# BASICS OF CPM SCHEDULING

June 28, 2016
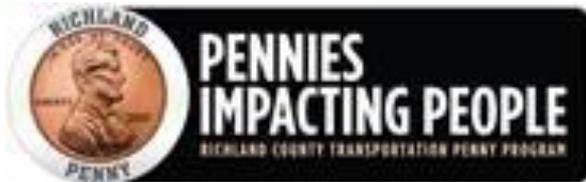
BASICS OF CPM SCHEDULING

Today's Agenda:

- What is CPM Scheduling?
- Why & When is it Needed
- What's Your Role in the CPM Schedule?
- Basic Components of a CPM Schedule
- Proper Scheduling Principals, Rules, and Techniques
- The Critical Path Method Schedule
- Understanding the Output
- Resource/Expense Loaded Schedules
- Computerized CPM Scheduling and Analysis
- Final Dos and Don'ts
- Glossary of Terms

CPM - Critical Path Method

A network analysis technique used to predict project duration by analyzing which sequence of activities (which path) has the least amount of scheduling flexibility (the least amount of float). Early dates are calculated by means of a forward pass using a specified start date. Late dates are calculated by means of a backward pass starting at a specified completion date (usually the forward pass's calculated Project early finish date).
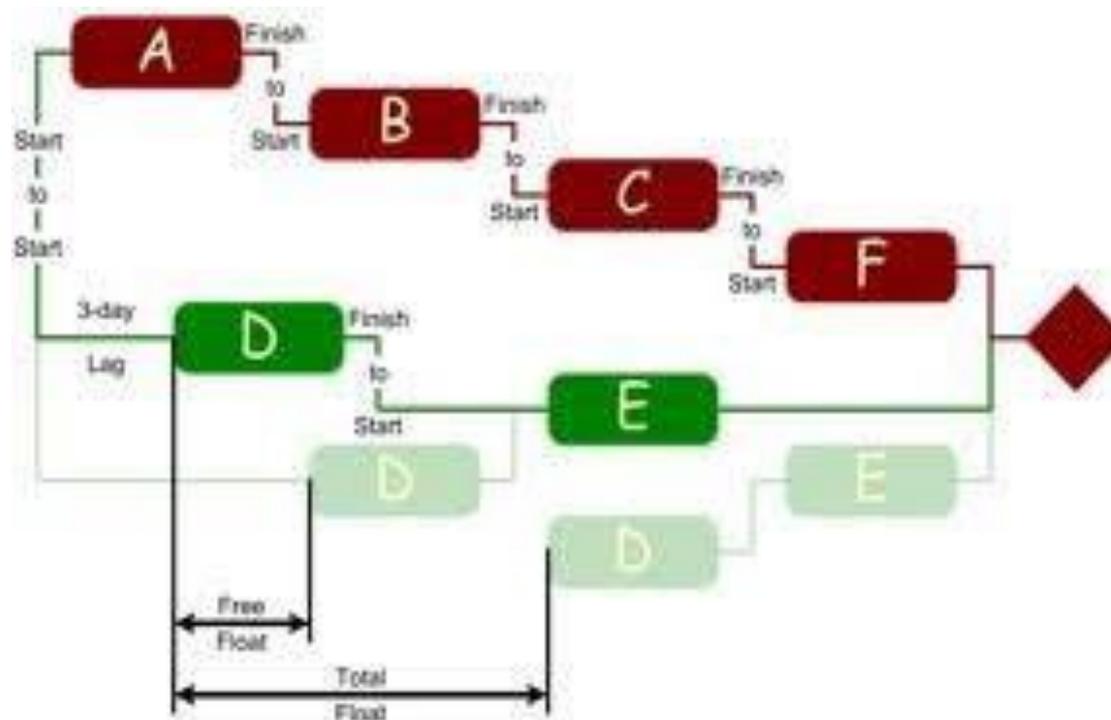
What is CPM Scheduling?

Art, Science, or Bull

- Some in our industry characterize scheduling as a "modern-day art form", "a loose construct of ideas and principles which are masterfully applied to overcome obstacles and to complete the job."
- Underlying premise is that projects are complex beyond predictability - intuitive genius is the essential element needed for success.
- Others take a decidedly scientific view, as if all factors could be "predicted and every alternative charted in advance."
- "Scheduling is cut and dried ... Check the status ... Review the plan ... Move forward."
- Still others see scheduling as pure bull.
- "Lengthy reports and fancy charts."

What is CPM Scheduling?

- Critical Path Method (CPM) scheduling is just another tool in the company's, project manager's or engineer's toolbox used to develop project schedules.

- The basis is to a single, deterministic start and finish date for activities based on specified, sequential logic.

- The focus of CPM is on calculation of float in order to determine which activities have the least scheduling flexibility (the schedule's critical path).

Why Do We Need CPM Scheduling?

- It keeps people and projects on track.
- It's a means of efficient modeling, sequencing, & detailing of a project plan.
- Prepared for timely and profitable job completion.
- Reviewed to ensure practicality &
- compliance.
- Allows extremely complex project to be planned effectively.
- Change that affects critical work can be managed well with the CPM.
- Delay impacts can be analyzed with new activities or duration changes.

Keep Pushing…I think I see the project's path over this next hill.

Why Do We Need CPM Scheduling?

Schedules - Make Things Happen

Scheduling is a vital part of planning and controlling time and cost of resources on any project.

Yet it is often omitted, or performed on a cursory level.

Corporate Managers tend to focus on continued profitability - how to keep it going.

Project Managers and Superintendents focus on a project's conclusion - how to get it done.

This is why scheduling is different - because by definition projects are unique.

hey are one-time, complex undertakings with a defined start and finish.

- "The livelihood of a company is derived from winning new projects and managing them to successful conclusion. To be profitable, the company must become very good at projects: planning them, tracking them, doing them - making it happen."

It's schedules that bring together how to keep it going and how to get it done.
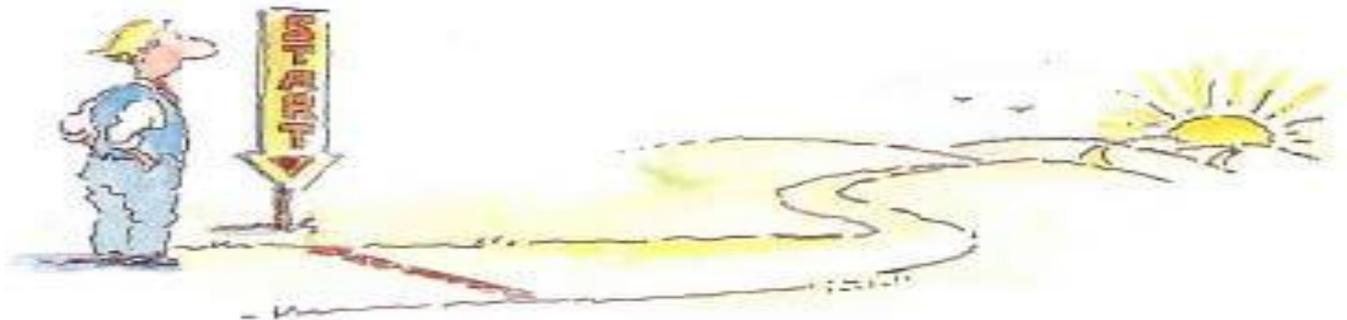
Benefits and Issues of CPM

Benefits of CPM:

- Shows the graphical view of the project.

- Discovers and makes dependencies visible.

- Helps in project planning, scheduling, and controlling.

- Helps in schedule reserve planning.

- Shows the critical path, and identifies critical activities requiring special attention.

- Helps you assign the float to activities and flexibility to float activities.

- Shows you where you need to take action to bring project back on track.

Issues with CPM:

- Assumes that all resources are available for the project at all time, therefore resource constraints must also be taken into consideration.

- May cause less attention on non-critical activities, therefore causing them to be critical.

When Do We Need CPM Scheduling?

- CPM Schedule is Required in the Work Specification/Contract.
- The Critical Path Method schedule shall include all work specified in the Contract Documents, including all expected activities of subcontractors, vendors, suppliers and all other parties associated with construction of the project.
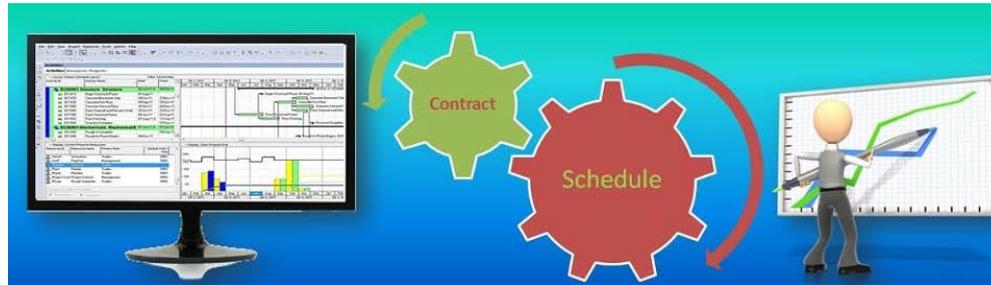
- Your forced to provide a schedule by the Prime Contractor or Owner regardless of contract.
- Colorful bar charts become construction office decorations.
- You have chosen to implement a CPM Scheduling Program in your company as another tool in your tool box.
- You have seen the light – profits, project controls, justifying claim wins.

Why and When Do We Need CPM Scheduling?

The Facts

No matter what view you have regarding CPM Scheduling, even badly managed projects somehow reach completion (most times). Not always on time. Not always on budget. Not always up to the standard of excellence.

They limp to the finish line - and everyone wonders what happened.
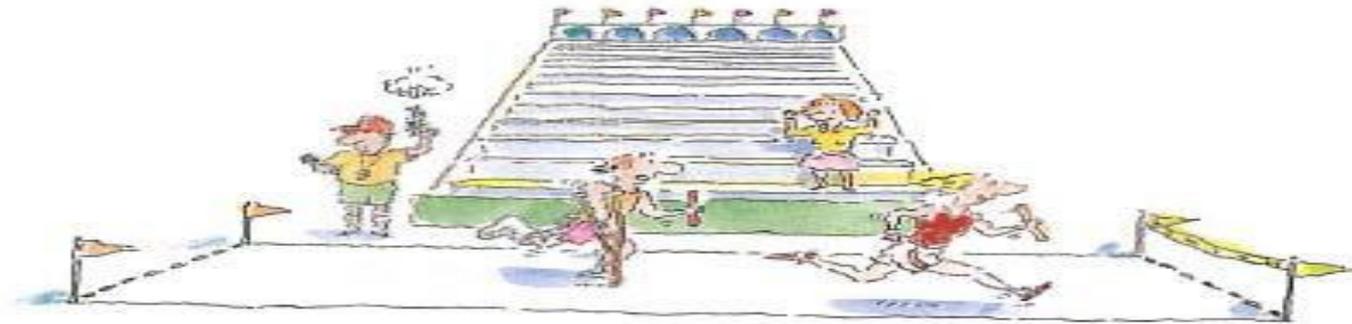
Examples
- Project Management (or the Owner) is regularly assured that things are running on schedule while, in reality, delay after delay is occurring.
- Or, there are signs to the contrary, management prefers to believe that all targets will be met.
- Worst, but may be the most common: Project Management is keenly aware that the project is off course, but can't act decisively or doesn't know how to act.

Should my firm be using CPM Scheduling?

There are many reasons why a firm might choose to adopt a CPM Scheduling program.

Often a project (or subcontracted work) is awarded to the firm who demonstrates superior project management capability, rather than on price alone.

CPM Scheduling can:

- Maximize the Profitability of Your Construction Projects
- Early use of a CPM Scheduling results in either shorter or more realistic construction periods resulting in;
- Maximized resource utilization
- Decreased general conditions costs
- Earlier return on investment for the owner
- Increased profitability
- Improved communication
- Dispute and Delay avoidance
- Claims Justification
- Competitive advantage in the marketplace

Notice To Proceed

There Be Magic Here

Complete Project
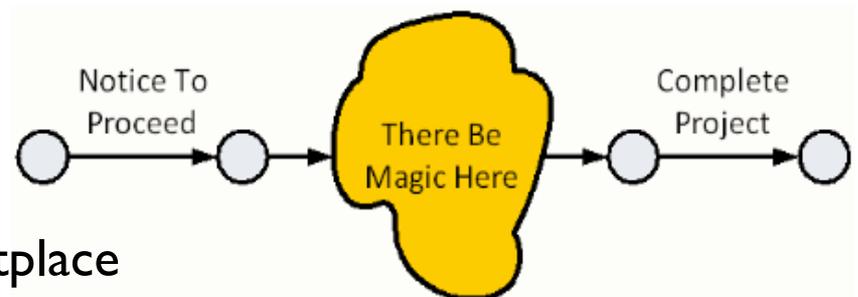
What's Your Role in the CPM Schedule?

Prime or Subcontractor?

Need to Understand the Difference Between the Baseline Schedule
Baseline schedule is a business term for a the timeline to indicate the progress of a specific project per the contract.

Let's review the major differences:

- Project Schedule is a "living" document, whereas Schedule Baseline is "frozen".
- Project Schedule is the "actual", whereas Schedule Baseline is the "plan".
- Project Schedule is a Project Document, whereas Schedule Baseline is a part of the Project Management Plan.
- Project Schedule is updated as the project is being executed, whereas Schedule Baseline is revised only as a result of an approved change.
- Schedule performance is measured by comparing the actual (Project Schedule) vs the baseline - (Schedule Baseline).
- At the beginning of project execution, the Project Schedule is the same as the Schedule Baseline. As work is done on the project, the actual progress is updated on the project schedule.
- At any given date, the latest version of the actual (project) schedule is referred to as the "Project Schedule".

What's Your Role in the CPM Schedule?

You're the Prime Contractor:

- Review and understand the Scheduling Specification or Special Provisions included in the Contract.
- Communicate with the Owner on their CPM Schedule expectations.
- Development of the Preliminary 60-day schedule (or 90-day, etc.).
- Development of the Baseline CPM Schedule (may need to be resource/expense loaded with quantities and cost) that meets the project scope and contract. (Means, Methods, and Sequence of Work)
- Conveying Start & Finish Dates to Subcontractors or incorporating subcontractor schedules into Master Schedule.
- Obligation to the subcontractors.
- Include all external players into your CPM Schedule:
  - ✓ Utility Companies
  - ✓ Owner, Architects, Engineer review times.
  - ✓ Equipment fabrication and delivery.
  - ✓ All Subcontractors.
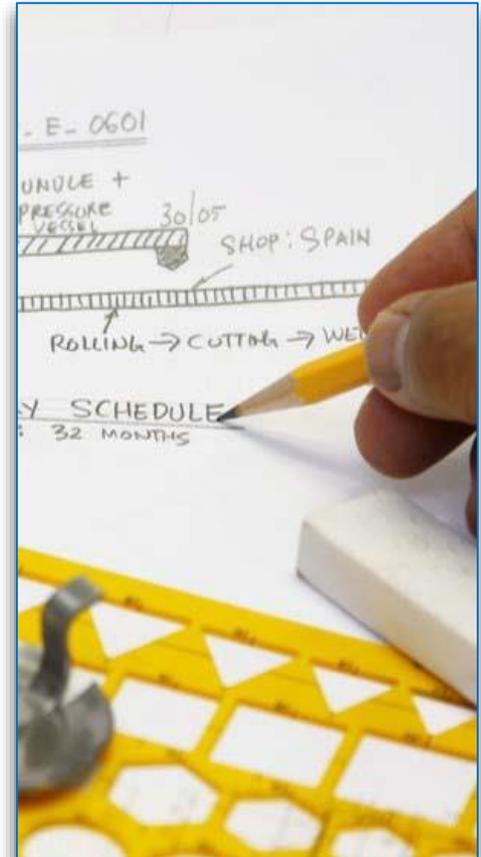
What's Your Role in the CPM Schedule?

You're the Prime Contractor:

- Updating the Monthly Progress – informing and communicating schedule status to the owner, your staff, and subcontractors:
  - ✓ Receiving Actual and Forecast dates and percent complete of activities for self performed and subcontractor's work.
  - ✓ Collecting actual costs and/or quantities for work self performed and from subcontractors (if required) and insuring schedule matches pay application.
  - ✓ Informing your staff and subcontractors of the critical path and any impacts to the critical path based on the status they provide.
  - ✓ determining potential delays to the work
  - ✓ Rescheduling/revising the CPM schedule to meet project completion or interim milestone dates while maintaining budget and making profit.
  - ✓ determining alternative sequences

What's Your Role in the CPM Schedule?

You're the Prime Contractor:

- Prepare Monthly Narrative of CPM Schedule update.
- Changes
- Work Performed
- Presenting Schedules and Schedule Reports to the Owner.
- Be prepared and educated to defend Claims and Liquidated Damages through use of the CPM Schedule (work self performed and for subcontractors) by thorough documentation of:
    - ✓ Weather Delays
    - ✓ Owner caused delays
    - ✓ External factors caused delays
- Develop recovery schedules and/or re-baseline schedules.
- Develop and submit final as-built schedule.
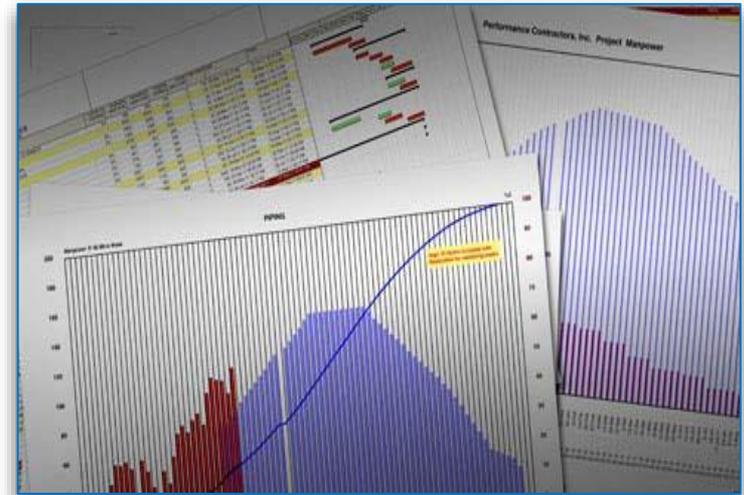
What's Your Role in the CPM Schedule?

You're a Subcontractor:

- Review and understand the Scheduling Specification or Special Provisions included in the Contract – Pass down in most cases.
- Communicate with the Prime Contractor on their CPM Schedule expectations.
- Create your own internal schedule…Or…
- Provide input for the development of the Baseline CPM Schedule (may need to be resource/expense loaded with quantities and cost) that meets the project scope and contract. (Means, Methods, and Sequence of Work)
- Provide accurate CPM Schedule status to the Prime Contractor.
- Provide Actual and Forecast dates and percent complete of activities.
- Collect actual costs and/or quantities (if required) and insuring your completed schedule activities matches your pay application.
- Informing your staff of the critical path and understand how your work impacts the critical path based on the status from all others.
- Rescheduling/revising the your activity sequencing to meet project completion or interim millstone dates while maintaining budget and making profit.
- Be prepared to provide status using the CPM Schedule at project meetings.

What's Your Role in the CPM Schedule?

Regardless of Your Role:

- The CPM schedule is the mutually-agreed construction plan which demonstrates to the owner that the construction team has thought through all elements of the construction process, has conformed to the requirements of the contract, and can execute (and in updates, is executing) the activities within the contractual time frames.

- Make it a useful tool for communication, re-evaluation, recovery and adjudication of disputes.

- All members of the construction team must assure the CPM Schedule is providing maximum benefit to all parties, and the Prime Contractor should consider to what degree they wish to specify how the subcontractors will handle their portion of the CPM schedule.

What's Your Role in the CPM Schedule?

Regardless of Your Role: **Commitment to the Schedule**

- Ask a project/construction manager the single most important ingredient for project success and you'll probably hear somewhere in the reply - COMMITMENT.
- More projects fail (or flounder) from lack of commitment than from any errors in scheduling or problems with resource allocation.
- Don't get it wrong - with commitment things happen. But, for things to happen on time, a project schedule is needed.
- Without commitment to a schedule, target dates get set - target dates get missed - the "schedule becomes nothing more than a calendar" and a wish list rather than a plan of action …

… You might as well hire one of these.

I see in your future 3 activities completing on time, 4 will be behind…

What's Your Role in the CPM Schedule?

When Schedules Go Bad

"If it's March, then we must be halfway done ... right?"

- Surprisingly, once underway, even the most carefully scheduled project can reach a point where it is very difficult to tell where it stands.
- Project related factors such as late delivery of material, failed test procedure, etc. are part of a schedule and are not causes for a schedule going bad.
- However, many Human Factors typically cause schedules to go bad:
  - Poor communication.
  - Sound planning is subordinated to emotional or political considerations.
  - Fear of variances limits the ability to identify problems.
  - Decisions are allowed to be "reevaluated" and changed to the detriment of the project.
  - A lack of an identifiable "owner" of the activities or project cause fragmented decision-making.
  - Personnel incentives are not aligned with project incentives.
  - Institutional barriers make it difficult to alter a project's direction.
  - Inadequate attention is placed on the needs of "external stakeholders".
  - Too many people are allowed to influence work and make decisions ("Too many chefs in the kitchen").
- AND THE LIST GOES ON ....

True Quote:

"The sooner we get behind schedule, the more time we have to make it up. "
Anonymous Construction Superintendent

Basic Components of a CPM Schedule

When is a schedule not a schedule even when looks like a schedule?

The word "schedule" means different things to different people:
- "What's your schedule on this?" might be nothing more than a question of approximately how long a task might take.
- "Give me schedule!" could return a list of major phases of a job and when, hopefully, they will be completed.

To Project Managers and Engineers the term "schedule" has a very specific meaning:
- A project schedule isn't a schedule unless it involves detailed consideration of all the activities necessary to complete the project;
- Realistic estimates of how long each activity will take and thoughtful relationships between project activities.

Together, these elements provide the answer to what must be done when and, equally important, is how it must be done - This is when a schedule looks like a schedule.

Scheduling Definitions

|	
Project	A temporary endeavor undertaken to create a unique product or service with a defined beginning and end.
Scheduling	Detailed planning of work/tasks with respect to time.
Critical Path Method (CPM)	A network scheduling technique that uses project activities and their interrelationships to predict project duration by analyzing which sequence of activities (i.e., path) has the least scheduling flexibility.

Basic Components of a CPM Schedule

CPM Scheduling Terminology

- **_Activity (or Task)_** – A discrete scheduled component of work to be performed during the course of a project.

- **_Milestone_** – A significant event in the project schedule, such as an event restraining future work (watertight milestone) or marking the completion of a major milestone (substantial completion).

- **_Planned Duration_** – The total number of working days estimated to complete a schedule activity.

- **_Resource Estimates_** – The estimated quantity (and types) of resources required to perform each schedule activity.

- **_Logical Relationship_** – A dependency between two schedule activities, or between a schedule activity and a schedule milestone.

  - **_Predecessor_** – An activity required to be completed prior to the start of a (successor) activity.

  - **_Successor_** – An activity that follows the start/completion of a (predecessor) activity.

- **_Float_** – The number of days an activity can be delayed before impacting a successor (or the end date of the project)

Basic Components of a CPM Schedule

CPM Schedule Components
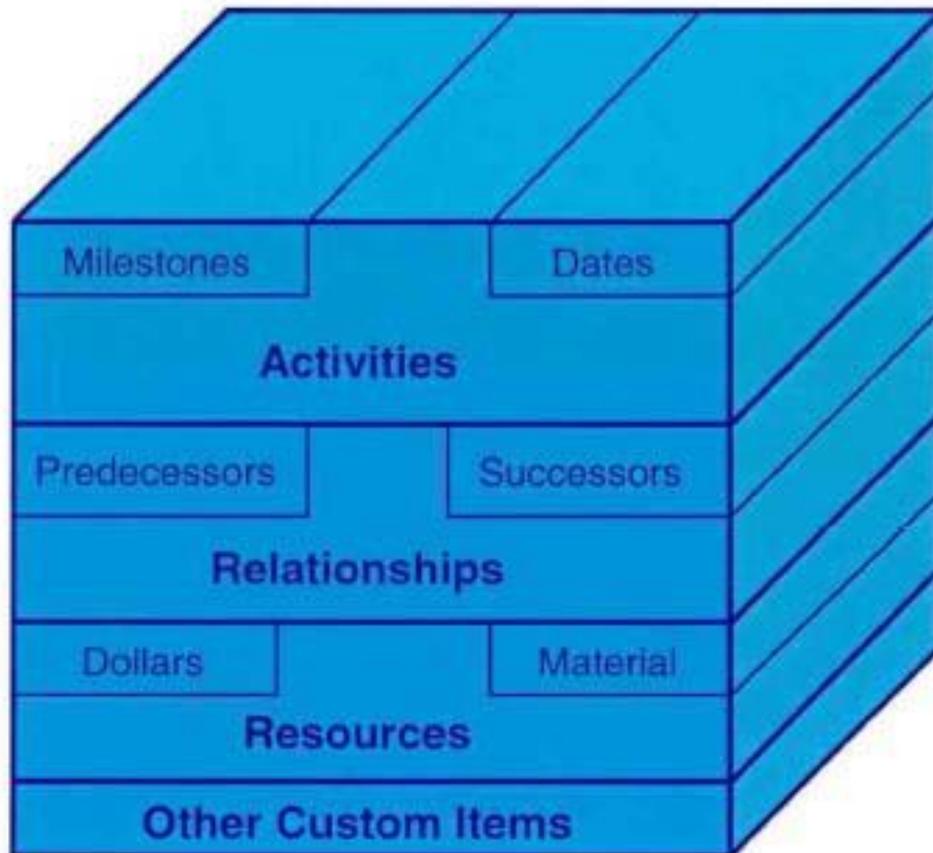
Activities
- Activity ID
- Description
- Activity Codes
- Durations
- Dates
- Calendar
- Type

Relationships
- Constraints
- Lag
- Float

Resources/Expenses
- Labor Hours
- Labor/Equipment Dollars
- Material Quantities

Other Custom Items
- Logs
- Work Breakdown Structure (WBS)

Basic Components of a CPM Schedule

Activity

A basic element of work, task or measurable amount of work that must be accomplished in order to complete a project.

An activity occurs over a given period of time, utilizes resources and produces a deliverable for the project.

Pour Concrete Pad

Basic Components of a CPM Schedule

Activity Types

Fixed Duration
Duration estimate based on amount of calendar time necessary for task completion.

Effort Driven
Duration estimate based on amount of effort required to complete activity.

No Duration
Milestone: An important / critical event that must occur during project start, completion of significant activity.
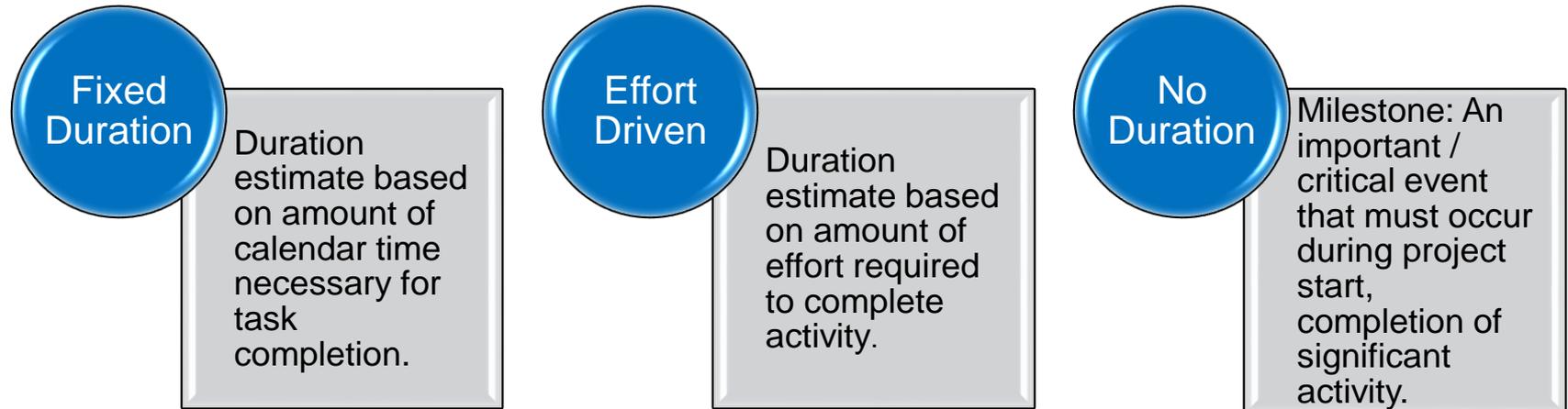
Basic Components of a CPM Schedule

PREPARING THE ACTIVITY LIST

- **Include all activities required to complete the work (this is a no brainer, but still requires quite a bit of thought)**
  - This includes discussions with PM's and Superintendents
  - Subcontractor Schedule Submissions are useful prior to finalizing

- **Activities should not be too broad and not to detailed**
  - 5 (min) – 20 (max) working days each (1 week to 1 month durations)
  - A maximum of 100 activities per trade for the project
  - Don't exceed 2000 activities

- **Crews and/or process/order are very important**
  - Early coordination discussions between CM's and Subs is useful
  - Must have achievable crew sizes
  - Give some thought to the Activity Code / WBS Structure

Basic Components of a CPM Schedule
ESTIMATING ACTIVITY DURATIONS

- **Consider Resources Required to estimate "Best Case" Durations:**
  - Visualize the Space and Estimate an Efficient Crew Size
  - Use Estimate to Determined Planned Man-hours/days for the Activity at hand
  - Divide Number of Estimated Man-days / Estimated Crew Size to get "Best Case Scenario" Activity Duration.
  - Enter into First Draft of CPM Schedule

- **Review CPM Schedule and modify Durations to Account for Risk items:**
  - Need to Consider Crew Restraints
  - Need to Consider Trade-Stacking
  - Need to Consider Delay Issues that _could_ arise

- **Important: The more "Best Case" Durations that exist in the Schedule, the higher the risk of budget overruns and delays.**

Basic Components of a CPM Schedule

Activities have Calendars

Each Activity is assigned to a specific Calendar (Dates).

Example – 9-day activity on a 5-day Calendar.
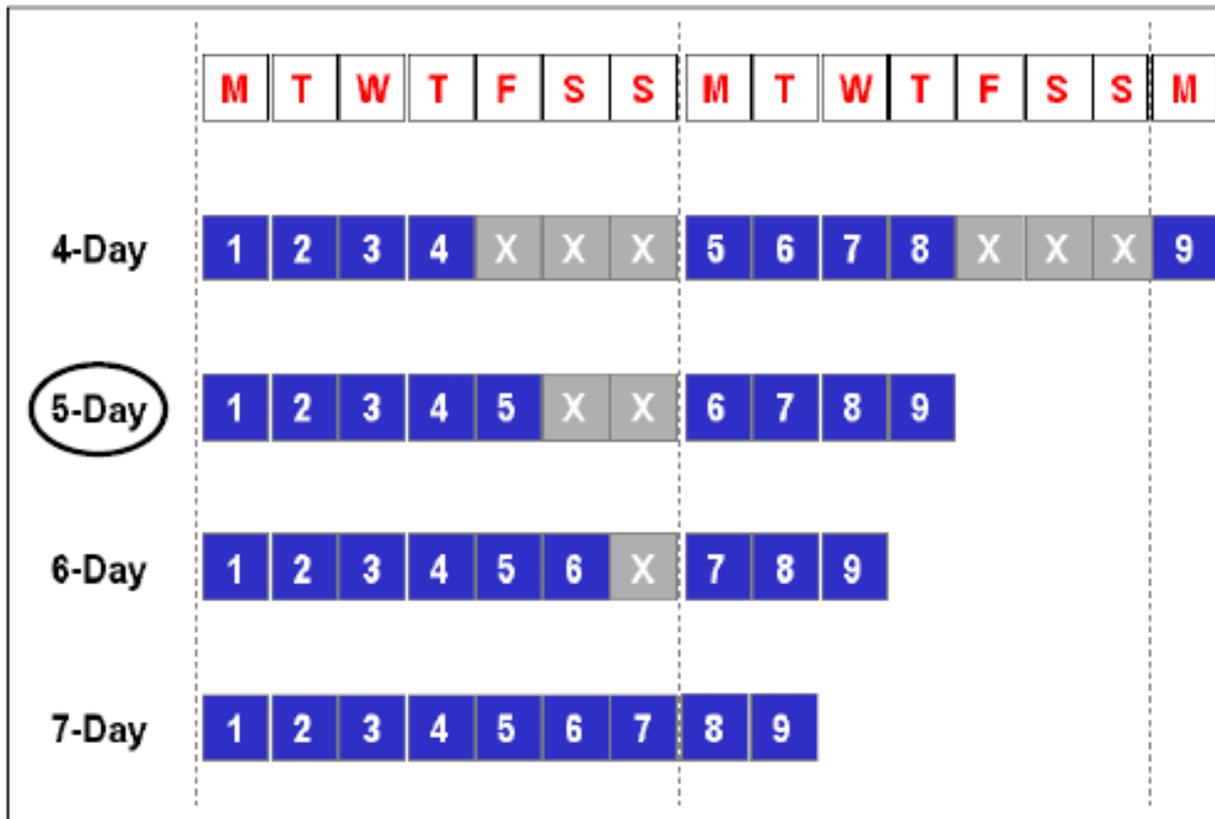
Basic Components of a CPM Schedule

Milestone

An activity that represents a significant point in time but has no duration. Milestones can indicate the start or the end of a series of related activities or an accomplishment in the course of a project.

▼
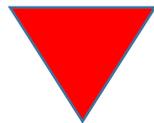
Phase 1 – Concrete Sidewalk Complete

Basic Components of a CPM Schedule

SETTING ACTIVITY RELATIONSHIPS - LOGIC

- **"Logic" is the building blocks for a CPM schedule.**
- **Understanding of the Various Relationship Types:**
  – Finish to Start Relationship
  – Start to Start Relationship
  – Finish to Finish Relationship
  – Start to Finish Relationship
- **What is Lag?**
- **All activities should have a predecessor and successor (except for the first and last activities/milestones)**

Basic Components of a CPM Schedule

Start & Finish

- **Early Start (ES):** The earliest time that one activity can start without affecting the successors.

- **Early Finish (EF):** The earliest time that one activity can finish without affecting the successors.

- **Late Start (LS):** The earliest time that one activity can finish without affecting the successors.

- **Late Finish (LF):** The latest time that one activity can finish without affecting the successors.

- **Free Float (FF):** Delay allowance for one activity without causing any delay on the immediate successors.

- **Total Float (TF):** Delay allowance for one activity without causing any delay on the project completion date.

EXAMPLES OF RELATIONSHIP TYPES – FINISH TO START

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Predecessor

Finish-to-Start, Lag 0

Successor

Predecessor

Finish-to-Start, Lag 2

Successor

Predecessor

Finish-to-Start, Lag -2
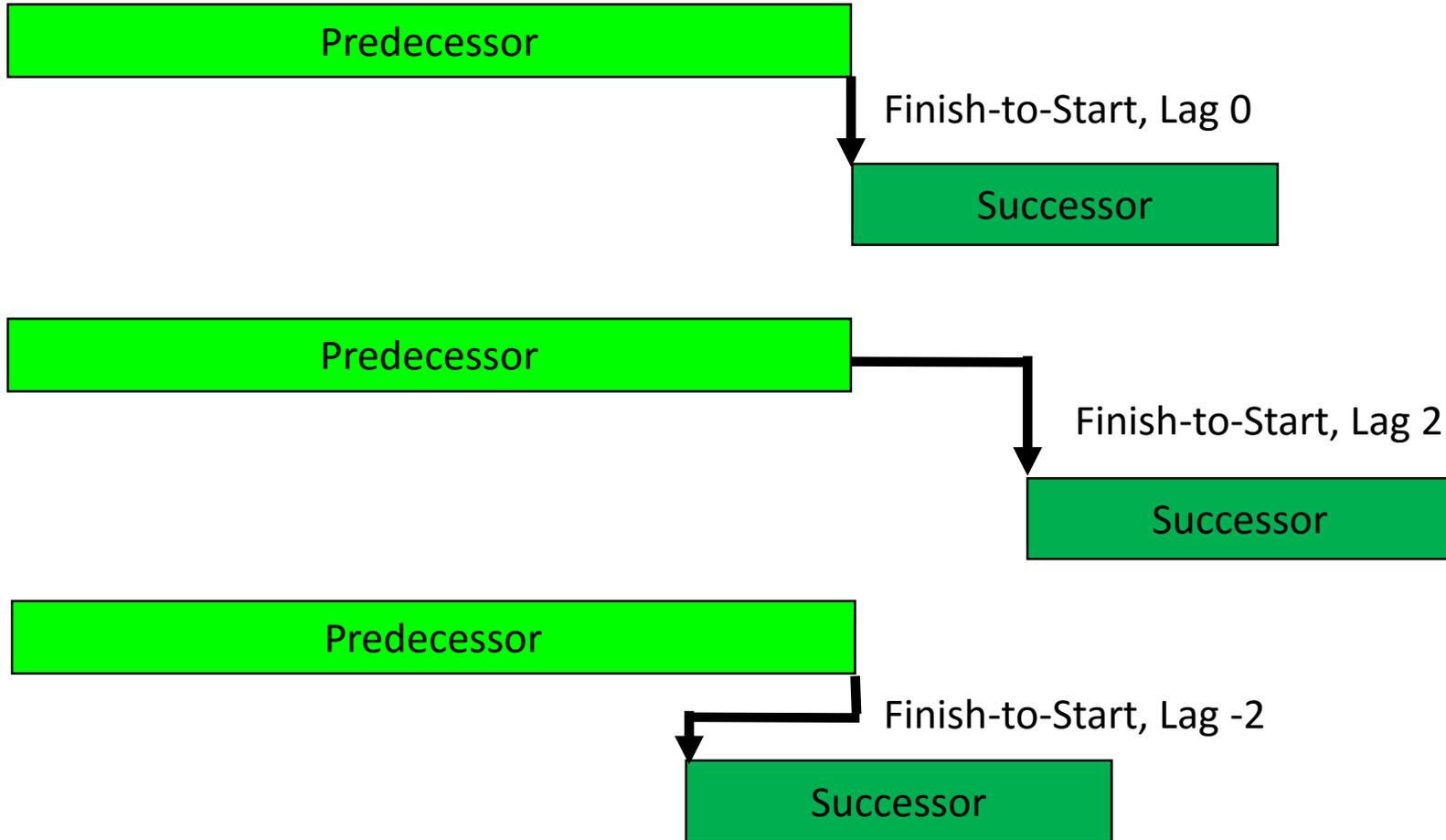
Successor

EXAMPLES OF RELATIONSHIP TYPES – START TO START

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |

Predecessor

Start-to-Start, Lag 0

Successor

Predecessor

Start-to-Start, Lag 2

Successor

Predecessor

Start-to-Start, Lag -2
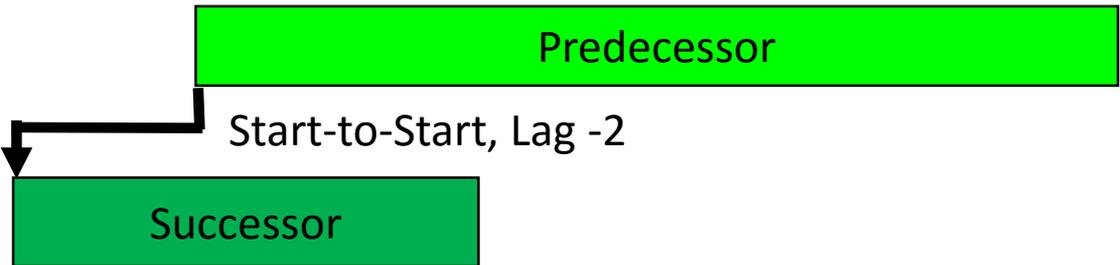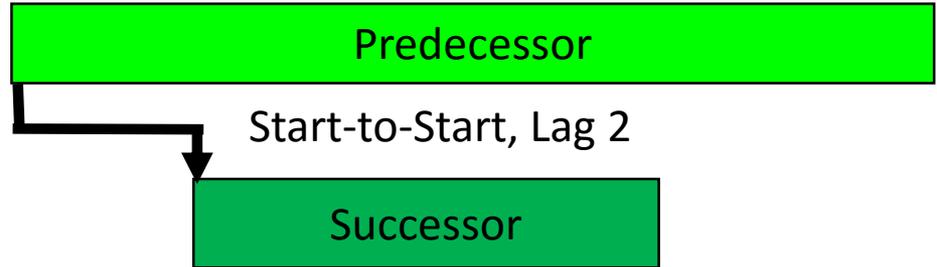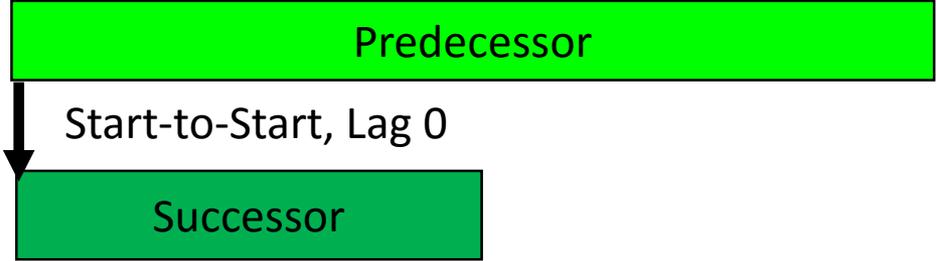
Not Recommended

Successor

EXAMPLES OF RELATIONSHIP TYPES – FINISH TO FINISH

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |

Predecessor

Successor

Finish-to-Finish, Lag 0

Predecessor

Successor

Finish-to-Finish, Lag 2

Predecessor

Successor

Finish-to-Finish, Lag -2

Not Recommended
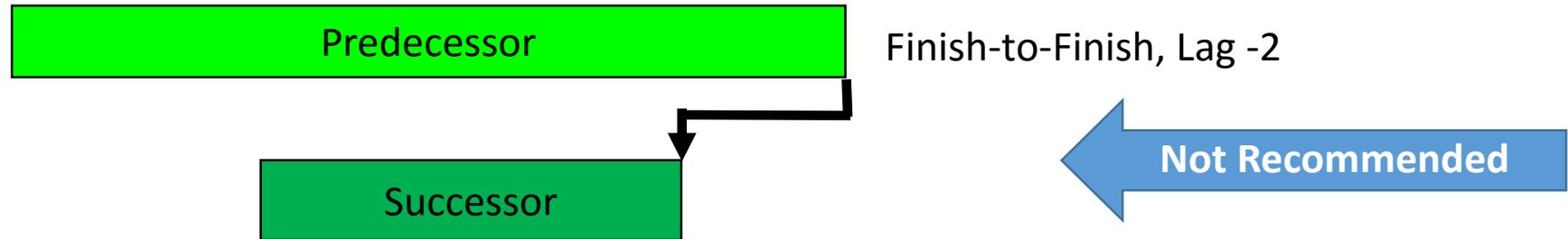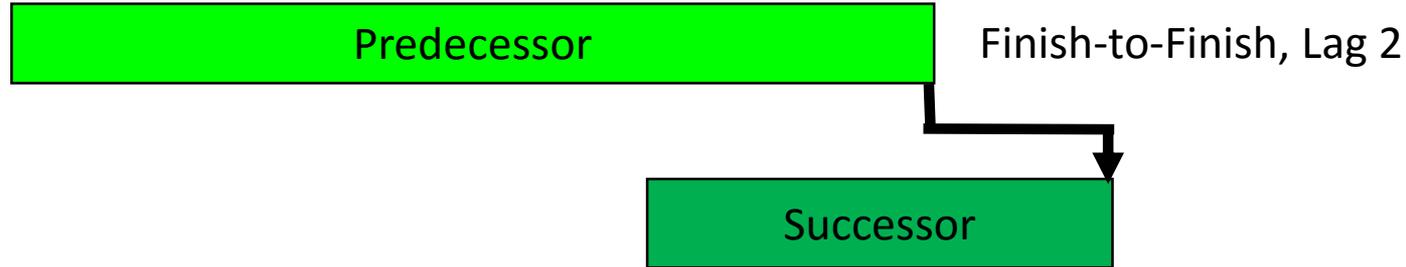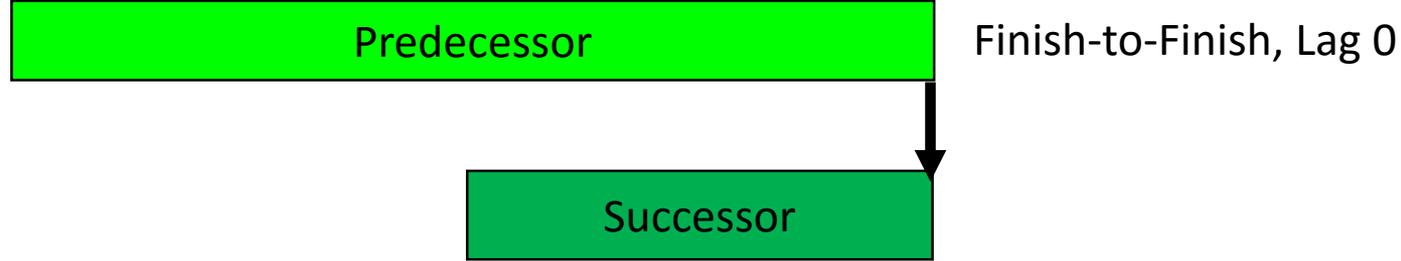
Start-to-Finish

- The successor can't finish until the predecessor starts.
- Seldom used.

Basic Components of a CPM Schedule

Constraints

- Imposed restrictions (such as dates) used to reflect project requirements that cannot be built into the logic.

- Aid in building a schedule that more accurately reflects the real world aspects of your project.

- Provide added control in the schedule.

Constraint Types

- **Mandatory Start**
- **Mandatory Finish**
- **Start On or After**
- **Start On or Before**
- **Finish On or After**
- **Finish On or Before**
- **As Late as Possible**

Examples

- **Start/Finish Constraints**
  - **Availability Constraints**
  - **Government Requirements**
  - **Contractual**
  - **No Real Predecessors/Successors**
- **Crew Management**
  - **Crew Leveling**
  - **Availability of Area**
  - **Trade Stacking**
- **Calendar Constraints**
  - **Union Requirements**
  - **Acceleration Requirement**
  - **Seasonal Constraints**
  - **Preference**

Constraints

Soft Constraints

- Start No Earlier Than (SNET).
- Start No Later Than (SNLT).
- Finish No Earlier Than (FNET).
- Finish No Later Than (FNLT).

Hard Constraints

- Must Start On (MSO).
- Must Finish On (MFO).

Why Limit Constraint Use?

- Generally supersedes network planning/solution.

- Affects the ability to identify the network critical path:

  - ➢ NET – forward pass.

  - ➢ NLT – backward pass.

  - ➢ Imposed – possibly both.

Resource or Expense Loaded CPM Schedules

Assigning Resources

Resource Types
• Labor • Materials • Equipment • Facilities • Rentals • Subcontractors • Other suppliers

Resource or Expense Loaded CPM Schedules

- A schedule that contains only activities (tasks) can adequately support the scope of a project as you need only make sure that the plan includes all of the activities required to accomplish the goals.
- If you want to exercise total control , cost and schedule, of your project, both at the project level and activity level, one would assign resources and expenses to activities.
- Cost curve projections from the baseline schedule graphically depict the planned rate of project expenditures. Resource loading provides evidence that the contractor has planned thoroughly, identifying all resources and equipment required to complete the project.
- There is no downside to a cost and resource loaded baseline schedule, which is why many owners require them for projects above a certain size.
- For example: SCDOT requires CPM Schedules to be expense loaded using did tab items and the CPM Schedule must match the Pay Application.

Resource or Expense Loaded CPM Schedules
Resource Planning

- What is it?
  - ✓ Planning resource availability in conjunction with scheduling activities.
- Why should I use it?
  - ✓ Required by Contract (i.e, SCDOT)
  - ✓ Provide visibility of resource constraints.
  - ✓ Improved cost and schedule project decisions.
- Cautions and Issues
  - ✓ There must be reasonable limits to the number of resources assigned to the project schedule, by specified trades, construction material, equipment, etc.

"The bearing of a child takes nine months, no matter how many women are assigned."
Fredirick P. Brooks, Jr.
The Mythical Man-Month

….Establishing the CPM SCHEDULE

- The Forward Pass and Backward Pass Calculations.
- Thank goodness for computerized scheduling (I did this by hand in the good ole days).

Backward Pass
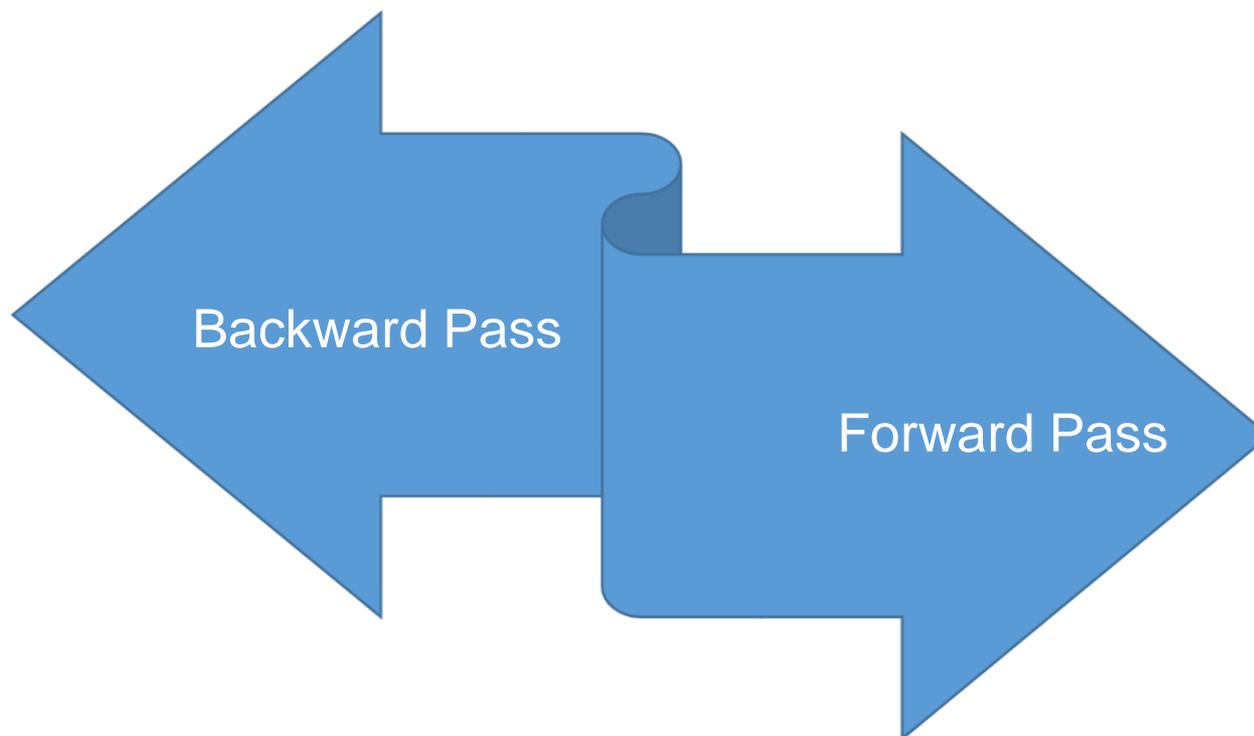
Forward Pass

Calculating the Network

Forward Pass

- From project start to finish.

- Determines project duration.

- **Calculates Early Start/Finish:**

  - ❖ **Early Start:** Earliest start date/time an activity/ task or milestone can begin the precedence relationship.

  - ❖ **Early Finish:** Earliest finish date/time an activity/task or milestone can end based on its early start and its duration (calculated by adding the duration to the early start).

ES + Duration -1 = EF
ES (next activity) = EF (preceding activity) + 1

Calculating the Network, Continued

Backward Pass

- From project finish to start.

- Determines when project must start to meet completion date.

- **Calculates Late Start/Finish:**

  - **Late Start:** Latest start date/time an activity/task or milestone can begin, based on it's late finish and its duration, without impacting the completion date.

  - **Late Finish:** Latest finish date/time an activity/task or milestone can end without impacting the completion date.

LF - Duration +1 = LS.
LF (next activity) = LS (preceding activity) – 1.

Getting Closer to a true CPM Schedule

❖ The forward and backward pass established our early and late start and finish dates thus establishing our activity and schedule **<u>FLOAT</u>**.

What is FLOAT?

❖ Calculated by Subtracting the Early Finish Date from the Late Finish Date Represents the amount of time "days" an activity can slip (move, float,) before it impacts other activities and the end of the project.

Why is FLOAT Important?
Activities with ZERO (0) Total Float are CRITICAL.
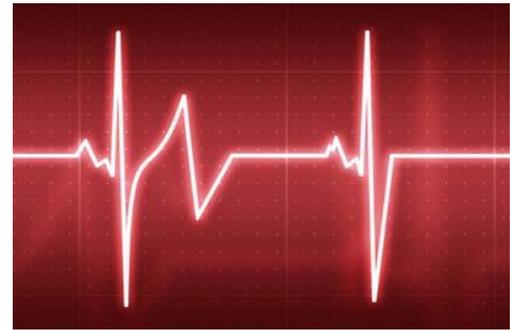
Calculating the Network, Continued

Total Float

"How much an activity can be delayed before it impacts the project finish date."
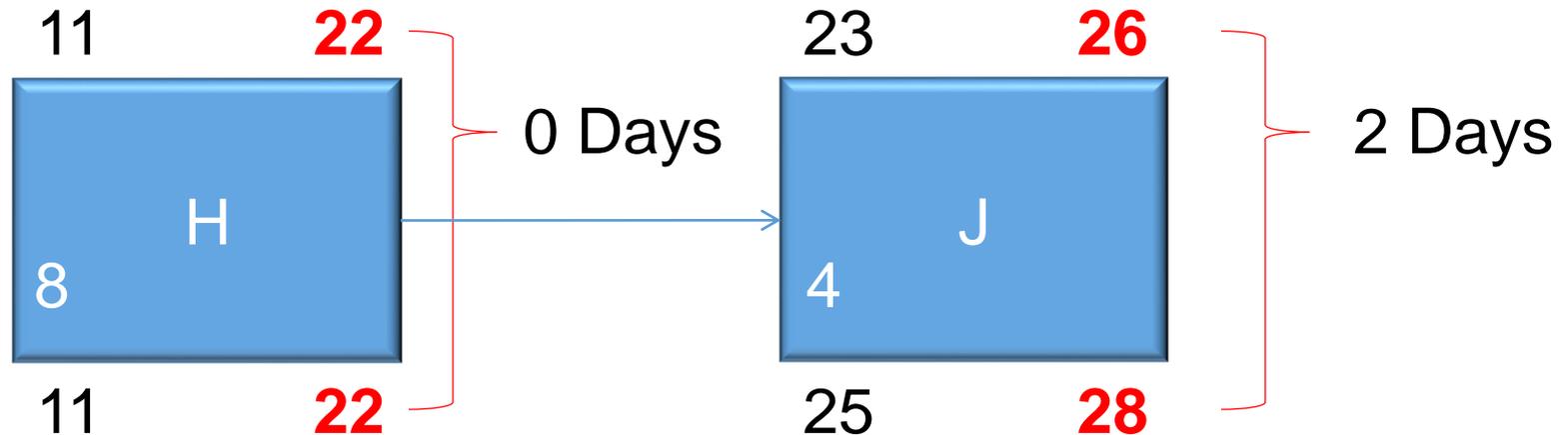
The number of work periods the start or finish of an activity can be delayed without affecting the project finish date.

(Total) Float is measured in hours, days, weeks, or months depending on the project's planning unit, and can have negative, zero, or positive values.

(TF=LS-ES or TF=LF-EF)

Calculating the Network, Continued

Free Float

"How much an activity can be delayed before it impacts a direct successor activity."
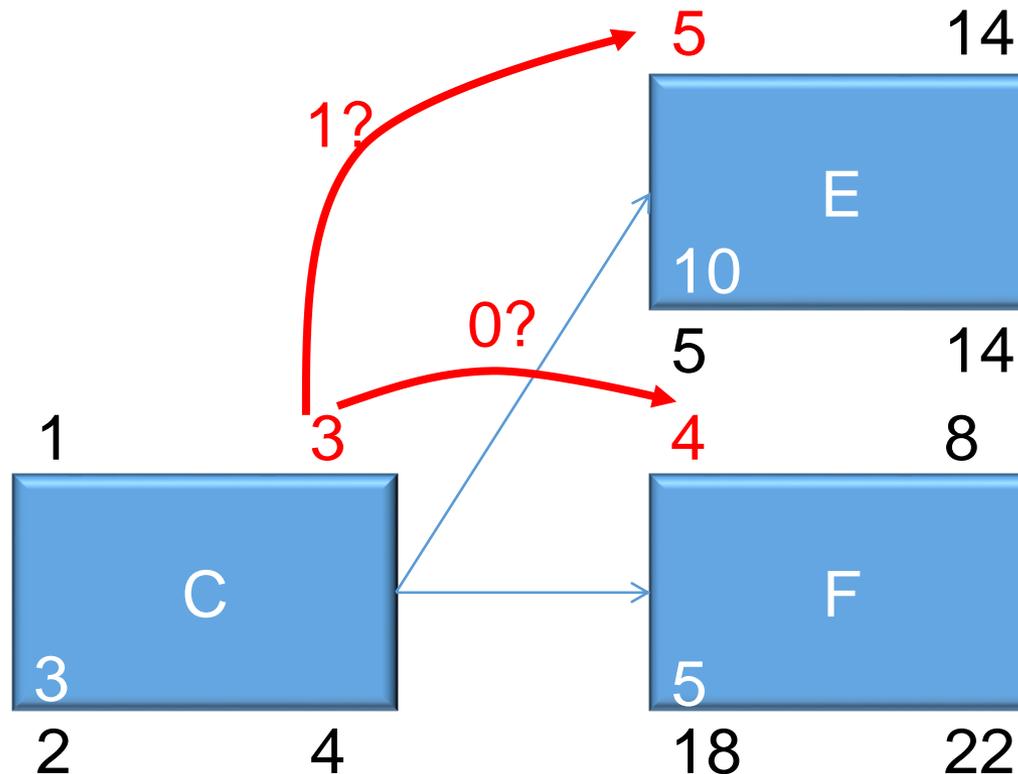
Therefore Activity C has "0" free float.

Calculating the Network, Continued
Total Float
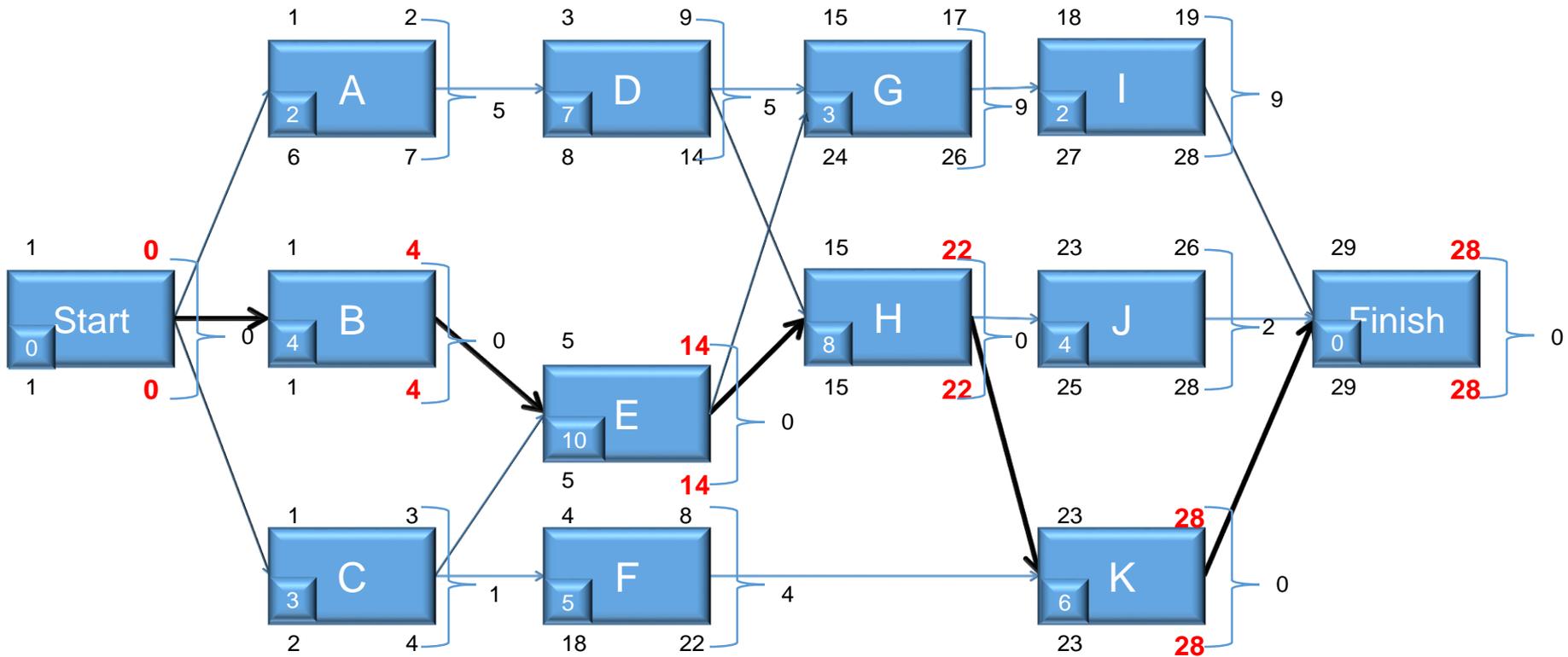
The Critical Path

The schedule now has gone through a forward/backward pass and float has been calculated.
These methods also determine which chain of activities represent the longest path from beginning to end. This longest path has special significance and is known as (for the purpose of out training) the Critical Path.

Definition:

Sequence of activities in the network whose total is the longest time path (sequence) through the network.
Series of activities with the least amount of total float (may be positive, negative, or zero.)
Reducing the project duration can only be achieved through reduction of the length of the Critical
Path: 1) changing logic of Critical activities, and/or 2) reducing Critical activity durations.

What does Critical Really Mean?

When talking about scheduling, "Critical" does not necessarily mean "important". It means "necessary" to getting the project completed on time and with the available resources.
 In scheduling terms, "Critical" can also be described as a schedule path that has zero or negative float.

The Critical Path

- Longest path of logically related activities through network which has "least" total float.
  - Bars in RED

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float
C1	Slab	6	01JUN02	06JUN02	0
M1	Notice to Proceed	0	01JUN02		0
S1	Window & Door Submittal	5	01JUN02	05JUN02	1
R1	Review & Return W&D Submittal	5	06JUN02	10JUN02	1
C2	Frame Walls	5	07JUN02	11JUN02	0
C6	Windows & Doors	3	12JUN02	14JUN02	0
C3	Frame Roof	4	12JUN02	15JUN02	3
C7	Drywall	3	15JUN02	17JUN02	0
C8	Siding	2	15JUN02	16JUN02	4
C4	Set Skylight	1	16JUN02	16JUN02	3
M2	Skylight On-Site (OFCI)	0	16JUN02		3
C5	Roofing	3	17JUN02	19JUN02	3
C10	Exterior Paint	2	17JUN02	18JUN02	4
C9	Interior Paint	2	18JUN02	19JUN02	0
C11	Interior Finishes	3	20JUN02	22JUN02	0
C12	Close-out (Punchlist)	2	23JUN02	24JUN02	0
M3	Finish	0		24JUN02	0

Start Date	01JUN02
Finish Date	24JUN02
Data Date	01JUN02
Run Date	31OCT01 17:11

© Primavera Systems, Inc.

Early Bar
Progress Bar
Critical Activity

SHED
Sheet 1 of 1

Vanir Construction Management

New Shed Project
Baseline Schedule

Date	Revision	Checked	Approved

- Defines project duration.

Understanding the Output
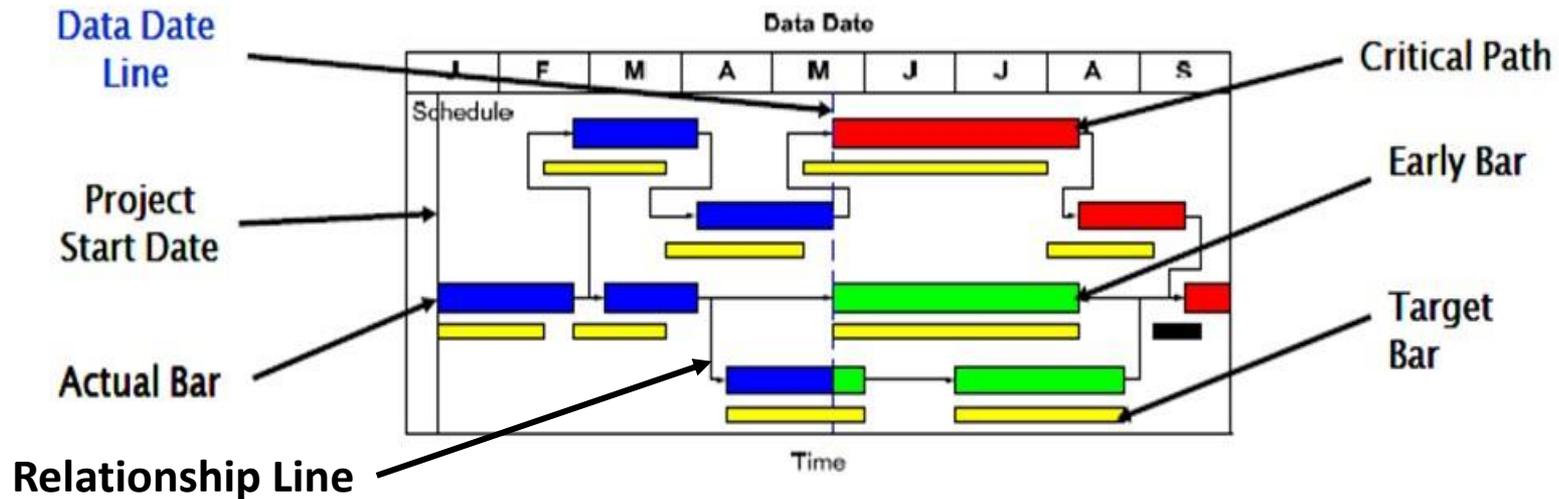
Navigating a CPM Schedule – Reading the Bars and Lines

"You need to read the schedule as it won't talk to you!"

Actual quote to me as I inaccurately presented the schedule to a senior manager.

SCHEDULE UPDATES – BASICS

- What is a Schedule Update?

- Why are Schedule Updates Useful?

- Recommended Scheduling Updating Process:
  1. Activity Status Discussions between Schedulers and Project Management
  2. Scheduler to upload activity status into the schedule and study results
  3. Delays need to be discussed with Project Mgt., Supers and Subs
  4. Conduct Planning/Mitigation Meetings with Site Team (PM's, Supers, Subs)
  5. Update go forward schedule based on discussions held (incl. mitigation Strategy)

- Schedulers who have limited knowledge on what's going on in the field should not modify logic or durations (ie. mitigate) "on the fly"

Schedule Updating – Do's and Don'ts

| DO	DON'T
Status Schedules Updates in Real Time	Issue Schedule Updates 1+ Months late
Update Schedules on a consistent basis (Week/Month)	Update Schedules less than once per Month
Modify Plan based on Discussion's Held in Coordination/Strategy Meetings	Modify Plan without Field Input
Adjust Plan based on Historical Performance	Leave Incomplete Activity Durations pegged to the Original Anticipated Durations
Incorporate Resource/Trade Constraints when Updating	Crash the Schedule
Document (and substantiate) all modifications to activity status, logic, durations, etc.	Update Activity Status and modify Logic, duration, etc. w/o substantiating
Perform a Monthly Delay Analysis and Mitigation Summary	Save Delay Analysis until the end of the Project
Produce and Utilize 3 Week Look-Ahead Schedules	Hope that everyone has a copy of the Latest CPM and will figure it out themselves

SCHEDULE UPDATES – IMPORTANT RULES

- Use Historical Data/Info to Produce Realistic Future Projections

- Update Schedule with Data; Review; Modify

- Collaborate/Coordinate with Field Personnel to form Mitigation Strategies

- Use Feasible Logic Structures when Mitigating Delay

- Know the Resource Pool and Incorporate Crew Constraints

- Avoid Trade Stacking / Crew Spreading

- Have Discussions with other Stakeholders, Be Transparent.

- **Fear the Crash** – Crashing Schedules leads to claims

ALWAYS COMPARE CURRENT SCHEDULE TO THE APPROVED PLAN

Case Study – Updating the Schedule and Comparing to the Original Plan

UPDATE WEEK 1

UPDATE WEEK 2

UPDATE WEEK 3

	Webinar						
	ACTIVITY ID	ACTIVITY	ORIG DUR	START	END	PERCENT P
1	10	Demolition	2	Feb 2	Feb 4	100
2	20	Excavation	3	Feb 3	Feb 6	100
3	30	Foundation Concrete	5	Feb 11	Feb 11	100
4	40	Foundation Walls	3	Feb 12	Feb 13	100
5	50	Level 1 Slab	6	Feb 16	Feb 20	100
6	60	Level 1 Structure	4	Feb 23	Feb 26	0
7	90	Basement MEP	3	Feb 26	Mar 2	0
8	70	Level 2 Structure/Roof	7	Feb 24	Mar 4	0
9	100	Level 1 MEP	3	Mar 3	Mar 5	0
10	130	Basement Finishes	3	Mar 3	Mar 5	0
11	120	Equipment room (Bsmt)	4	Mar 3	Mar 6	0
12	80	Exterior Doors/Windows	6	Feb 27	Mar 6	0
13	110	Level 2 MEP	4	Mar 6	Mar 11	0
14	140	Level 1 Finishes	4	Mar 6	Mar 11	0
15	160	Exterior Siding	4	Mar 9	Mar 12	0
16	150	Level 2 Finishes	4	Mar 12	Mar 17	0

Schedule Review

- Compliance with specification requirements.

- Do milestone dates and contract completion dates comply with contract?

- Is there any negative float?

- Are all work items included ?

- Does the overall sequencing and logic make sense?

- Are durations reasonable? Limited to 15 days?

- Is the critical path reasonable? 15-25% of tasks?

Schedule Review

- Is Float accurate (inflated durations, forced finish dates, unnecessary logic, …)?

- Regulatory requirements

- Is schedule Cost & Resource Loaded (if required)?

- Are Owner items identified (equipment, materials)?

- Is Weather addressed per specification requirements?

- Are the Punch List and other close-out items included?

- Are Submittals, Reviews, and Procurement identified?

Delays Evaluation

Owner Responsibility

- Errors and Omissions
- Changed and Unforeseen Conditions
- Owner added work

Contractor Responsibility

- Mismanagement by contractor
- Defective workmanship
- Non compliance with contract provisions

Other

- Force Majeure – Weather, etc. (Force beyond control)

Delays Evaluation

Three Types of Delay:

1. **Critical** – Impacts milestones or completion dates.
2. **Non-Critical** – Impacts activities without impacting milestones or completion dates.
3. **Concurrent** – Separate and simultaneous delays.

Delays Evaluation

The 3 "KEY Questions:

1. Was the "event" a **Delay**? Did it impact an activity on the critical path such that the project completion date was delayed?

2. Is the delay **Excusable**? Was it caused by the Owner or was it outside of the control of the contractor?

3. Is the delay **Compensable**? Was it within the control of the Owner?

Scheduling Specifications

Consider:

- Software requirements

- Acceptance of contractor's schedule

- Early completion

- Float ownership

- Weather Clauses: appropriate for location and type of work.

- Liquidated damages clause

- Part of Pay Application Process

Scheduling Specifications

Consider:

- Short Interval Schedules

- Cost & Resource Loading

- Number & Length (15 days max.) of Activities

- Submittals/Rev/App/Procurement Included in schedule

- 15-25% of the Activities Critical or Near Critical

- Owner Furnished Equipment Identified

Computerized CPM Scheduling and Analysis

"Thank goodness for scheduling software."
Quote attributed to Phil D'Ambrogi

- Although no shortcuts exist for managing projects, some tools and practices can help prepare you for the job. Using project management software, including scheduling software and schedule analysis software, can organize your thinking and identify potential problems.
- In today's rapidly evolving technological market, software for scheduling is available at very reasonable prices. The lowest paid software can handle one method of scheduling up to several hundred activities. More expensive software can handle unlimited activities, resource loading, and a host of other features.
- By using computers for scheduling, the scheduling effort can be performed with more thought and less of the tedious work than the old days - hand calculating and drawing the schedule.

Excel	MS Project	Primavera

Least Complex   Most Complex
Least Expensive   Most Expensive
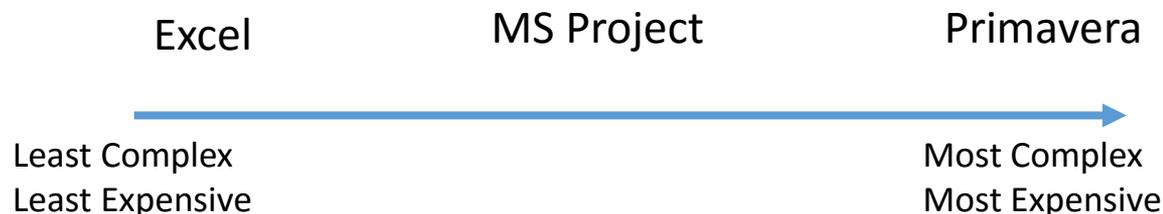
Initial Schedule Development Dos and Dont's

Do COMMIT to the schedule and development process.

Do review the CPM Scheduling section of the contract/specifications.

Do understand your role in the schedule development process.

Do provide information on the forms and in the level of detail required by the contract and Prime/Lead Contractor (if you are a subcontractor).

Do break the work down into all phases if the project is phase.

Do assign at least one predecessor to every activity, except the first, and a successor to every activity except the last.

Do provide Submit, Approve, and Fab & Deliver activities for all materials and equipment that is not "off the shelf".

Do provide as a minimum, a concise Activity Name, and reasonable durations in workdays.

Do provide as reasonable and honest Man-hour and Cost loading of each activity if required.

Do educate and communicate the schedule to your field staff.

Do ask questions if you need to.

Don't assume that the Prime/Lead Contractor will do any of this for you.

Don't take your scheduling task for granted, you may live to regret it.

Don't "pad" the duration days; you don't really want to wind up on the Critical Path unless it is true.

CPM Schedule Updating Dos and Dont's

Do COMMIT to the schedule and the update/status process.

Do read the printed instructions on how to prepare for and perform your update.

Do use the provided forms and complete them properly.

Do provide the start and finish dates for completed activities, and start date, remaining duration or expected finish on started but incomplete activities.

Do provide status as of the "Data Date".

Do provide accurate percent completes.

Do provide an accurate updated resource/expense loaded CPM Schedule that matches your pay application – otherwise expect to get paid late.

Do call and ask for help if you need it.

Don't allow activities to bump up against the date date.

Don't assume that just because an activity is complete that you do not have to report it's start and finish date.

Don't try any of the Tips, Tricks, and Ploys - WE"LL CATCH YOU.

Don't assume that the Prime/Lead Contractor will do any of this for you.

Glossary of Terms
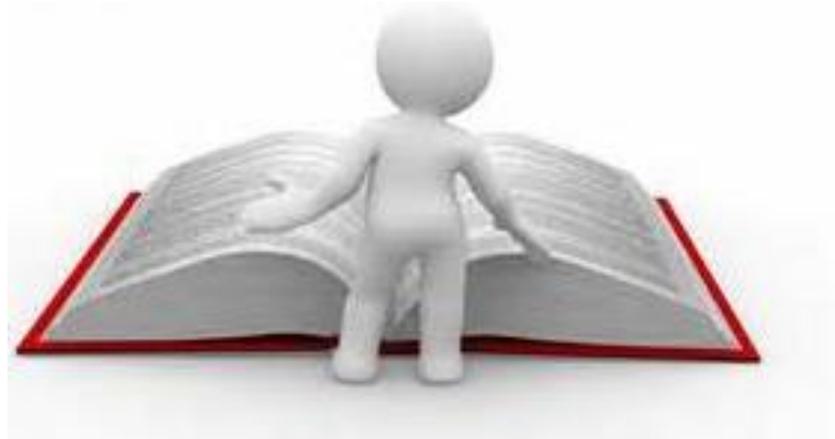
Glossary of Terms

Activity - An individual work task that is the basic component of a project.

Activity Codes - Values assigned to project activities to organize then into manageable groups for updating, analyzing, reporting, plotting, and summarizing.

Actual Cost - The cost incurred to date for a resource or activity.

Actual Dates - Start (AS) and Finish (AF) dates that you record for an activity that has progress or is complete.

Actual Quantity - The amount of a resource used to date.

Backward Pass - The calculation of a network's late dates.

Bar Chart - The graphical display of activities according to time. Relationships between activities are not shown. A bar chart is also called a Gantt Chart.

Baseline Schedule - The original planned schedule for a project.

Budget - The estimate of the total units or costs required by a resource or cost account for an activity.

Calendar - The workdays and holidays defined for a project that determine when an activity can be scheduled.

Completion Date - The date on which a project is to be finished. **Constraint** - A restriction imposed on the start or finish of an activity. **Critical Activity** - An activity that has the least amount of total float.

Critical Path - The series of activities in a project that will take the longest to complete. **Critical Path Method (CPM)** - The calculation of the earliest and latest start and finish dates of activities based on their duration and relationships to other activities.

Data Date - The date used as the starting point for schedule calculations.

Glossary of Terms

Driving - A predecessor/successor relationship in which the predecessor.
Relationship - Determines the successor's early dates.
Duration - The amount of time (in workdays) needed to complete an activity.
Early Start (ES) - The earliest date when an activity can begin after its predecessors have been completed.
Earned Value - The value of work performed rather than actual work performed. **Exception** - A day when work must occur that was originally designated as a non-workday. **Finish to Finish (FF)** - A type of relationship in which a successor activity finish depends on its (FF) predecessor activity's finish.
Finish-to Start (FS) - A type of relationship in which a successor activity can begin only when its (FS) predecessor activity finishes.
Float - The amount of time that the start or finish of an activity can be delayed without affecting the project finish date.
Forward Pass - The calculation of the network's early dates.
Free Float - The amount of time that an activity's early start can be delayed without delaying the early start of a successor activity.
Lag - An offset or delay from an activity to its successor.
Late Finish (LF) - The latest date when an activity can start without delaying the project's completion.
Late Start (LS) - The latest date when an activity can start without delaying the project's completion.
Loop - Circular logic within a network.

Glossary of Terms

Milestone - An activity that represents a significant point in time, that has no duration. **Negative Float** - The total number of days that the start or finish of an activity exceeds the time allowed. Negative float indicates a delay in the schedule.

Negative Lag - An offset or lead time from an activity to its successor in which the successor's start date is earlier than the predecessor's start date.

Network - The series of activities required to complete a project.

Non-work period - A period of time when work may not occur.

Open End - An activity that has no successor or predecessor relationships to other activities in the network.

Out-of-Sequence Progress - Work completed for an activity before it is logically scheduled to occur.

Percent Complete - The proportion of an activity that is complete.

Performance Measurement - The comparison of the current plan to a target plan to assess whether it is progressing as intended.

Planning Unit - The increment of time used to schedule a project. The planning unit can be in hours, days, weeks, or months.

Predecessor - An activity that must logically occur before another activity.

Progress - The completion of work.

Resources - The people, materials, equipment or services required to complete a project.

Schedule - A list of the activities needed to complete a project, along with their start and finish dates.

Schedule Calculation - The calculation of early and late dates for each activity in the project.

Glossary of Terms

Slack - See Float.

Slippage - Lateness determined by measuring the target finish of an activity from its actual or current early finish.

Sorting - The arrangement of data in a specific sequence.

Start-to Start (SS) - A type of relationship in which a successor's start depends on the start of (SS) its predecessor.

Status - The process of updating a project by indicating progress at regular intervals.

Successor - An activity that must logically occur after another activity.

Target - A project plan that can be compared to the current schedule to measure progress. May be referred to as Baseline.

Task - A unit of work. Also called an activity.

Total Float (TF) - The total number of days that the start or finish of an activity can be delayed without affecting the project finish date. Float can be negative, zero, or positive.

Updating - The process of recording progress in a project at regular intervals.

Variance - The difference between the current and target schedule dates.

Work Breakdown Structure (WBS) - The graphical depiction of the hierarchy of work needed to complete a project.

Workday - Any day of the week when work can be scheduled.