Week 5

Project Work Plan

457.307 Construction Planning and Management

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Project Work Plan

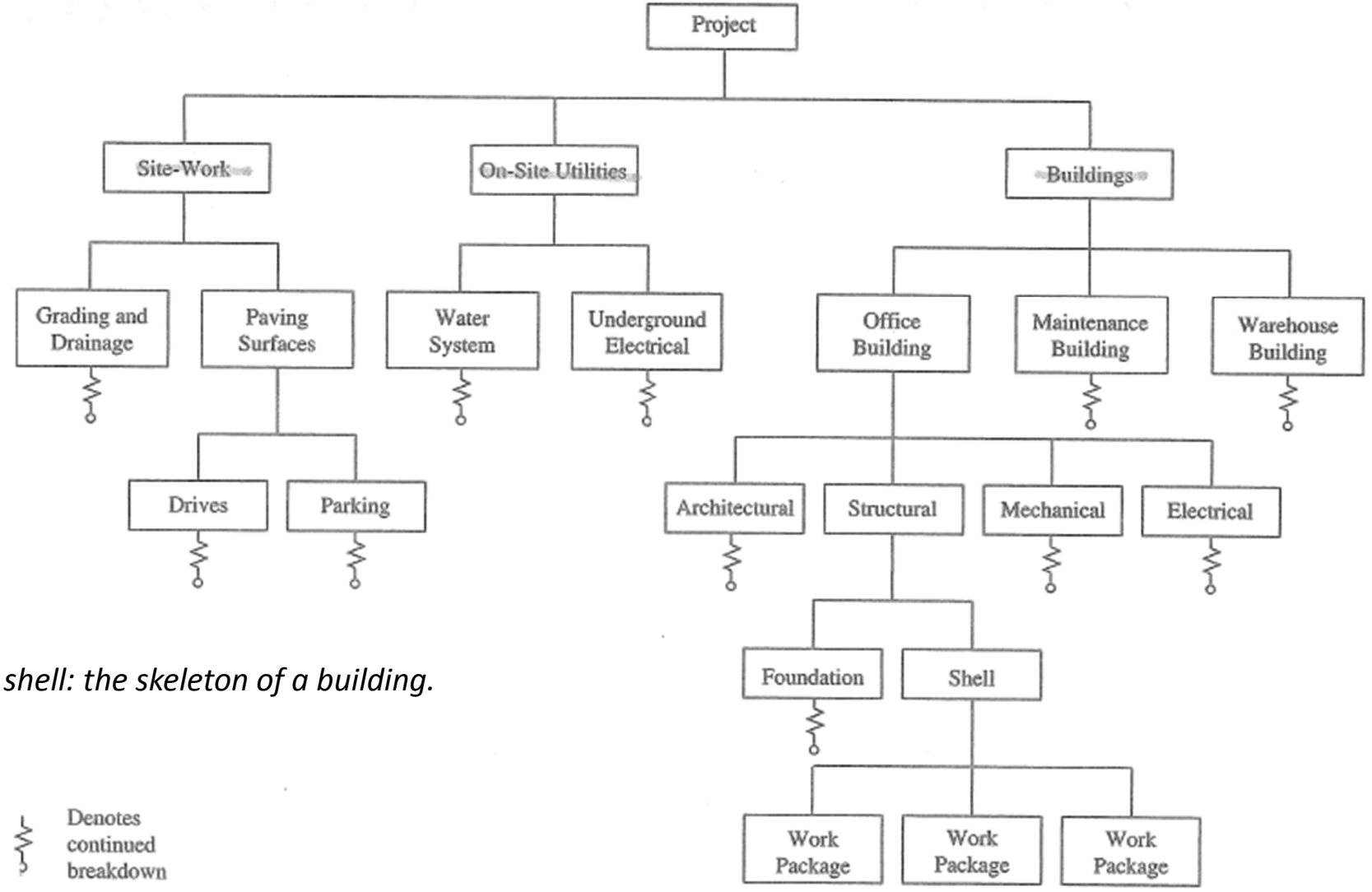
- **Identifies the work to be done**
  - Who will do it, When
  - Costs
- **Basic components**
  - Overview/Directory
    - Project title, objective scope, organization chart
  - Tasks
    - List of tasks, groupings
  - Schedule
    - Sequencing and interdependencies, durations, start/finish
  - Budget
    - Labor hours and staff costs, billing approach
  - Measurement
    - Accomplishment of tasks, completion of work package

Work Plan Development

1. **PM initial duty is to review sponsoring organization material regarding**
   - Project scope
   - Budget
   - Schedule
2. **Meet with sponsor to determine requirements and priorities for**
   - Quality
   - Scope
   - Time
   - Cost
   - Determine owner's level of involvement
3. **Develop work breakdown structure (WBS)**
   - Define work to be performed
   - Identify needed expertise
   - Select project team
   - Establish project schedule and controls

Work Breakdown Structure (WBS)

- Divides the project into identifiable part that can be managed



**Building shell: the skeleton of a building.*

Work Breakdown Structure (WBS)

- Divides the project into identifiable part that can be managed
- Concept of WBS is simple: to manage the whole project must control each of the parts
- All the work contained within the WBS is to be identified, estimated, scheduled, budgeted, and controlled
  - Identifying work, compiling the budget, and developing an integrated schedule
- Shown in graphical display to organize and subdivide the total scope of work

Work Breakdown Structure (WBS)

- **Project work is structured into WBS elements (work packages) must be:**
  - Definable: easily described and understood
  - Manageable: meaningful unit of work where specific responsibility can be assigned
  - Estimateable: duration and costs can be estimated
  - Independent: minimum interface with or dependence on other ongoing elements
  - Integratable: integrates with other project work elements
  - Measureable: has start and completion dates and interim milestones
  - Adaptable: flexible so the addition/elimination of work scope can be accommodated

Work Breakdown Structure (WBS)

- **Characteristics of WBS**
  - Most commonly produced in the form of a table or chart
  - Procedure in the associated work flow is used to produce this work product
  - Progresses downward from the general to the specific
  - Provides a framework for turning project objectives into specific deliverables

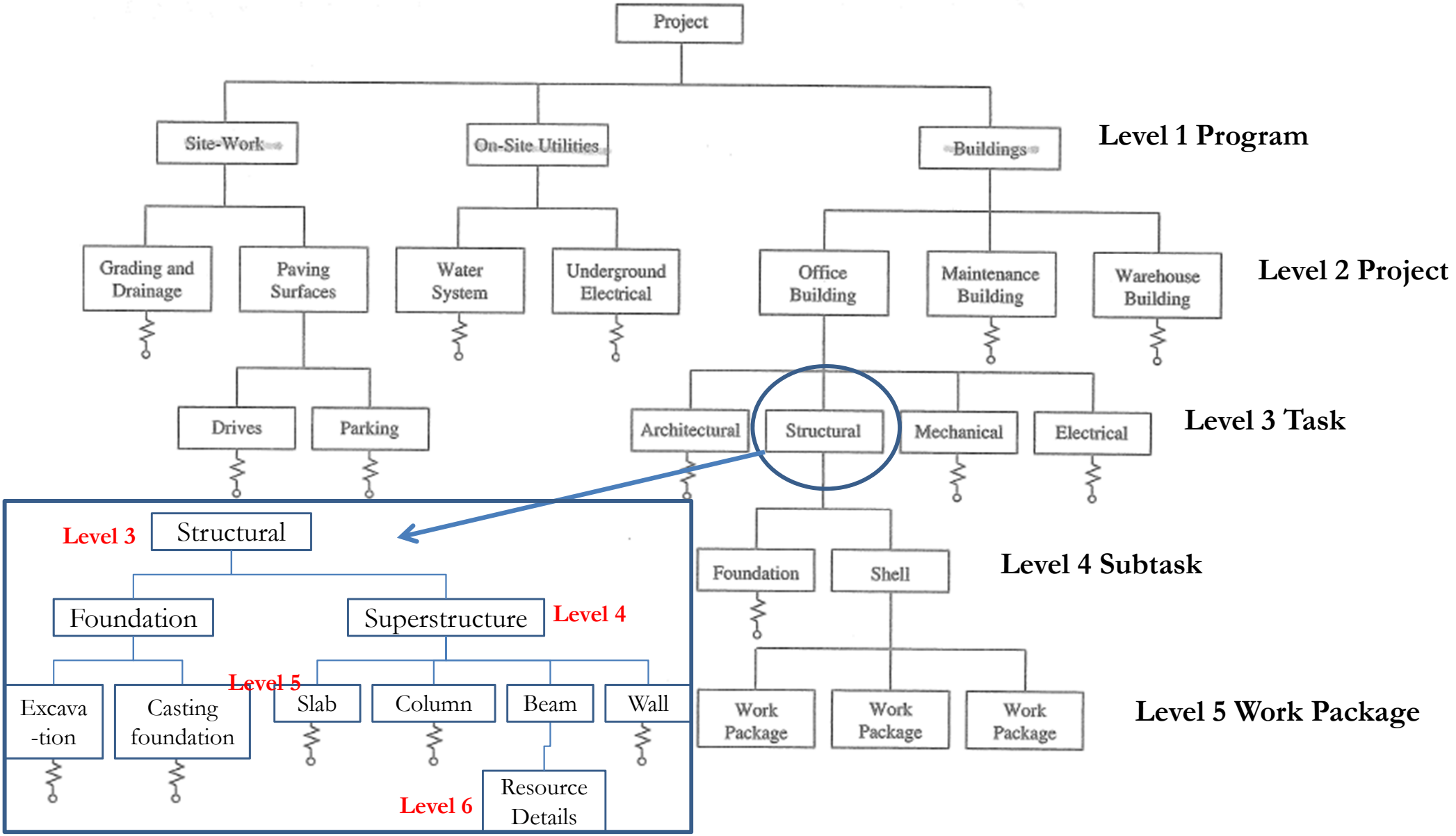
Work Breakdown Structure (WBS)

- **Typical levels of WBS**
  - Level 1: Total program
  - Level 2: Project
  - Level 3: Task
  - Level 4: Subtask
  - Level 5: Work package
  - Level 6: Level of effort

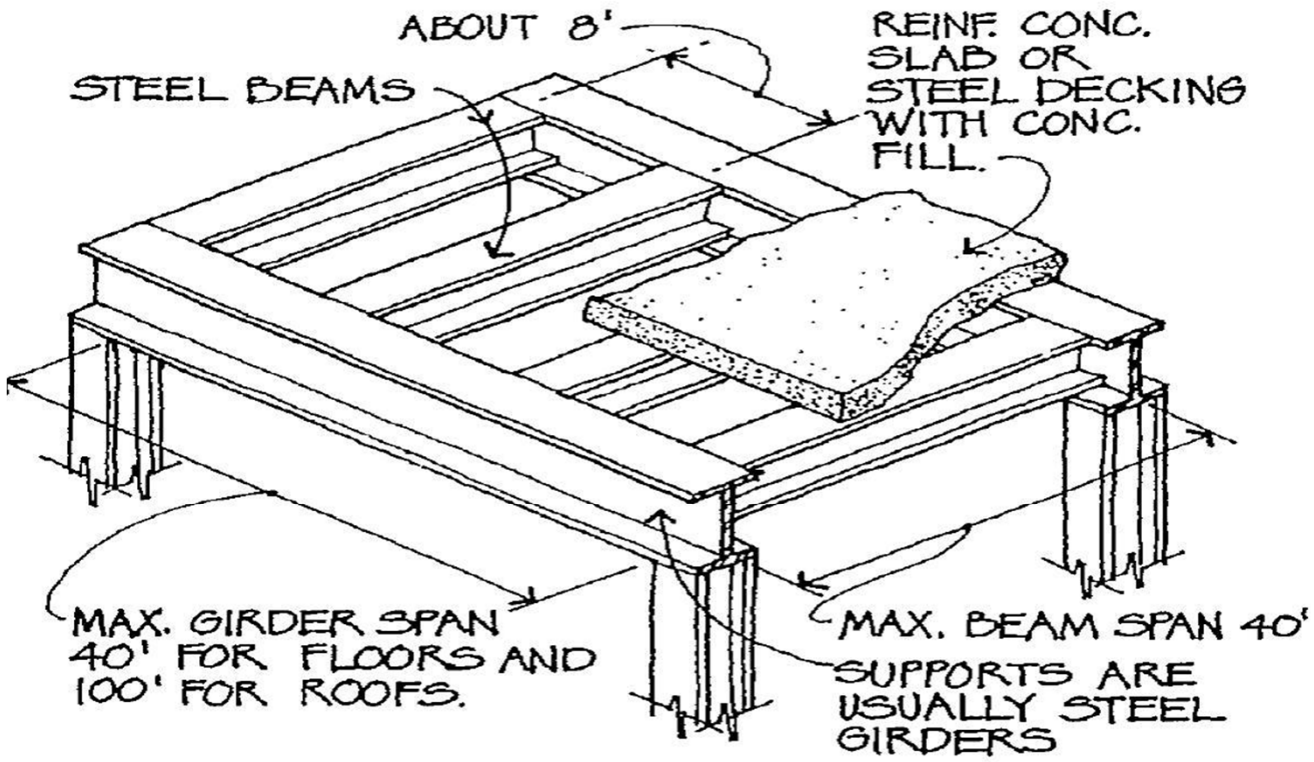
  Managerial Levels

  Technical Levels
- **Upper 3 levels normally specified by the owner**
  - Level 1: authorization and release of work
  - Level 2: budgets prepared
  - Level 3: schedules prepared
- **Lower 3 levels are generated by the contractor**

Work Breakdown Structure (WBS)



Superstructure



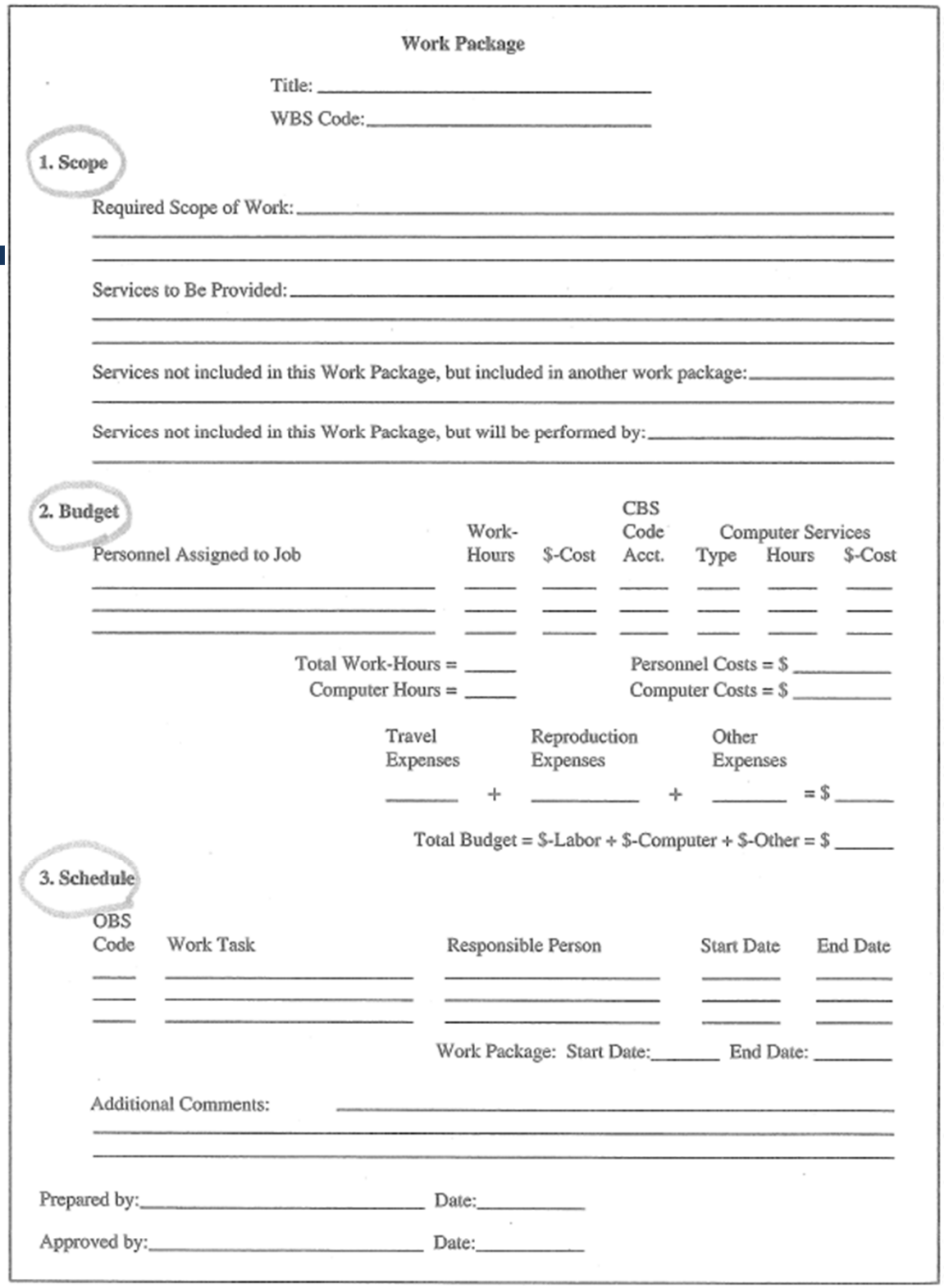
STEEL BEAM AND GIRDER SYSTEM

- BEAMS AND GIRDERS MAY BE PART OF MAIN SKELETON FRAME
- COMPOSITE ACTION BETWEEN BEAM AND SLAB POSSIBLE
- ECONOMICAL FOR MOST BUILDING LOADS.

A girder is the primary horizontal member carrying loads from other beams and slabs connected to it. That is a girder has other beams connecting to it on its sides .Typically beams do not have other beams connecting to it but generally have only slabs transferring the loads to it.

WBS

- **Work Package**
  - Lowest level in the WBS
  - Baseline for scheduling, tracking, cost control



Work Package

Title: _____

WBS Code: _____

1. Scope

Required Scope of Work: _____

_____

_____

Services to Be Provided: _____

_____

_____

Services not included in this Work Package, but included in another work package: _____

_____

Services not included in this Work Package, but will be performed by: _____

_____

2. Budget

Personnel Assigned to Job	Work-Hours	$-Cost	CBS Code Acct.	Computer Services Type	Hours	$-Cost

Total Work-Hours = _____ Personnel Costs = $ _____

Computer Hours = _____ Computer Costs = $ _____

Travel Expenses _____ + Reproduction Expenses _____ + Other Expenses _____ = $ _____

Total Budget = $-Labor + $-Computer + $-Other = $ _____

3. Schedule

OBS Code	Work Task	Responsible Person	Start Date	End Date

Work Package: Start Date: _____ End Date: _____

Additional Comments: _____

_____

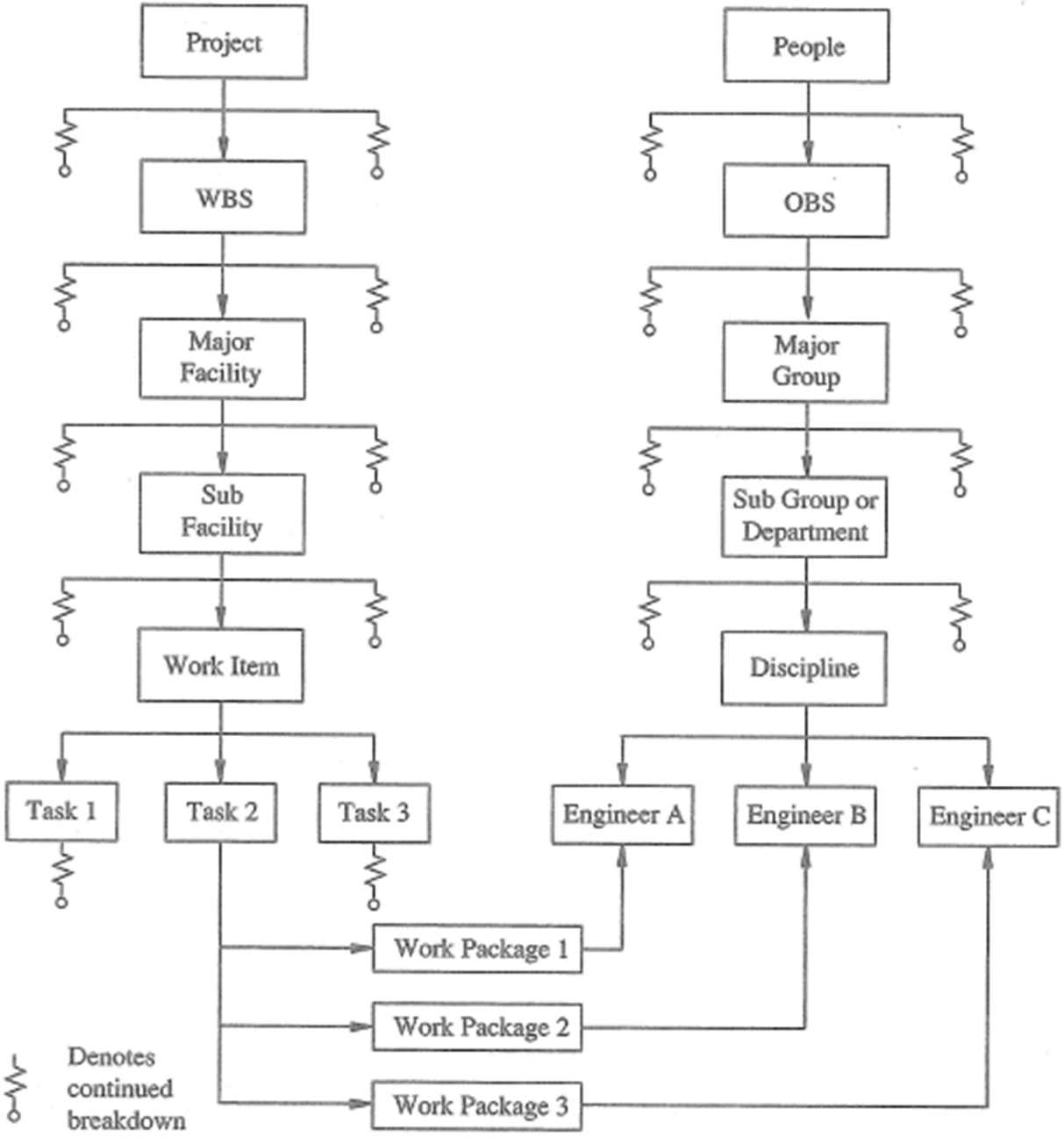
_____

Prepared by: _____ Date: _____

Approved by: _____ Date: _____

WBS vs OBS

- WBS: define the work to be accomplished
- OBS (Organizational Breakdown Structure)
  - Define who is responsible for performing the work

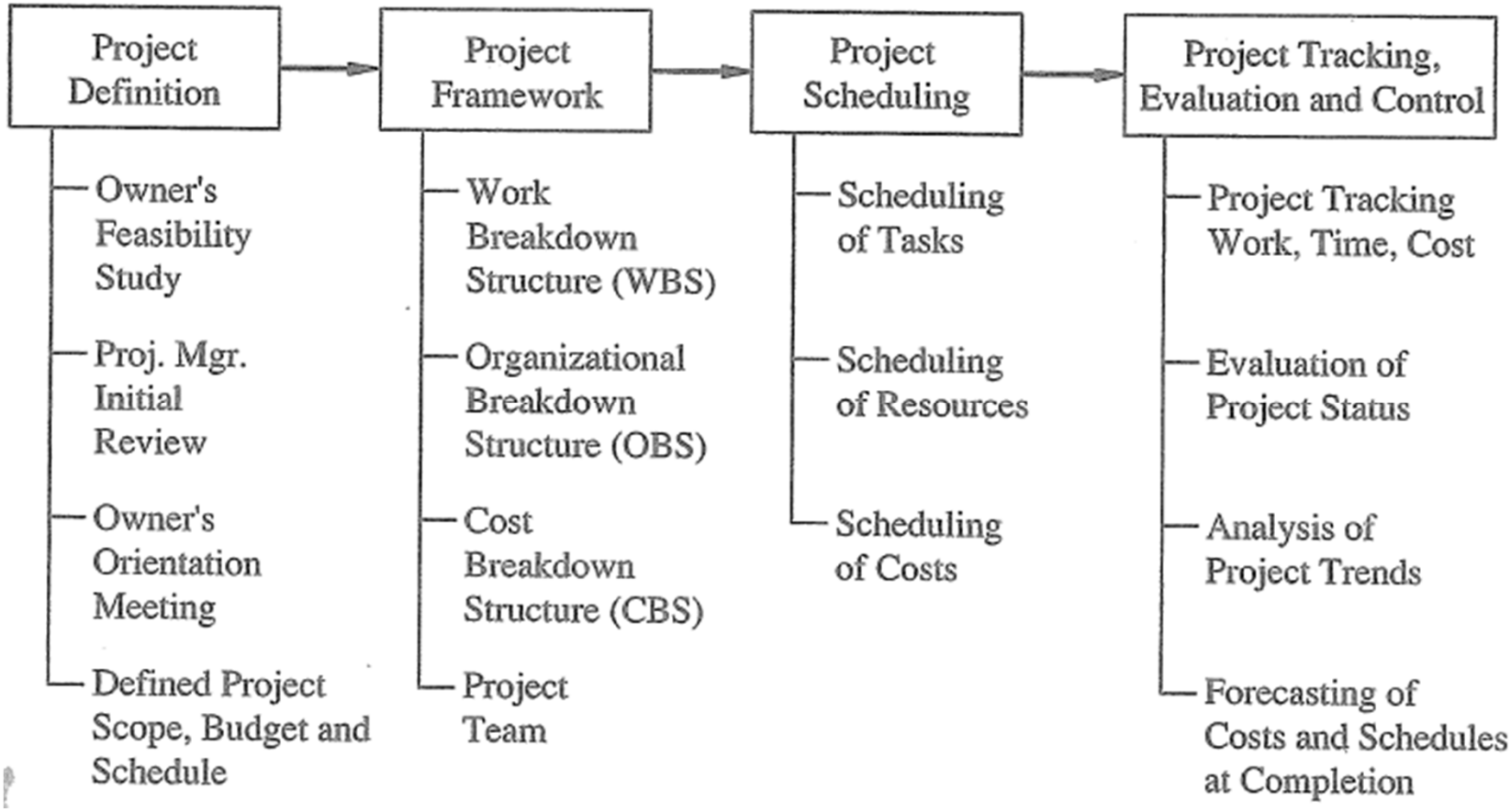


Good work packages

- **Connects the abstract (schedules, production analysis) with the physical**

- **To link schedules into production, consider**
  - A complete design
  - A list of materials to be installed
  - A specific area to be worked on
  - A start and end date (handover dates)
  - *A materials handling plan*

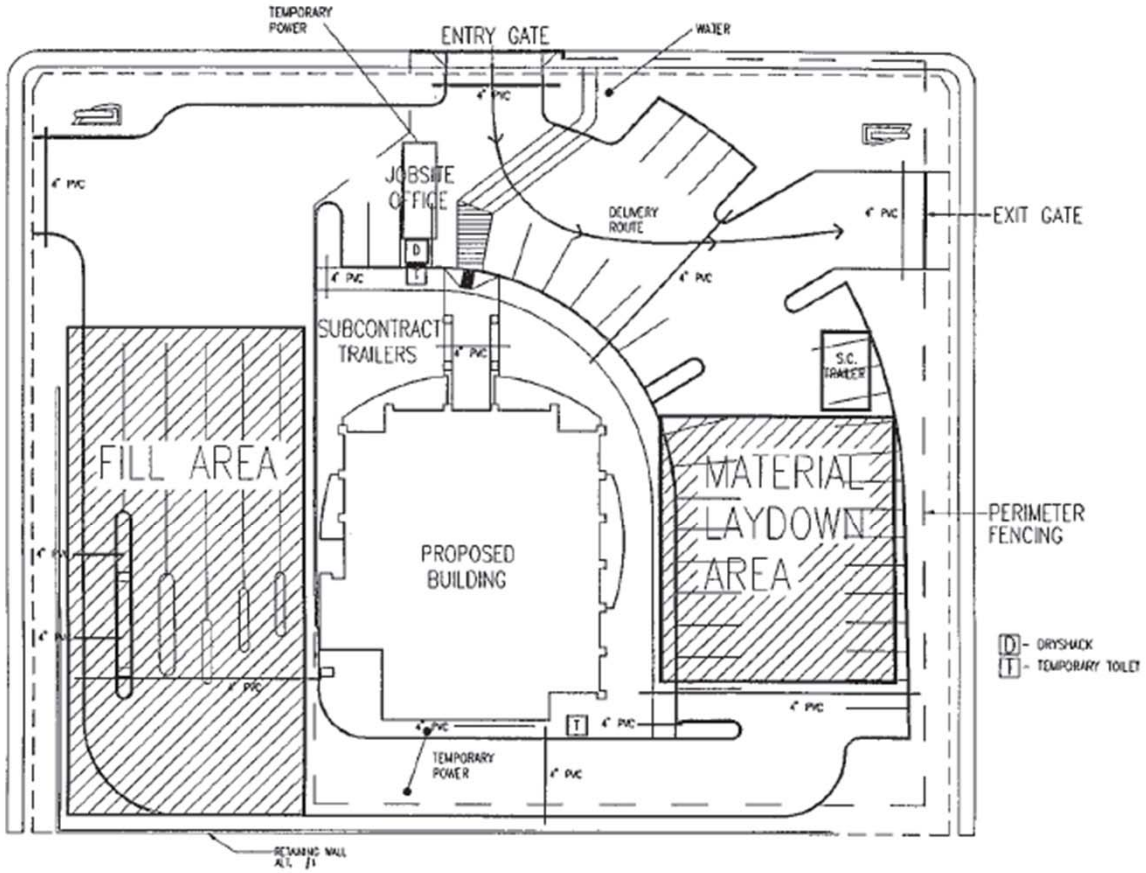
Phases of Development of Work Plan



Site Layout

- **Definition:**
  - Assigning areas to staging, materials storage, and shared resources (e.g., cranes)
- **Site layout is:**
  - Dynamic; can cause access conflicts
  - Should be considered with work packaging when developing construction plan
  - Site layout (big picture) constraints, then
    - Work packaging <--> Site layout (micro analysis)

Jobsite Layout



SITE LAYOUT PLAN

SCALE: 1" = 50'-0"

Jobsite Layout Overview

- **Jobsite layout plan**
  - Plan for temporary facilities, material movement, storage, and handling
- **Areas of consideration**
  - Labor productivity
  - Material handling
  - Equipment constraints
  - Site constraints
- **Jobsite layout plan aspects**
  - Jobsite space allocation
  - Jobsite access
  - Material handling
  - Worker transportation
  - Temporary facilities
  - Jobsite security
  - Signage and barricades

Labor Productivity

- **Travel time: non-productive time elements**
  - From gate to worksite
  - To sanitary facilities (for toilet, gas, water, etc.)
  - Coffee breaks and lunch
  - Moving material and asking questions
  - ***Need to be minimum!***

Piping Activity: Layout

Week 5

Project Scheduling (1)

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Project Scheduling (PMBOK Chapter 6)

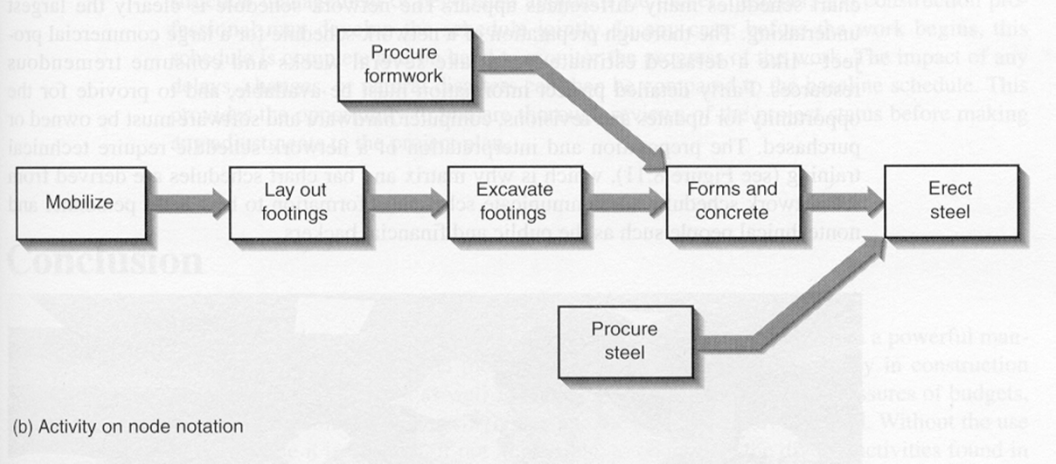
- **Project Time Management**
  - Includes the process required to ensure timely completion of the project
- **Major Processes**
  1. Activity definition
  2. Activity sequencing
  3. Activity duration estimation
  4. Schedule development
  5. Schedule control

Project Scheduling – Activity Definition

- **WBS being the basis for development of the final activity list**
- **Tools and Techniques**
  - Decomposition
    - Involves subdividing project elements into smaller, more manageable components in order to provide better management control
  - Templates
    - An activity list, or a portion of an activity list from a previous project, is often usable as a template for a new project
    - Resource skills, required hours of effort, risk identification, expected deliverables, etc.

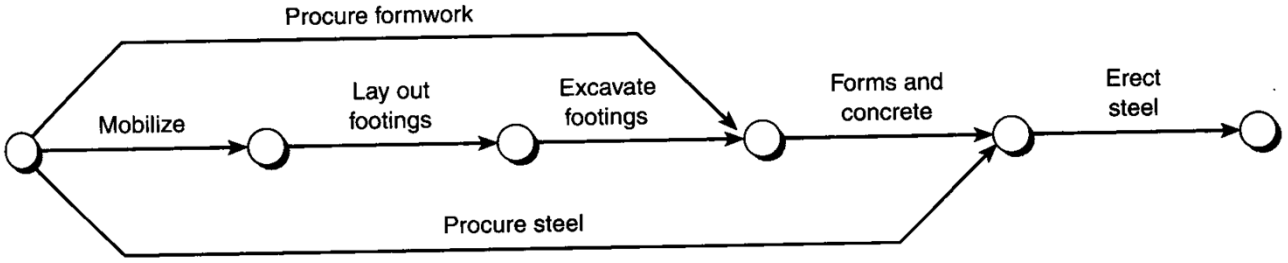
Project Scheduling – Activity Sequencing

- **Identifying interactivity dependencies**
  - Precedence Diagramming Method (PDM) called Activity-On-Node (AON)



(b) Activity on node notation

  - Arrow Diagramming Method (ADM) called Activity-On-Arrow (AOA), "old school" not much used as more



(a) Activity on arrow notation

Project Scheduling – Activity Sequencing

- **Precedence Notation**
  - Activities or operations are placed on nodes
  - Arrows defines relationships between activities
    - Finish to Start
    - Start to Start
    - Finish to Finish
    - Start to Finish
  - Apply "leads" and "lags" provide ability to overlap activities, allowing the scheduler to model more accurately the project's operation

Project Scheduling – Duration Estimate

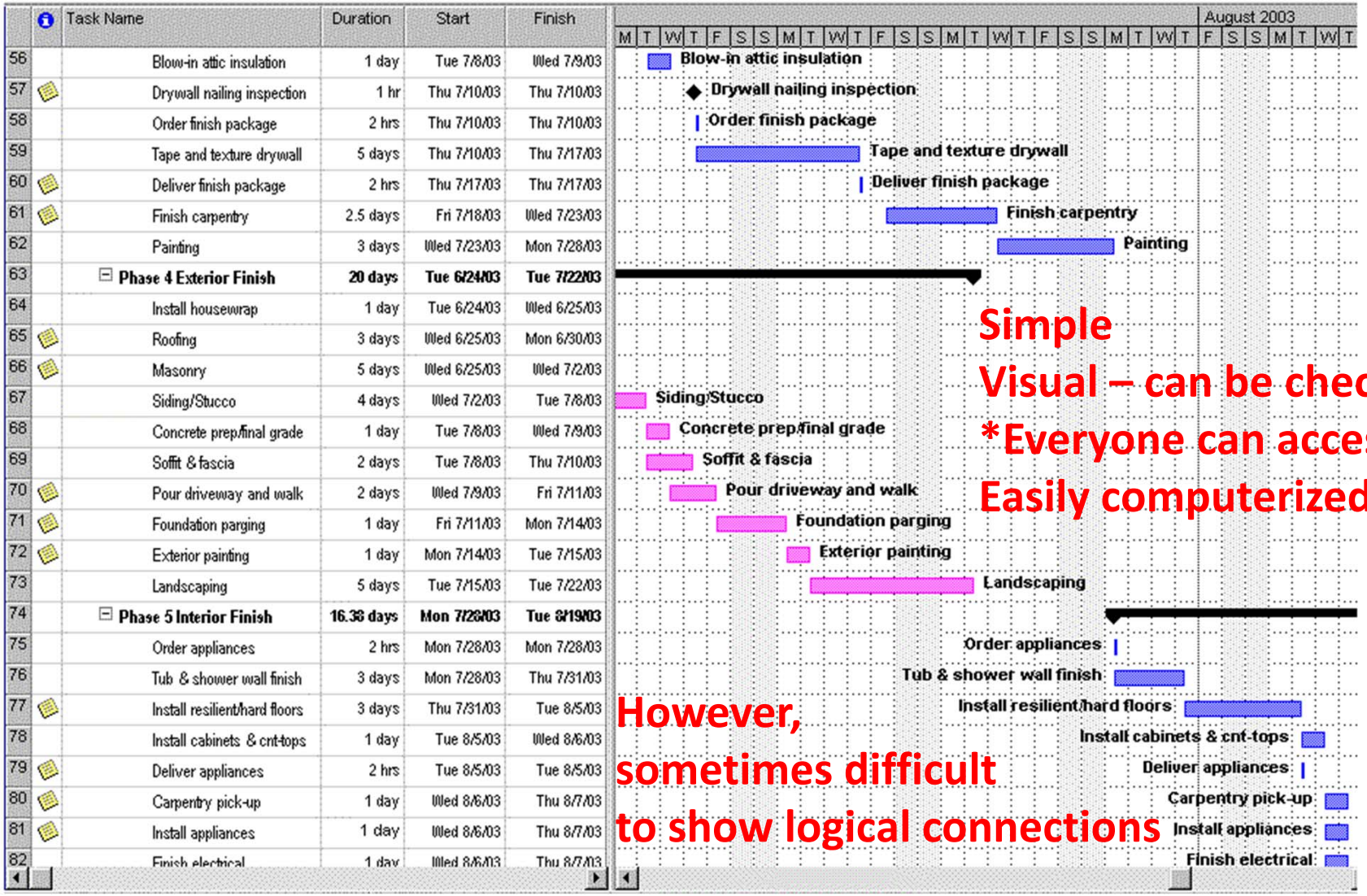
- **Estimating the number of work periods which will be needed to complete individual activities**
- **Tools and Techniques**
  - Expert judgment: historical information may be used
  - Analogous estimating: called top-down estimation, means using the actual duration of a previous, similar activity
  - Simulation: involves calculating multiple durations with different sets of assumptions

Project Scheduling – Duration Estimate

- **Duration of an activity varies according to the activity type**
  - Production
    - Consult subcontractors
    - Calculate based on quantity and productivity
    - Job conditions, new construction vs. renovation, crew size, work schedule, weather, project calendar, resource calendar
  - Procurement
    - Consult suppliers
    - Review contract documents
  - Administrative
    - Consult agencies
    - Past projects

Project Scheduling – Schedule Development

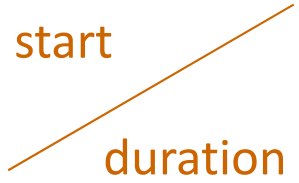
- Bar (Gantt) chart



	Task Name	Duration	Start	Finish
56	Blow-in attic insulation	1 day	Tue 7/8/03	Wed 7/9/03
57	Drywall nailing inspection	1 hr	Thu 7/10/03	Thu 7/10/03
58	Order finish package	2 hrs	Thu 7/10/03	Thu 7/10/03
59	Tape and texture drywall	5 days	Thu 7/10/03	Thu 7/17/03
60	Deliver finish package	2 hrs	Thu 7/17/03	Thu 7/17/03
61	Finish carpentry	2.5 days	Fri 7/18/03	Wed 7/23/03
62	Painting	3 days	Wed 7/23/03	Mon 7/28/03
63	**Phase 4 Exterior Finish**	**20 days**	**Tue 6/24/03**	**Tue 7/22/03**
64	Install housewrap	1 day	Tue 6/24/03	Wed 6/25/03
65	Roofing	3 days	Wed 6/25/03	Mon 6/30/03
66	Masonry	5 days	Wed 6/25/03	Wed 7/2/03
67	Siding/Stucco	4 days	Wed 7/2/03	Tue 7/8/03
68	Concrete prep/final grade	1 day	Tue 7/8/03	Wed 7/9/03
69	Soffit & fascia	2 days	Tue 7/8/03	Thu 7/10/03
70	Pour driveway and walk	2 days	Wed 7/9/03	Fri 7/11/03
71	Foundation parging	1 day	Fri 7/11/03	Mon 7/14/03
72	Exterior painting	1 day	Mon 7/14/03	Tue 7/15/03
73	Landscaping	5 days	Tue 7/15/03	Tue 7/22/03
74	**Phase 5 Interior Finish**	**16.38 days**	**Mon 7/28/03**	**Tue 8/19/03**
75	Order appliances	2 hrs	Mon 7/28/03	Mon 7/28/03
76	Tub & shower wall finish	3 days	Mon 7/28/03	Thu 7/31/03
77	Install resilient/hard floors	3 days	Thu 7/31/03	Tue 8/5/03
78	Install cabinets & cnt-tops	1 day	Tue 8/5/03	Wed 8/6/03
79	Deliver appliances	2 hrs	Tue 8/5/03	Tue 8/5/03
80	Carpentry pick-up	1 day	Wed 8/6/03	Thu 8/7/03
81	Install appliances	1 day	Wed 8/6/03	Thu 8/7/03
82	Finish electrical	1 day	Wed 8/6/03	Thu 8/7/03

Project Scheduling – Schedule Development

- **Matrix Schedules**

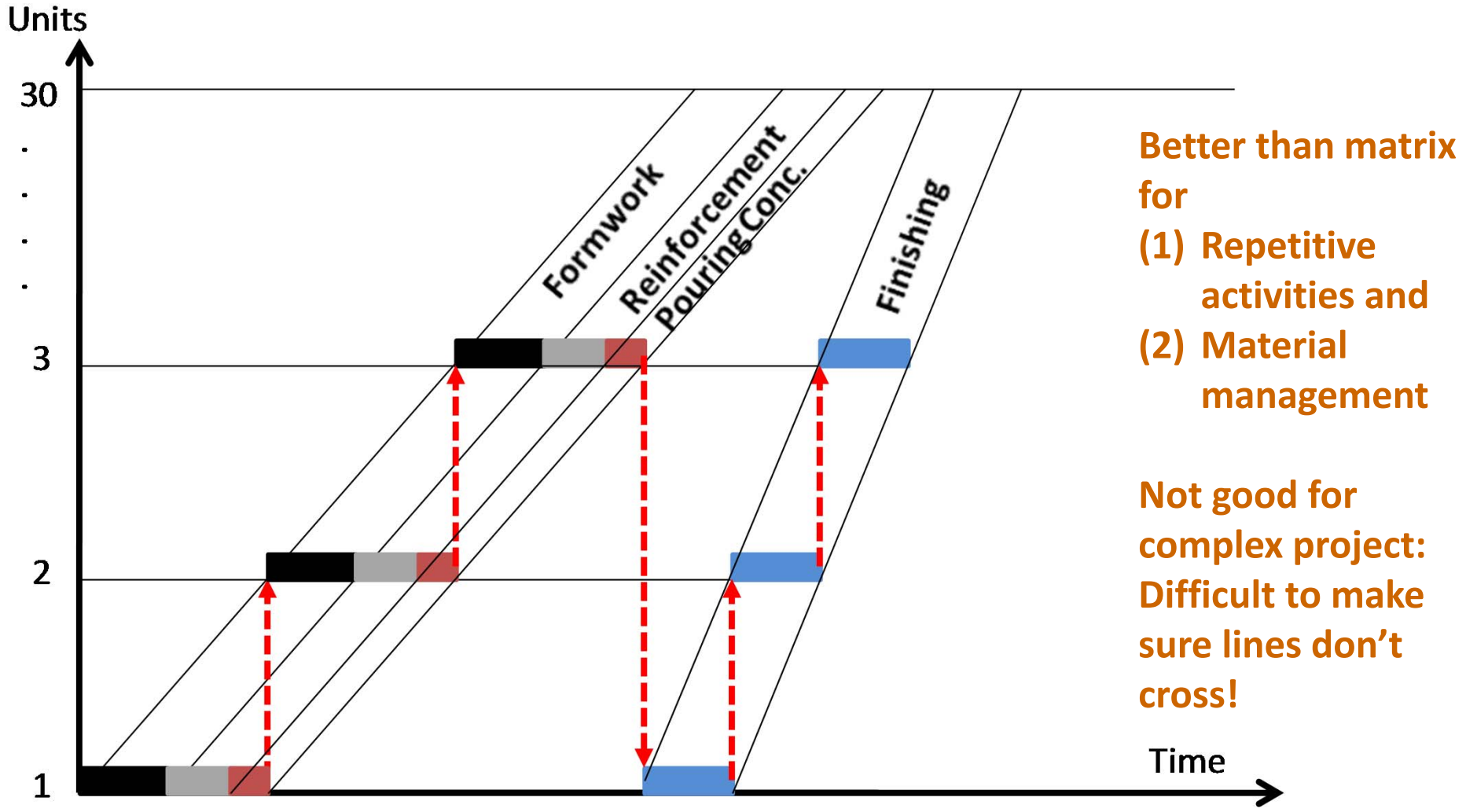


Simple
Good for repetitive work
Doesn't require computer

Hard to use for complex work
Typically useful only for part of project
Difficult to define relationships

Project Scheduling – Schedule Development

- Line of Balance



Better than matrix for
(1) Repetitive activities and
(2) Material management

Not good for complex project: Difficult to make sure lines don't cross!

Project Scheduling – Schedule Development

- **Terminology**
  - Early Start (ES): earliest possible time an activity can start based on the logic and durations identified in the network
  - Early Finish (EF): earliest possible time an activity can finish based on the logic and durations identified in the network
    - **EF = ES + Activity Duration**
  - Late Finish (LF): latest possible time an activity can finish based on the logic and durations identified in the network without extending the completion date of the project
  - Late Start (LS): latest possible time an activity can start based on the logic and durations identified in the network without extending the completion date of the project
    - **LS = LF – Activity Duration**

Project Scheduling – Schedule Development

- **Terminology**
  - Float: additional time an activity can use beyond its normal duration and not extend the completion date of the project
    - Total Float (TF): maximum time an activity can be delayed without delaying the project completion
    - Free Float (FF): maximum time an activity can be delayed without delaying the start of any succeeding activity
  - Critical Path: path from start to finish with no float. Therefore, it is the minimum time to complete the project and highly impacts on the entire project schedule.

    Delay in Critical Path = Project Delay!

Project Scheduling – Schedule Development

- **Development Methods**
  - Critical Path Method (CPM): calculates a single, deterministic early and late start and finish date for each activity based on specified, sequential network logic and using duration estimate
  - Program Evaluation and Review Technique (PERT): uses sequential network logic and a weighted average duration estimate to calculate project duration

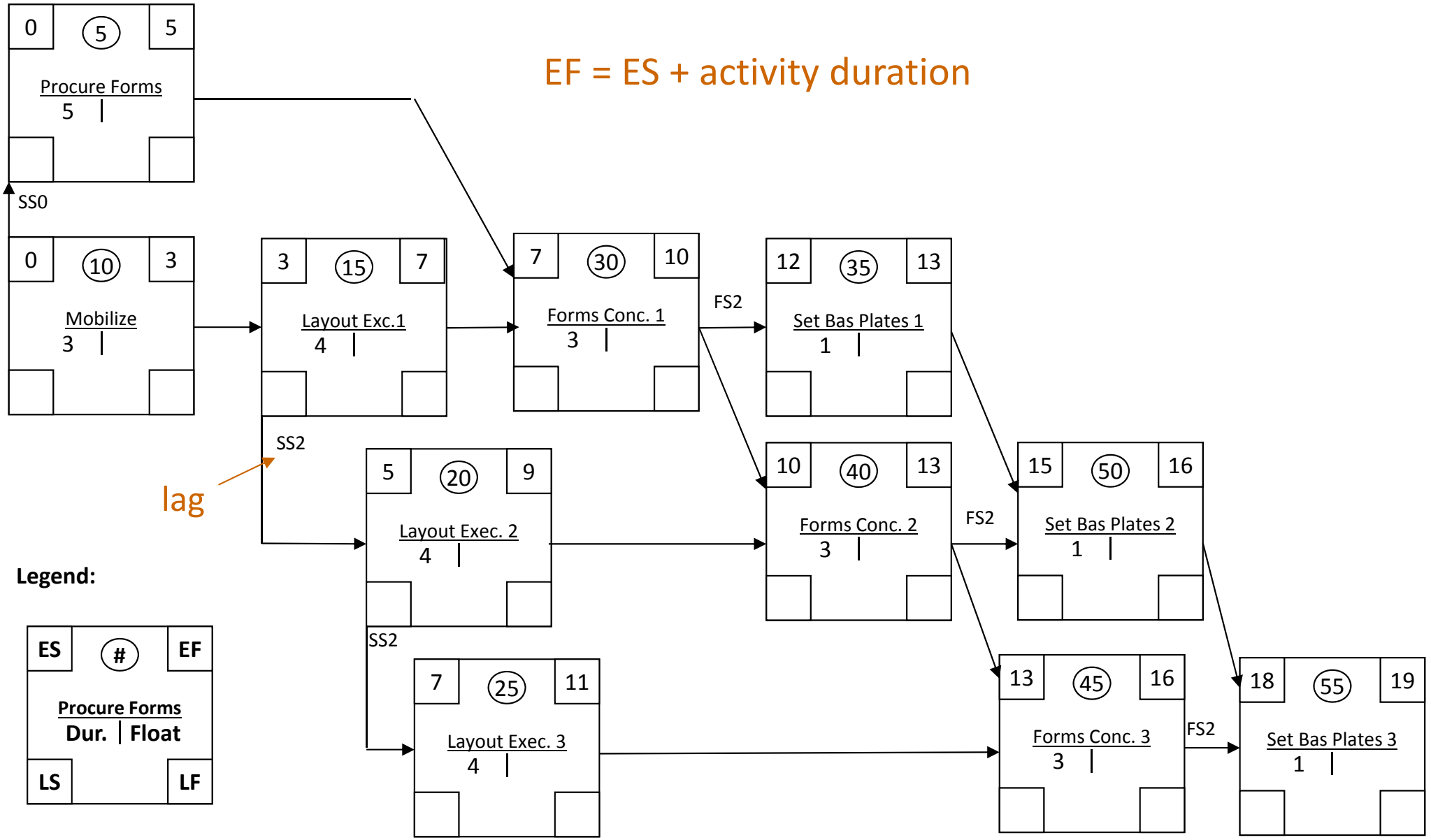
Project Scheduling – Schedule Development

- **Network Forward Path Calculations – AON**
  - AON (precedence notation) – Finish to Start Links
    - Activities without predecessors
      - Early Start = 0
      - Early Finish = Early Start + Activity Duration
    - Activities with predecessors
      - Early Start = maximum Early Finish among predecessors
      - Early Finish = Early Start + Activity Duration

IMPORTANT: Pay attention when working with different link types or when there are leads/lags

Mobilize and procurement of forms → Concrete layout setting → Place concrete in forms → Finalize base concrete plate

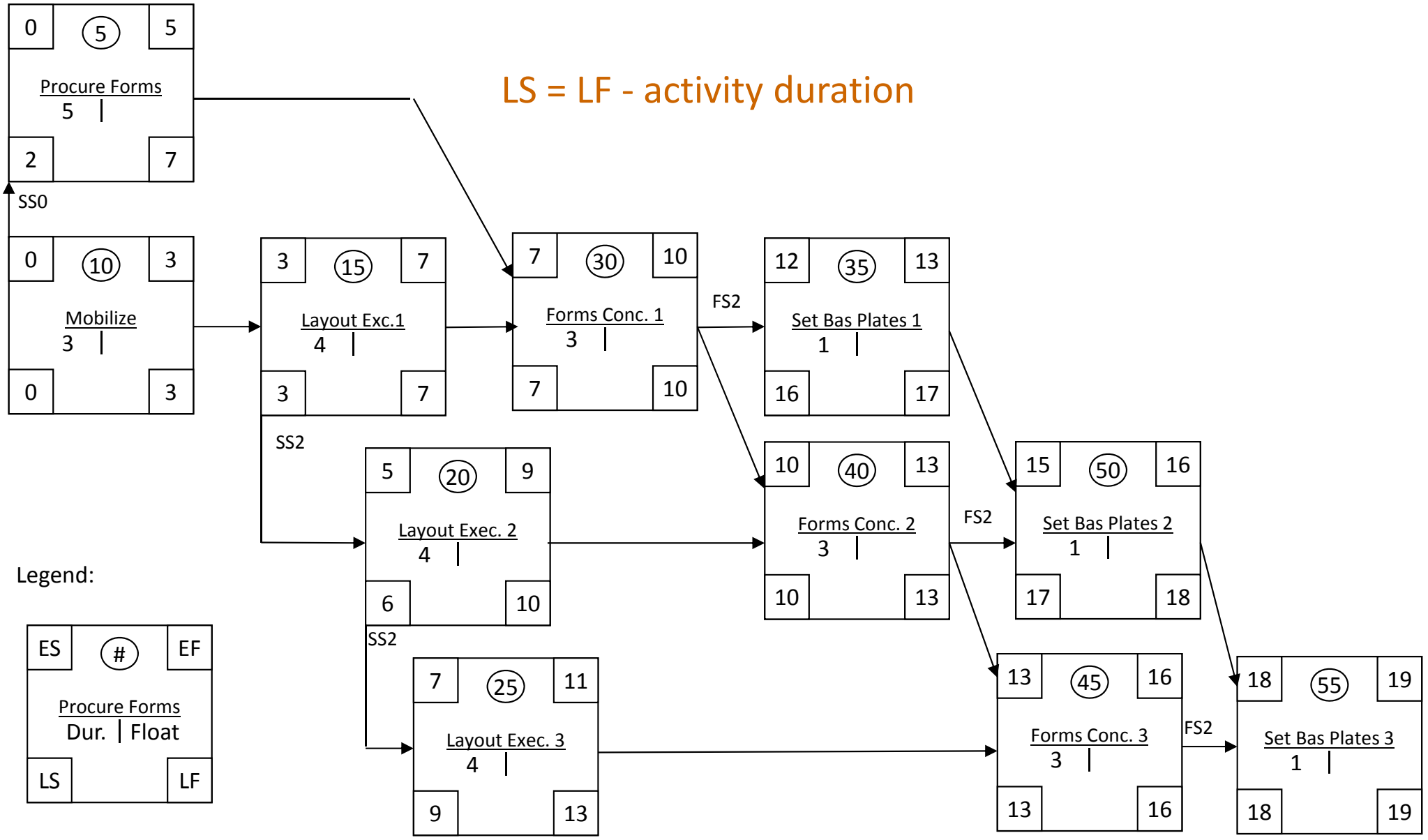
Forward Path Calculation



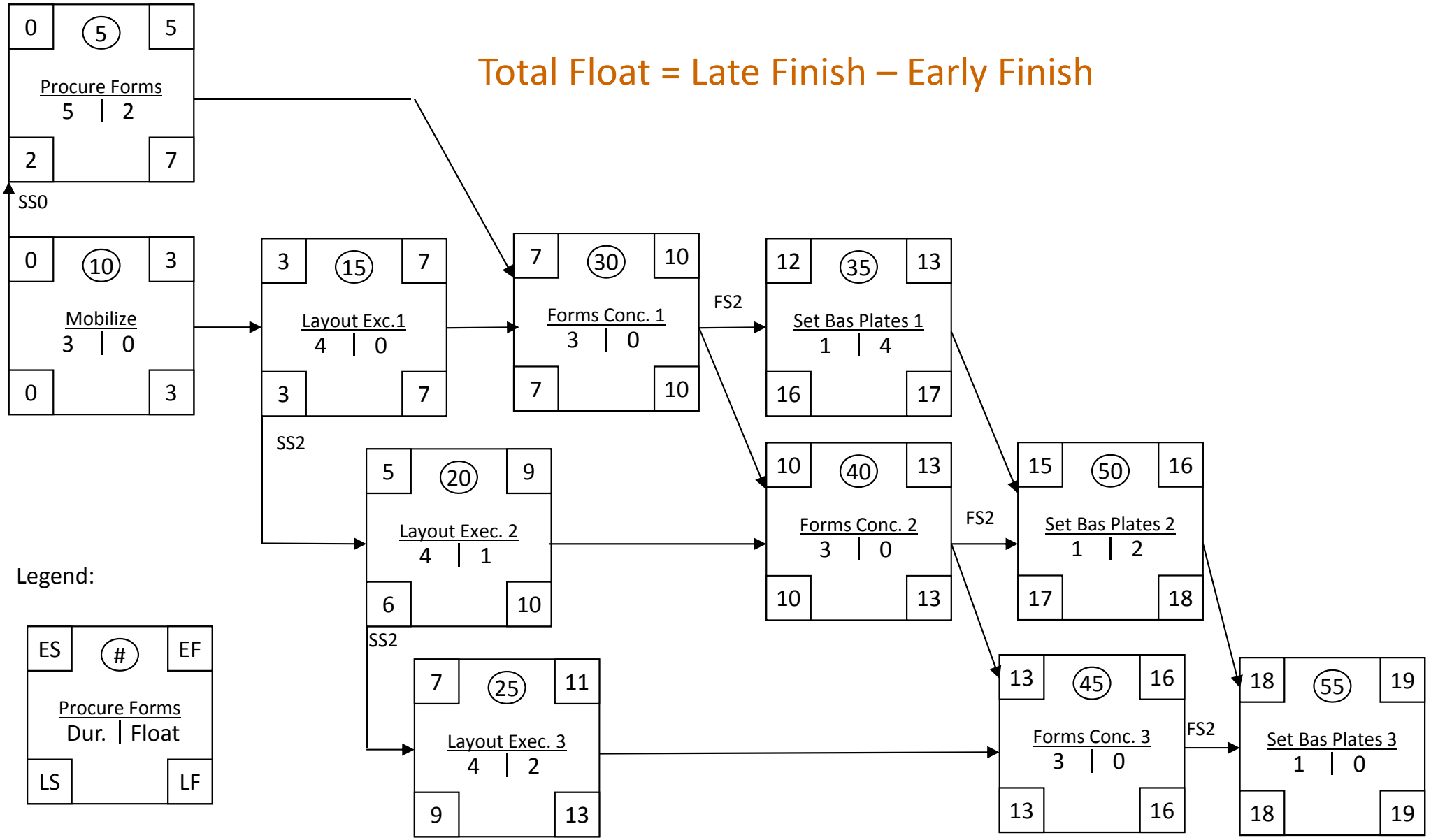
Project Scheduling – Schedule Development

- **Network Backward Path Calculations – AON**
  - AON (precedence notation) – Finish to Start Links
    - Activities without successors
      - Late Finish = Early Finish (or project duration)
      - Late Start = Late Finish – Activity Duration
    - Activities with successors
      - Late Finish = minimum Late Start among successors
      - Late Start = Late Finish – Activity Duration

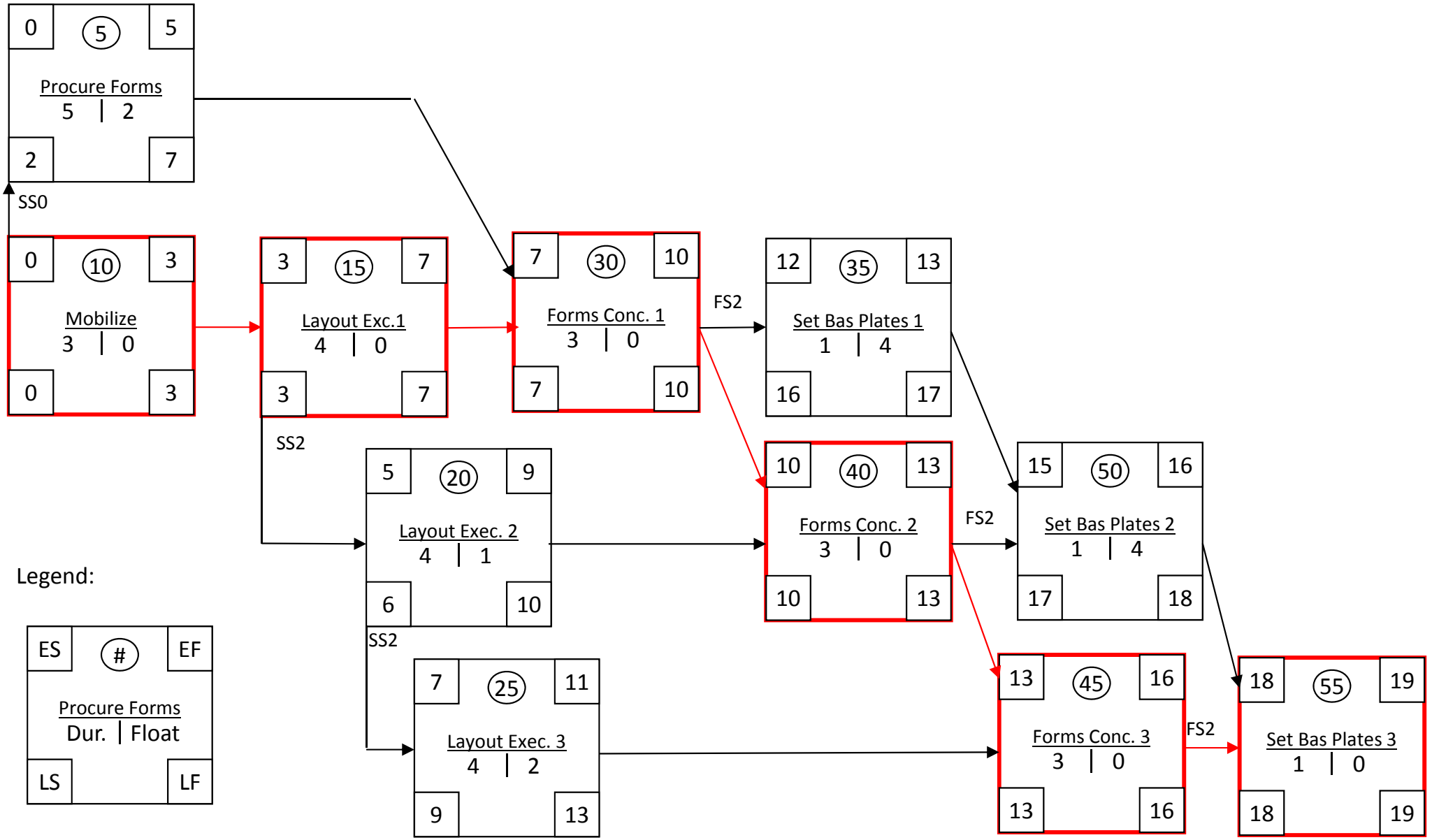
Backward Path Calculation



Total Float Calculation



Critical Path



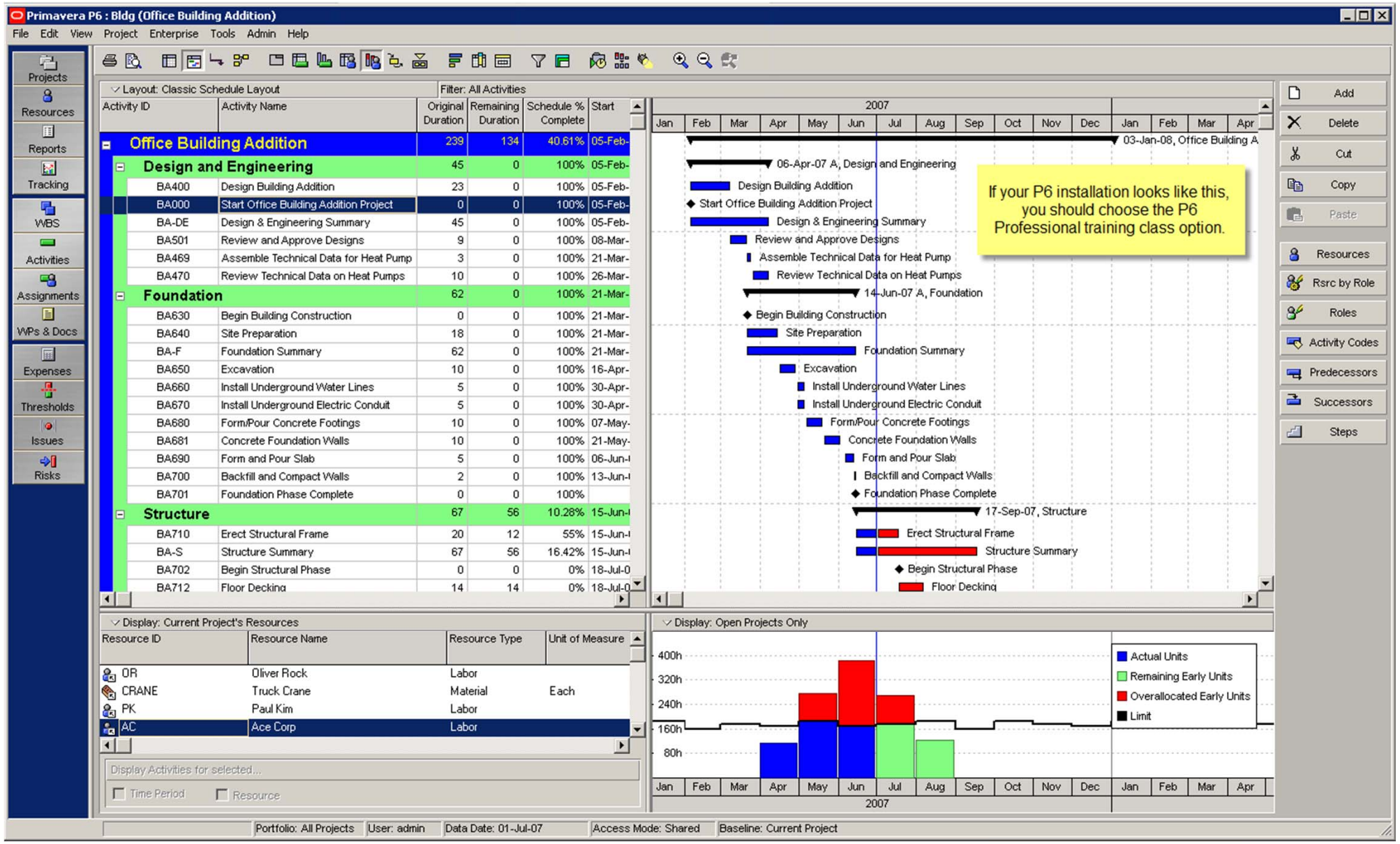
Project Scheduling – Schedule Development

- **Duration Compression**
  - Looks for ways to shorten the project schedule without changing the project scope
  - Fast Tracking: means you look at activities normally done in sequence and assign them instead partially in parallel. For instance, you would start construction in areas where you felt the design was pretty solid without waiting for the entire design to be completed.
  - Crashing: means to throw additional resources with additional costs to the critical path without necessarily getting the highest level of efficiency. For instance, you might add a second worker to the activity usually performed by one worker.

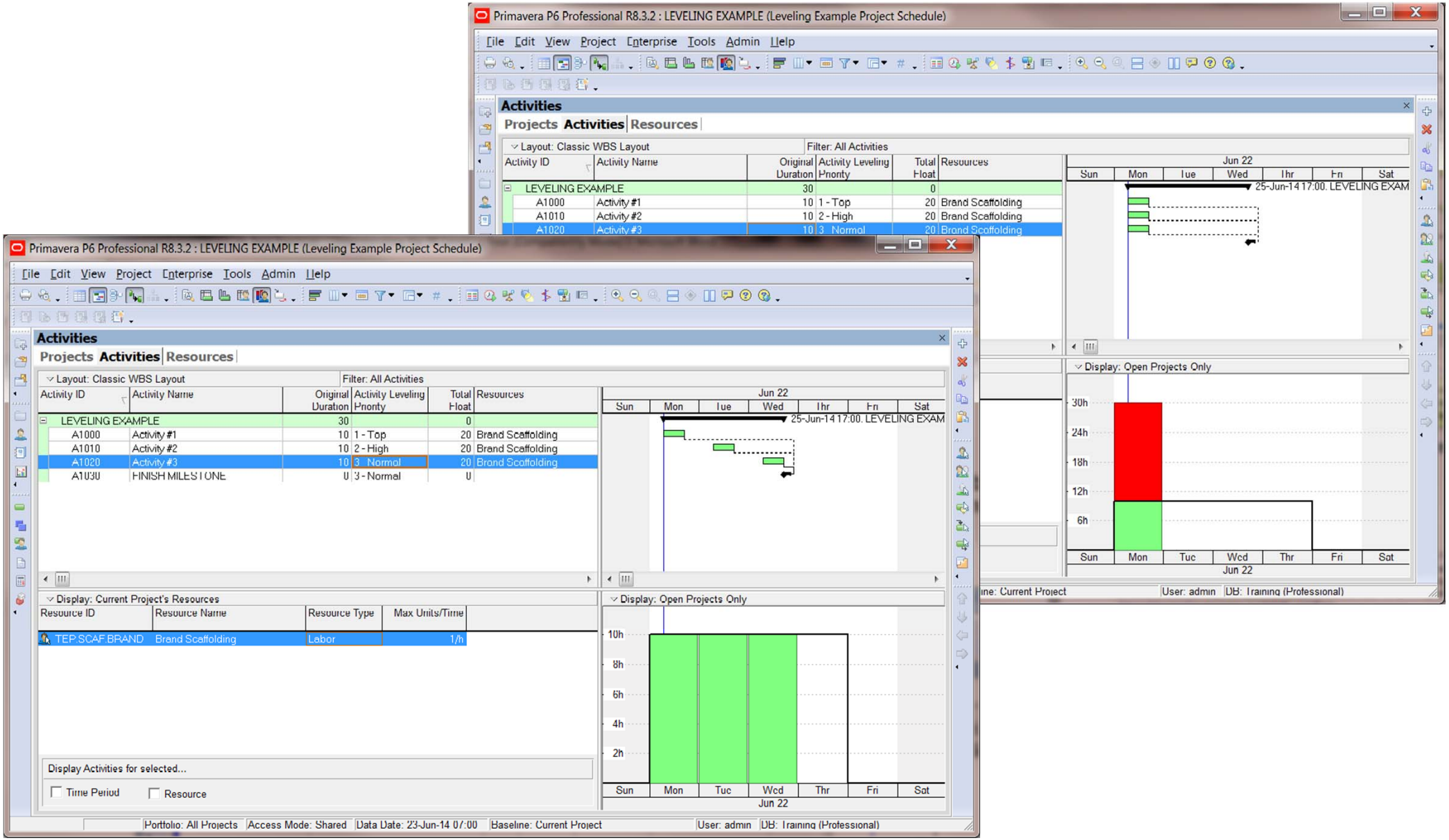
Project Scheduling – Schedule Control

- **Controlling changes to the project schedule**
- **Tools and Techniques**
  - Schedule change control system: includes the paperwork, tracking systems, and approval levels
  - Performance measurement: assesses the magnitude of any variations
  - Additional planning: due to prospective changes

Project Scheduling – Schedule Control



Project Scheduling – Schedule Control



In-Class Scheduling Exercise

- **Project Start Date: 5/1/2016**

Activity	Description	Duration	Predecessor	Code
10	Mobilization	1		GC
20	Excavation	2	10	GC
30	Place gravel	2	20	GC
40	Place slab forms	3	20	GC
50	Place rebar	2	30	GC
60	Rough in plumbing	2	50	PC
70	Pour & cure concrete	9	40, 60	GC
80	Remove forms	2	70	GC
90	Erect frame & sheath walls	4	70	GC
100	Sheath roof	3	80, 90	RC
110	Electrical	3	100	EC
120	Install siding	4	100	GC
130	Finish carpentry	3	100	GC
140	Finish roof & flashing	3	100	RC
150	Paint	5	110, 120, 130	GC
160	Clean-up	2	140, 150	GC

Code Value	Code Title
GC	General Contractor
PC	Plumbing Contractor
EC	Electrical Contractor
RC	Roofing Contractor

In-Class Scheduling Exercise

1. Draw the precedence diagram network
2. Use CPM calculations to determine the project duration
3. Develop a Gantt chart

Group Assignment Exercise

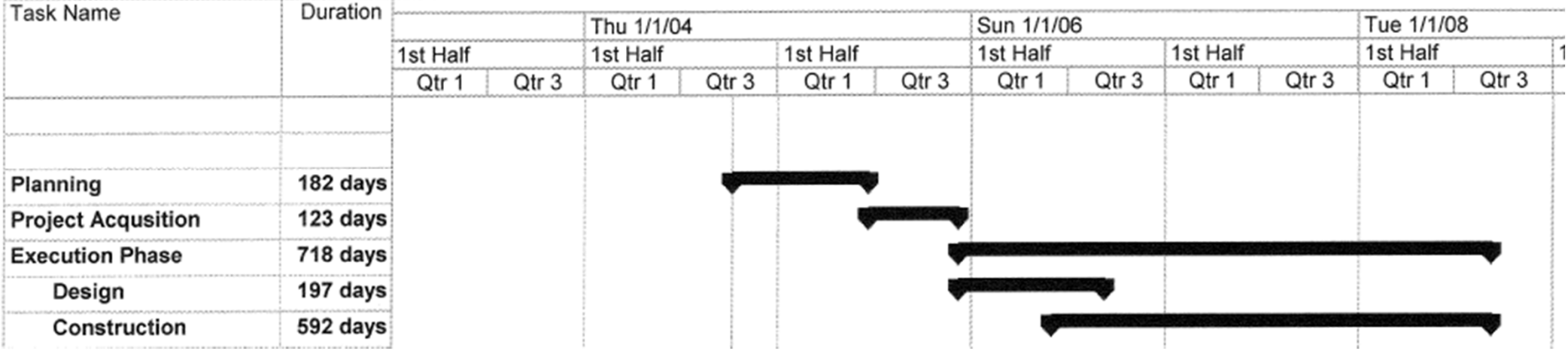
The U.S. Navy plans to design and construct two new recruit barracks to replace the old ones built between the years of 1958 and 1966, located at Naval Station Great Lakes, Illinois. This movement is a part of the RTC RECAP project, transforming Boot Camp from a deficient, facility-centric base into a state-of-the-art, training-centric environment. The entire project includes the development of the complete infrastructure (roads, sidewalks, utilities, storm drainage, elevated water tank, railroad underpass, landscaping, etc.) for a 48-acre parcel of land, adjacent to the existing RTC campus. Additional incidental related work must also be considered to provide a complete and useable facility. Each barrack will measure 16,700 square meters and will provide open bay housing for 1,100 recruits, classrooms, and advanced food service and dining facility. The total estimate cost is approximately $80 million including two barrack (each $30 million) facilities and green land development.

Group Assignment Exercise

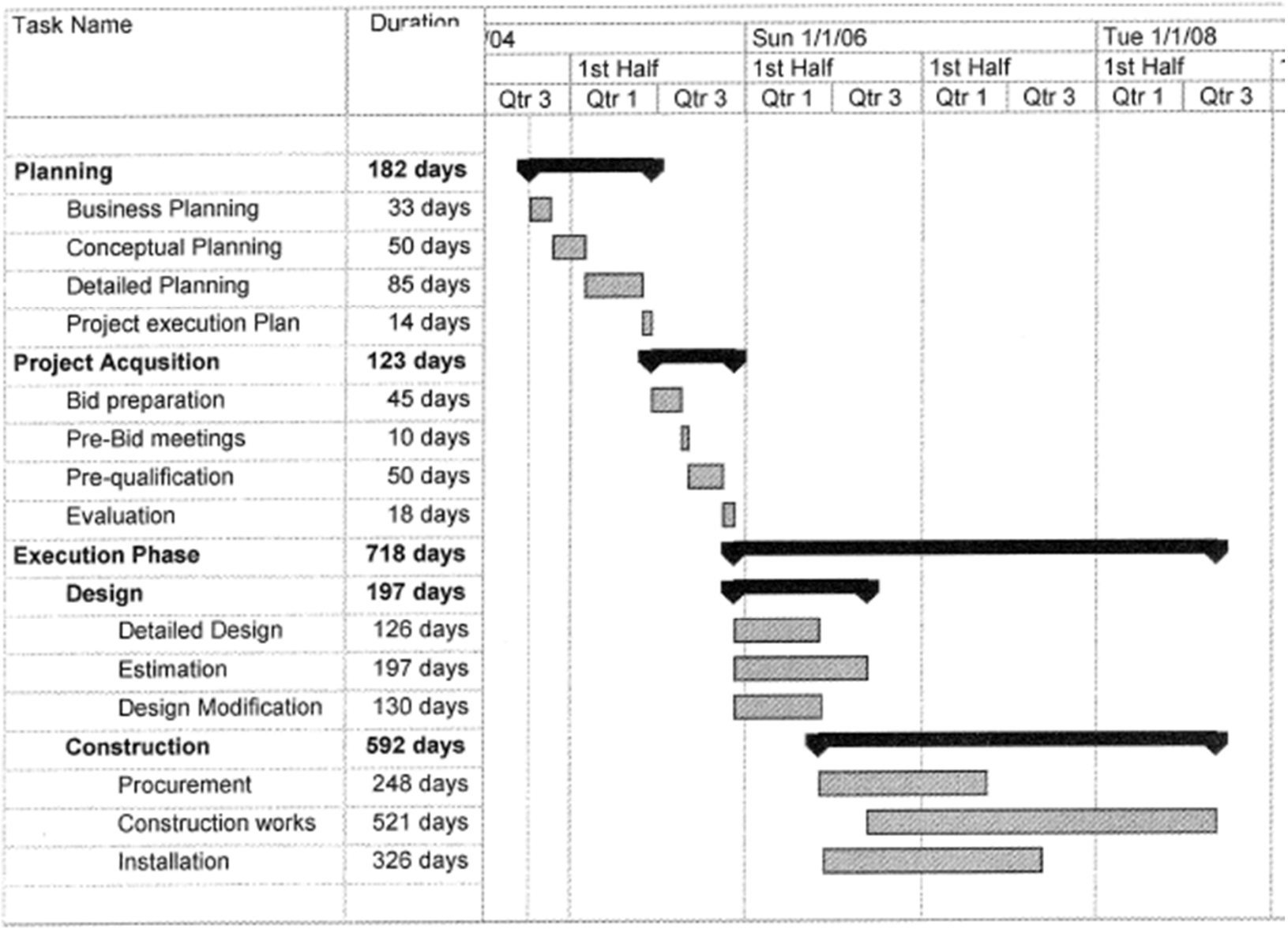
- Assuming a planning time of 6 months for the project, develop a high-level schedule for the project, showing planning, acquisition, design and construction

	Budget	Schedule
Planning	3 – 5%	6 months
Project Acquisition		4 months
Design	10%	6 – 7 months
Construction	85%	20 months

2 years



Group Assignment Exercise



Task Name	Duration
Planning	**182 days**
Business Planning	33 days
Conceptual Planning	50 days
Detailed Planning	85 days
Project execution Plan	14 days
Project Acqusition	**123 days**
Bid preparation	45 days
Pre-Bid meetings	10 days
Pre-qualification	50 days
Evaluation	18 days
Execution Phase	**718 days**
Design	**197 days**
Detailed Design	126 days
Estimation	197 days
Design Modification	130 days
Construction	**592 days**
Procurement	248 days
Construction works	521 days
Installation	326 days