International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 10 | Oct 2018 www.irjet.net p-ISSN: 2395-0072

Quality Matrices of Project Schedule

Prabuddha Sarkar[1], Neeraj Bansal[2]

[1]*Prabuddha Sarkar PMP, Project Controls Engineer in Fluor Daniel India Pvt. Ltd.*
[2]*Neeraj Bansal, Senior Project Controls Engineer in Fluor Daniel India Pvt. Ltd.*

Abstract - Schedule slippage & cost over-run of projects prompted many Government agencies & MNCs to develop their schedule quality matrices guidelines. This article discusses about various quality matrices for a project schedule developed through critical path method (CPM). The objective of this article is to appraise the project management/ project controls community on quality matrices for a CPM Schedule.

Key Words: Construction Project Management, Project Scheduling, Project Schedule Quality, DCMA-14, Project Planning, Project Controls, Construction Engineering.

1. INTRODUCTION

Overall project schedule developed through CPM (Critical Path Method [12]) plays a very important role in controlling the project for its entire duration. Many researchers have published their work to identify most important success criteria for a project. Sound schedule management remains one of the most critical criteria to determine project's outcome [9, 10].

Hence, it is essential that for project management, a project schedule guideline has to be developed & implemented. The US Defense agencies have pioneered in developing such schedule guidelines. In the USA, Government & Defense Contracts runs in billions each year. US Government Agencies & specially US Defense agencies have developed a range of Schedule Management protocols over the time, such as Naval Air Systems Command Cost Department (NAVAIR) 11-Point Schedule assessment, Scheduling best practices developed by Dept. of Homeland Security (USA), NASA's Schedule Management Handbook, USGAO (US Govt Accountability Office) Schedule Assessment Guide. [1, 2, 4, 5, 6, 7]

The project schedule is an indicator or mechanism which answers the what/ who/ when questions of Project Management i.e. what needs to be done, which resources must be utilized and when the project activity is due. A project schedule is a living document that collects all the activities/ work, which is in the scope, needed to deliver the project on time. A schedule is a logically linked listing of a project's milestones, activities or deliverables, usually with a specific start and finish dates. The Project schedule to also includes information about resource allocation, budget, activity duration, and linkages of dependencies and scheduled events.

This article assumes that the reader is accustomed with standard terminologies (Mentioned in Table-1) of CPM Project Schedule, however detailed description of each can be found in Practice Standard for Scheduling [13] published by Project Management Institute, USA.

2. Quality Matrices

The quality points mentioned in Table-1 help us to objectively evaluate the quality of the Project Schedule over the life-span of the project.

Table -1

1. Schedule Logic*	9. Invalid Dates
2. Leads*	10. Resources
3. Lags*	11. Missed Tasks
4. Relationship Types (% Ratio)*	12. Critical Path Test
5. Hard Constraints*	13. Critical Path Length Index (CPLI)
6. High Float	14. Baseline Execution Index (BEI)
7. Negative Float*	15. Current Execution Index
8. High Duration*	16. Total float Consumption Index

A brief description of the criteria & their respective thresholds are given below. The Schedule example pictures/ Figures are taken as a screen-shot from a Project Schedule developed in Oracle Primavera P6.

2.1 Schedule Logic:

The Overall Logics (Predecessor/ Successor & interlinking) in a CPM schedule should be checked for Missing Logic, total number of tasks which doesn't have predecessor or successor should be kept to bare minimum, preferably only the start & finish activity of the project may have missing predecessor or successor.

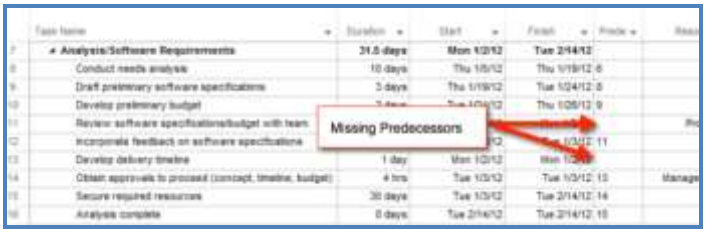

Fig -1: Logic Checks

2.2 Leads:

Leads or Negative Lags between two tasks / activities means successor activity will start before finishing predecessor activity; such type of logical link is to be avoided. The reason is that having leads distorts the Total Float in the CPM schedule & cause resource conflict sometimes, which has to be critically reviewed. Moreover negative time-line (i.e. Leads) is not logical & should be discouraged.

Fig -2: Leads

2.3 Lags:

Although Leads are discouraged, Lags may be accommodated with a limit,

Fig -3: Lags

2.4 Relationship Types (% Ratio):

Arguably among the four (4) relationship types, i.e. Finish to Start (FS) (After the predecessor is finished, then the successor will start), Start to Start (SS), Finish to Finish (FF) & Start to Finish (SF), the FS relationship is the most logical & mostly used in the logical relationship of CPM schedule. Preferably 90% of the tasks should have this FS relationship.

2.5 Hard Constraints:

In scheduling terminology, "Hard Constraints" are those constraints, when applied to a activity (Start/ Finish) becomes fixed on to that date and relations to other tasks are ignored. That means activity date (Start/ Finish) will not move even if its predecessor pushed it out. Hard constraints in CPM schedules override logical relationships; hence should be avoided. Following constraints are considered HARD Constraints,

- Must-Finish-On (MFO)
- Must-Start-On (MSO)
- Start-No-Later-Than (SNLT)
- Finish-No-Later-Than (FNLT)

Preferably tasks with Hard Constraints should not be more than 5% of total tasks. Hard Constraints to be used in few cases i.e. to highlight contracted Mile-Stone Dates, which cannot be moved.

2.6 High Float:

The number of incomplete (not finished) activities with a Float greater than 44 Days (2 working months), to be less than 5% of all incomplete activities.

High Float % = [(Total # of incomplete tasks with high float) / (Total # of incomplete tasks)*100]

Generally CPM paths with High floats evolve due to constrained activities, which impede logical flow of the CPM schedule, hence high floats to be avoided, and also high float tasks should be investigated for optimization.

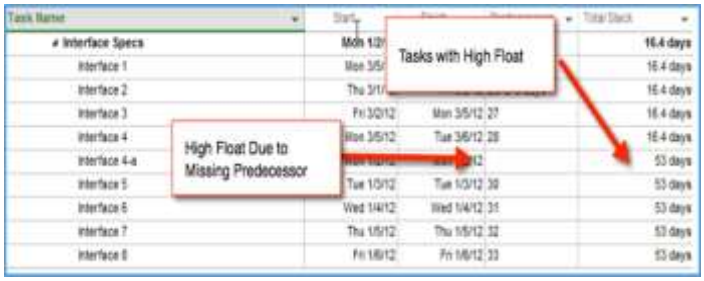

Fig -4: High Float

2.7 Negative Float:

In general, presence of Negative Float means, the actual (real life) dates are not to achieve the planned Milestones/ Finish dates. Typically Negative float is generated in a schedule when it is artificially constrained or accelerated (using Hard Constraints). There should not be any incomplete activity with negative float, under normal circumstances.

2.8 High Duration:

As a rule of thumb all the activities should be broken down into further smaller, more manageable activities, this way the CPM schedule become more controllable and gives better insight on the schedule's cost & schedule performance. Ideally, there could be only 5% of the activities which have duration more than 44 days (2 working Months).

2.9 Invalid Dates:

As we know, the entire CPM schedule has a Data Date or Status Date (Cut-off date on which CPM schedule has been updated). An invalid dates means;

a) Any task/ activity could not have a Forecast Date, which is prior to the status date,

b) Any task/ activity could not have an Actual (start or finish) Date, which is after (in future) the Status Date.

There should not be any invalid dates in the CPM schedule.

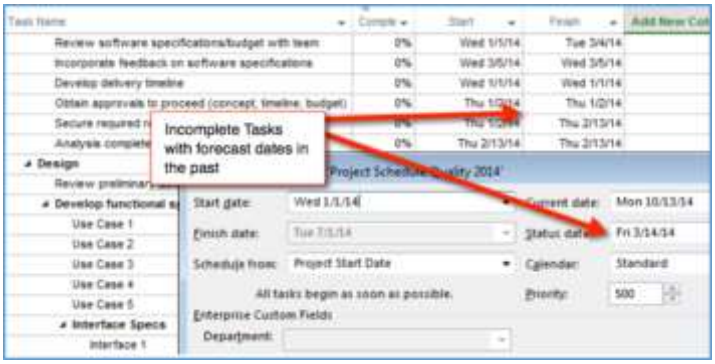

Fig -5: Invalid Dates

2.10 Resources:

In a practical Schedule, all the incomplete tasks/ activities should have resource or cost assigned, although it is not a mandatory criterion, however rule of thumb is that the more resourced & cost loaded the schedule, is more realistic.

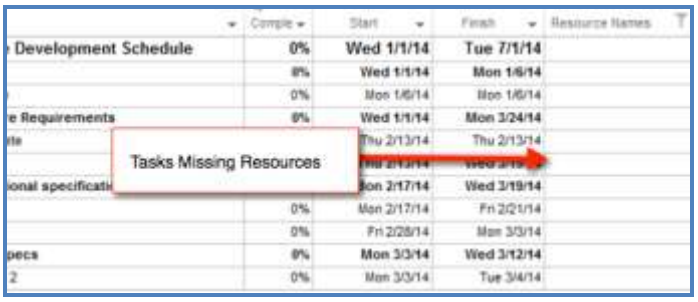

Fig -6: Missing Resources in Schedule

2.11 Missed Tasks:

This metric is about how well the schedule is performing as on the Data/ Status Date. Missed tasks are those tasks which overshot their Baseline (BL) Finish dates, either they have completed after BL-Finish or their Forecasted (ongoing activities/ tasks) Finish date is after the BL-Finish. In other words these tasks have positive Finish Variance (Early Finish minus Baseline Finish).

Calculating this metric is little tricky. To calculate, we need to divide the number of missed tasks, by number of Tasks with BL-Finish dates on or before Status/ Data date. Ideally, Missed % should be less than 5%.

Missed % = (# of tasks with actual/forecast finish date past baseline date)/ (#of tasks with baseline finish dates on or before status date) * 100.

2.12 Critical Path Test:

The Critical Path test checks the integrity of the CPM schedule logics. When a complete CPM Schedule prepared, the scheduler introduces a large (For example 400 days) slip/lag in the Schedule, if the CPM shows that Finish milestone is impacted to similar amount of delays, then the schedule has passed the test.

In case the Finish Milestone is not affected by similar amount of delay (approx. 400 days), that means there are some "Broken Logic" in the CPM schedule.

2.13 Critical Path Length Index (CPLI):

CPLI is a performance index for the CPM Schedule. A CPLI of 1.0 means the Project is just on the schedule, whereas a CPLI less than 1.0 means the project execution is inefficient & the project is going to end late.

Critical Path Length Index (CPLI) = (CPL+TF)/ CPL

Here, TF is Total Float, The Total Float (TF) is the variance (days) between Forecasted & Baseline Project Finish date. CPL is Critical Path Length of the project; basically it is number of working days left from status date to the Project Finish. Sometimes activities on the critical path can have positive float and can be delayed without extending the overall project finish date, due to the use of advanced scheduling features (i.e. multiple calendars, etc.)[11].

It can be measured in a unique way, in the CPM Schedule's native file (i.e. .xer in Oracle Primavera P6, .mpp in Microsoft Project). One has to introduce a dummy activity/ task, with start date on the Status date, then by hit-and-trial one has to change the task's duration so that task's end date should match with the current finish date of the project (as per the CPM, before introducing new activity). The duration is the Critical Path Length.

Normally CPLI more than 0.95 is okay, less than 0.95 raises a flag & need to be investigated.

2.14 Baseline Execution Index

Baseline Execution Index (BEI), signifies how efficiently the project tasks are being completed on time, or it is a measure of the throughput of the schedule execution.

BEI = (Total # of Tasks Complete)/ (Total # of Tasks Completed Before Now + Total # of Tasks Missing Baseline Finish Date).

So, if more tasks have been completed than Baseline-Plan (as of Status date) then BEI will be more than 1.0, which means a higher task throughput than baseline Plan.

If BEI is less than 1.0, means task throughput is less than the Baseline planned.

A BEI score less than 0.95 is a flag & should be investigated.

2.15 Current Execution Index (CEI):

This Index measures with how much accuracy the project finish milestones' are forecasted & how accurately project is meeting those milestones/ finish dates. By measuring this metric Project managers' can emphasis the accuracy of the forecasted schedule.

All the schedules are updated on a fixed timeframe, mostly weekly/ bi-weekly & monthly. This fixed time frame is termed as window.

CEI = (# of forecasted Tasks, actually finished in that window) / (# of Tasks forecasted to finish in that defined window).

Note that tasks in this formula should exclude LOE & Summary tasks.

Using CEI ensures ownership & accountability which are indispensable for project's success. It is preferable to have CEI > 0.8.

2.16 Total Float Consumption Index (TFCI):

TFCI predicts the long term scenario, if project continue to execute in the current pace, what will happen in the End. TFCI identifies average rate of "Float" consumption of the project to the remaining schedule, then forecast finish date of the project at the current pace of work.

TFCI indicates the achievability of final completion date.

TFCI = (Project Actual Duration + Critical Path Total Float) / Project actual duration

Note that if CPTF (Critical Path Total Float), are not being calculated to the BL-Finish date then variance between Forecast Finish & BL-Finish should be considered CPTF.

3. ADDITIONAL SCHEDULE CHECKS

Additional schedule checks may be performed for issues such as,

- Avoid allotting resource on a summary task (Most cases not appropriate).
- Any relationship among summary tasks should not be allowed.
- Schedulers also need to avoid unnecessary logic used in a schedule.

All of these quality matrices checks can be performed manually, with use of filters/ grouping functions in the scheduling tools (i.e. Oracle Primavera P6/ Microsoft Project). There are also dedicated software products commercially available in the market (i.e. Deltek Acumen Fuse) to calculate these matrices. All of these quality matrices are important contributor in the Project's success.

4. CONCLUSIONS & RECOMMENDATIONS

Quality metrics of a CPM schedule identify certain measurable quality parameters.

Schedule's health checks should be a regular process, may be monthly and any skewed outcome, should be investigated. Root-cause analysis may be performed to address these issues. All the mentioned Schedule Matrices & their respective thresholds may be difficult to achieve at one go. The responsible scheduler may select important criteria and their thresholds as per complexity & applicability in that Project.

We have identified around seven important criteria which could be implemented as "Starred (*)" in Table-1.

The Quality matrices establish, a "Technical Structure" for the schedule and ensure sound Practices of scheduling have been followed. Such schedule helps project management in effective execution.

ACKNOWLEDGEMENT

The authors would like to acknowledge the generous support & guidance of Mr. Narasimham V Suri & Mrs. Kanchan Narang.

The authors would like to thank Mr. Mukesh Gupta and Mr. Pramod Gupta, the reviewers of this paper for their helpful comments and suggestions to improve this paper.

We express our appreciation to Mr. Yash Kant Varshney, Mr Wesley Brubaker & Mr. Pankaj Pande for sharing their thoughts and wisdom with us.

REFERENCES

[1] Earned Value Management System (EVMS) Program Analysis Pamphlet (PAP) DCMA-EA PAM 200.1 (October 2012) by Defense Contractor Management Agency, US Army.

[2] Schedule Assessment Guide By US Government Accountability Office

[3] PMBOK® Guide and Standards. by PMI, USA

[4] NASA/SP-2010-3403, "NASA Schedule Management Handbook," March 2011.

[5] SCHEDULE QUALITY ASSURANCE by Texas Dept. of Transportation

[6] Project Scheduling with Primavera , Training Manual by State of California Department of Transportation

[7] Planning & Scheduling Excellence Guide by National Defense Industrial Association (NDIA), USA

[8] DCMA 14-Point Schedule Assessment by Ron Winter, PSP

[9] Analysing Delay Factors In Indian Affecting Construction Projects – by Veera Vijay. Divi & Sundara Kumar. P

[10] Causes and Effects of Delays in Indian Construction Projects – by Dinesh Kumar R

[11] Construction Delays by Theodore Trauner

[12] James E. Kelley, Jr, Morgan R. Walker, Proceeding, IRE-AIEE-ACM '59 (Eastern) Papers presented at the December 1-3, 1959, eastern joint IRE-AIEE-ACM computer conference, Pages 160-173

[13] Practice Standard for Scheduling – Second Edition (2011), PMI, USA.