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Introduction

In the last year there has been a lot of soul searching about the effectiveness of CPM scheduling for managing projects. It all started with an article in ENR giving out a poor report card for CPM scheduling as a tool for managing projects and proposed some very drastic fixes to the tools used in CPM scheduling. The ensuing uproar over the proposed fixes has obscured two important points – first, that there is agreement that the system is broken and second, the fix required is not as much in the tool but the framework of agreements and practices in which the tool is used.

A Project where CPM Scheduling did not help

Findings from a current project where CPM scheduling was used will illustrate some of the problems faced. The project is a \$5 million building project to be completed in 15 months. The specifications required CPM scheduling. The main players were the Owner, his AE, his CM and the GC. The GC, responsible for developing and maintaining the schedule was competent and knew how to use CPM scheduling.

Right at the inception the project fell behind a month due to ‘unforeseen’ site conditions. While the cause, a dimensional error, was clear, the responsibility for paying for it was in dispute. The schedule was monitored in monthly updates. From the beginning, the GC and the CM’s scheduler disagreed on the interpretation of the results which the updates presented. By about four updates, it had come to a ‘he said – she said’ stand off. The essential issue of risk sharing became obscured by technical discussions on work sequencing and who owned float.

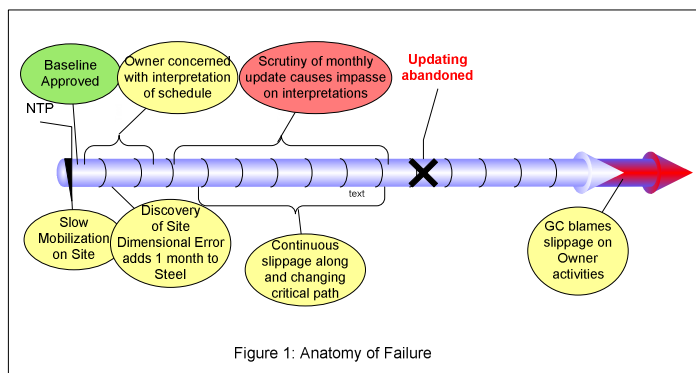
The Owner had no capability or interest in refereeing the technical nature of the dialog. His choice was to either let matters go to court or to come to a business agreement with the GC to get the project done. In either case he ended up spending more money than the contract. So he chose to make a business agreement with the GC on the end results he wanted and stopped paying attention to the monthly updates.

What went wrong?

There were a number of factors that contributed to the failure of CPM scheduling as an effective tool for managing this project. A closer examination of the factors will show that it was not so much that the tool failed but the lack of a framework in which it was used that made it ineffective.

Figure 1 shows the timeline of the essential points of failure in the use of a CPM schedule as an effective tool to manage this project. The nature of disagreements that led to the impasse and eventual abandonment of the use of the schedule were as follows:

- Although the Owner had a scheduling specification in the contract and had 'Approved' the baseline schedule, the schedule was not much better than a bar chart spaced out by convenient logic ties. The Owners scheduling specifications covered the 'mechanics' of scheduling but not how the project should be modeled. There were no industry standards or accepted practice for modeling project plans into an activity network. When the Owner started scrutinizing the schedule (with the aid of a consultant) it became obvious that the schedule did not cover the full scope of the project either in necessary details for subcontractor work or correct sequencing of logic and allocation of time for Owner activities
- Even when looking at the same analysis results, the interpretation between the parties differed, each essentially blaming the other. The scheduling specifications put out by the Owners did not include updating standards.
- The schedule failed as a communication tool at two levels. The GC continuously revised the schedule to absorb delays caused by them but attributed slippage of the end date to purported Owner actions. Thus the GC used the tool to mask the problems rather than communicate. The Owner did not have the training to understand what was being presented.
- There were no linkages between the findings of the scheduling exercise and corrective and follow up actions that needed to be taken in the real world. The process for scope control, the mechanism for risk sharing, the effectiveness of the GC project delivery setup, the Owners change control etc were all outside the influence boundary of the CPM scheduling process.



Why CPM Schedules Fail

The failure of CPM scheduling occurred in the inability to translate technical facts to business impact. The failures occurred in four major areas of application. These are as follows:

- There were no agreed Codes or Standards of Practice for use of the CPM scheduling tool both in terms of how to operate the tool and more importantly how to model the project from bricks to clicks

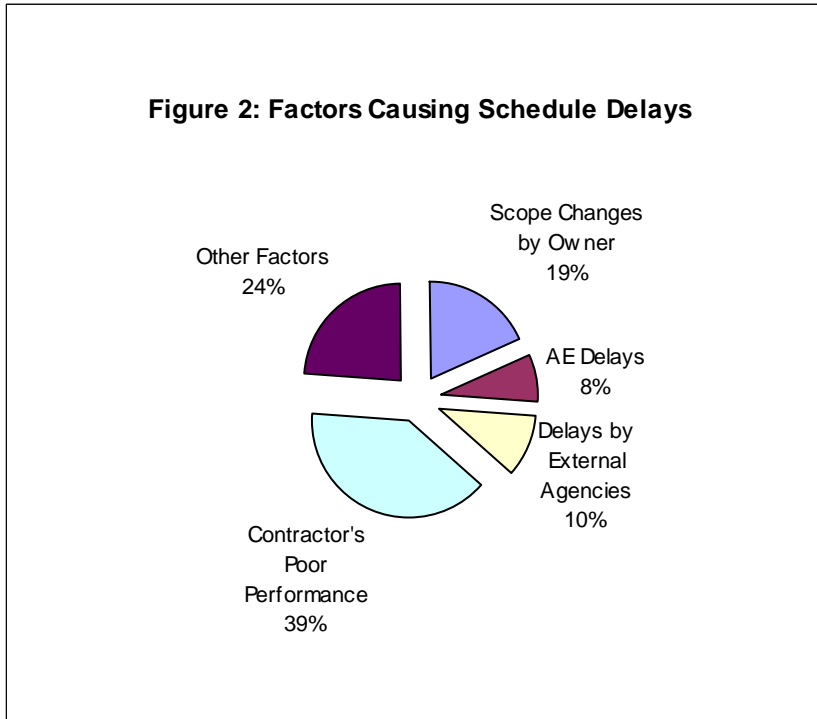
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- There were no industry standards or metrics to facilitate agreement about whether the project was in trouble and if it was in trouble what were the recommended actions to fix it
- Quick and timely actions to mitigate many of the main problems that arose were stymied by contractual issues related to the ability to direct means and methods, sharing of risks etc.
- Failure to fix organizational issues such as staffing and change management made solutions at the technical (CPM schedule) level impossible

Owners, Contractors and AEs share major responsibility for delays

Research points to the Owner and the Contractor for the bulk of the responsibility for schedule delays. In the early 1990's there was an initiative to develop 'Parametric Schedule' models. These were linear equations which tied overall schedule durations to technical building parameters like type of constructions (steel / concrete), number of floors, type of facade etc. This research was abandoned when the researcher found that changes by the Owner and lack of organization of the contractor had a far greater impact on the outcome of the project than any technical parameter such as building height or type of facade.

In 2003 a paper presented quantitative analysis of the factors that delayed project completion. The study was based on a large number of projects in South Africa for which records had been kept. A key finding of the study is shown in Figure 2. It shows that more than three quarters of delays are caused by the Owner, Contractor, the A/E or other agencies. Although this data is for South Africa, it seems to support the earlier observation of US research on parametric scheduling. These findings clearly indicate that a disciplined Owner, a competent contractor and responsive A/E team members are the main ingredients for a successful project.



The Steps for effective CPM scheduling

The process of developing and using CPM schedules comprise of the following steps:

- develop work plan
- model/translate the work plan into a CPM schedule network
- input network into scheduling tool and establish baseline
- gather progress information and update baseline
- generate variance reports and provide feedback on recommended corrective actions
- take corrective action.

This fits into the larger framework of project management. See figure 3.

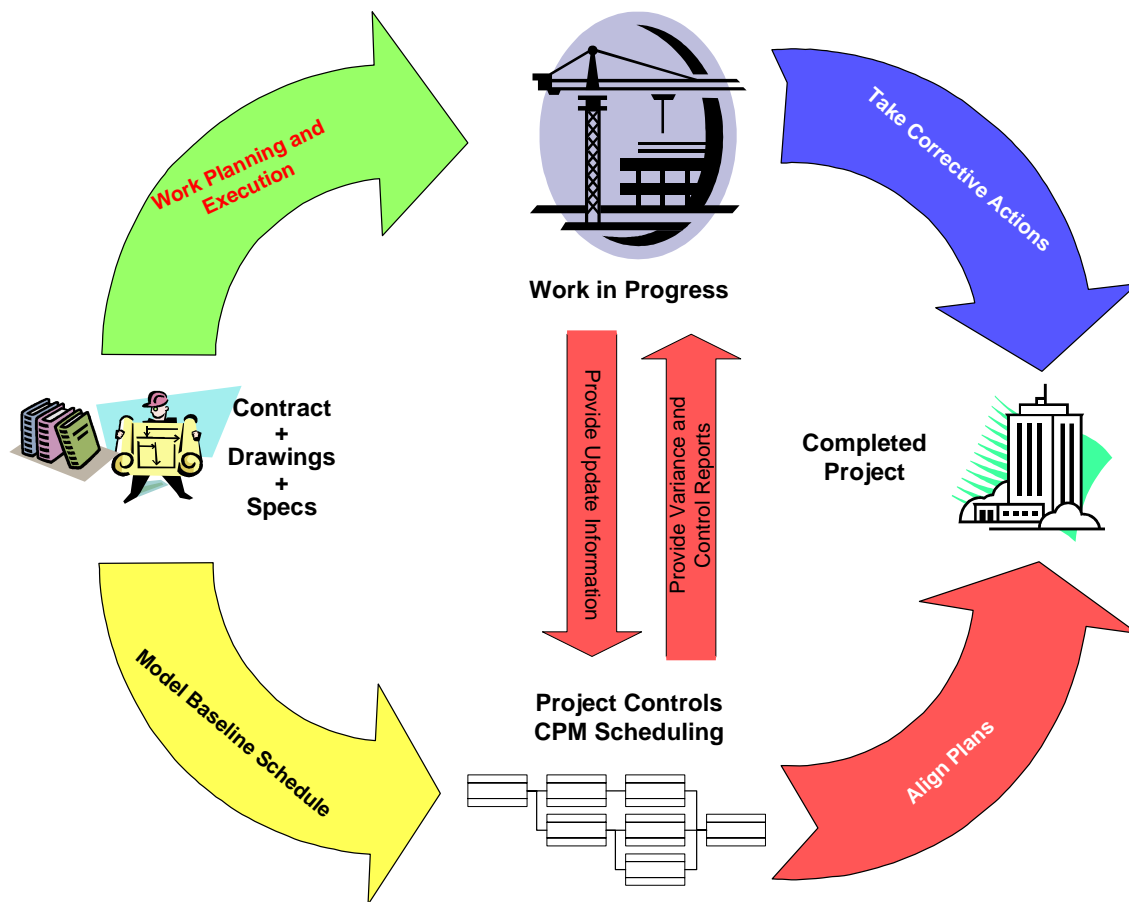


Figure 3: Framework for CPM Scheduling

Limits of CPM Scheduling

A good CPM schedule is a model, a symbolic representation in the form of activities in a network, of the work to be carried out physically. It is a reflection of the plans to get the work done - it does not itself get the work done. It is a passive tool. If properly executed, CPM Scheduling as a tool can measure and communicate the health of the project. It can however only point to corrective actions in planning and executing the job. Getting the job done needs organization and actions which are outside the jurisdiction of CPM scheduling.

Categories of Failure

The study on project delays cited above points to a few areas which largely contribute to schedule delays. The delay factors fall in two major categories. The problems in the first

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category can be mitigated by improving scheduling practices and standards and scheduler training.

The problems in the second category need more fundamental changes in sharing of responsibilities and risks. The Owner causes delays by changing scope and delaying decisions, the AE by not being responsive during construction, outside agencies because they were probably not in the communications loop and the contractor because he is not properly staffed and organized for success. These areas are not within the control of the scheduler and can be mitigated only by streamlining the framework in which scheduling is carried out.

Starting out with Handicaps

Too much faith is put on an 'Accurate' schedule and a 'Good' scheduler. Often enough, the schedule logic may be already skewed by the impact of administrative decisions which have been made 'upstream'. The scheduler, most times, is not provided a level playing field and has little influence and no authority to take corrective actions.

Some of the ways that the schedule is skewed by 'upfront' decisions and actions are as follows:

- Incomplete scope coverage, last minute scope additions – increases coordination, takes away float, adds quantity often without additional time
- Delayed/deferred Owner decisions – delays coordination, increases cost of changes, takes away float
- Incomplete designs / design intents – shifts risks and increases coordination, takes away float
- Incomplete / insufficient existing conditions investigations – shifts risks, hides scope
- Slow AE responses - slows approvals, coordination, increases risk
- Lean general conditions – insufficient manpower for buyouts, submittals and coordination stretches procurement, delays coordination, increases risk, takes away float from construction

All of the above almost always take away float and often add coordination to the project. Unrealistic risk sharing / transferred risk create administrative overheads in effect putting the schedule in the late date mode. The CPM schedule is not the right vehicle for adjudicating risk sharing.

Framework for Successful Application of CPM Schedule

A good CPM schedule needs a good scheduler and good scheduling practices. However to make it all work, it needs the framework in which the schedule can be developed and executed.

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The foundation of the framework for the execution of the project is laid out in the contract. The contract covers scope, general terms and conditions, drawings and specifications.

Generally the people who draft the contract try to stay clear from specifying 'means and methods'. The theory is that the bidders should be free to innovate and develop efficiencies which lower costs and benefit the project. This is what makes the US construction industry fast and flexible.

However not focusing on means and methods is missing an opportunity to better evaluate the credentials of the team and lay down some ground rules for performance standards. Some of the 'means and methods' when translated into a CPM schedule fall under the category of bad scheduling practice.

When CPM scheduling is specified, the specifications generally focus on the narrow area of how the scheduling tool is operated. The specifications and guidelines are vague or non-existent in the areas of developing the work plan, transferring the work plan into the network model, metrics for tracking and reporting, communicating results and check points and thresholds when corrective actions are called for.

More importantly, major factors which influence the outcome of the schedule and the project such as risk sharing and contingency management are most times covered in general terms in the contract. These impacts are factored in reactively after they happen causing delays and disputes.

Finally there are generally no agreements on 'how' and more importantly 'when' to take corrective actions such that even when a problem surfaces there is neither the mechanism nor the will to get it fixed proactively.

Improving the impact of CPM scheduling

As discussed earlier, improvements are needed in two categories i.e.

- Improving the use of the scheduling tool
- Strengthening the framework in which the tool is used

Improving the use of the scheduling tool

This has to start with choosing the correct tool. The tool has to be a CPM network schedule properly constructed using a professional grade off the shelf scheduling package. There are only a few 'professional' grade CPM scheduling software available on the market.

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The next step is to model the physical work into a set of activities and relationships in a network. This step requires competent planning of the physical work and accurate translation of this plan into the scheduling language. As the computer is dumber than humans, it puts an extra burden on the planner to breakdown and shape the plan into a set of inputs the computer can use.

The scheduling program has evolved from being a simple tool for calculating dates and floats to a complex machine trying to cater to a multiplicity of interests ranging from creating colorful show and tell presentations for marketing to accurate budget and forecasts for accountants who are interested in matching figures to the last penny. The scheduling package comes with a myriad of options which create opportunities for misuse some times out of ignorance and some times purely to deceive. There is a great need to clarify what constitutes CPM scheduling and establish standards of practice.

There is a large gap in expertise in these areas of modeling the work plan into a CPM network and operating the scheduling software. Scheduler competence needs to be developed by education, training and substantial experience on the job. All this takes time and money. Unfortunately cost cutting has impacted this area the most. There seems to be a mistaken belief that the scheduling package does the job and anybody can schedule once the package has been purchased.

The schedule reports and graphics are often used to overwhelm and confuse the User and hide important information in meaningless clutter. Again standards of practice need to be established to make schedule reports effective as communications tools.

All this points towards User education. There are categories of Users and they need varying degree of training. This costs money but more importantly a commitment from upper management that CPM scheduling provides a payback.

Strengthening the Framework

Project scheduling measures the health of a project. It works only in the context of the information supplied to it. The schedule must cover the complete and accurate scope of the project. Scheduling however is only a reporting tool. Timely corrective actions must be taken to make it meaningful.

Making the schedule inclusive and taking timely actions is outside the bounds of the CPM scheduler. These need agreements among the project stakeholders to happen. The more important areas where agreements are required are reviewed below.

Managing and Controlling Scope

There are two aspects in managing scope. In most projects, the player, generally the contractor, entrusted with scheduling draws up the schedule to cover his scope of work

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only. Activities relating to the scope of work of other players such as the Owner are ignored or abbreviated. It is very important to get an agreement from all stakeholders to provide meaningful and timely information to ensure that the total scope of the project is included in the schedule.

Scope of work is generally always understood to be physical work. Thus when an alternate is added, the need for additional time is appropriately recognized. However a lot of important effort such as coordination is not recognized as work. Often it is not identified as a schedule activity. Thus impact of delayed decisions from the Owner or the Architect may add to non material work. The industry needs to develop standards of practice in this area.

Equitable risk sharing and contingency management

Lack of a clear agreement of a risk sharing and contingency management plan can paralyze a project. While the schedule can effectively show the impact of risk events it is not the right vehicle for adjudicating risk or the use of contingency.

There is a substantial body of knowledge in court cases on dealing with and sharing of risks. But these are not widely known or understood by the people using schedules. For example how to allow for weather impacts in schedules is well established in court cases, but it is not understood by many schedulers, owners and other stakeholders.

One of the difficult issues both in scope and risk management is the fact that contracts are bilateral and do not adequately cover multilateral responsibilities for timely interaction and coordination on a job.

Means and Methods

It is important to stop being shy about scrutinizing the 'means and methods' of how the project will be administered. In current market conditions, the general conditions budgets are under severe cost cutting pressures. It is necessary to establish that the project is adequately staffed and is organized for success. The problem of staffing and organization may start with the Owner who may decide to retain scope for parts of the project and not have the adequate staff to carry out the functions in a timely function. The contractor must have adequate staff to manage procurement, submittals and coordination. The AE should be committed to providing timely approvals and RFI's.

It should be realized that the CPM scheduling effort needs to be supplemented and enhanced with supplemental tools for document control, logistics planning, cost reporting, change order control, Submittals and RFI management etc.

The industry needs to develop guidelines and standards for an effective project organization.

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Better Metrics and Communications

At the technical level, the schedulers talk about early and late dates, critical path, total float, variance, ownership and consumption of float and a host of other things that make very little sense to the decision makers at the business level. How do all these parameters relate to the business decisions that the Owner must take regarding project end date, cost, contingency and risk?

The industry needs to develop some guidance and educate the decision makers of the business impact of technical parameters. Thus if a decision is delayed, at the technical level it may be consuming float and generating variance but at the business level it may be increasing risk and cost.

A major deficiency today is in not establishing thresholds to determine when remedial action should be initiated and beyond which recovery is not possible. Too often the project manager will not acknowledge a problem and raise the flag in the hopes that the problem goes away. At the beginning of a project all parties should agree that if some observable intermediate milestone dates are not met the project is in jeopardy and corrective actions should be initiated.

All this calls for better all round education and training. While the scheduler and project manager certainly need the most thorough training, it is very important to train the more non technical business stakeholders in the managerial aspects of scheduling.

Triggering Action

Finally agreements for initiating action must be in place. Scheduling provides metrics of the health of the project and administrative setup but by itself cannot take preventive or corrective action to keep the project on track.

Making Business sense out of Scheduling

Finally, we come back to our original quest – does CPM scheduling add business value? What do we need to do to translate schedule analysis results to business decisions?

Project scheduling, done correctly, is not cheap and seems to be an early target for trimming down general conditions in the competitive market place. What does one lose when proper scheduling support is trimmed out of the budget? The quality of planning, the lack of metrics for progress tracking and taking corrective actions are all adversely affected. A big impact which is not obvious is the loss of flexibility to change and work around problems and do what ifs. Every impact tends to come associated with increased cost and time.

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In summary, we know that when properly executed, CPM scheduling can immensely improve the quality of planning, provide metrics for progress measurement and provide feedback on the health of the project. We must realize that these alone are not enough to keep the project on track. Corrective actions are needed and the stakeholders must have clear agreements on a variety of issues so that these actions are taken in a timely and cost effective manner.

There are no published data which correlate the quality of scheduling to cost and time impacts on the project. The industry needs to focus on developing some bench marks in this area.