Tweaking the Scheduling Paradigm

(\textit{The time of discontent with CPM is past})

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Human history teaches us, however, that economic growth springs from better recipes, not just from more cooking.

(Paul Romer, 2008)
Latest Instances of Discontent with CPM from the ENR Bully Pulpit

Eric Lamb, in a sequel to a theme that originated in 2003, states in “How to Fix a Broken Scheduling System”

“Schedules with an exhaustive level of detail in a CPM network try to predict day-to-day activities years in advance and are inherently flawed”

“For an industry striving to be more productive, the current state of scheduling practices is wasteful”

“Simply, we have created a monster”
In a prior ENR article “Dearth of Scheduling Software Expertise Still Bedevils Many Legal Cases,” Stu Ockman, alluding to a 2,900-activity schedule that had 928 constraints, lamented that

“The multiple constraints made finding the critical path for the project’s start and end dates impossible, not to mention the nearly 83 workdays of negative float they yielded. Lawsuits followed the project”
OFF THE CRITICAL PATH?

Experts debate the state of CPM scheduling

JAMES J. O'BRIEN
Project Management Consultant
Recalling the Article That Created the Genre

“What is described as a CPM schedule these days sometimes is not one at all”

“They say they see widespread abuses of powerful software to produce badly flawed or deliberately deceptive schedules that look good but lack mathematical coherence or common sense about how the industry works”
Scheme of Thought Influencing the CPM Meltdown

Planning is a sidebar to scheduling and can be accomplished by proxy (stakeholders are MIA and are replaced by a savvy scheduler).

Overly-detailed level 3 schedules that require too much effort and doubling down on scheduling software to attain a modicum of validity.

Use of constraints to supplant logic or to back into required dates.

Oh, about the weather, it’s in there!

Considering a baseline that completes on the contract date \textit{realistic}.

Critical path float on the whole is a first come, first served commodity.

Updates that rely on software shortcuts for actual progress.

No CPM calculations whatsoever left of the update data date.

A logic Gantt Chart is a somewhat useful way to display the network.

Anticipated owner or force majeure delay off the critical path within total float cannot justify an extension in the required completion date.
Tweaking the Planning/Scheduling Paradigm

1. The network is built and the schedule is generated in planning sessions that meaningfully engage all key project stakeholders
2. When building the network, forward planning and backward planning are used interchangeably and as appropriate
3. The baseline schedule is a separate level 2 network schedule that has priority and remains integrated with the level 3 schedule
4. Normal adverse weather planning factors production loss (i.e., incremental delay) when crews work through extreme temperatures
5. Planned dates are used in place of constraints wherever possible
6. The baseline is treated as inherently stochastic and is managed based on completion risk vs. based on the deterministic critical path.

7. Early completion established to support a 70%-80% probability of completing on time generates contingency, not surplus total float.

8. Every update incorporates the impact of force majeure weather.

9. Updates that algorithmically establish credible critical/near-critical paths left of the data date are potentially reliable forensic tools.

10. When predicting the impact of a delay on completion prospectively, the criticality index of the impacted path is a more reliable indicator than whether delay falls on the deterministic critical path.
1. Plan and Schedule in the Open, in Full View

Building the plan, with key stakeholders as active participants, takes place simultaneously with scheduling and it happens transparently.

The key deliverable is a level 2 schedule conveying logical flow at the facility-area and/or elevation level, with natural logic ties prevailing, yielding a non-complex schedule that project stakeholders can follow.
The “Smart-Wall Trick”

NetPoint with a projector and a clear wall is the base set-up

A Mimio (Bluetooth stylus) device is helpful if the facilitator is skilled with it.
Immediate Turnaround Is Crucial

If NetPoint is used, it is feasible to issue the schedule for group comment the day after the planning session ends, with the final deliverable, allowing for comments, within one week.

If Post-it notes on butcher-block paper are used, a week may be needed to validate the draft schedule (if any) that is available when the session ends.
E-Wall vs. Butcher-Block-Paper-on-Wall Planning

Diagram showing task timelines and dependencies for construction projects.

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2. In the CPM World, Networks Are Built *Forward*, Starting from the Project Start Event

Because CPM schedulers have fallen into the habit of building the network by adding activities and logic directly onto the computer rather than on a canvas, *push* planning is the MO.
GPM Was Conceived as a Method for *Switch-Planners*

Because GPM reverts to building the network on a canvas (albeit electronic & algorithmic), the planner can switch from push planning to *pull* planning when nearing completion of an area, system, or phase, and then switch to push planning to further advance the network.
Switch-Planning Entails Pushing Logic & Pulling Logic Interchangeably, as Appropriate

As a practical matter, there are situations where one of the three techniques better supports reducing the risk of logic errors

<table>
<thead>
<tr>
<th>Forward Planning</th>
<th>Pull Planning</th>
<th>Switch-Planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 executive schedules</td>
<td>Level 5 look-ahead schedules</td>
<td>When building a level 2 strategic schedule, a level 3 control schedule, or a level 4 working schedule, the approach switches to pull planning when nearing a key completion event</td>
</tr>
<tr>
<td>What activities follow a start milestone?</td>
<td>What activities precede a finish milestone?</td>
<td>Pulling logic is a more objective approach than pushing logic when vetting whether all predecessors to an activity are accounted for</td>
</tr>
<tr>
<td>What activities denote the start of a construction phase?</td>
<td>What activities denote the end of a construction phase?</td>
<td></td>
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3. The Level 2 Scheme of Thought

**Principle:** The Level 2 schedule is a separate network schedule that is largely developed through interactive planning sessions rather than by merely summarizing the level 3 schedule using filters.
**Level 2 Schedule Fundamentals**

**Level 2:** Time-scaled network, displayed in months, organized by area and/or elevation scheme within each building/facility according to the WBS context inherent in the drawings, and detailing activities needed to substantiate that the planning supports timely completion.

For each building/facility in the project, activities follow a structure similar to the standard classification in UNIFORMAT Level 2 or combine UNIFORMAT Level 2 groups, as in the case of MEP and interior finishes.
Attributes of a Sound Level 2 Schedule

Major project norms for physical work activities include:

- For each building/facility, 5-15 physical work activities per area/elevation scheme
- Activity durations range between 5%-15% of contract duration; generally, 6 weeks-6 months
- Activity duration time units are in weeks or half-months, and may integrate normal adverse weather impacts
- In some cases, low-value, large-total-float work may be detailed at level 1; on the other hand, high-visibility, critical/near-critical work may be detailed at level 3
Partial Level 2 Construction Phase Schedule
Displaying Physical Work Activities Only

Durations in Weeks
Another Sample Level 2 Construction Schedule
Displaying Field Fab and Physical Work

Durations in Months
4. Normal Adverse Weather Planning

The three most common fallacies in weather planning:

1. Normal weather is already suitably captured in *historical* activity durations

2. Anticipated weather days model only *downtime* due to normal weather

3. Let’s go with the state DOT or Corps standard applicable to the project site
All three premises overlook the following:

Besides the conventional half or full weather day when work at the site is stopped due to adverse weather, incremental delay (without crews actually stopping) accumulates when crews work less productively through extreme cold temperatures & windchill as well as through extreme hot temperatures & relative humidity.
## 5. Constraints—A Historical Perspective

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1957</td>
<td>Neither start nor finish constraint dates are envisioned by Kelley &amp; Walker, the original CPM developers</td>
</tr>
<tr>
<td>1959</td>
<td>Finish (no-later-than) constraint dates are a feature in PERT as originally introduced</td>
</tr>
<tr>
<td>1963</td>
<td>The IBM Project Control System (PCS) introduces specified start &amp; finish dates aka date constraints</td>
</tr>
<tr>
<td>1965</td>
<td>1st ed. of <em>CPM in Construction Management</em> makes no mention of date constraints</td>
</tr>
<tr>
<td>1966-1998</td>
<td>Except for O'Brien’s <em>Scheduling Handbook</em>, which acknowledges the PCS concept of specified dates, it appears that no CPM text—and there were plenty of them—dealt with date constraints</td>
</tr>
<tr>
<td>1999</td>
<td>5th ed. of <em>CPM in Construction Management</em> discusses the use of “artificial” constraints</td>
</tr>
<tr>
<td>2006</td>
<td>CPM texts begin to reflect the view that constraints may be hazardous to the health of the schedule</td>
</tr>
<tr>
<td>2009</td>
<td>The principle that the GPM algorithm preserves drift when planned dates are used was presented in “GPM®: A Project Networking Method Anchored on Objectbase Principles” at the PMICOS Conference</td>
</tr>
</tbody>
</table>
In CPM, to place an activity on a planned date—between early and late dates—a constraint or preferential lag is imposed.
Planned Dates in GPM

GPM was conceived so that placing an activity (i.e., start date) between the early start and late start is a natural proposition.

Because GPM allows activities to be scheduled between early and late dates without resorting to SNE constraints or preferential logic, drift is preserved and, therefore, total float is not sacrificed.
6. The Deterministic Baseline Is Treated as Inherently Stochastic

Because conventional schedules are inflicted by “optimism bias,” i.e., activity durations tend toward the lower end of their duration ranges, empirical data shows that it is not uncommon for a baseline schedule predicted completion date to at best correspond to a 25% probability threshold.

Stochastically speaking, this data translates to a 75% probability that the length of the as-built critical path will exceed the length of the initial-baseline critical path.
Thou Shalt Always Know the Probability That the Project will Complete by the Contract Date

For a construction contract, because the baseline schedule selected, when assessed for risk, should support a reasonably high likelihood of meeting the required completion date, an option is to upgrade the network from one that is deterministic to one that is stochastic.
The schedule is built relying on historical (formulaic) activity durations and, where duly vetted, on durations provided by the activity owners.

<table>
<thead>
<tr>
<th>If a database is used, it captures <em>normal</em> durations factoring production rates, e.g., steel tons/day, concrete CY/day, large bore pipe LF/day, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideally, distributional information (mean, mode, low/high) is included</td>
</tr>
<tr>
<td>For a <em>normal</em> baseline, a 70%-80% completion probability threshold is targeted for the required completion date, which typically causes the baseline to complete early</td>
</tr>
</tbody>
</table>
7. Tweaking the Early Completion Doctrine

In conventional scheduling, where the focus is on the critical path:

The gap between planned, early completion, and the required completion date is generally considered surplus critical path total float

Because the schedule is assumed deterministic, an argument ensues relative to who benefits from surplus critical path total float in the event of critical path delay
Early Completion When the Schedule Is Risked

When schedule risk is considered in establishing a deterministic baseline, the gap between planned, early completion, and the required completion date is not surplus total float; rather, it is schedule reserve measuring the interval between the two dates in the completion distribution function obtained in risk assessment.
Risk Approach to Generating Early Completion

The schedule is built as a stochastic model and is risk assessed:

For the baseline, early completion is the byproduct of risk assessment trials that culminate on a completion distribution function that supports the targeted completion probability threshold for the required completion date.

Risk assessments on real projects suggest that, for a normal baseline, a targeted completion threshold of 70%-80% entails early completion and schedule margin of 5%-15% of the length of the critical path.
Heuristics Approach to Early Completion

The schedule is strictly managed as a deterministic model:

Well-reasoned contingency heuristics established by experienced managers and planners are common substitutes for early completion and schedule margin otherwise determinable through risk assessment.

4%-8% of the length of the critical path, but at least 1 week, is a norm.

However reasonably determined, schedule margin is total float on the critical path solely for the contractor’s use.

Arguably, excess critical path total float is *shared* float as conventionally defined.
8. Common, Flawed Weather Statusing Practices

Assumption: no pre-contract study was made to establish anticipated weather days using the prior 10-year weather record

When every month closes, the number of workdays lost due to adverse weather is tallied up and reported without differentiating between normal and abnormal aka force majeure adverse weather

A *noticing* technique to preserve the right to a weather-related extension at the end of the contract
Assumption: the contract prescribes the number of weather days due to precipitation for each calendar month.

The owner may be exposed to an inflated weather delay claim should actual workdays lost due to weather account for all weather conditions, e.g., rain and snow, rain and snow recovery days, wind-caused down time, lost production due to extreme temperatures, etc.
### Tweaking Conventional Weather Statusing
Best Practices

<table>
<thead>
<tr>
<th>When working with a conventional deterministic schedule, every update is used to assess cumulative weather delay/gain that originates from <em>actual</em> weather losses in the prior month</th>
</tr>
</thead>
<tbody>
<tr>
<td>No later than the 5th calendar day of each month, an analysis is submitted documenting hourly weather readings (precipitation, wind speed, and temperatures) during the work shift for each workday during the prior month</td>
</tr>
<tr>
<td>A generally accepted methodology is applied to actual weather data to determine workdays lost and the corresponding force majeure weather days</td>
</tr>
<tr>
<td>Non-compensable weather days result from workdays lost when critical path work at the site was stopped due to force majeure weather</td>
</tr>
<tr>
<td>Depending on the extent of extreme temperatures, non-compensable incremental (vs. no-work) weather days on the critical path may result from crews reasonably working through force majeure weather (e.g., force majeure rain, cold temperatures, or hot temperatures)</td>
</tr>
</tbody>
</table>
Neither Kelley & Walker, the developers of CPM, nor Professor Fondahl, credited with the original development of precedence techniques, envisioned a data date in their algorithms.

Forensic Schedule Analysis, the AACE International protocol better known as RP 29, reminded everyone of the Achilles heel of the CPM algorithms when it acknowledged:

The concept of a data date must be used when evaluating delay.

The critical path and total floats can be computed by CPM only for the portion of the schedule right of the data date.
The CPM Update Dilemma

Because CPM updates can deploy neither the forward pass nor the backward pass left of the data date, it should come as no surprise that (in the CPM world) updates are unsuitable tools to evaluate delay in the past.

A consequence of passive (nonworking) CPM updates left of the data date is sloppy handling of out-of-sequence progress and possibly inaccurate actual dates.

A plethora of schedule analysis methods has been devised to overcome the fact that CPM updates can, at best, be reliable only right of the data date.
For every statused or rebaselined GPM schedule, the network is calculated to have a continuous critical path left of the data date (from the project start event to the data date)

For a GPM update, the *then-existing* as-built critical path is algorithmically calculated by the scheduling software, and it is continuous from the project start event to the first activity on the critical path right of the data date

Every activity on the as-built critical path has forensic drift = 0 and forensic float = critical path *float* right of the data date
Working with GPM Left of the Data Date

Because GPM calculates total floats as of 31 Jan 13 both before and beyond the data date, GPM algorithmically identifies the critical path left of the data date.

**Activities on the as-built critical path have drift = 0 & float = -6**
The *Then-Existing* As-Built Critical Path Principle

As total floats and the critical path change right of the data date, *forensic* total floats correspondingly change, and the as-built critical path is the critical path *then-existing* left of the data date for that update.
10. Emerging Delay *Forecasting* Principles

Where the scheduling approach is *deterministic* (conventional approach), the critical path (in the future of the data date) is assumed to be certain.

As the project progresses, for each update, this can be restated as the *then-existing* critical path is assumed to be certain.
Conventional Delay Forecasting Principles

Excluding early completion considerations, this assumption gives rise to the following conventional delay principles:

- A delay on the critical path equates to a day-per-day extension in schedule completion
- A delay off the critical path within total float does not impact schedule completion
- A contractor delay on the critical path may be construed as reasonable evidence of a potential contract breach, possibly justifying withholding liquidated damages
Delay Principles When the Schedule Is Instead Managed Based on Completion Risk

Where the scheduling approach is based on completion risk, any anticipated delay—on or off the deterministic critical path—may potentially impact the probability of meeting the required completion date depending on the impacted activity’s criticality index.
The likely impact of a delay on completion risk reflects the criticality indices then existing when the delay occurs rather than whether the delay falls on the deterministic critical path.

The likely impact of a delay on the required completion date is the interval between the required completion date and the date in the impacted schedule completion distribution that corresponds to the probability of completing on time on a but-for schedule scenario that collapses the delay.
Baseline: Bid/Award Steel Falls on the Critical Path, But Elec Equipment Path Does Not
Risked Update: Owner Delay Has a Likely 4-Day Impact, Bid/Award Steel Delay Has No Likely Impact

Completion Probability Update: 63%
But-for Scenario: 72%
The Time of Discontent with CPM Is Past

It has been a decade since Ockman, Plotnick, O’Brien & Wickwire jump-started the floundering CPM mantra.

It is highly improbable that the CPM paradigm will self-correct.

Rather than “slashing the monster” and reverting to level 2 schedules, a doubling down on complexity has become the endgame, i.e., yet more software to figure out where the analytics went wrong.

Not that Kelley & Walker need apologize for a soon-to-be sexagenarian method.
Ten years to the date from its inception and almost six years from its introduction to the profession, the GPM scheme of thought is proving a worthy successor to the CPM paradigm.

It is *back to the future*:

<table>
<thead>
<tr>
<th>Back to <em>seeing</em> the network on a time scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back to <em>social</em> planning &amp; scheduling</td>
</tr>
<tr>
<td>Back to <em>truth</em> in scheduling</td>
</tr>
</tbody>
</table>
Be that as it may, GPM and NetPoint, the software embodiment of the method, will only realize their full potential if embraced by planning-centric professionals, such as those attending this conference, to a level that ensures their continuing evolution.
The Four Stages of Acceptance

As stated by J.B.S. Haldane

1. This is worthless nonsense.
2. This is an interesting, but perverse, point of view.
3. This is true, but quite unimportant.
4. I always said so.


Korman, R. (2003). “Critics can't find the logic in many of today's CPM schedules.” Engineering News-Record, 26 May 03.


Thank You

Gui Ponce de Leon PhD, PE, PMP, LEED AP

Inventor of GPM® and Developer of Net Point® and NetRisk™

Truth in Scheduling®