Schedule Quality Assurance Procedures

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ABSTRACT

Many project schedules are often poorly prepared and require extensive rebaselining during project execution to become a useful project management tool to properly measure progress, determine the effect of changes in scope, and forecast the completion of contractual milestones and overall project completion dates. Poorly prepared schedules do not provide a reliable tool to measure the amount and responsibility for delays that occur during project execution to provide a basis for a time extension or to assess the need for acceleration to mitigate delays. This paper discusses procedures to rectify these common problems with project schedules, including: ensuring that the schedule accurately reflects the complete contractual scope of work, evaluating schedule metrics to assess the schedule integrity, reviewing the schedule logic for reasonableness, evaluating the reasonableness and completeness of the critical path, and comparing the schedule to the baseline or previous updates to identify significant changes.

Keywords: Schedule quality assurance, schedule integrity, and schedule reasonableness

COMMON PROBLEMS WITH PROJECT SCHEDULES

A project schedule typically is intended to model the execution plan of a contractor in performing a scope of work for an owner over a specified period of time. In order for a project schedule to model the execution plan, it must accurately reflect the scope of work, have sufficient detail to monitor progress, and contain activity relationships that properly define the sequence of the work progress. Shortcomings or deficiencies in any of these areas threaten the ability of the schedule to accurately forecast the completion dates of tasks or milestones or to properly identify when interfaces are required with outside parties.

The schedule's ability to forecast task completion dates and interface requirements with other parties is a key purpose of the schedule from a management perspective. Additionally, individual task execution delay or late delivery of interface requirements should be reflected in the schedule updates once activity delays have been incorporated into the schedule. It is the completion date forecasting and delay monitoring capability of a properly prepared project schedule that makes it such a valuable tool, allowing management insight into the effect of delays. Management can then make timely decisions to address and mitigate the delays.

Therefore, it is important when evaluating the quality and reasonableness of project schedules to look for deficiencies in the areas of work scope, activity durations, and activity sequencing. The schedule quality assurance procedures described below can help to identify potential schedule deficiencies and correct common problems.

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SCHEDULE QUALITY ASSURANCE PROCEDURES

To effectively review a project schedule, the electronic file must be made available to the reviewer. Without access to the native software file, it is difficult to review and identify potential schedule problems. First, the project schedule should be reviewed to ensure that the complete scope of work is represented in the schedule. Next, schedule metrics should be calculated and compared to industry norms. Then, the schedule logic should be reviewed in detail to ensure that the logic is reasonable and compete. Lastly, the project schedule critical path should be identified and reviewed in detail. The findings from each of these examinations can then be compiled in a report to serve as a guide for schedule improvement or correction if necessary.

The comparison of a completed or in-progress schedule to an earlier progress update or baseline schedule will reveal changes made to the schedule. These changes can identify adjustments in the plan, changes in the scope, or mitigation efforts to overcome a delay, which should be reviewed when evaluating the quality of a schedule.

SCOPE OF THE PROJECT SCHEDULE

To effectively evaluate a project schedule to determine if it accurately reflects the project Scope of Work, the reviewer must understand the project scope. The project contractual Scope of Work is usually identified in project documents such as the project contract, drawings, and specifications. Large complex projects are generally divided up into areas or units. The schedule reviewer should be familiar with the industry sector for the project to ensure a complete work scope review. A list or work breakdown of the activities or tasks required to achieve the contractual scope of work should be compiled.

By way of example, an EPC schedule for a process plant project may include activities for each of the following tasks:

A. **Engineering**
- Process Design, Plant Layout and Detailed Design
  - Discipline-Specific Activities
  - HAZOP and Design Reviews
  - Modules
  - EPC Contractor Interfaces

B. **Procurement**
- Component Procurement
  - Equipment
  - Bulk Materials
  - Factory Acceptance Testing and Qualification
  - Transportation

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- Pipe and Module Fabrication and Assembly
  - Fabrication and Assembly
  - Testing and Qualification
  - Transportation

C. Construction

- Site Preparation and Temporary Facilities
  - Earthmoving/Soil Preparation
  - Laydown Area Preparation
  - Storage Area/Warehousing/Tool Room Construction
  - Waste Disposal Construction
  - Security Construction
  - Temporary Office/Support Base and Services Construction
- Construction
  - Process Units
  - Utilities
  - Piperacks
  - Main Control Rooms, Administration, Workshop Buildings, and Shelters
  - Main/Backup Power Supply and Substations
  - Wharf
  - Tank Farm
  - Other Plant Systems
- System Completion and Turnover
  - Safety Systems
  - Main Control Room Systems
  - Electrical & Instrumentation Systems
  - Mechanical Systems
  - Plant Utility Systems
  - Other Plant Systems
  - Plant Optimization and Tuning

D. Pre-Commissioning and Start-up

- System Testing and Qualification
- Safety Systems
- Main Control Room Systems
- Electrical & Instrumentation Systems
- Mechanical Systems
- Plant Utility Systems
- Other Plant Systems

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E. **QA/QC**

- Owner Approvals
- Engineering Model Reviews
- Safety Reviews (HAZOP)
- Equipment Inspection and Factory Acceptance Tests
- Pipe Fabrication and Module Shop Inspections
- On-site Construction Inspections
- Testing and Qualification Reviews

To review the project schedule scope of work, the project schedule activities can be exported from the schedule to a database or spreadsheet. Individual schedule activities generally have a multitude of data or activity codes associated with the activity. The activity description, along with the activity codes should be reviewed and each schedule activity can then be categorized against the work breakdown list. A tabulation of the results can then be made and evaluated to ensure schedule activity coverage of the entire scope of work.

SCHEDULE METRICS COMPARISON

Schedule metrics can be compiled and calculated from a review of the individual schedule activities and activity characteristics. The process for this type of analysis starts with the export of all activities and activity data to a database or spreadsheet. A table of activity characteristics is created where one record or row in the spreadsheet contains all relevant information about an individual schedule activity. This table should at a minimum contain the following activity data for each activity:

- Activity ID
- Activity Description
- Activity Duration Information
  - Original Duration
  - Remaining Duration
  - Actual Duration
- Activity Type
- Activity Status
- Activity Percent Complete
- Activity Dates
  - Early Start
  - Early Finish
  - Late Start
  - Late Finish

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- Activity Float
  - Total Float
  - Free Float
- Activity Constraints
  - Early Constraints
  - Late Constraints
- Activity Resources
- Activity Codes
  - Phase
  - Location
  - Responsibility
  - Discipline

This table can then be reviewed and analyzed to generate various schedule metrics. A listing of several of these schedule metrics along with an explanation of the procedure used to compile each metric from the activity data follows below.

1. ACTIVITY TYPE SUMMARY

Proper evaluation of project schedule metrics requires knowing what type of schedule activities are being reviewed, compiled, and tabulated. Schedules generally have a mix of Task activities, Start and Finish Milestones, and Hammock activities. This metric sums the total number of Task, Milestone, and Hammock activities. Hammock activities are generally not used in the calculation of other schedule metrics. In fact, most schedule metrics are calculated using only the Task type of activity.

2. ACTIVITY STATUS SUMMARY

Various schedule metrics calculations are made on groups of activities depending on the status of the individual activity. Whether or not that activity is complete, in-progress, or not-started can determine if the activity is included in the calculation of a particular metric. This metric sums the total number of complete, in-progress, and not-started activities.

3. NUMBER OF ACTIVITIES PER US $1MM OF COST

This metric is a calculation of the total number of Task activities in the schedule divided by the project cost in millions of dollars. The metric can be compared to similar sized projects as a measure of the level of activity detail.

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4. NUMBER OF ACTIVITIES PER MONTH CYCLE TIME

To compile this metric, the span of the schedule is documented from the start of the first task activity to the completion of the last task activity. Analysis of this metric involves totaling the number of task activities in progress during each month of the project, based on actual and early activity dates. This information can then be grouped by project phase or other pertinent factors, reviewed, and presented graphically to reveal if the activity detail is balanced over the course of the project. Sometimes projects have a tendency to be more detailed in the beginning, then more general and less detailed in the later stages of the project.

5. AVERAGE ACTIVITY REMAINING DURATION (DAYS)

The average activity remaining duration metric excludes completed work. The remaining durations for all tasks is summed and divided by the total number of task activities that are in-progress or not started.

6. EXCESSIVE ACTIVITY DURATION CHECK

The activity table should be reviewed for activities with excessively long planned durations. The logic for these activities should be investigated and an evaluation made as to whether these long duration activities should be broken down into several shorter duration activities. New relationships between the shorter duration activities and other activities in the schedule may be required.

7. NUMBER OF ACTIVITY CALENDARS

The schedule calendar definitions are reviewed and then the activity table is evaluated to identify which calendar is applicable to each activity. Evaluations are made of the calendar usage as to whether the calendar assignment is reasonable based on where each task is preformed and which project resource or resources are assigned to complete the work.

8. ACTIVITY CODE ASSIGNMENT CHECK

The activity table is reviewed for information relating to the activity codes. The activity codes are used to organize and sort the individual activities in the schedule. A review of the utilization of activity codes allows for an assessment of whether or not coding is used consistently and is of sufficient detail to properly sort and organize the schedule for reviews and reporting requirements.

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9. NUMBER OF CONSTRAINED ACTIVITIES

The activity table should be reviewed for information relating to activity date and float constraints that can affect the forecasting ability of the schedule. Activities are identified that have constraints and the type of constraints. This information is tabulated and analyzed. The improper use of constraints may affect total float values and potentially distort the critical path of the Project. Constraints can also control which activities are impacted by delays or changes. Mandatory start or finish constraints prevent the schedule from responding to changes or delays. The reasoning for the use of these constraints should be explored and other constraints or logic ties considered that are not as restrictive to float calculations.

10. AVERAGE ACTIVITY FLOAT (DAYS)

The average activity float duration metric excludes completed work. The total float for non-hammock activities remaining to be complete is summed. This value is the divided by the number of remaining non-hammock activities, yielding an average total float value. A high average float value can indicate that the project is not sufficiently detailed or tied together logically.

11. FLOAT RATIO

The calculation of this metrics uses the previously calculated metrics of average activity float and average activity remaining duration. The float ratio is simply the average activity float divided by average activity remaining duration. A high float ratio can indicate excessive available float or insufficient logic in the schedule.

12. RESOURCE LOADING

The project schedule is reviewed to determine whether activities have been resource loaded. If resources have been used in the schedule, there are a number of metrics that can be calculated and reviewed. For example, the reviewer can tabulate the different Resource Types and Resource categories. Which activities have resources and what type of resources? Has resource leveling been utilized in the schedule?

13. METRICS FOR IN-PROGRESS SCHEDULES

If the project schedule reviewed is a status update, there are additional metrics that can be calculated to reveal potential problems. Two of these metrics are described below.

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13.1 PLANNED DURATION V. ACTUAL DURATION CHECK

This metric reviews completed task activities. A review of the planned duration compared to the actual duration of individual activities reveals activities that were delayed in completion. A review of how many of the completed activities in an area or phase of the project can reveal problems that should be investigated. The calculation of the average activity actual duration divided by the average activity planned duration may indicate a trend regarding the forecasting accuracy of the schedule.

13.2 PERCENT COMPLETE V. REMAINING DURATION ANALYSIS

This metric reviews in-progress task activities. The percent complete versus remaining duration check is used to identify activities that may show incorrect progress reporting. Typically, the percent complete value is linked arithmetically to the remaining duration value, where: Percent Complete = (OD – RD) / OD x 100.[1] A review of these values in the activity table will identify activities where the percent complete or the remaining duration is not consistent with this calculation.

SCHEDULE LOGIC REVIEW

The first step in a schedule logic review is to export the activity relationships to a database or spreadsheet. The table of activity relationships should include the predecessor and successor Activity ID, activity description, type of logic relationship, and lag value. In addition to these minimum requirements, activity information from the activity table can be correlated by using the Activity ID as a common element. Information relating to activity status and activity codes indicating the project phase or area can be applied to both the predecessor and the successor activities. This step can help assess whether activity relationships spanning from one phase to another phase are treated consistently.

The schedule logic review should utilize information from both the activity data table and the activity logic table to assess the reasonableness and completeness of the schedule logic. A fragnet of a changed event can be inserted in the network along the early part of the critical path and the schedule recalculated to test whether or not the schedule completion date and other contractual milestones are properly updated.

[1] OD = Original Duration. RD = Remaining Duration.

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14. OPEN ENDS

Each activity is reviewed to identify if it has at least one predecessor and one successor. Activities that do not have at least one predecessor and/or one successor are identified and the activity is reviewed to determine if the open end may adversely affect the schedule calculations for forecasting dates and activity float. A listing should be provided of all activities that are missing predecessor or successor logic other than Project Start and completion milestones.

15. PERCENT OF ACTIVITIES WITH NETWORK TIES

This metric involves the review of logic ties for milestones as well as task activities. Activities with missing predecessor logic and/or missing successor logic are identified and tabulated. The number of activities with missing logic is subtracted from the total number of activities resulting in the number of activities with logic or network ties, this value is in turn divided by the total number of activities to generate a percentage of activities with network ties.

16. EXCESSIVE LAG CHECK

The activity logic table should be reviewed and activities with large lag values identified. Activities with large lag values should be reviewed and a determination made if the large lag values can be replaced with an activity. If activities have negative lag values, the predecessor and successor should be reviewed to determine whether breaking either activity into smaller activities would better serve the intended relationship.

17. EXCESSIVE FLOAT CHECK

The activity table should be reviewed for activities with excessively large float values. The logic for these activities should be investigated and an evaluation made as to whether additional logic is required for these activities to accurately reflect the project plan or if dependencies exist that are not reflected in the schedule logic.

ACTIVITY PROGRESS ERRATA

The activity table should be reviewed to determine if any activities have progress reporting errata. The recommended checks to perform fall into the following categories:

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1. Activities with actual dates after the schedule data date
2. Activities with an actual finish date that are not recorded as 100% complete
3. Activities with progress measured as percent complete greater than zero, but without an actual start date
4. Activities progressed as 100% complete but with no actual finish date

A listing of the activities with progress errata should be generated for review.

CRITICAL PATH EVALUATION

The schedule reviewer should review the reasonableness and completeness of the critical path for the engineering, procurement, construction, and pre-commissioning activities, and any available near critical path activity chains. Where potential vulnerabilities to the critical path are identified, recommendations to mitigate the delays should be made. The critical path can be influenced by preferential logic, work activity estimated durations, and calculation methods used by the CPM software. The reviewer should determine if there is any evidence that preferential logic was utilized to force the critical path. In addition, the reviewer should determine if activity durations are consistent when compared to similar activities.

There typically are numerous side paths for subordinate tasks which normally can be performed without affecting the critical path. However, these subordinate tasks, if improperly scheduled or unduly delayed in performance, can become critical and thus change the critical path for the entire project.

The schedule reviewer should evaluate near-critical paths and identify activities that are likely to impact contractual milestones and the project completion date, but have not been identified as being on the critical path. These identified activities should be placed on a watch list for evaluation on future schedule updates. The reviewer should also identify activity chains where Owner approval or review is required, thus providing the Owner with awareness where its timely performance is essential to not delay the Contractor's work or the project.

PROJECT SCHEDULE UPDATE COMPARISIONS

If the schedule being reviewed is a periodic update or a schedule of an in-progress project, the schedule should be compared to a baseline or an earlier schedule update. This review can identify changes that have been made to the current schedule. These changes can then be catalogued and examined as to how they affected the schedule, the forecast of task or milestone completion date, or the required date of interface with a third party. The list of changes to the schedule, individual activities, and logic relationships that should be investigated include the following:

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- Added and Deleted Activities
- Activity Start and Finish Delays
- Activity Duration Changes
- Changes to the Critical/Near Critical Paths
- Significant Changes to the Schedule Logic
- Added or Changed Constraints
- Changes in Schedule Calculation mode
- Changed Activity Coding
- Added or Changed Resources
- Added Schedule Log Entries

Any adjustments to the project Scope of Work that the two schedules represent should be taken into account when making the above comparison.

CONCLUSION

A thorough review of large and complex project schedules is possible utilizing the procedures identified in this paper. The results of the analysis can provide insight into potential problems in the project schedule. Correcting the potential problems by changing logic or adding the appropriate detail to the schedule can restore the schedule as useful project management tool to properly measure progress, determine the effect of changes in scope, and forecast the completion of contractual milestones and overall project completion dates.

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