppose a person wants to transfer a CPM instruction from a PDM to an RDM. Under the PDM, the instruction has codes assigned to activities that indicate the resource used as well as the location of the work being performed. As a result, rules can be written to set the link category to "physical" (code value 1) for a transfer from one craft resource to another at the same location, and to "resource" (code value 3) for a transfer from one location to another using the same resource. Reports can be prepared highlighting a handoff from one subcontractor to another that requires additional supervision by the general contractor, engineer, and owner. To account for the tearing down and rebuilding of scaffolds, for example, the user might implement a global change that sets a two-day lag for each finish-to-start restraint whenever the masonry subcontractor changes location. The uses of this new feature are almost infinite.

Conclusion

With RDM, planners can incorporate the following information into their project plans:

- Reason/why codes and description fields
- Events and restraints between activities
- Relationship codes that indicate the relationship between two activities

The evolution of CPM to incorporate and understand these important relationships has allowed project planners and schedulers to achieve more-accurate project plans. Primavera Risk Analysis is certified to be compliant with RDCPM, and it allows the user preparing a CPM to better model the real world. In addition, the user reviewing the CPM submitted by another can perform a more in-depth evaluation. Oracle's Primavera Risk Analysis allows the project team to better monitor the progress of a project and to make midcourse corrections when needed.

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