

CONSTRUCTION

and Materials

TIPS



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**Project Schedule
Development Guide
Using Critical Path
Method (CPM)**

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Introduction

This article is intended for contractors and department personnel. The purpose of this article is to provide guidance for monitoring project schedules and analyzing scheduling impacts with a spirit of partnership.

This article provides tools for scheduling projects using the critical path method (CPM), however, the general techniques may also be employed for projects using a bar chart. The following techniques are recommended to foster a spirit of partnering with contractors using the CPM schedule and on projects without a CPM specification.

Schedule Basics

To develop a full understanding of the schedule by all parties, the project schedule should include all activities necessary for successful completion of the project.

Activities should include:

- actual construction operations in the field;
- delivery and approval of all submittals impacting schedule;
- any required materials or mix design approvals;
- procurement of significant materials and equipment furnished by the contractor, supplier, or the department which might impact the schedule;
- activities performed by the department or third parties such as ROW or utilities;
- interim milestones or specific scheduled activities in the contract where completion of specific portions of the work may be required at specific times and may include incentive and disincentives.

The following **categories** of work should be considered:

- **Mobilization** includes field offices and temporary access roads, utilities for construction, construction equipment, surveys, site testing, concrete plants, etc., and can occur at any time.
- **Construction** includes all field construction activities organized by sequence of construction that follows the traffic control plan.
- **Start-up** and **Testing** include vegetative watering, maintenance and performance periods, etc.

Activity Durations

Activity durations should consider:

- *idle and non-productive time* associated with the movement and setup of equipment and expected downtime;
- *special conditions* associated with the project and supplier production capacity;
- *estimated available resources* which include labor, materials, equipment, subcontractors and suppliers;
- *planned resource productivity* based on anticipated site conditions.

Activity durations should be estimated based on available resources, anticipated production rates and unique project conditions. Activity durations should be calculated by dividing a quantity of work defined in the plans by a production rate. Production rates should be defined as planned daily average production with consideration to available resources, the work location and the work environment.

Activity Relationships

The activity relationships (logic) are critical to the development and maintenance of the schedule. Changes in schedule logic after the project’s baseline schedule is established should be avoided whenever possible.

If a change in logic is required, the contractor should inform the department of the changes. From time to time major changes that are made to the schedule and agreeable to both parties will require a change to the schedule logic.

Activity Coding

Activity coding can be an essential part of facilitating an understanding of the schedule by all parties.

Best practices for activity coding include: traffic control phase, location, work type, etc. An example of activity coding can be found in the following table.

Table 1. Activity Coding Examples

CODE TYPE	EXAMPLE VALUES
Phase	Phase 1
	Phase 2
	Phase 3
Area	Left Frontage Road
	Right Frontage Road
	Left Mainlane
	Right Mainlane
Location	Specific Intersection on the project
	Specific ramp of the project
	Specific structure on the project
	Roadway Station to Station
Responsibility	Prime contractor
	Subcontractor
	Supplier
	TxDOT
Work Type	Project-wide
	Excavation and Embankment
	Base
	Storm Sewer
	Utilities
	Paving
	Retaining Wall
	Bridges
Traffic Signals	

Activities should be coded in the following format:

- An alphanumeric designation system tied to the traffic control plans.
- Each activity has a concise description of the work.
- Organized plots of the schedule may be produced.

Project Calendars

Lost days due to weather should be addressed with the project calendars. For calendar day projects, normal production rates should be used. The anticipated weather is addressed by use of the calendars. Actual weather on the project should be addressed in the calendars and entered as they occur. A hammock activity and calendar should be included to reflect contract time.

Multiple calendars should be used for the various work activities. The following table displays best practices for calendar usage.

Table 2. Project Calendars

CALENDAR CODE	CALENDAR TYPE	DESCRIPTION
0	Global Calendar	Includes holidays only
1	Dirt Work	Includes rain and “too wet” days
2	Bridge Work	Includes rain days
3	Curing	24/7 calendar
4	Asphalt	Includes asphalt season
5	Seeding	Includes growing season
6	Project Specific	An example might be non-work periods around retail center
T	Contract Time	Models how time will be charged

Schedule Logic

To develop the project schedule logic, a critical path should be established. Critical path is defined as a logical sequence of critical activities in a project that impact the project completion date.

To facilitate partnering as impacts occur, the following best practices should be followed:

- ➔ Networks should have a beginning milestone and an ending milestone to tie the schedule together at the beginning and end of the project.
- ➔ Start and finish milestones will be connected with a hammock(s) with one calendar corresponding to contract time.
- ➔ Excluding hammocks, the majority of all activity relationships should be finish-to-start relationships.
- ➔ Whenever possible, constraints and negative lags should not be used since these may alter the true critical path and activity float values.
- ➔ The use of positive lags should be minimized to the extent possible. Avoid or limit the use of constraints and negative lags.

Schedule Updates

Schedule updates should be submitted on a monthly basis. The data date is the 1st of the month, to show the progress through the last day of the previous month or the cut-off date of the monthly pay estimate. The status of every activity should be determined when making schedule updates.

The schedule update for each activity in the schedule includes:

- ➔ **Actual Start Date** - The day when work on an activity is actually started with the intention of completing the activity. It is not necessarily the 1st day that any work was performed on the activity.
- ➔ **Percent Complete** - Depends on the method used to estimate the activity’s original duration, either by work-in-place, time expended (when the activity is based on time only), cost incurred or resource used.
- ➔ **Remaining Duration** - Typically, this is calculated by the software when a “Percent Complete” is determined by the “Remaining Duration.” However, if an activity is believed to take much longer to complete than what the remaining “Percent Complete” dictates, the relationship between “Percent Complete” and “Remaining Duration” can be removed from the schedule, or a succeeding activity can be created with a duration to match the realistic “Remaining Duration” of the original activity.
- ➔ **Actual Finish Date** - Like the “Actual Start Date,” the “Actual Finish Date” may not be the last day on which work

on an activity is performed. The activity can be substantially complete when minor or remedial work remains and successor activities can start without being hindered by the remaining minor work on the predecessor being updated. If the remedial or remaining work of the predecessor is of concern, the activity then can be split to show the original activity as complete and the remaining work as its successor.

Schedule Revisions

Changes are inevitable. A schedule can be revised between “Schedule Updates” in a number of different ways, including:

- adding and deleting activities and logic relationships between activities;
- modifying durations on activities that have not started;
- decreasing percent complete or increasing remaining durations to activities in progress;
- changing the project calendars;
- adding constraints to activities and milestones;
- inserting delays and unplanned events; or
- changing from progress override to retained logic or vice versa.

Because “Schedule Revisions” alone can impact the critical path and the project completion date, the schedule should be run first with the revisions using the previous data date. By using this procedure, the true impact of the changes can be noted and submitted to the department. This allows all parties to fully understand the changes. A copy of this schedule should be provided with the “Schedule Update.”

Next, the “Schedule Update” should be run with the incorporated revisions and the new data date. This will facilitate discussion of any delay or gain caused by the schedule changes.

If the monthly “Schedule Update” contains both progress updates and revisions, the engineer may request the following: 1) perform the progress update first, 2) note the project completion date, 3) save a copy of the schedule, 4) incorporate the schedule revisions, and 5) run with the same data date.

Finally, we do not encourage changing activities using previously used activity identification numbers. This makes schedule analysis more cumbersome when comparing different updates.

Schedule Narrative

Each schedule submitted should include a brief narrative. A narrative is intended to outline: 1) key points and factors in the schedule and 2) changes made since the last update.

The purpose of the narrative is to facilitate communication on the project regarding the status of the project schedule and identify impacts as early as possible. For these purposes, the narrative should address the following:

- a brief description of the physical progress during the update period;
- plans for continuing the work during the forthcoming report period;
- actions planned to correct any behind-schedule activities;
- an explanation of potential delays or problems and their estimated impact on performance, milestone completion dates or overall project completion date;
- alternatives for possible schedule recovery to mitigate any potential delay or cost increases; and
- if a potential impact is identified that could result in additional costs, the potential impact should be included in the narrative. However, in accordance with the contract, the contractor must submit a separate Request for Additional Compensation to comply with Article 4.4.

Further guidance regarding resolution of disputes and the change order process can be found at the [Construction and Materials Tips](#) Web page.

Contact Information

If you have any questions about the contents of this article, please contact Ken Barnett, P.E., at 512/416-2456.