Project Planning and Scheduling using the Critical Path Method

Presented by: Fredric L. Plotnick, Ph.D., Esq., P.E. , P.L.S.

Purpose and Learning Objectives

The purpose of this presentation is to educate or perhaps re-educate our audience of the genesis and purpose of Critical Path Method of Planning and Scheduling: That all is based upon a proper Pure Logic Network of:

Events Constraints Activities Restraints and Relationships

At the end of this presentation you will be able to:

1. Understand the necessary information needed to prepare a CPM Plan
2. Identify and avoid common errors of pasting info from barcharts and estimates
3. Describe the flow of work by primes, subcontractors and other stakeholders
4. Explain the critical and lesser “Main-Chain” paths of primes (and also of subs)

Presenter Introduction

- Presenter Introduction: Fredric L. Plotnick, Ph.D., Esq., P.E., P.L.S.
- **EnProMaC®** Engineering & Property Management Consultants, Inc. Choreographers for the Construction Industry™ since 1983
- CPM in Construction Management, of McGraw-Hill, with James J O'Brien, PE
- Contracts and the Legal Environment for Engineers & Architects, McGraw-Hill, w/ Joseph Bickrath
- Teaching Law to Engineers and Engineering to Lawyers since 1979
- Creator of RDM, RDCPM®, RD CPM® Compliance Certified BoBL(Pat), MHRM(Pat), others pending
- **Construction CPM Conference**, creator 2010 through 2026, now emeritus
- Member Speaker Friend of AACE since 1978 and also ASCE PMICOS NSPE others and **Bar Associations** of Pennsylvania NewJersey Florida Louisiana, Member Bar of SCOTUS
- President-Elect PSPE Pennsylvania Society of Professional Engineers
- Also to be known as **The Olde Fisherman of the Seas**

Planning , then Scheduling

Critical Path Method
developed for automated re-scheduling of an
Initial Schedule Calculated from a
Pure Logic Network Diagram

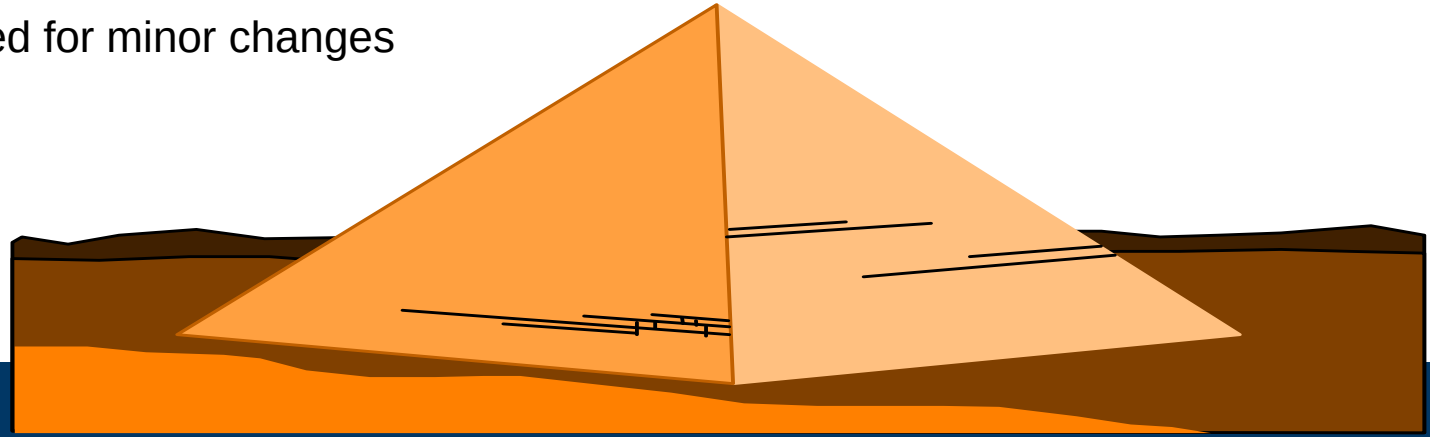
Gantt Chart and other bar charts

advantages:

- Easy to read

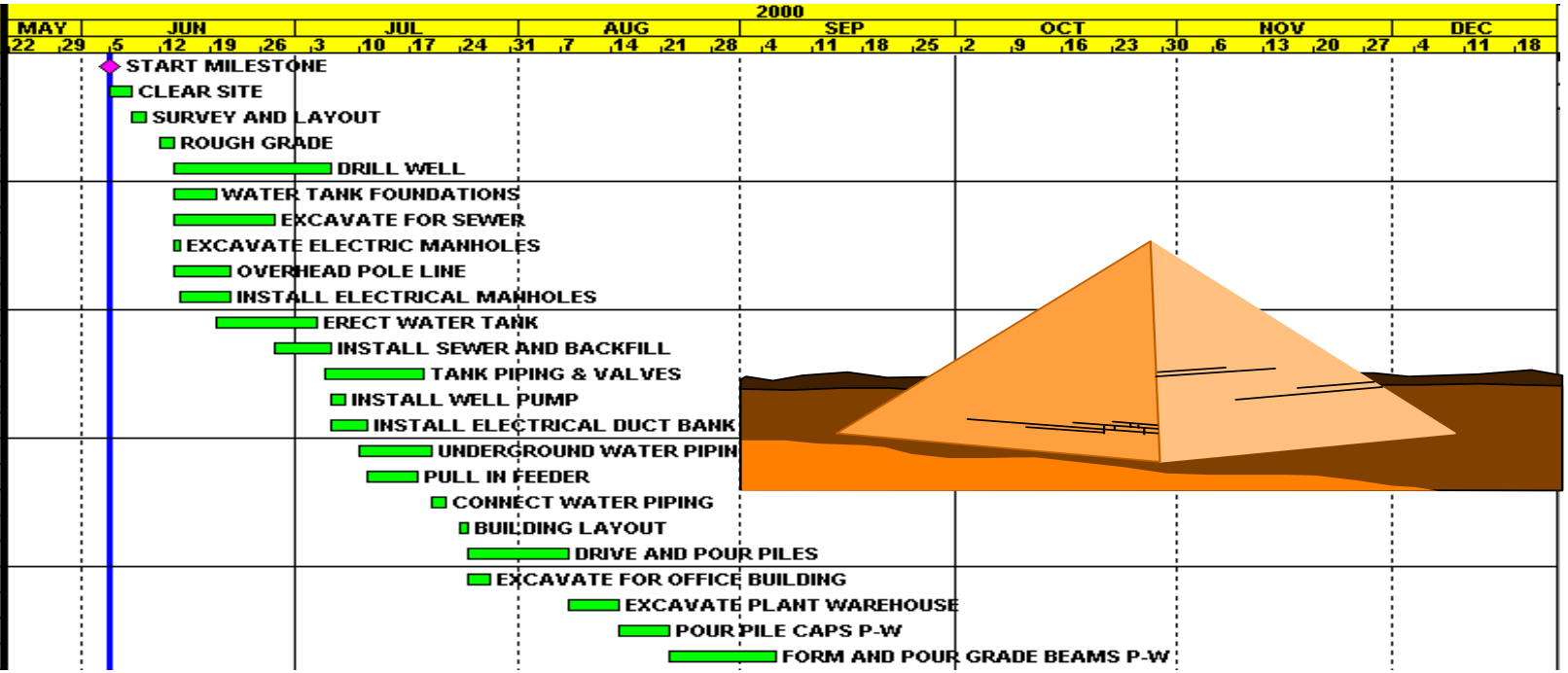
disadvantages:

- Static, not dynamic
- Relationships not defined
- 40% rework required for minor changes



Gantt Charts are Easy to Read

Activity Description	Orig Dur
START MILESTONE	0
CLEAR SITE	3
SURVEY AND LAYOUT	2
ROUGH GRADE	2
DRILL WELL	15
WATER TANK FOUNDATIONS	4
EXCAVATE FOR SEWER	10
EXCAVATE ELECTRIC	1
OVERHEAD POLE LINE	6
INSTALL ELECTRICAL	5
ERECT WATER TANK	10
INSTALL SEWER AND	5
TANK PIPING & VALVES	10
INSTALL WELL PUMP	2
INSTALL ELECTRICAL DUCT	3
UNDERGROUND WATER PIPING	8
PULL IN FEEDER	5
CONNECT WATER PIPING	2
BUILDING LAYOUT	1
DRIVE AND POUR PILES	10
EXCAVATE FOR OFFICE	3
EXCAVATE PLANT	5
POUR PILE CAPS P-W	5
FORM AND POUR GRADE	10



But if you want to make even a small change...

Activity Description	Orig Dur
START MILESTONE	0
CLEAR SITE	3
SURVEY AND LAYOUT	2
ROUGH GRADE	2
DRILL WELL	15
WATER TANK FOUNDATIONS	4
EXCAVATE FOR SEWER	10
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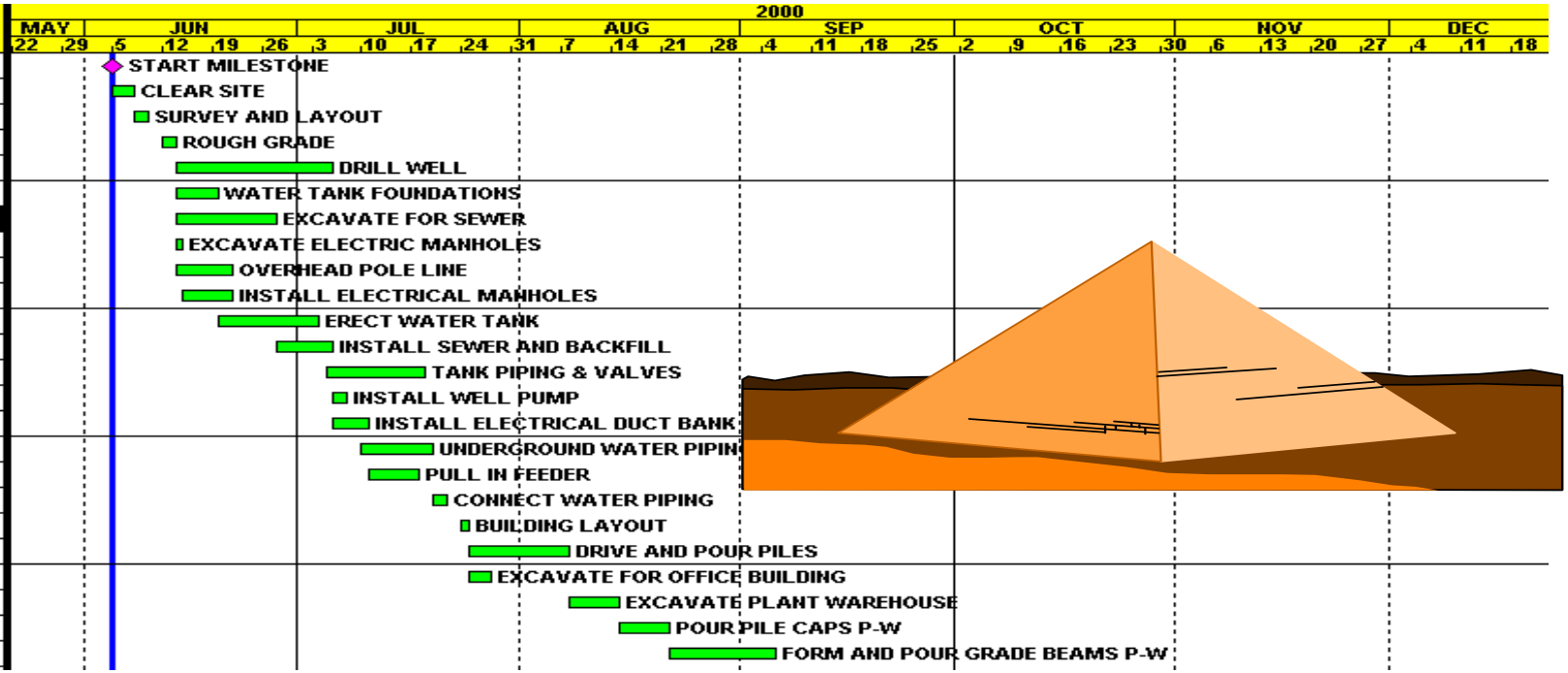

...to the duration of one activity ...

you have a great deal of work to perform to determine the impact

Activity Description	Orig Dur
START MILESTONE	0
CLEAR SITE	3
SURVEY AND LAYOUT	2
ROUGH GRADE	2
DRILL WELL	15
WATER TANK FOUNDATIONS	4
EXCAVATE FOR SEWER	20
EXCAVATE ELECTRIC	1
OVERHEAD POLE LINE	6
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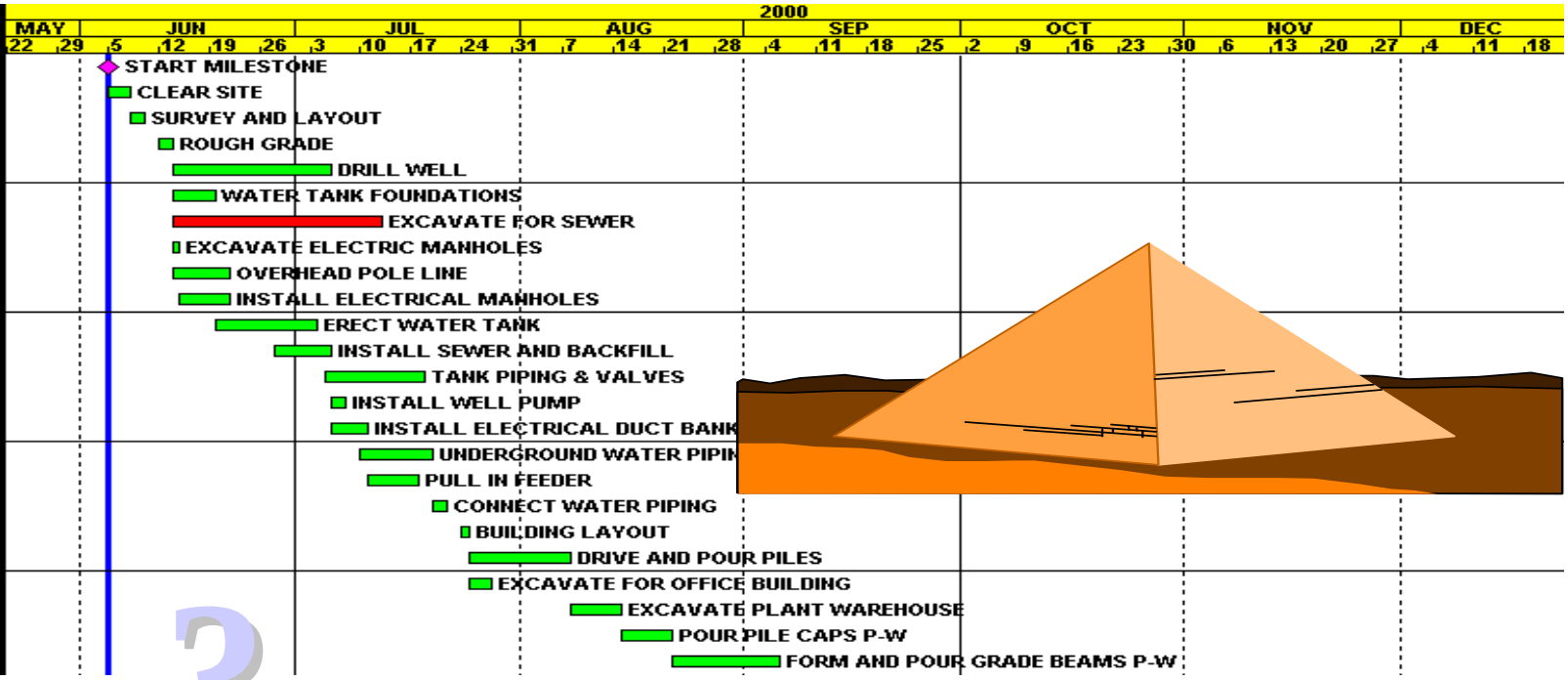

CPM requires you to record the relationships between activities ...

Activity Description	Orig Dur
START MILESTONE	0
CLEAR SITE	3
SURVEY AND LAYOUT	2
ROUGH GRADE	2
DRILL WELL	15
WATER TANK FOUNDATIONS	4
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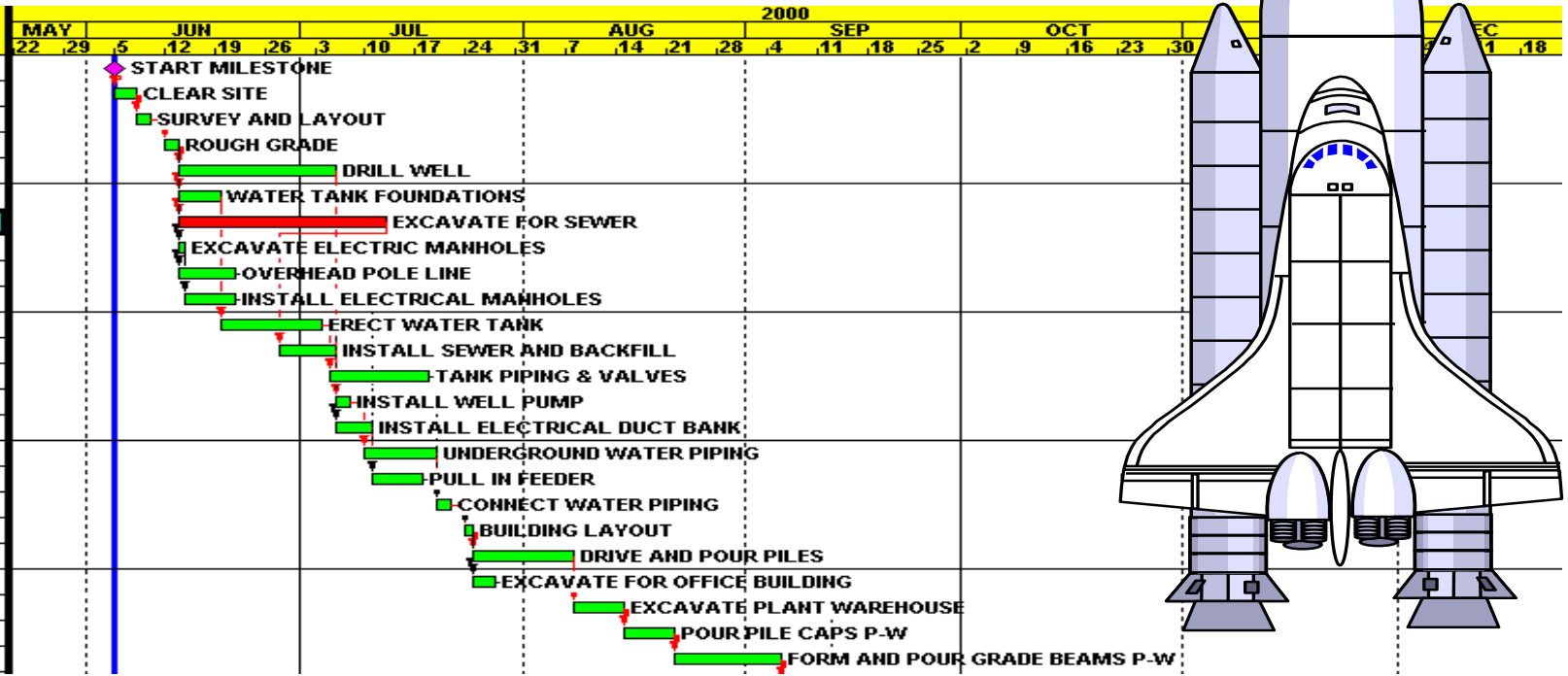

... and allows the computer to recalculate the impact of changes made ...

Activity Description	Orig Dur
START MILESTONE	0
CLEAR SITE	3
SURVEY AND LAYOUT	2
ROUGH GRADE	2
DRILL WELL	15
WATER TANK FOUNDATIONS	4
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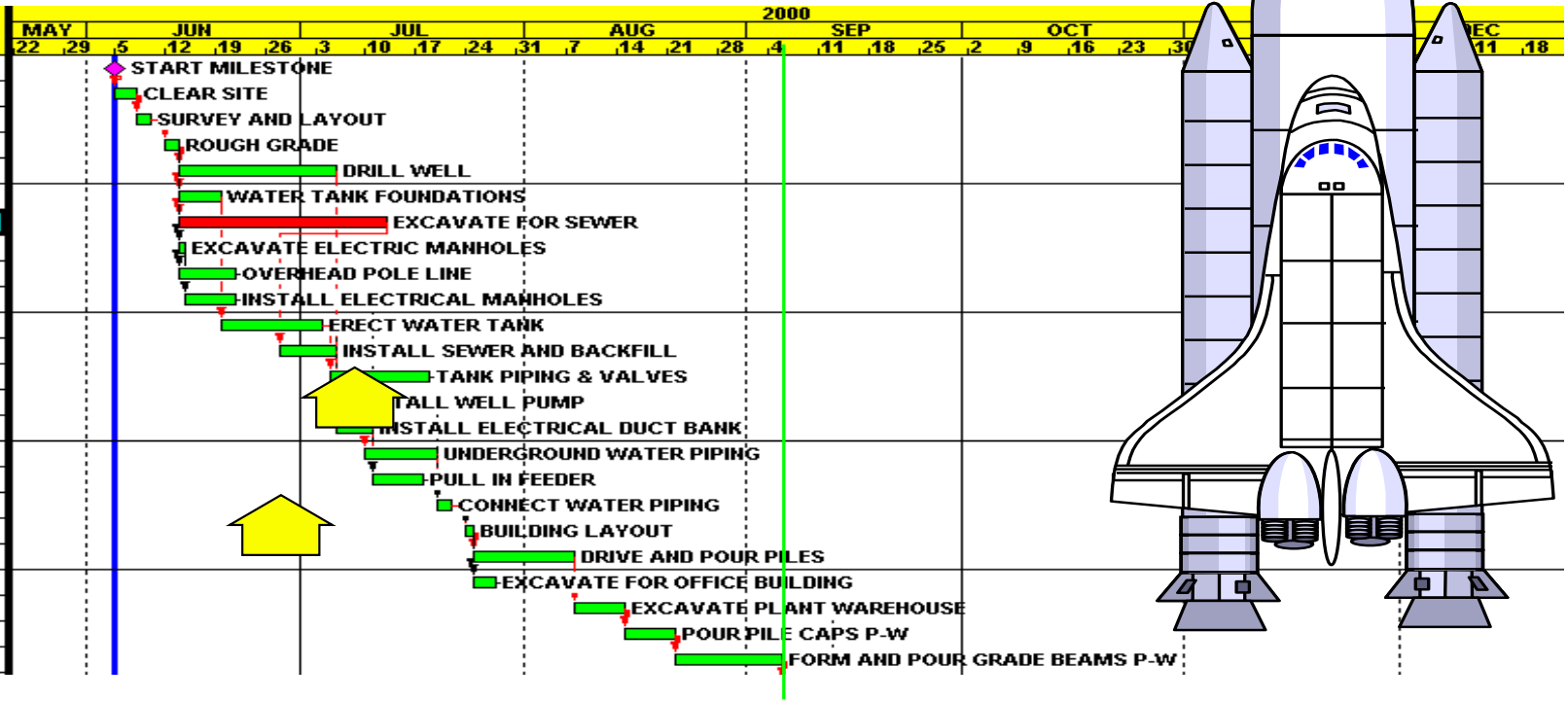

… reducing the 40%+ rework effort to that of a keystroke

Activity Description	Orig Dur
START MILESTONE	0
CLEAR SITE	3
SURVEY AND LAYOUT	2
ROUGH GRADE	2
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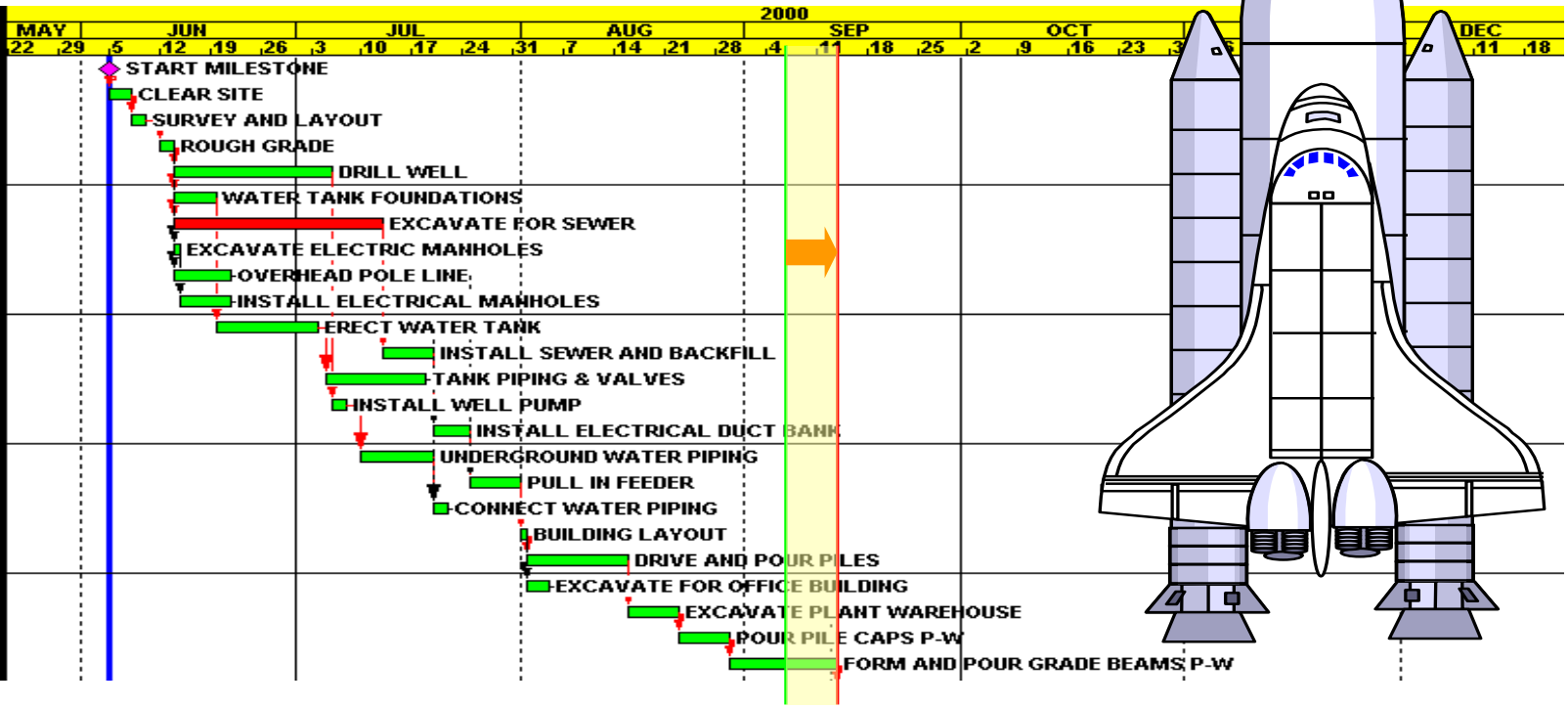
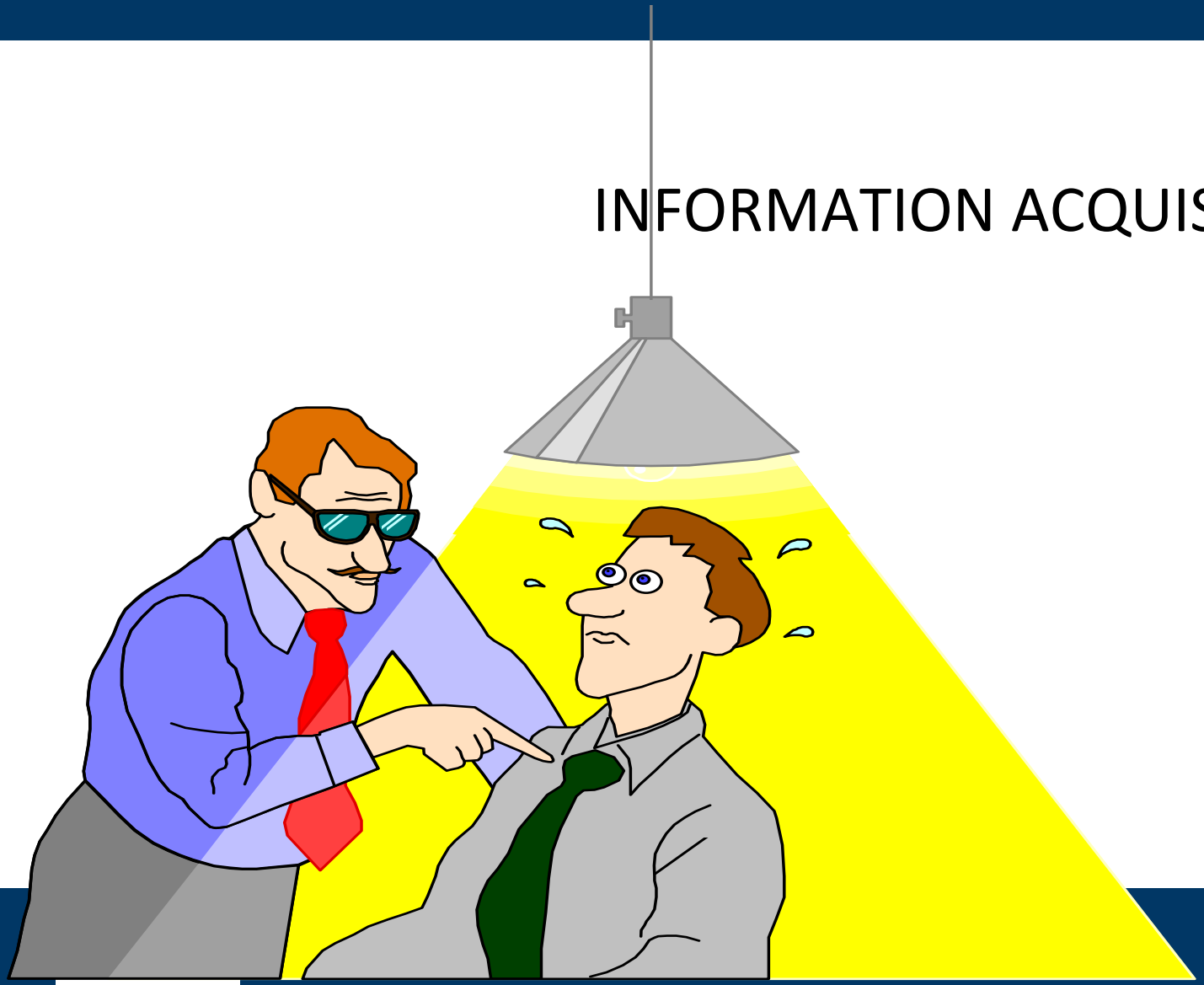


Recap and Discussion

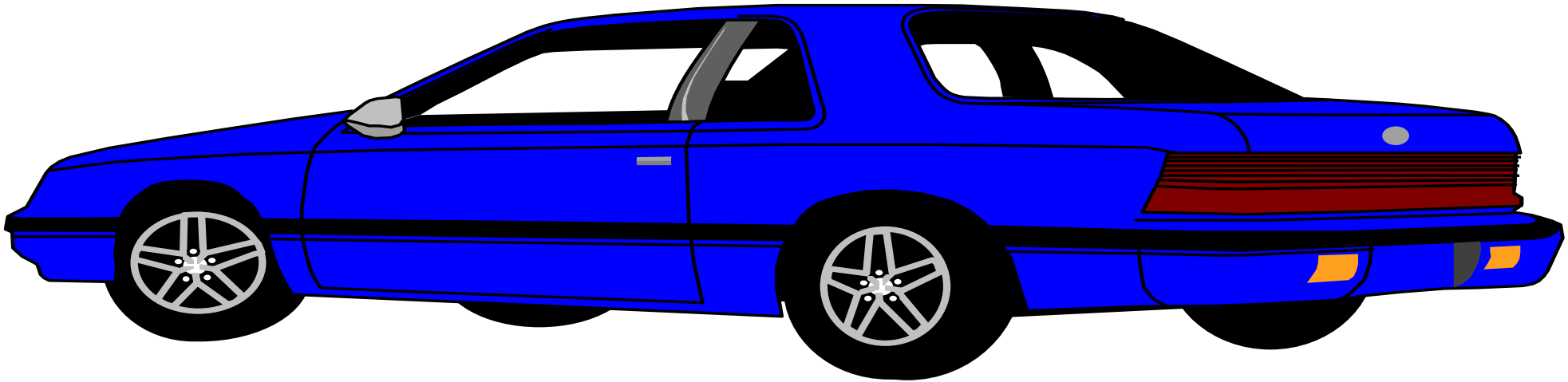
- What is an **Early Start Early Finish** string or chain of activities?
  - What is a **Late Finish Late Start** string or chain of activities?
  - What is the Critical Path "main chain" string of activities?
  - What is a Scheduled Start Scheduled Finish string of activities?
- What is the meaning of curse-word: Re-Baseline?
- When is a Re-Baseline warranted? What is LEGAL impact of Re-Baseline?
- What is included? / excluded? from a CPM Pure Logic Network?

INFORMATION ACQUISITION

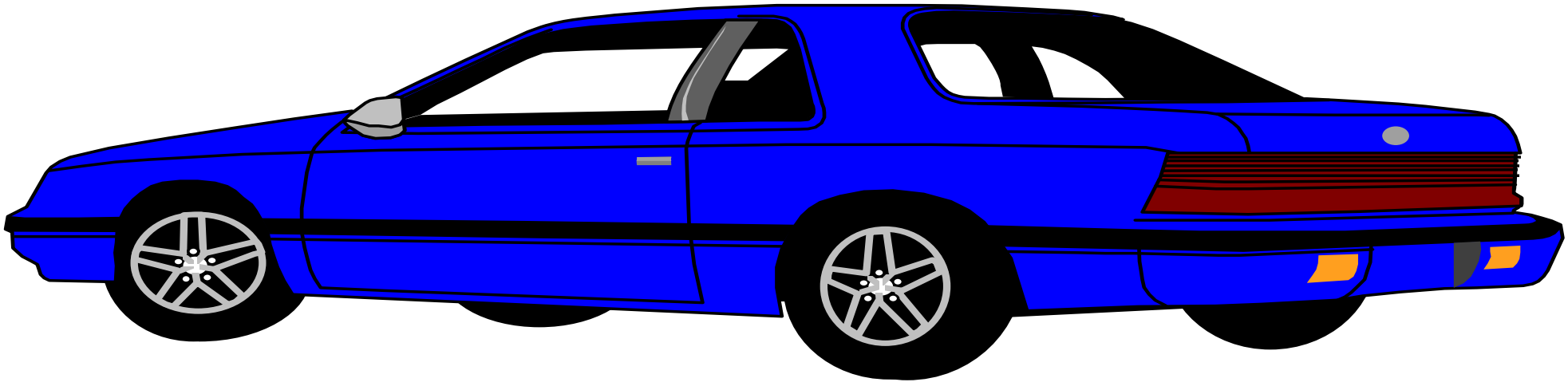


Example -- changing the oil in your car

see Chapter 4.5, pages 37 through 40

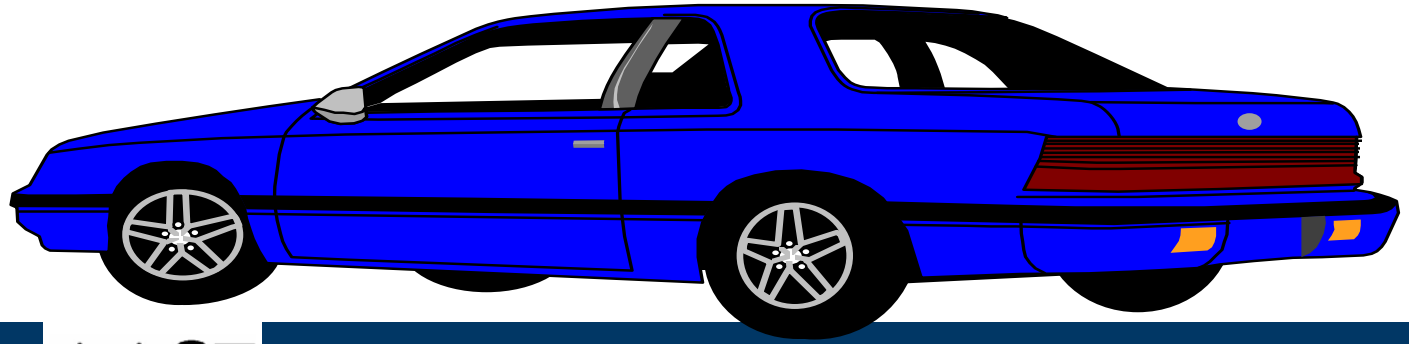


What work do we want done?



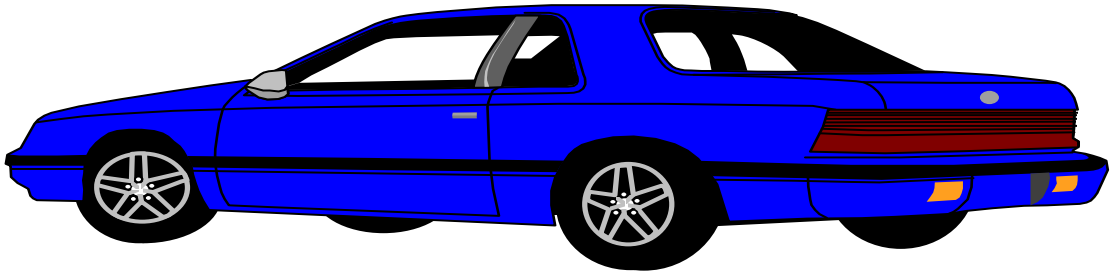
- What work do we want done?

- Rotate Tires
- Lubricate
- Change Oil
- Wax & Polish
- Drain Antifreeze



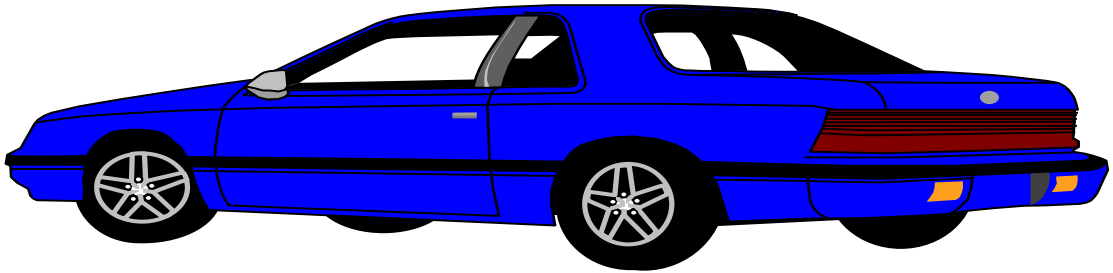
Preparing a Logic Diagram

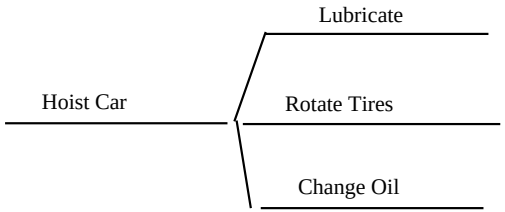
- Rotate Tires
- Lubricate
- Change Oil
- Wax & Polish
- Drain Antifreeze



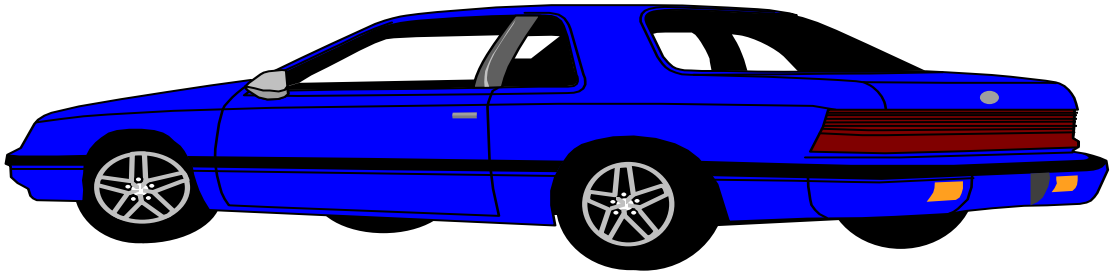
Hoist Car

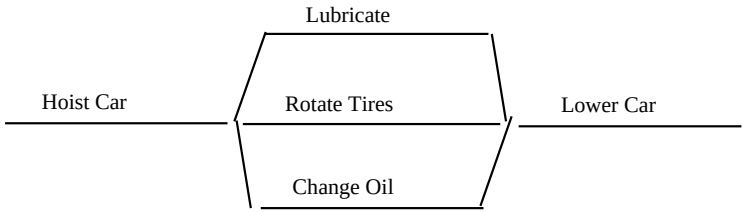
- Rotate Tires
- Lubricate
- Change Oil
- Wax & Polish
- Drain Antifreeze





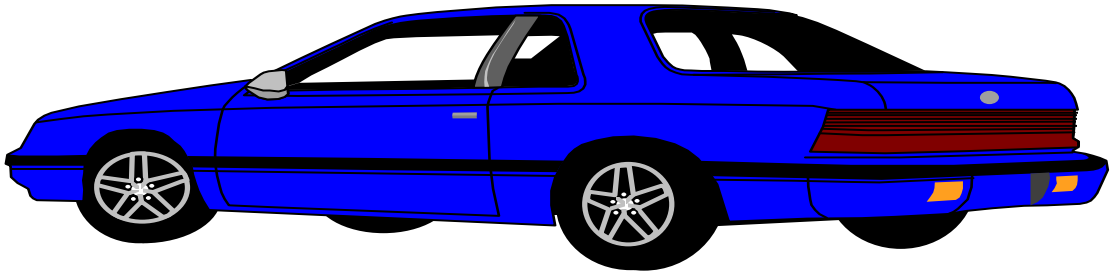
- Rotate Tires
- Lubricate
- Change Oil
- Wax & Polish
- Drain Antifreeze

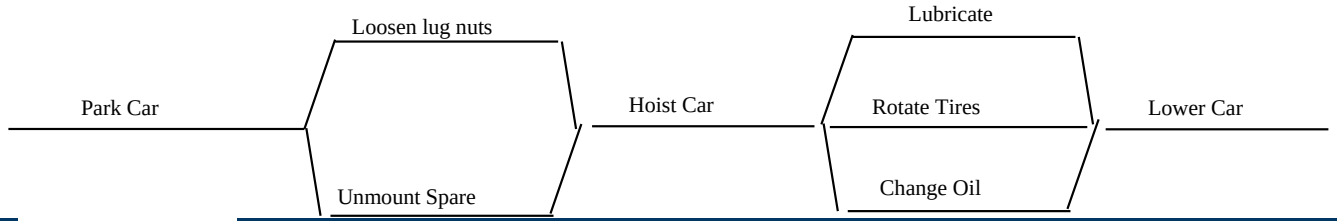




Preparing a Logic Diagram

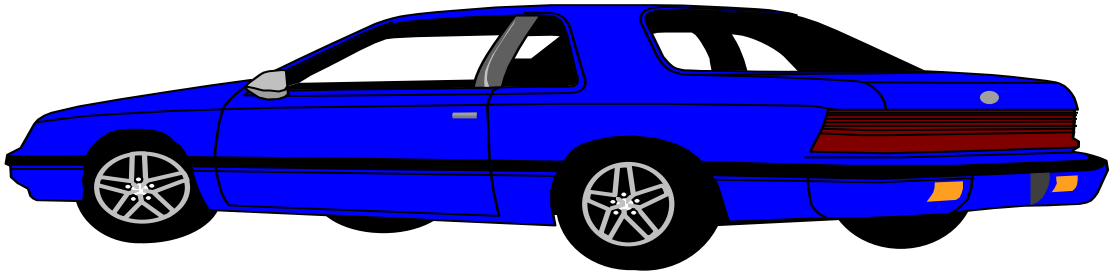
- Rotate Tires
- Lubricate
- Change Oil
- Wax & Polish
- Drain Antifreeze

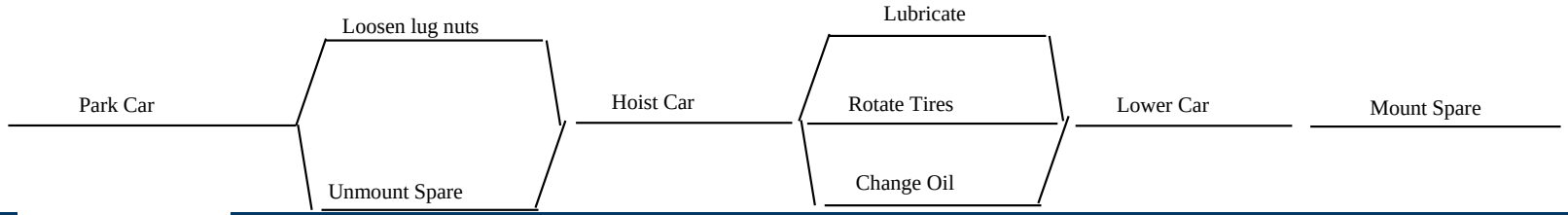




Preparing a Logic Diagram

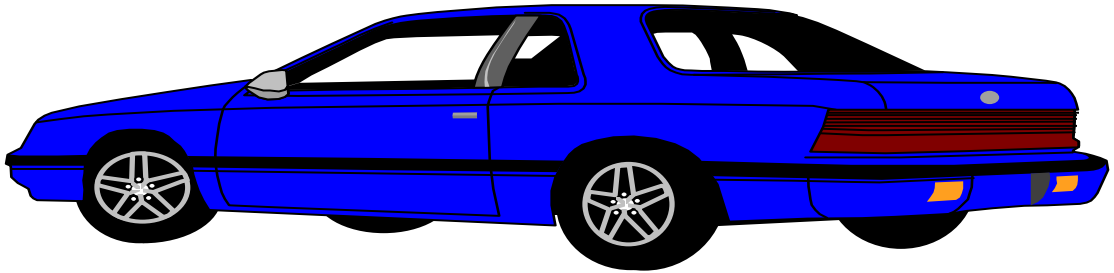
- Rotate Tires
- Lubricate
- Change Oil
- Wax & Polish
- Drain Antifreeze

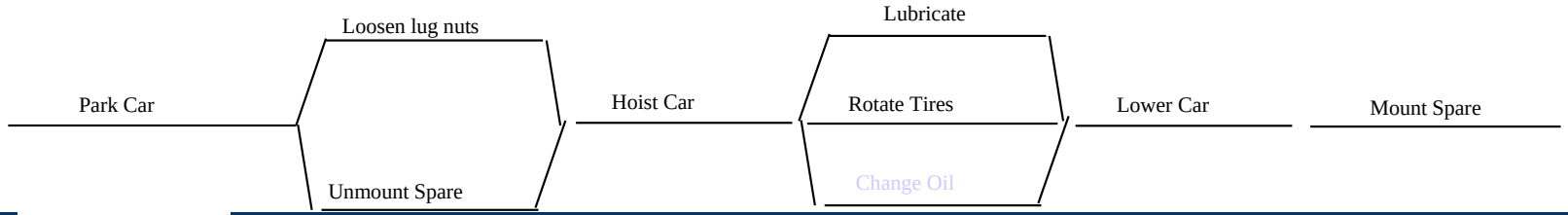




Preparing a Logic Diagram

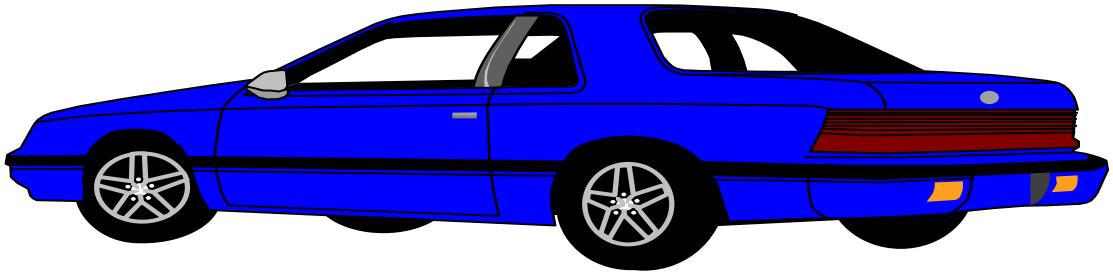
- Rotate Tires
- Lubricate
- Change Oil = Drain Oil, Check Filter, Add New Oil and Check Under Hood
- Wax & Polish
- Drain Antifreeze



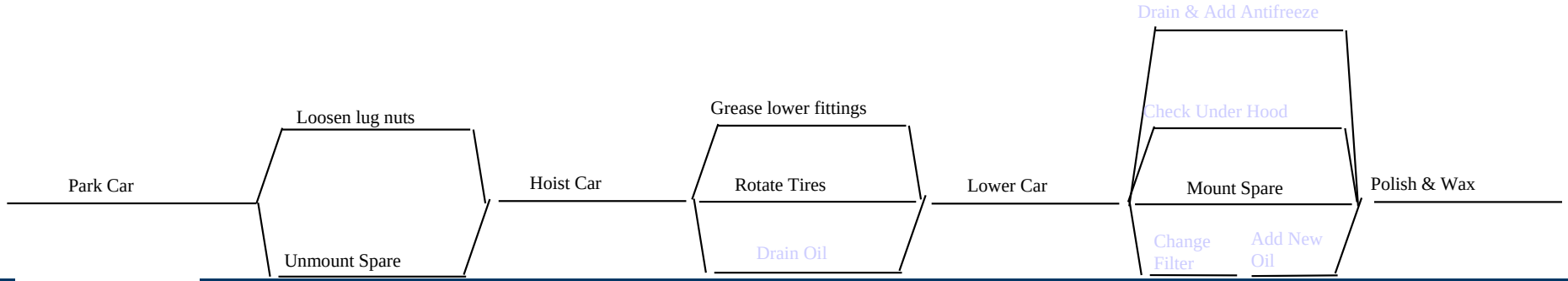


Preparing a Logic Diagram

- Rotate Tires
- Lubricate
- Change Oil
- Wax & Polish
- Drain Antifreeze



see Figure 4.6.1 on page 40

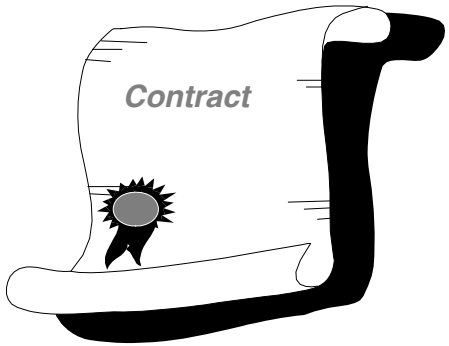


Superintendent Must “Own” Official CPM

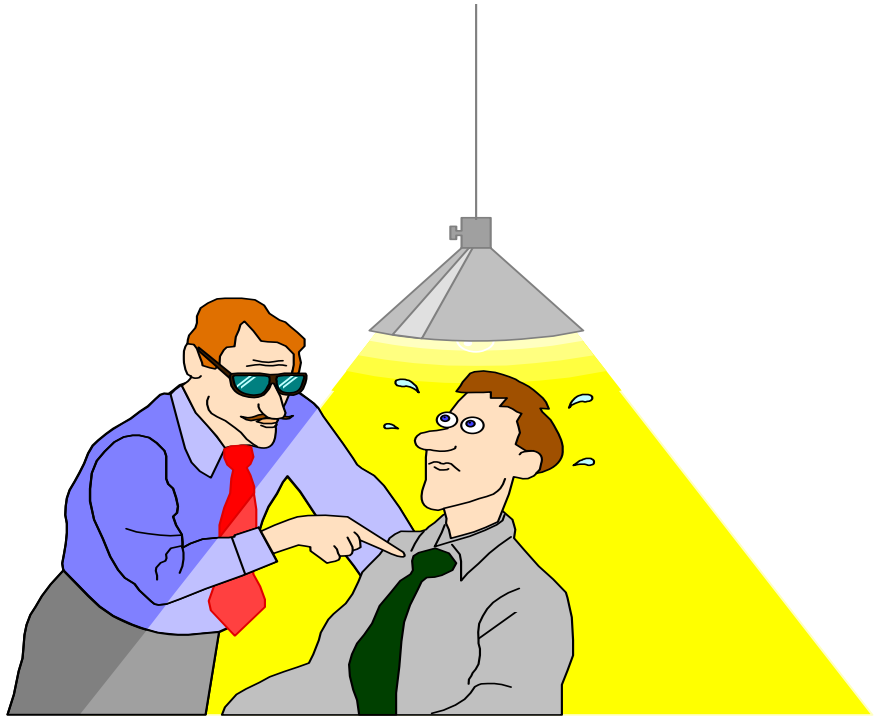
Get contractor’s or major subcontractor’s superintendent input and acceptance

Engineer’s approval must include owner’s acceptance of duties

CPM clarifies and modifies the contract between parties



Developing Network Logic



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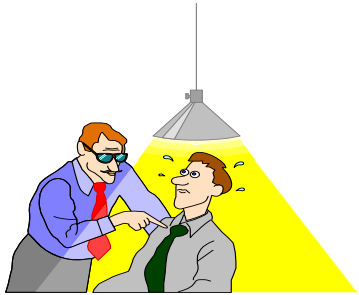
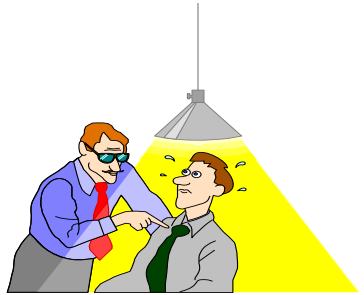
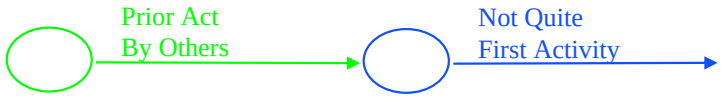
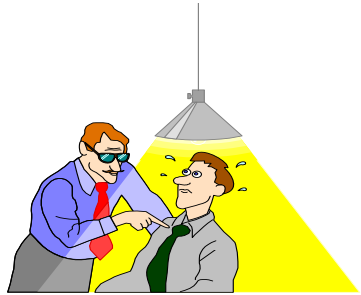


1. "What is your first task after NTP?"



1. "What is your first task after NTP?"
2. "What must others do prior to you beginning said task?"





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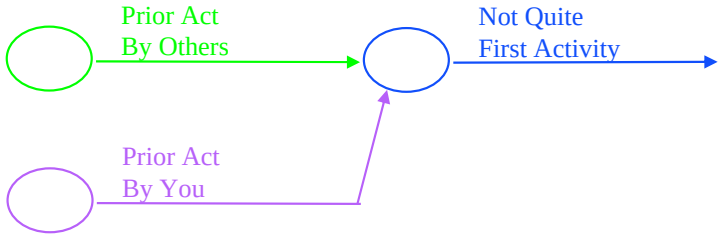
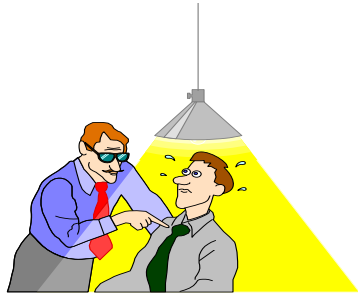
2. "What must others do prior to you beginning said task?"
3. "What else must YOU do prior to beginning said task?"





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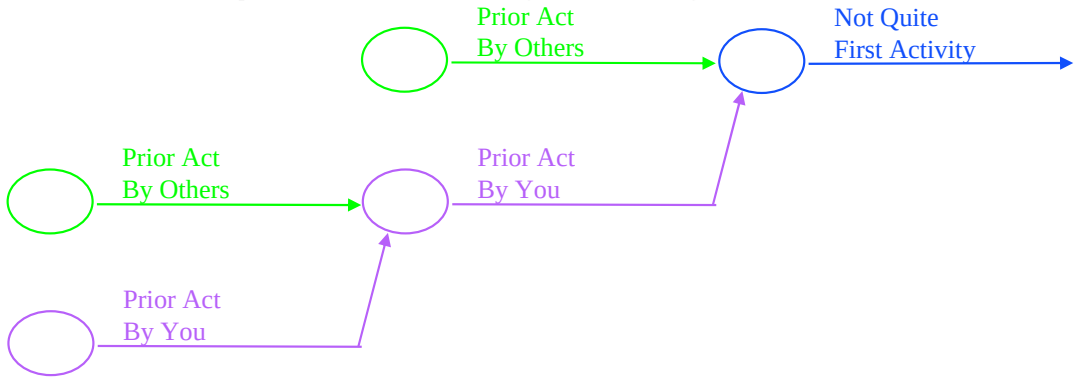

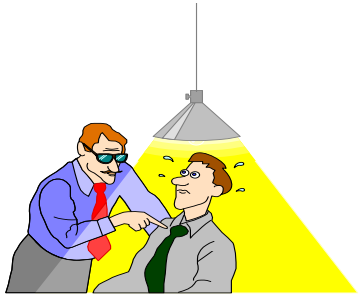

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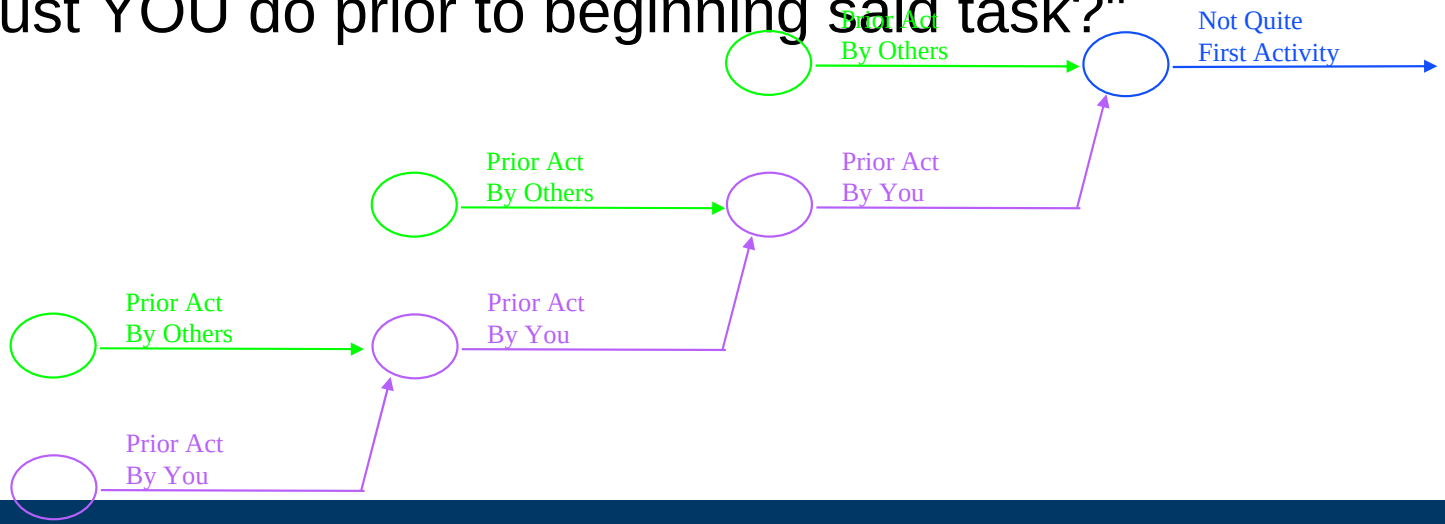

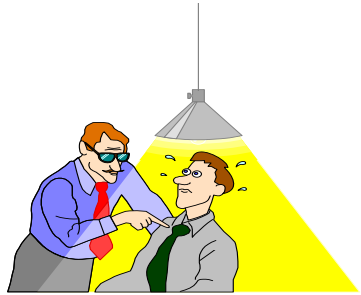

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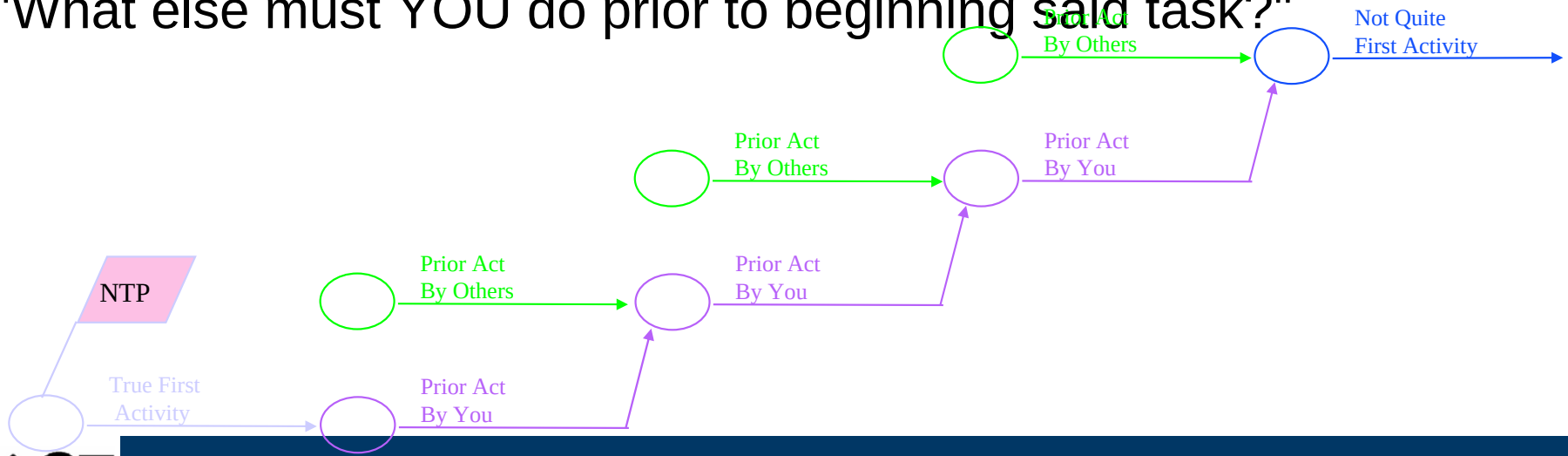

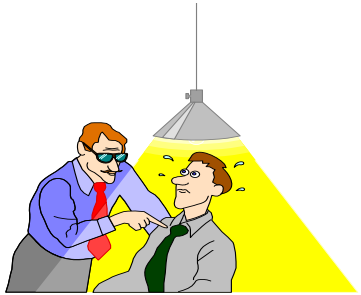

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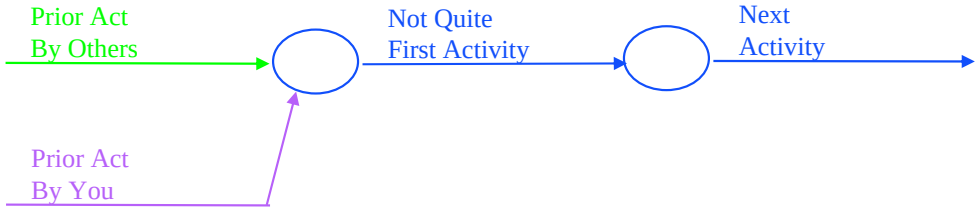

Developing Network Logic

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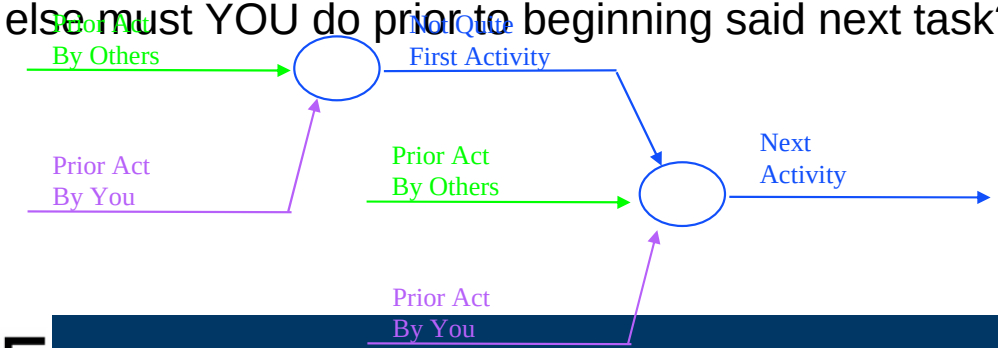

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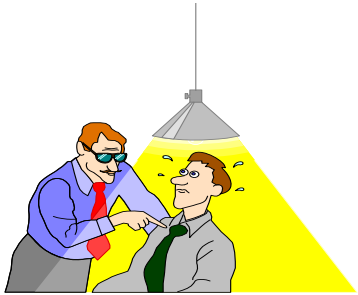
7. Repeat 4 through 6 until project completed.

Developing Network Logic



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6. "What else must YOU do prior to beginning said next task?"
7. Repeat 4 through 6 until project completed.
8. Review and repeat 1 through 7 until walk-through accomplished without any significant changes.

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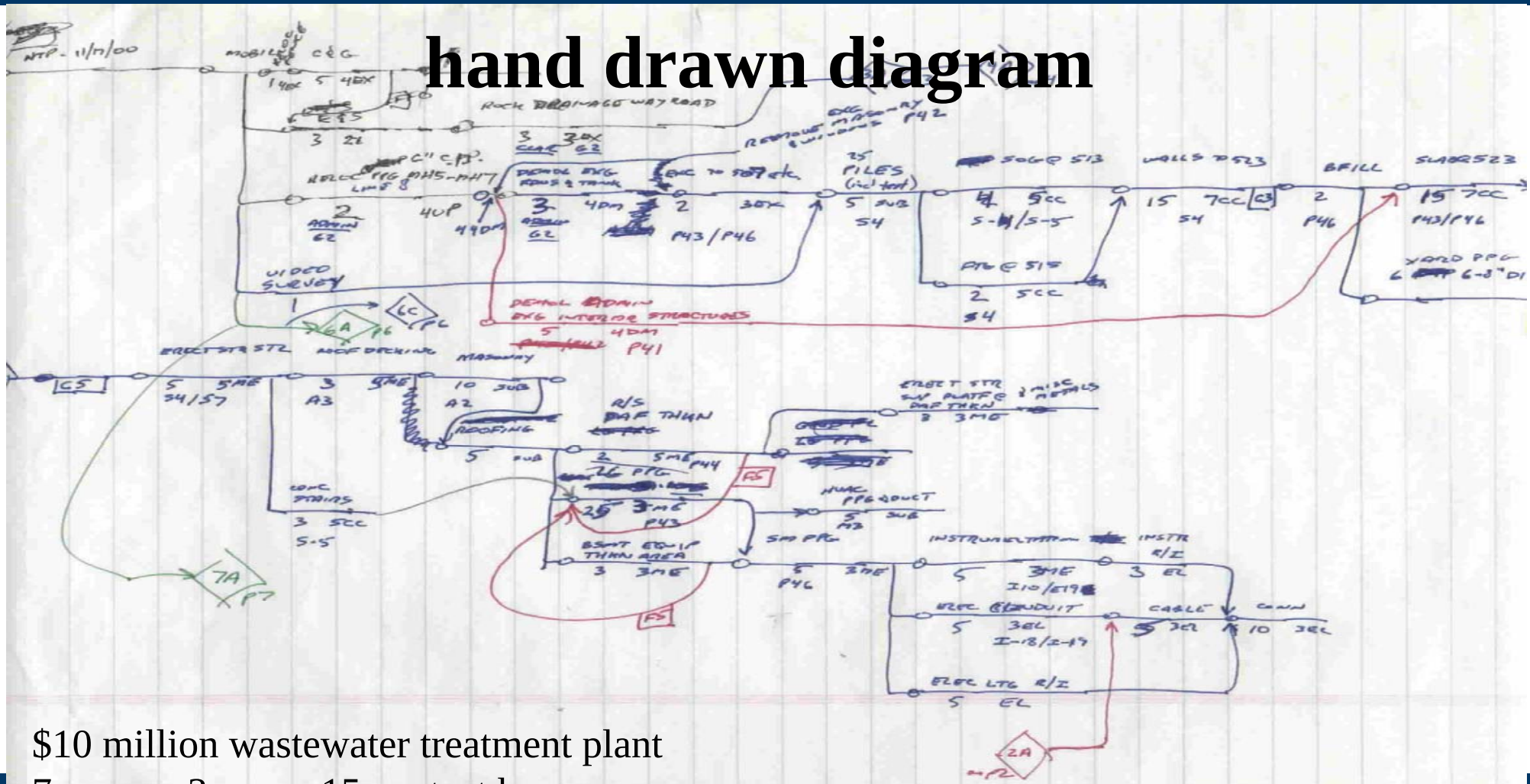
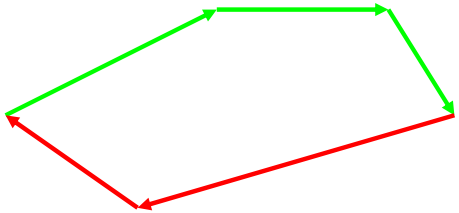
hand drawn diagram



$10 million wastewater treatment plant
7 pages - 3 men - 15 contact hours

Recap and Discussion

- What is included? / excluded? from a CPM Pure Logic Network?
- Contract Drawings – PLAN and SECTION – Contract Specifications
- Bar-Chart as envisioned by Architect Owner Owner Estimator Superintendent?
- Estimate of Architect Engineer Contractor – Senior or Junior or Janitor?



- Do NOT copy to repeat errors by Estimates or Gut Bar-Charts

AACE REGION 2

Homework Assignment

Prepare a Logic Diagram

Choose a simple project which you have never performed

such as changing the brakes in your automobile or baking a cake

Locate a person who knows how and has done this before

Interview the person to ascertain the various tasks and logic required to perform this project

Draft the information in a logic diagram format

It is not necessary for this assignment to obtain durations

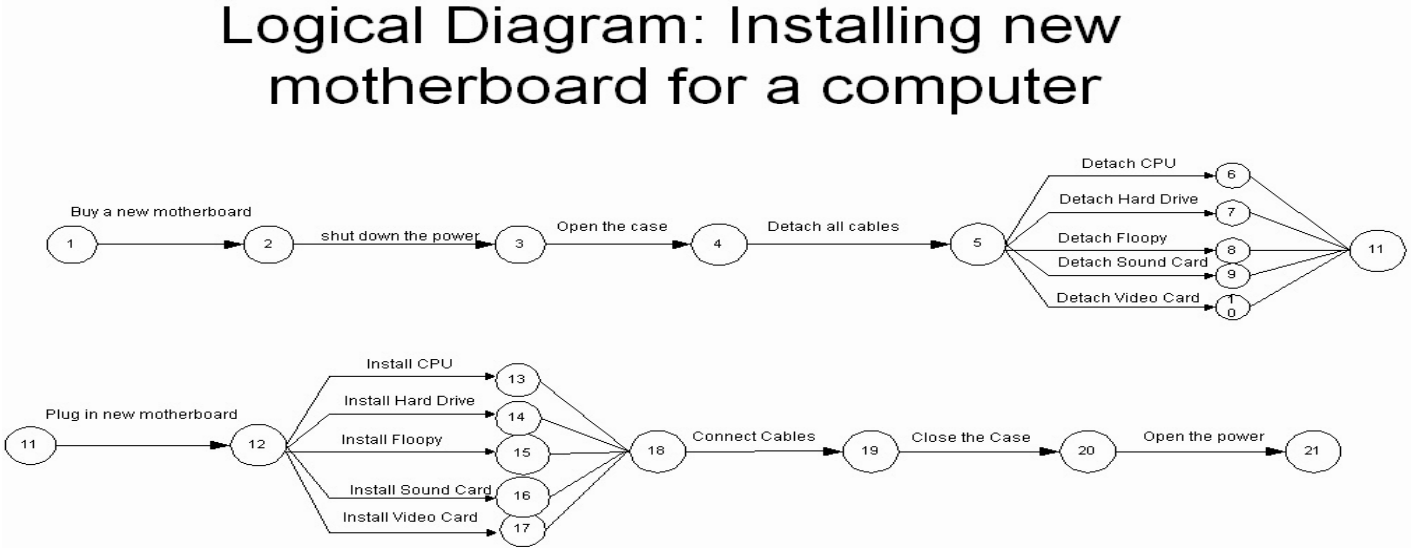
HAND-DRAFT YOUR LOGIC NETWORK

Scan & email OR fax OR mail per instructor

It is necessary to submit this homework assignment to obtain access to the next class lesson

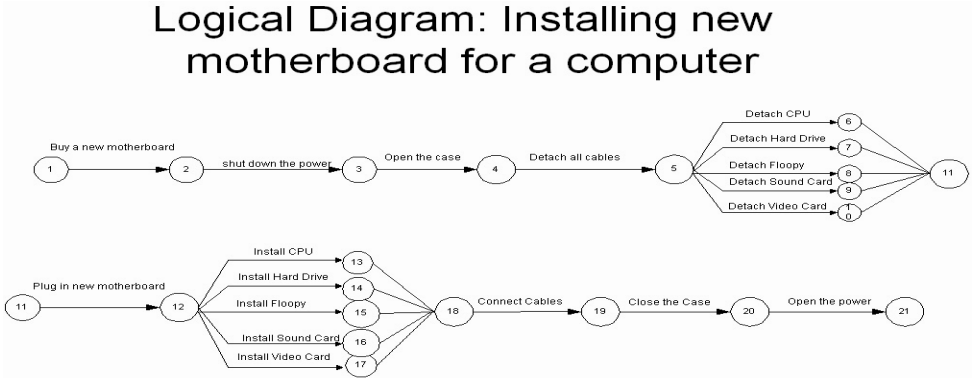
Answers to Homework

----- Original Message -----
From: "xiaobo wang" xw28@drexel.edu
To: "fplotnick" fplotnick@fplotnick.com
Sent: Sunday, March 31, 2002 1:47 PM
Subject: CIVE 572
Dear Mr. Plotnick:
Attached is the logical diagram of the homework.
Yours, Xiaobo Wang
Ph. D. Candidate in Structural Engineering



Answers to Homework

Dear Mr. Wang:
Thank you for your homework submission. This is a very good example of a logic network. It illustrates several issues that we will raise in class.
First, we note that it meets not only the requirements of the homework assignment for a logic diagram, but that it is properly formatted for entry into the computer using the rules of "ADM" requiring a unique ***i - j*** node for each activity. Therefore, this network could be entered into the early CPM computer programs without further adjustments by a scheduler.
Second, do note that we have several unnecessary logic restraints (or "dummies") as either 6-11 or 7-11 or 8-11 or 9-11 or 10-11 could be deleted without violating the unique node numbering rule. (Same with the -18 series.) When this course was taught in the 1970's, this "error" would result in a grade reduction - because in the real world, fee systems for computer time would charge equally for a real activity, a logic restraint ("dummy") or an unnecessary dummy. Today, with computer processing costs vastly reduced, proper practice may even encourage a few "extra" logic restraints than absolutely necessary.
Third, it is probable that activities 5-6 -7 -8 -9 and -10 (and similarly 12-13 -14 -15 -16 and -17) could not be done concurrently by, for example, five people at once. And yet this is what is shown by the logic! How can resolve this so that we neither (1) dictate a fictitious order of work (5-6 then 5-7 then 5-8, etc.,) nor (2) incorrectly provide a network whose calculated solution will be a project completion time earlier than that which may reasonably be achieved? Again, thank you for this network.
Sincerely yours, Fredric L. Plotnick, Esq., P.E.



The next layer of the onion

What is an Activity?

An activity is ...

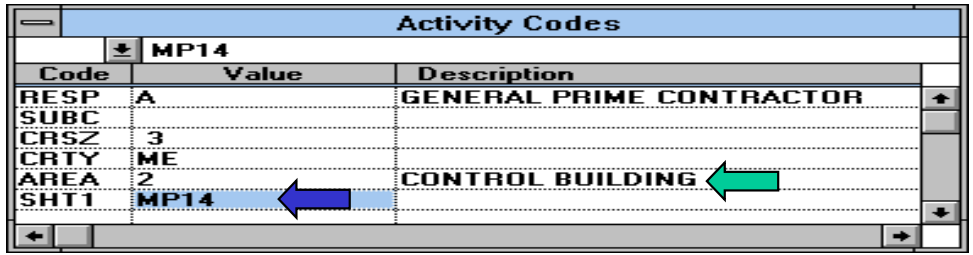
"...a set of instructions, given to a competent foreman, who is then expected to complete such without further supervision or interaction with other than his own subordinates."

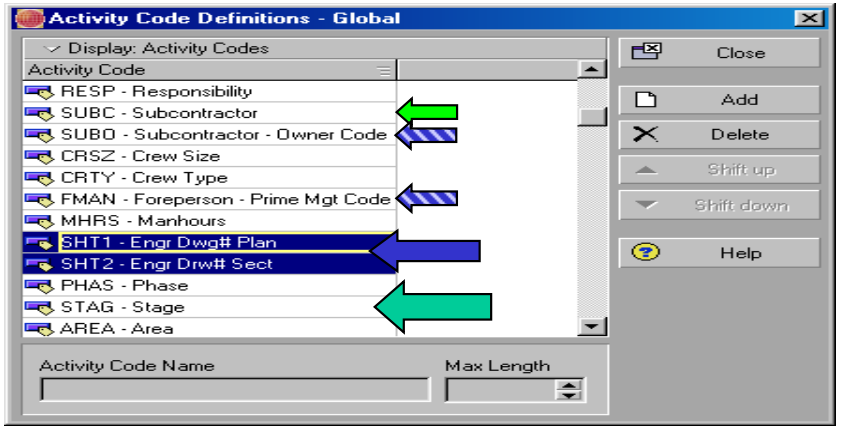
A gross abbreviation

Use logs to explain further

Use code fields SHT1, SHT2 to refer to design engineer's drawings

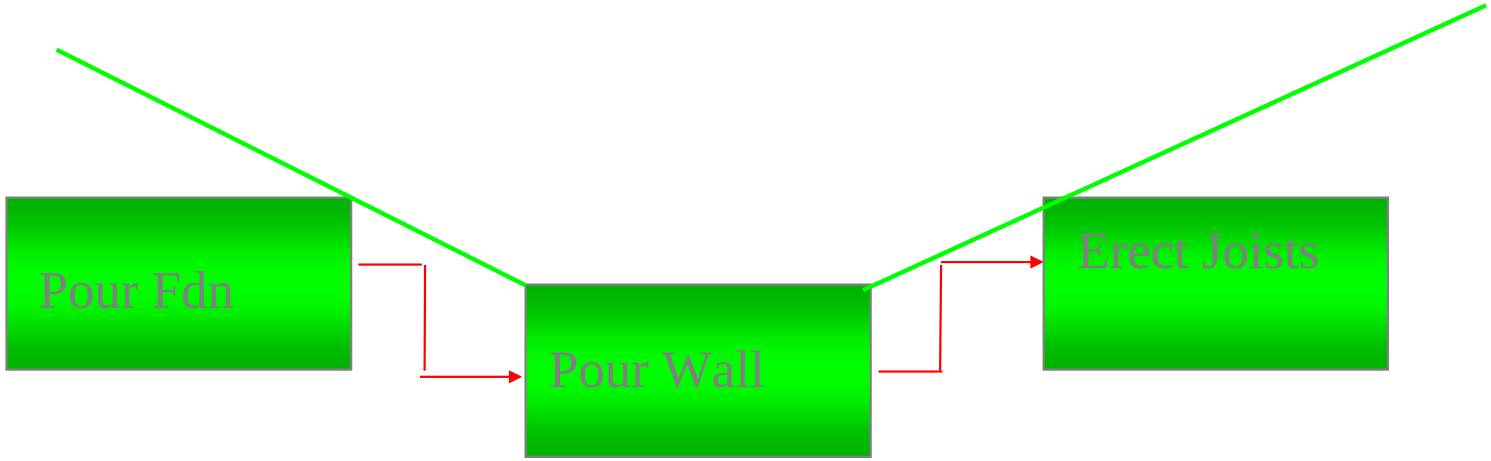
Note issues of local v global codes





A gross abbreviation

Form/Rebar/Pour Wall shown on Dwg C27 and Dwg C28 Section B upon completed foundations for the purpose of supporting joists and including sleeves for plumbing and electrical penetrations.



Activity Title

A gross abbreviation

Suggest reference to Drawing # or Spec section

Activity Codes

CB

Code	Value	Description
RESP	C	General Civil Contractor
AREA	CB	Control Building
SHT1	C27	Control Bldg Plan
SHT2	C28 @B	Control Building Sections

Activity Title

A gross abbreviation

Suggest reference to Drawing # or Spec section

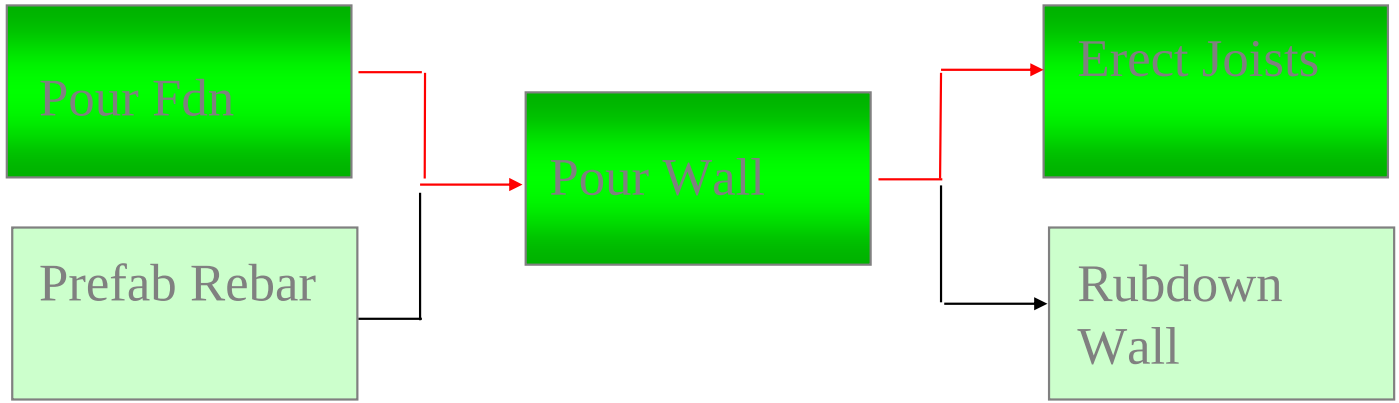
Further defined by Predecessors and Successors

Activity Title

A gross abbreviation

Suggest reference to Drawing # or Spec section

Further defined by Predecessors and Successors



Activity Predecessors and Successors

Limits of the CPM analysis - no .or. statement

Activity title further defined by predecessor and successors

Hard physical logic *vs.* soft resource logic *vs.* no logic

- Each activity **must have** at least one physical relationship
- Each activity should have **only one** resource restraint per resource
- Explain and record reasons for non-physical restraints as notes or in logs
- Explain and record reasons for any constraints as notes or in logs

Physical v. Limited Resources v. Leveled Resources

The First 90 Days *vs.* the Last 90 Days

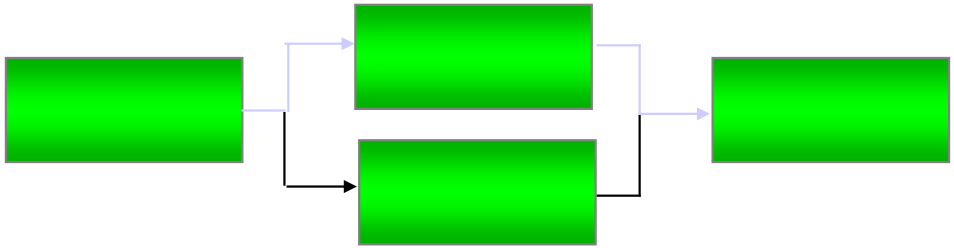
Good work, but I think we need a little more detail right here

- Detail of latter part of project is often deferred
- Detail of less knowledgeable areas is often deferred, such as:
  - Architectural, HVAC and plumbing of control building of a process plant
  - Electrical connections and instrumentation
- Engineer is often sloppier on end items
- Project manager will never have more time than at the start of project

Now - let's walk through the project
and check the logic

The forward pass: Why is this task necessary for the next?

- Hard logic *vs.* resource restraints *vs.* placemarker
- How hard is the hard logic? ...on a scale of 1 to 10?
- Purpose of resource logic—question of entitlement
- SNET constraints—question of entitlement
- FNLT constraints—usually mandated by owner



Let's walk through the project
and check the logic

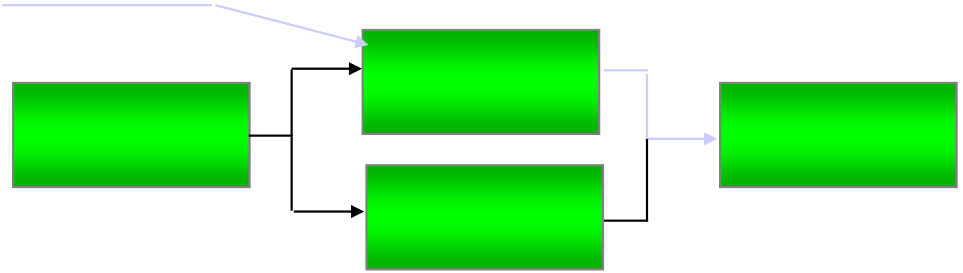
The backward pass: Are we missing any requirements for this task?

Contractor — owner — third party activities

Physical *vs.* access vs. limited resource restraints

Calendar considerations—seasonal weather, etc.

?

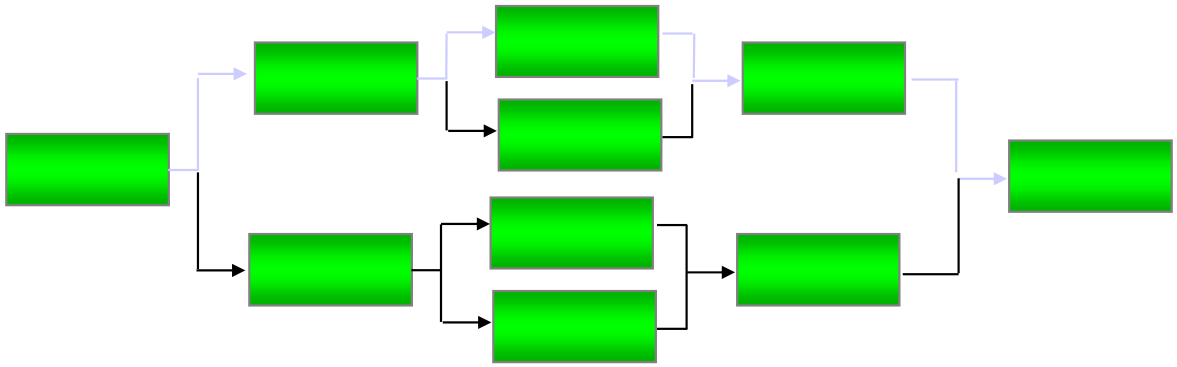


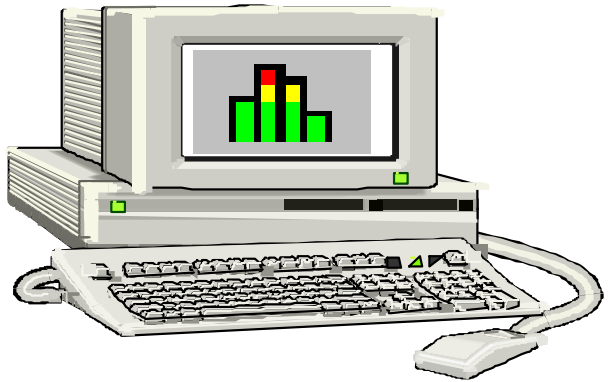
The Plan *vs*. the Schedule

Use the pure-logic diagram as basis for all calculations

Use calculated schedule as tabular and graphical depictions for analysis

Then evaluate manual and automated leveling and smoothing routines





Recap and Discussion

- Describe the workflow by primes, subcontractors, and others
- Are you showing all dependencies of Prime by others? upon others?
    - Are you able to show dependencies and float of subcontractors?
- RDM by FRED: Just-in-Time `Finish Start Float` versus Kelly Free Float alternately by using 1956 “Reel to Reel” Free Float and HAND calculation
- Remember Events Constraints Activities Restraints and Relationships
- Compare Modern to softwares of 1960s 1970s 1980s pre-DOS but proper maths
- Examples: Distinguish Start-to-Start Begin-to Begin Finish-to-Finish End-to-End Distinguish the Work Day from Days Hours 1/100th of Hour; interruptible vs continuous duration
- Do not hobble your project nor your voice to software written by and for software writers

Thank you for your time!

This concludes the educational content of this presentation

Questions?

Fredric L. Plotnick, Ph.D., Esq., P.E., P.L.S.
fplotnick@fplotnick.com
215-880-8899
www.fplotnick.com www.enpromac.com www.rdcpm.com

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