

Title: Construction CPM Network Requirements and Characteristics

By: Zoltan Palffy Jr.

Abstract:

What Makes a Good Schedule? There are many things to consider when developing or reviewing a CPM schedule. What things should be incorporated into a schedule when developing or reviewing a schedule?

This paper will provide a guideline as well as the rationale for the user to follow when creating or reviewing CPM schedules for large scaled construction projects.

- All activities have at least one appropriate predecessor and successor. Only “Start Project” and the “End Project” are open ended. The entire CPM schedule must be tied together as one cohesive entity.

If an activity does not have a predecessor the Early Start date will be the project start date or the data date whichever is later in time. For projects without a Must Finish By date, activities without successors are assigned a Late Finish date equal to the latest calculated Early Finish date. If the project uses a Must Finish By date then the Late Finish date will be assigned to this date.

In essence if an activity does not have a predecessor or a successor the float values will be incorrect. Float values will be too large since the backward pass will erroneously begin at the project completion date.

- The CPM schedule must model the Design-Access-Material-Manpower constraints inherent to construction projects.

Design - Construction design documents must be timely available to the contract trades for them to develop and submit shop drawings and to put work in place. Excessive RFIs (requests for additional information or clarification) may indicate that the design documents are insufficient. Until the trades can work productively and efficiently (without interruption) - they may resist bringing manpower to the project.

Access - The trades must have efficient access to the work. If trade workers do not have efficient access to their work, or if materials cannot be efficiently located to the work areas, the trades will tend to avoid working in those areas. In-adequate crane “hook time”, insufficient load/unload areas, excessive trade collocation, improper trade sequencing, insufficient scaffold / man-lift planning can lead to access inefficiency. Until the trades can work productively and efficiently - they may resist bringing manpower to the project.

Material - must be timely available. Shop drawings prepared, accepted, materials ordered, fabricated and delivered. Until the trades can work productively and efficiently (without interruption) they may resist bringing manpower to the project.

Manpower - Sufficient and appropriately skilled manpower must be available. Note however that unless the design, access, and material requirements are met, manpower alone is insufficient.

Efficient progress cannot occur unless all four key elements (Design-Access-Material-Manpower) are adequately addressed. All four are directly related to each other. If one element is adversely affected, another may also be negatively impacted. It is essential that these four elements are available when creating a CPM schedule.

- The CPM schedule must be able to model subcontractor contract obligations.

Usually the Prime contract obligations transfer a host of items to their subcontractors. Some of these as they relate to the schedule usually are payment, warranties, extras, time requirements for performance, suspension of performance, termination of contract, claims, and dispute resolution.

The schedule should include the entire scope of the subcontractors as well as the prime contractor and all work should be scheduled to complete within the given contractual completion date by ALL parties.

- Must be able to indicate work flows (crew movement requirements).

Crew Flow Activity is a series of scheduling activities that are linked together that apply to a specific area or type of construction. Crew Flow logic is applied when these areas exist in several locations within the Project to develop a sequencing (or Flow) of the similar areas or types of construction.

The use of Crew Flow maximizes resource efficiencies and coordination for all trades. By using a Manpower “S” Curve Analysis for Crew Flow Activities adjustments to activity sequencing can be performed to acquire the ideal manpower S curve.

- Schedule activities should be capable of occurring without interruption from other activities.

If the activity will need to stop so that other trades can work, then resume; then the activity should further detailed into additional activities to prevent this.

- Activities can be measured in terms of units or a commodity i.e. (1000 LF of small conduit, or 400 LF of large cable, or 650 Light Fixtures, etc.) or man-hours.

In order to determine the duration of the activity it is necessary to be able to measure the activity to know some type quantity for that activity. It is necessary to know how much of something there is before a determination can be made as to how long it is going to take to perform that task.

- Construction activity durations should not exceed 21 working days.

Typically on large projects a reporting period is 1 month which is typically 21 working days. If an activities duration is too long then it would be difficult to estimate the remaining duration when statusing the activity. Using 21 working days as a guideline forces the schedule to be broken down into meaningful, trackable, and measurable activities. This does include long lead time items such as procurement items.

An exception to this is when developing the schedule using a [rolling schedule especially](#) in a Design/Build environment when the finishes have not yet be determined.

- Relationships are Finish-to-Start, or Start-to-Start AND Finish to Finish. SF relationships are not used.

Typically only Finish-to-Start, or Start-to-Start AND Finish to Finish relationships are used in a construction schedule.

- Negative lags (leads) should not be used in a schedule.

There has been a lot of debate over the use of negative lags in a CPM schedule. The use of negative lags provides incorrect float vales. There is no such as going backwards in time. Anything that can be modeled with a negative lag can be modeled with a positive lag. Negative lags, or leads, are counter to schedule flow and can make it more difficult to analyze the Critical Path. It is difficult to trace back a schedule path that has a negative lag. This may also indicate that the schedule does not contain a sufficient level of detail.

- The typical chain for long lead time items and major material deliverables should be identified as separate activities in the schedule.

Activities for Submittals, Review/Approval, and Procurement time that support the installation of the item should be clearly identified so that they may be tracked to ensure that the entire process supports the installation or need by date.

- Relationship Lags should do not exceed the Predecessor Duration.

Typically the relationship lag should not exceed the duration of the predecessor. When this occurs it results in an unintended non-overlapping activity. For example an activity that has a duration of 10 working days and a successor relationship to another activity with a start-to-start relationship with a 5 day lag. The intent is that half way through the first activity the second successor activity can start. If this lag is greater than 10 days this relationship in essence has changed into a finish-to-start with a lag which was not the original intent of the relationship lag. This often happens when a schedule is created then for whatever reason the person decides to reduce the original duration but does not look at the lag duration to its successor.

- Weather sensitive work is properly assigned to a “Weather Sensitive Calendar”. Anticipated adverse weather is programmed into the CPM network calendar.

Often there is work that must be performed outdoors. This work can be subject to temperature, moisture, freezing and a host of other restrictions. Any work that is weather sensitive should be assigned to a weather sensitive calendar.

The number of Monthly mean Anticipated Adverse Weather days is typically calculated based off of historical data that can be provided by National Oceanic and Atmospheric Administration (NOAA). This calculation is based on geographical locations and will list the Monthly Anticipated Adverse Weather Delay Work Days. This is often listed in the scheduling specification.

When creating a weather sensitive calendar the number of Monthly Anticipated Adverse Weather days should be indicated as non-working days on a month by month basis.

- Contract finish milestones are calculated using a Finish On or Before constraint.

In order for the backward pass schedule calculation algorithm to work properly any contractual finish milestones should use the Finish On or Before as its Primary Constraint type.

- The “As-Planned” CPM network is based on conditions known on bid-day.

When creating the As-Planned Baseline CPM schedule only the information that was known on bid day should be considered when creating the schedule. The As-Planned CPM network represents the contractor’s plan for prosecuting the scope of work known as of bid day. In some cases the project CPM network is developed several weeks after NTP is issued. It is imperative that the CPM network development team build the as-planned CPM network with “blindings” on, so that information received after bid day is not incorporated into the project plan. For example, the contractor may find out after

the bid date that the soil on site is contaminated. The additional time for removal of the contaminated soil must not be included into the Baseline As-Planned CPM network. Without a Baseline As-Planned CPM network as a reference point, the time impact for the added scope of work (contaminated soil) cannot be accurately measured.

- Obtain input and gain formal commitment (buy-in) from all project team members (foreman, superintendents, etc).

It is imperative that there is formal buy-in from all parties involved in the project. It is nearly impossible to hold someone accountable for something that they have never seen, reviewed, or agreed to.

- All stakeholders are committed to one active contract CPM network. Separate “Owner” and Subcontractor”.

There can only be one agreed to Project Schedule and there should not be different schedules floating around. This will only cause confusion amongst all parties involved.

Additional Guidelines

Another guideline to adhere to is the Defense Contract Management Agency (DCMA) 14 Point Schedule Metric. This is another way to make sure that the schedule meets certain standards. The DCMA 14 Point Schedule Metric uses certain guide lines, thresholds, and criteria as standards that every schedule should strive to meet.

These 14 points can be broken down into 2 distinct categories, Quality and Performance. This paper will briefly discuss the Quality aspect category.

DCMA

<u>Point #</u>	<u>Description</u>	<u>Explanation</u>	<u>Pass or Failure Threshold</u>
1	Logic	Counts the number of Activities missing a predecessor or missing a successor	Must be Less than 5% of the total number of activities
2	Leads	Check for Negative lags	Must Be Zero
3	Lags	Checks the Total Number of Activities with a lag	Less than 5% of the total # of activities should have lags
4	Relationship Types	Checks the number and types of FS predecessor relationships to the Total number of Relationships	At least 90% of the total predecessor relationships must be of the Finish to Start type
5	Hard Constraints	Checks the number of constrains being used in the schedule (does not include Milestones & finish as late as possible is not a hard constraint)	Less than 5% of the total # of activities should have hard constraints

DCMA

<u>Point #</u>	<u>Description</u>	<u>Explanation</u>	<u>Pass or Failure Threshold</u>
6	High Float Values	This counts the number of Total Activities with high Total Float values	High float values where float is greater than 44 working days. Must be 5% or less of the Total Activities
8	High Durations	This check looks for activities with too large (or 'high') of a duration	5% or less of the Total Activities having less than 44 working days of duration.
10	Resources	This test is intended to verify that all tasks with durations of at least one day have dollars or hours assigned	Must Less than 5% of the total # of activities

There is also the GAO (General Accounting Office) of the US Schedule Assessment Guide here is the link.

<http://www.gao.gov/products/gao-16-89g>

In summary there are many different guidelines that can be used to determine the overall quality of a schedule and what makes a good schedule. This paper pointed out several basic items to consider when creating a schedule or when reviewing a schedule.