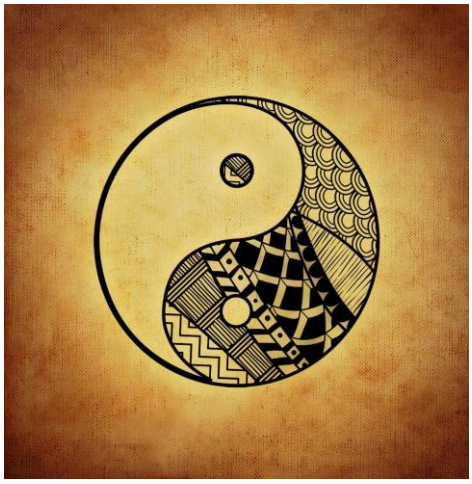
MILESTONE

Pull Planning
&
CPM Scheduling:
Counterparts Not Competitors



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Abstract

Over twenty years ago, when Lean Construction methods introduced Pull Planning or the Last Planner system, general contractors in commercial construction considered it the silver bullet to solve all their schedule issues. That did not come to pass. Why?

Pull planning was intended to be a better means of project planning and utilizing the CPM schedule. However, CPM scheduling was thrown out by those who had not given the method due diligence or appreciation—replaced by pull planning. Thus, a key tool of project navigation was lost.

There exists a need for both methods, operating together so that the master schedule reflects the pull planning efforts, allowing the communication to stakeholders more readily identifiable progress. Such comprehensive collaboration requires discipline, effort, and consistency for the desired results, the lack of which inspired the innovation of Lean Construction.

This paper outlines the roles of the Master Schedule, as developed using the critical path method vs. the roles of pull planning. It articulates the confluence of the two efforts and the need of both in unison.

Introduction

In the construction industry, scheduling has a critical role to play in project management. What that role should be to achieve successful project execution is up for debate.

There are two major methodologies of project planning and scheduling competing for the loyalties of contractors. The first is the critical path method scheduling used to create the master schedule or baseline project schedule. There is also the Last Planner® System, from which comes the pull planning technique.

The Last Planner System® involves the final planners of the work (the field superintendents and foremen) in collaboration and commitment to near-term upcoming work. It makes use of constraint identification to clear potential restraints from the ability to deliver promised work. Continuous learning is built-in by analyzing the variance between work promised versus work delivered, called the PPC (Planned Percent Complete), and identifying reasons for such variance (1).

Over twenty years ago, CPM scheduling became perceived by some in the construction industry (as demonstrated by the development of new scheduling methods happening then) to be an inadequate tool of project management for bringing projects to completion on time, within budget, and within scope (2). A large percentage of projects were suffering from completion delays, and the CPM scheduling method took the blame.

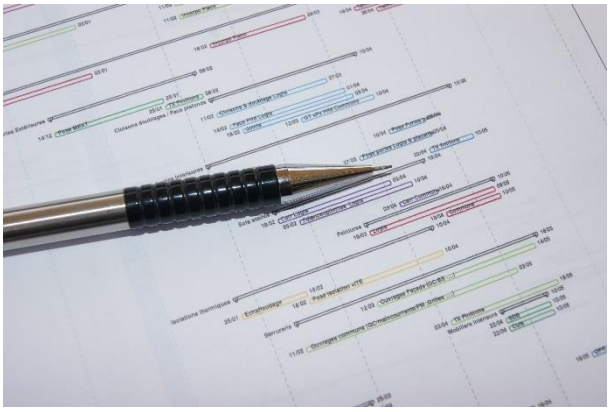
In response, the Lean Construction system was created in 1993 by the International Group for Lean Construction. The principles, borrowed from those of Lean manufacturing based on the Just-in-Time process developed after World War II during Japan's reconstruction by Toyota executive Taiichi Ohno (3 pp. 6,7). In 1996, the book *Lean Thinking* (James P. Womack, Daniel T. Jones 2003) brought this method

to the modern business world's attention (4).

Lean construction methods introduced **pull planning**. General contractors in commercial construction heralded it as the silver bullet to solve all their schedule issues. That did not come to pass because CPM scheduling was declared inadequate for project management. Pull planning, intended to be used in conjunction with CPM scheduling to improve project planning, replaced it.

There are contractors that swear by CPM scheduling and others that extol some version of pull planning as the answer to project execution troubles. However, this paper presents the thought that both complement each other and work best to affect project management success when used together.

This paper demonstrates the need for both, operating together in construction project management. Collaboration requires discipline, effort, and consistency for the desired results, the lack of which sabotaged CPM scheduling's usefulness and resulted in the development of LEAN Construction's pull planning. Pull planning alone is insufficient to consistently and proficiently deliver complex projects without a CPM schedule as a guide to achieve the targeted project's timely completion, within budget, and with quality of work.



The Role of Scheduling

Project scheduling serves multiple complementary functions for the project and the team. It is integral to the planning process. Scheduling results in time-scaled plans of tasks and a list of resources, including materials and equipment, needed to get such work done in the scheduled period. A well-developed schedule helps communicate the plan, thus resulting in a well-coordinated project. It is instrumental in reducing the stacking of trades and congestion in the area, effective deployment of equipment, and the strategic delivery of materials. All this is necessary for the efficient and timely completion of projects in time and budget (5).

Scheduling is more than a process to develop an approved fixed schedule, the master/baseline schedule. Action involves an ever-changing schedule that reflects project progress and specific schedules that capture details of a project's progress for different key project players and decision-makers.

Critical Path Method (CPM) scheduling and pull planning are two scheduling practices developed as tools in the 20th century to establish a consistent, adaptable process to assist in managing multiple and varied projects.

Historical Background

A glimpse into the history of CPM scheduling and pull planning helps us understand their purpose within complex construction project management. Insights into their perceived and actual benefits, as well as perceived and actual shortcomings, can be gleaned from their history. CPM scheduling came first, so its history will be presented first.

Critical Path Method (CPM) Scheduling

The history of CPM scheduling begins with a type of bar chart called the Gantt chart developed in 1908 by Henry Lawrence Gantt at the Philadelphia Naval Shipyard for transatlantic shipping schedules (6 p. 191). The Gantt chart was adapted for use with all types of projects, including the Hoover Dam in 1931 (7). Its shortcoming was its failure to show interrelationships between work-sequenced activities or possible imposed constraints involved between activities (8). However, it is still a useful project management tool often included in today's project management software (6 p. 191).

By 1956, project scheduling benefited from further attempts at improvements. Because the Gantt chart did not show the interrelationships of a project's scheduled activities, Dupont, a chemical company, and Remington Rand Univac, a computer firm, collaborated to produce the Critical Path Method to show these interrelationships (8).

Now, as then, the critical path represents the sequence of the most critical activities to be completed according to finish dates, beyond which delays would occur to the project's completion date. Each preceding activity on this critical path must complete before the successor activity can be finished. The critical path predicts the completion date of the project (8).

Since 1958, the CPM schedule has been a beneficial tool for project management when it is carefully planned, developed, and fully utilized. Still, in the 1980s, its effectiveness had become challenged by a lack of collaboration in planning and software advances that encouraged the misuse and trend toward minutia of unnecessary details (9 p. xxi). This trend opened the door for the development of its competitor—pull planning.

Pull Planning

In 1993, the International Group for Lean Construction coined *lean construction*, which refers to the industry, not the project phase. It is promoted as useful for each key participant in construction projects, such as owner, contractor, subcontractor, or supplier (1).

The Last Planner System of Production Control®, a method of pull planning developed by Greg Howell and Glenn Ballard, involves the last people to plan the work during collaborative planning and

scheduling sessions to realistically define the activities, duration, and hand-offs necessary to accomplish the most efficient and timely execution of the project. Pull planning is part of the Last Planner System (10), developed to support Lean Construction (11).

A Summary of the Basics of CPM Scheduling and Pull Planning

More than a peek at the history of these two practices is necessary to make a case for blending the two to empower project management with the means of timely completion within budget and also promote the quality of the final product. These benefits make a lasting impression upon the owner and end-users. Therefore, the next step is to present the basics of each, without which comparison is not possible.

Critical Path Method Scheduling

The basics of CPM are surprisingly simplistic. At its core, CPM scheduling is breaking down the work into measurable components called tasks or activities. These activities need two critical pieces of information for the successful development of a schedule:

1. The duration or how long an activity will take and
2. What needs to be done before the activity can start (also called the predecessors or preceding work)

To use CPM scheduling requires knowledge of both the duration and precedence of each activity. Laying the foundation for using the CPM requires entering the duration and precedence data for every detail-level activity (6 p. 111).

The activity manager, usually the expert responsible for the work, should supply this information for each detailed-level activity of the work breakdown structure. For the sake of practicality, establish a hierarchy of delegation, assigning a portion of the work breakdown structure (WBS) to an appropriate person, department, or vendor, who then supplies the needed information (duration and precedence) about the assigned portion of the WBS (6 p. 111).

Development and Rollout of the Project Schedule

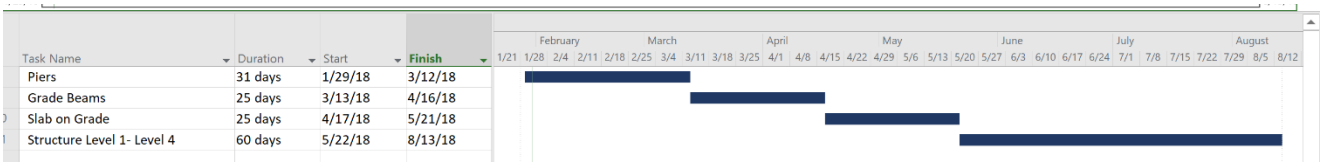
CPM scheduling is a method to document and model a comprehensive execution plan for the project. The CPM schedule built on established project management standards is useful for identifying critical and near critical work while providing the contractor with an effective way to level its resources. It also provides the means to track and document the project's progress, identify areas of risk, and develop alternative use cases on work execution. Impact analysis using CPM schedules is now broadly accepted as a valid analytical technique (12).

The critical path schedule should be developed at varying levels of detail based on the project phase. For this paper's purposes, the project's lifecycle is active once the owner has decided to move forward with it. The primary focus of the master schedule is design/pre-construction/construction.

For the general contractor (GC), the development of a CPM schedule will typically start during the pursuit of the project. At this stage, it is called a bid level schedule. The structure of a concrete frame hotel building will be an example of how the schedule may be successively detailed during the various phases of a project and how/when the concept of pull planning and the last planner system fits in.

Bid Level Schedule

A bid level schedule will focus on the feasibility and evaluation of equipment and workforce needs. The GC uses it to solicit sub-contractor bids and to get an early consensus of milestone timings. It is also used to demonstrate to the owner that the GC has invested thought and time into the project planning during the bid phase. The following is an excerpt example created using Oracle P6 of the level of detail in a bid level schedule for just the foundation and structure of a building:



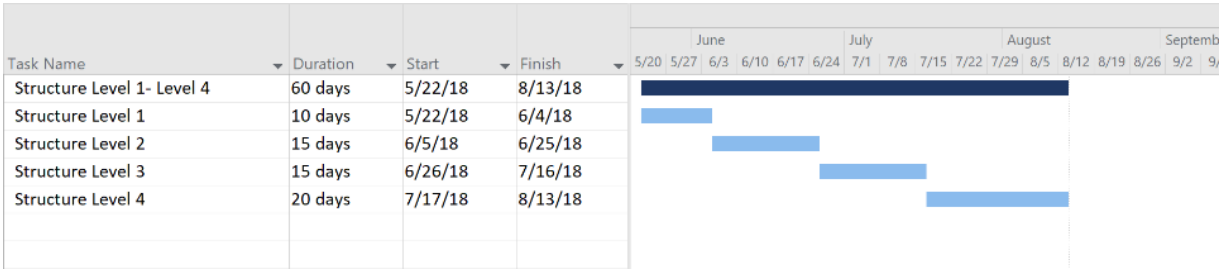
Task Name	Duration	Start	Finish
Piers	31 days	1/29/18	3/12/18
Grade Beams	25 days	3/13/18	4/16/18
Slab on Grade	25 days	4/17/18	5/21/18
Structure Level 1- Level 4	60 days	5/22/18	8/13/18

Figure 1-Bid Level Schedule Sample

Preliminary Schedule

As the scheduling process moves forward, if the project is not hard bid (or fixed priced), there will usually be a shortlist of companies invited by the owner to present their planning. At this stage, the GC will usually invest further thought and time into validating the bid schedule, detailing out possible challenge areas or areas and sequences where contenders believe they have innovated, adding significant value to the client. Such details and innovations differentiate them from their competitors.

Using just the one task, the example below shows how the bid schedule may be detailed further into a preliminary schedule.



Task Name	Duration	Start	Finish
Structure Level 1- Level 4	60 days	5/22/18	8/13/18
Structure Level 1	10 days	5/22/18	6/4/18
Structure Level 2	15 days	6/5/18	6/25/18
Structure Level 3	15 days	6/26/18	7/16/18
Structure Level 4	20 days	7/17/18	8/13/18

Figure 2–Preliminary Schedule Sample

Master/Baseline Schedule

Once the project has been awarded, the GC will have identified the project manager and superintendent. The baseline schedule is their attempt at refining the schedule. It will usually include input from the subcontractors that have already been bought-out (or contracted). This schedule will usually become a contractual document and becomes the baseline, or master schedule, to be measured against during the project's life.

During design, procurement, and construction, regular reports, and supplemental CPM schedules are made, which compare real-time progress with the master schedule.

Once again, using just one of the above tasks, the example below shows a subset of the details of a preliminary schedule to the master (baseline) schedule.

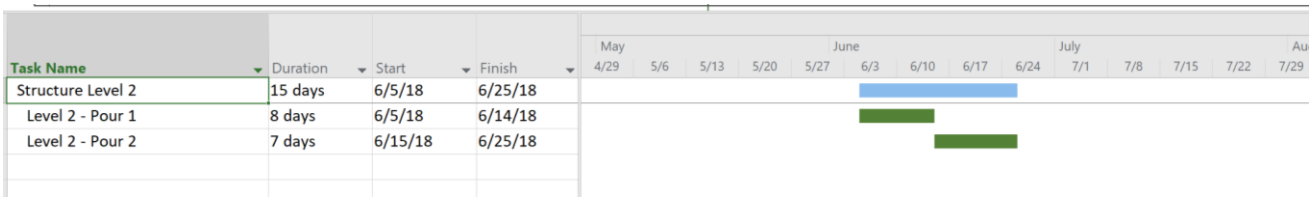


Figure 3–Master/Baseline Schedule Sample

Control Schedule

A control schedule is created using the concept of Lean Scheduling that details out 60–90 days at a time. It builds on the master schedule, mapping out in additional detail the coming 2-3 months. At this point, the pull planning system can be used to validate a phase of the project. By the time a control schedule is developed, the sub-contractor teams are usually in place, making this the perfect time to integrate the **master schedule** with the last planner concept.

Once again, using just one of the above tasks, the example below shows how activities in a master schedule are further detailed down to the level of a control schedule.

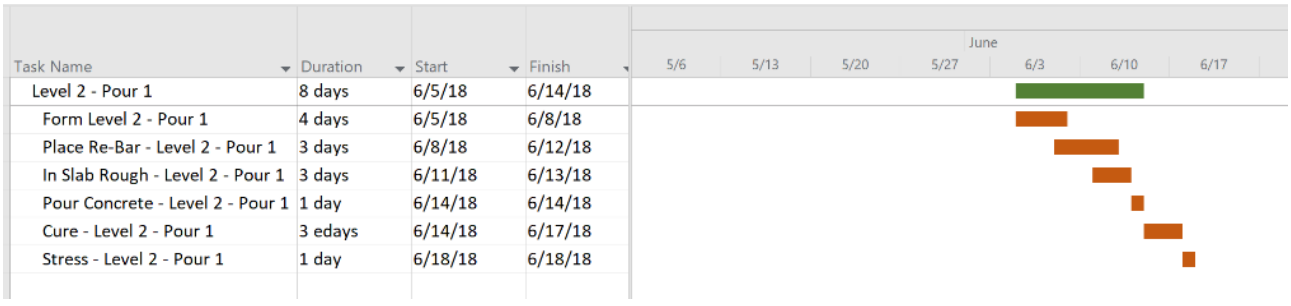
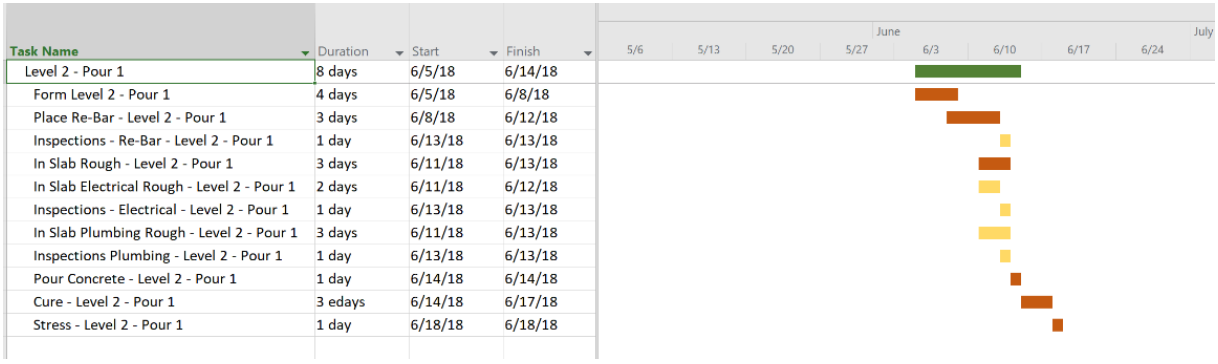


Figure 4–Control Schedule Sample

Lookahead Execution Schedule

The lookahead schedule should typically be a 4 or 6-week detailed forecast schedule. It is field-coordinated and can/should be used by the field superintendents and foremen to plan their day-to-day activities. This is an area where the pull planning system shines.

The Lookahead schedule provides an exceptionally structured way to detail out the work execution in a collaborative manner by the people that will be responsible for this work out in the field. The CPM schedule can and should do this irrespective of the use of the pull planning methods. However, such collaboration and structure require rigor and effort, which typical CPM (construction project management) in the construction industry has not usually accomplished. The current interest in the pull planning methods by the industry provides this to be the perfect opportunity to blend the two methods to allow effective results.



Task Name	Duration	Start	Finish
Level 2 - Pour 1	8 days	6/5/18	6/14/18
Form Level 2 - Pour 1	4 days	6/5/18	6/8/18
Place Re-Bar - Level 2 - Pour 1	3 days	6/8/18	6/12/18
Inspections - Re-Bar - Level 2 - Pour 1	1 day	6/13/18	6/13/18
In Slab Rough - Level 2 - Pour 1	3 days	6/11/18	6/13/18
In Slab Electrical Rough - Level 2 - Pour 1	2 days	6/11/18	6/12/18
Inspections - Electrical - Level 2 - Pour 1	1 day	6/13/18	6/13/18
In Slab Plumbing Rough - Level 2 - Pour 1	3 days	6/11/18	6/13/18
Inspections Plumbing - Level 2 - Pour 1	1 day	6/13/18	6/13/18
Pour Concrete - Level 2 - Pour 1	1 day	6/14/18	6/14/18
Cure - Level 2 - Pour 1	3 edays	6/14/18	6/17/18
Stress - Level 2 - Pour 1	1 day	6/18/18	6/18/18

Figure 5–Lookahead Execution Schedule Sample

These examples serve to give a general idea of how CPM, in conjunction with the pull planning process, is used to support construction project management. Of all the types of CPM schedules previously shown, the most critical is the Master/Baseline. Thus, it is necessary to give further details about the master schedule to identify its prominent role in CPM scheduling and establish its absolute necessity in project management.

What is the Master/Baseline Schedule?

The master/baseline schedule is the official project plan for accomplishing a project scope within an authorized budget and a specified period. The fully developed master schedule is the work plan for the total project and should include all work elements at a level of detail to adequately manage and monitor the project.

Although a defined master schedule is at times prepared as a part of project definition to assist with economic decisions, the focus of this paper is the design-build phase of the project; a time when such economic decisions have largely been made. Therefore, during the design-build phase, the master schedule is the principal guideline for execution (13 p. 166).

The master schedule is:

- A tool for planning
- A tool to assess project feasibility
- A road map of the project's planned execution
- A source of procurement and engineering information
- A guide of workforce anticipation
- The reference used for progress reporting
- A snapshot of the project's scope
- A budget reference tool
- A contractual requirement, and
- An excellent communication tool for all stakeholders of the project

The master schedule is the central point of reference for project management. CPM scheduling is a process that creates a package that includes the master schedule and supplemental schedules, which are used to measure the actual progress of a project and for analysis of delays or cost overruns.

With such a resource as CPM scheduling at hand, how could the commercial construction industry not grab hold of it with enthusiasm and seriously give due diligence and fully utilize it throughout the life of the project? The answer is that the perception of the CPM scheduling became corrupted.

The Corruption of the CPM Master Schedule's Perceived Usefulness

One factor that has contributed to this corruption is the fact that commercial construction has always had a love-hate relationship with the use of construction schedules. Since many sophisticated owners require it as part of their specifications, the GCs are forced to build a CPM schedule to meet contract requirements. Because of this, some GCs perceive that they are preparing the very tool that might be used to beat them over the head should claims arise, which they often do.

Another factor contributing to the fall from favor of the CPM schedule is the fact that the development of scheduling software, with all the bells and whistles, has provided the general contractor the means to buffer completion dates and alter schedules to the GCs advantage. Although this fact would seem to create a positive view of CPM schedules, the manipulation of the schedule creates false assurances to owners, inaccurate measures for real-time progress, and less motivation to develop accurate schedules that honestly represent the timeline of the project's execution. Without this accuracy, the schedule is not respected as a tool for management but merely as a tool for placation.

Thus, the CPM schedule became useful to fulfill obligations and support GCs' reasons for delay issues but is disregarded as an effective tool for project management. Without it, other methods of time

management and project planning have been sought to solve the plague of delays, cost overruns, and poor quality of work.

Shortcomings in the practices of the CPM schedule development process have also contributed to the corruption. The construction project is by nature fragmented. Construction teams are divided into groups by trade or purpose. The focus on each organization's abilities has caused teams to prioritize their own project goals, frequently in conflict with other teams working on the same project. The lack of performance to deliver projects is partly due to a lack of synergy between teams (14 p. 14).

Also, most contractors want their senior superintendents or the project manager to own the schedule. While this is an honorable intention, expecting a superintendent or a project manager to effectively work with a sophisticated tool to develop an accurate, detailed schedule model is a lot to ask. While they are excellent planners and builders, there is an impatience associated with putting the work into a technically viable model. Their resulting schedules provide a picture of the intent but do not respond to updates and impacts like a true CPM model. There is often overuse of constraints, missing logic, misuse of leads and lags, among other reasons, as pointed out in James O'Brien's "Off the Critical Path?" (15 p. 2).

In the industry today, most general contractors self-perform a very minute portion or none of the work; the project is subcontracted out to specialty contractors. Developing a schedule without the collaboration of each of these contractors is another key factor in the diminution of the CPM technique. Getting buy-in and assurance that the dependencies between contractors will be discussed and collaboratively resolved should become an integral part of the CPM schedule development methods. Various alternative means of planning and scheduling have emerged to answer this lack of collaboration, including pull planning.

With a lack of appreciation for the schedule, the role of the scheduler diminished to that of a schedule data entry specialist. There was a paradigm shift in the 1980s; an estimated 90% of seasoned professional schedulers had changed jobs, becoming project managers, procurement agents, field engineers, any position other than that of the scheduler (9 p. 20). Thus, these scheduling pioneers' skills, experience, and perspectives went with them to enhance other positions within the industry, leaving a vacuum of wisdom and perspective in CPM schedule development. This shift was partly due to the development of scheduling software and the idea that PMs could now fill that role as well (16).

Unfortunately, the scheduler's role became parceled out to random project team members because project managers are generally too busy with their primary responsibilities of managing project execution and putting out "fires." This distribution exacerbated scheduling and planning continuity and lessoned the reliability of the master schedule as a management tool for direction and control. In the wake of the CPM master schedule's failure to produce desired results, regardless of the true cause behind its failure, other methods arose to solve the project management deficiencies that resulted from its failure. Pull planning was a major contender as the solution.

Pull Planning

Lean construction took the existing principles of lean manufacturing and adapted them to the design and construction industry. It is involved with aligning universal improvements in every aspect of construction and the environment in a manner that minimizes cost while increasing the value provided to the project owner (1).

One of the core underlying principles is to get the subject matter experts (the superintendents and foremen) in the field, called the last planners, to come together and cooperatively work to deliver value to the project. Facilitating this collaborative environment can be a challenge if the right question is not being asked (17). What question?

Figure 6. Pull Planning Key Question (17)

This question is the basis for pull planning.

Every player's experience, talents, and skills are incorporated to isolate possible trouble and eliminate wasted time.

Pull planning requires a high degree of collaboration to be effective. The goal is to get the project's key stakeholders to identify the milestone or deliverable to be achieved and then work backward, identifying the constraints to be removed and work that needs to proceed. This process is worked backward towards the current date or the start of the project. It transforms siloed subject matter and working towards independent goals into working toward a common goal as a cohesive team. Every stakeholder's experience, talents, and skills are incorporated together to isolate possible trouble and eliminate wasted time (18).

Intended Role of the Pull Planning

Pull planning needs no trademark to be effective as our research later will show. Understanding its role will hopefully encourage its adoption within existing project management practices along with CPM scheduling.

The intention of pull planning:

- Identify milestones,

- Identify critical milestones,
- Put together a weekly plan,
- Review activities with crew leaders and evaluate what can be modified,
- Update and review activities weekly to analyze activities duration and prepare RCA if needed, and
- Update the schedule after reviewing activities and receiving feedback from the scheduler and all crew members (11)

It is important to understand that pull planning was not intended to replace CPM scheduling. There are some in the industry who, recognizing the need for CPM scheduling, considered pull planning to be a practice that ensures the proper planning of the project as well as the means to ensure the CPM schedule's accuracy and usefulness as a tool for communication of the project's progress (12).

Eventually, the goal of pull planning is to deliver a successful project for the project owner by collaboratively working as a team to identify and solve problems on the project (18).

Unfortunately, more than a few general contractors in commercial construction considered pull planning (which involved planning, planning, and more planning) to be the silver bullet to kill all the hairy project scheduling and cost overrun issues.

Limitations of Pull Planning

With all this planning, the silver bullet still failed to produce the results expected by the industry. The reason was that CPM scheduling was thrown out or under-utilized by some who implemented LEAN principles and some who did not. They basically broke the targeting sight off the planning rifle and were shooting without a means to aim accurately.

The lack of cooperative planning was a significant source of failure in projects using CPM scheduling, not CPM scheduling. Since pull planning had also often failed to deliver projects on time and within budget, it can be reasoned that all the planning in the world will not bring a project to completion efficiently without an effective tool of progress measurement and controls for project management.

Almost universally, construction projects are dynamic by nature. Plans are constantly changing due to the environment, site conditions, modified designs, substituted materials being among some of the reasons. Due to the nature of pull planning, such changes are difficult to analyze holistically.

The communication of a design change to a future construction flow is difficult to demonstrate using pull planning techniques. Pull planning does not allow for predictive analysis and metrics to be used for upcoming work (19). Along with such inherent limitations, the misperception of pull planning as a silver bullet has contributed to the challenges of bringing quality projects to timely completion within budget.

This paper does not intend to invalidate LEAN principles and practices, especially pull planning, because LEAN can make a difference when incorporated into construction management. A study by McGraw Hill

Construction showed that 62% of general contractors surveyed had implemented at least one LEAN practice, and pull planning was used by 39% of the 62% (20 p. 1). These 62% experienced the following benefits (20 p. 3):

- Higher Quality Construction – 81%
- Improved Safety - 75%
- Greater Productivity – 74%
- More Focus by Supervisory Staff on Managing Workers – 61%
- Greater Profitability/Reduced Costs – 58%
- Improved Lifecycle Costs/Cost of Ownership – 49%

With all these benefits, denial of pull planning as a worthwhile addition to project management would be imperceptive or biased. This paper contends that pull planning may not be a silver bullet, but it is one shotgun shell loaded into a double-barrel shotgun. The other shell is CPM scheduling. When using both together, it is much more difficult to miss target dates and budgeted costs than using just one or the other, or worse—nothing at all.

Using CPM Master Schedule and Pull Planning as Counterparts

Since the virtues and inadequacies of both CPM scheduling and pull planning have been expounded upon, the time has come to show how they complement each other. The graphic below demonstrates how scheduling aids project management and whether CPM or pull planning meets each role criterion. Where both meet common criteria, how they do so is specified to show how these methods work together. Where each might fail to fulfill some criteria, their compatibility is demonstrated in that, together, all criteria are met.

Role of Scheduling	Critical Path Method	Pull Planning
Facilitate project planning	**Design and development of schedule gives focus to the intent of the plan**	**The collaboration required during planning session promotes accuracy in schedule**
Facilitate collaboration of key		✓

project players		
Facilitate project feasibility assessment	✓	
Map out the project's planned execution	**Documentation of execution**	**Collaborative meeting of key players to create accurate timeline of necessary activities to be executed**
Create a resource of procurement and engineering information	✓	
Facilitate project progress reporting	**Measure & Document**	**Collaborative meetings of key players to report and examine progress**
Communicate details of project execution to all stakeholders of the project	✓	
Present a snapshot of the project's scope	✓	
Manage the overall project for timely completion (19)	**Map, measure, document**	**Collaborative Meetings for Planning, Progress, and Solution**
Determine which activities are critical (19)	✓	✓

Communicate to resources mobilization, work performance, demolition, and demobilization dates (19)	✓	
Manage activity of internal resources (19)	✓	
Manage and coordinate sub-contractors (19)	**Documented list of subs, timing & location of their activities and manpower**	**Subs participate in collaborative meetings on when and where who will do what and how.**
Coordinate with clients, owners, or end-users (19)	✓	
Manage a time-phased budget (19)	✓	
Predict milestones & completion dates (19)[16]	**Determined by PM, Scheduler &/ or others, documented in appropriate detail & made accessible to all stakeholders**	**Determined by Collaborative meeting of key players,**
Fulfill contract requirements for schedule provision (19)	✓	
Manage change (19)	✓	✓
Control time-related costs (19)	✓	
Avoid, defend, or document claims	✓	
Facilitate risk management	**Measure progress and notate**	**Collaborative Meetings**

	delays & potential risks	of Key Players to Facilitate Innovative Solutions to delays & risks
Track, document, and share lessons learned	✓	

Table1-Role of Scheduling Comparison Chart

This chart demonstrates where both CPM and pull planning benefit project management. There are real benefits to integrating and implementing these systems. Planning the project in a collaborative team environment with the key stakeholders should start during the early phases of the project. This allows early identification of constraints and key areas where detailed coordination may be required. This effort needs to continue throughout the lifecycle of the project using daily huddles and weekly planning sessions. It is important to instigate continuous learning by tracking variance and identifying reasons that promised objectives are not met. This allows for group discussions on ways to eliminate the rocks and allow for project success (12).

Note that most project management teams find it difficult or time-intensive to integrate both practices. While modifying the CPM schedule at each planning session and integrating the changes from a pull planning session to a CPM schedule might seem like a challenge, a structured way of successively detailing out the schedule, as described earlier in the paper, goes a long way in smoothly integrating the two practices.

Conclusion

This paper has shown that scheduling has a critical role to play in project management for construction. However, the construction industry has multiple scheduling practices, including no practice, of assigning dates to project activities or coordinating equipment resources, supplies, and labor with activities throughout the project life.

Two competing scheduling methods developed to meet this role were identified: Critical Path Method scheduling and pull planning. A brief history of the critical path method scheduling and pull planning was given to introduce their development and adaptation for use in multiple industries, including construction.

Each practice was summarized, revealing strengths and weaknesses in their ability to facilitate successful project completion. The weaknesses and perceived weaknesses of CPM turned out to be a catalyst for the development of pull planning. Pull planning's weaknesses led to disappointment in the hope that it would be the silver bullet to end the many delays and challenges to the industry. It is the failure of the method to do so that has given motivation for this paper to promote the use of both methods to get the best results in scheduling.

The paper then graphically demonstrated those strengths and weaknesses to be complementary in fulfilling the role of scheduling in construction project management.

While some contractors swear by CPM scheduling and others feel that some version of pull planning from Lean Construction principles is the answer, this paper presents the thought that both complement the other and work best to effect project management success when used together.

The paper has thus established the need for both types operating together on a construction project so that the master schedule reflects the collaborative efforts of pull planning, and progress is more easily identified and communicated to all stakeholders. When integrating the two methods, keep in mind that collaborative planning requires discipline, effort, and consistency for the desired results, the lack of which sabotaged CPM scheduling's usefulness. A continuation of missed finish dates and cost overruns by those in the industry who rely upon pull planning suggests that it is insufficient to deliver complex projects without the direction of CPM scheduling for perfect aim in achieving the targeted project's timely completion, within budget, and with quality of work.

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