

PLANNING & SCHEDULING PROFESSIONAL CERTIFICATION

REVIEW COURSE

[1]

COURSE OBJECTIVES

- **Participants ready for PSP Certification:**
 - Understand what it takes to successfully pass AACE's PSP Certification Exam
 - Refresher on topics not dealt with on a daily basis
- **Course *does not*:**
 - Teach fundamentals of planning & scheduling
 - Provide inexperienced or unknowledgeable planners & schedulers with necessary knowledge or experience to pass PSP exam
 - Guarantee results

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CERTIFICATION PROCESS

- **Must meet minimum requirements:**
 - **Experience requirements**
 - 8+ full years of professional experience
 - Up to 4 years may be substituted by college / university degree
 - **Application & fees** *
 - AACE Members \$500 | Non-Members \$625
 - **Submit application 45 days in advance of Exam**
 - Documented experience / education is reviewed & verified by AACE HQ
 - Must take exam within 6 months of registration
 - **Examination: 70% passing grade**
 - Overall on 5-hour exam
- **Recertification on 3 year cycle**
 - **Single point credits & fee for multiple AACE certifications**
 - * Verify current fee structure & changes to program at www.aacei.org

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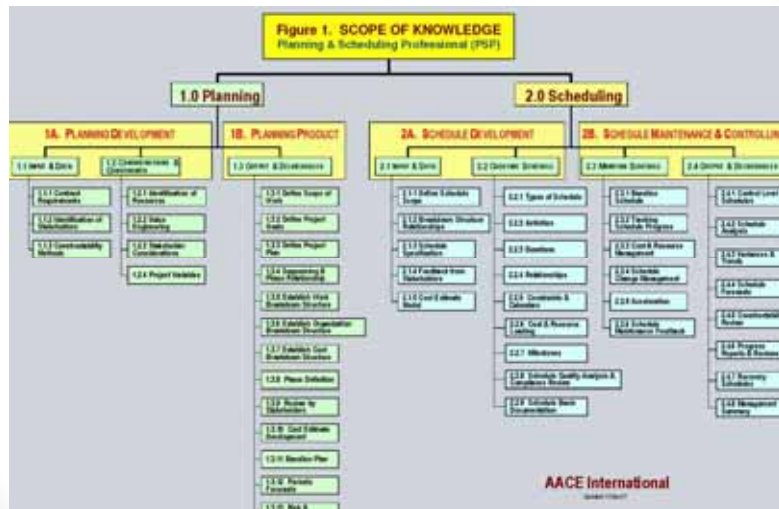
SCOPE OF KNOWLEDGE

- **TCM Framework**
 - Chapter 3. Strategic Asset Planning
 - Chapter 7. Project Control Planning
 - Chapter 8. Project Control Plan Implementation
- **Planning & Scheduling RPs**
 - for latest RP publication list www.aacei.org



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SCOPE OF KNOWLEDGE



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PRIMARY REFERENCES

- **AACE Recommended Practices ***
 - RP 10S-90 Cost Engineering Terminology (5Mar10)
 - RP 14R-90 Responsibility & Required Skills for a Project Planning & Scheduling Professional (19Sep06)
 - RP 23R-02 Identification Of Activities (3May07)
 - RP 24R-03 Developing Activity Logic (26Mar04)
 - RP 29R-03 Forensic Schedule Analysis (25Apr11)
 - RP 52R-06 Time Impact Analysis - As Applied In Construction (19Oct06)
 - RP 53R-06 Schedule Update Review - As Applied In Engineering, Procurement & Construction (14Aug06)
- **Reference Materials**
 - AACE: TCM Framework
 - PSP Certification Study Guide
 - Skills & Knowledge of Cost Engineering, 5th Edition
 - Sections pertaining to Scheduling
 - AACE's CCE/CCC Certification Study Guide
 - Sections pertaining to Scheduling
 - AACE Professional Practice Guide #4: Planning & Scheduling, 2nd Edition
 - AACE Annual Meeting
 - Technical Papers & S&K Track Workshops
- **Sample Problems**

* Constantly being updated & new RPs issued at www.aacei.org

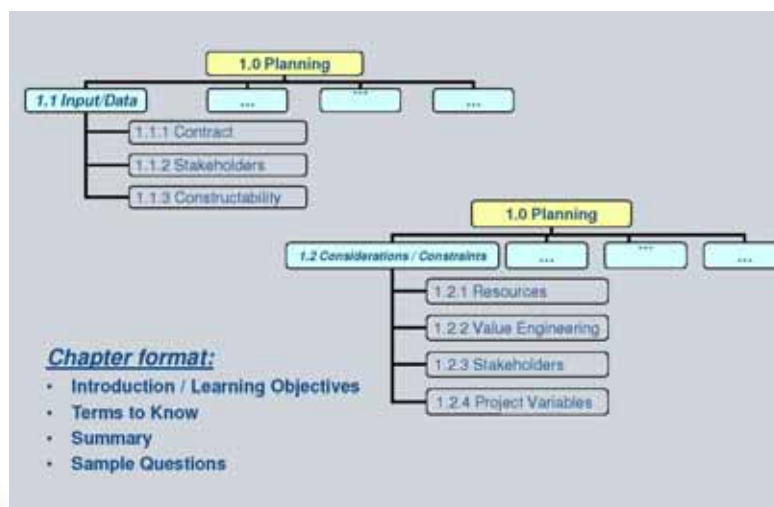
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PSP GLOSSARY

- **Glossary of PSP Terms: *AACE RP 10S-90***
 - Understanding meaning of terms is only first step
 - Multiple definitions for individual terms
 - Must be able to apply to practical applications
 - Must be able to communicate analysis & recommendations
- **Planning**
 - Identification of project objectives & ordered activity necessary to complete project
 - Thinking process
 - Involves answering
 - **WHAT** must be done in the future to reach project objective?
 - **HOW** it will be done?
 - **WHO** will do it?
 - **WHEN** it will be done?
- **Scheduling**
 - Process of converting general plan for a project into a time-based schedule based on available resources & time constraints

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PSP STUDY GUIDE FORMAT



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PREPARATION SUGGESTIONS

- **Examination**

- **Apply sound test-taking tactics:**

- *Read through exam & do problems of greatest comfort first*
- *Allocate time proportionally to value of problem*

- **Study & work example problems in all areas**

- **Master financial calculator before exam**

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Planning & Scheduling Overview

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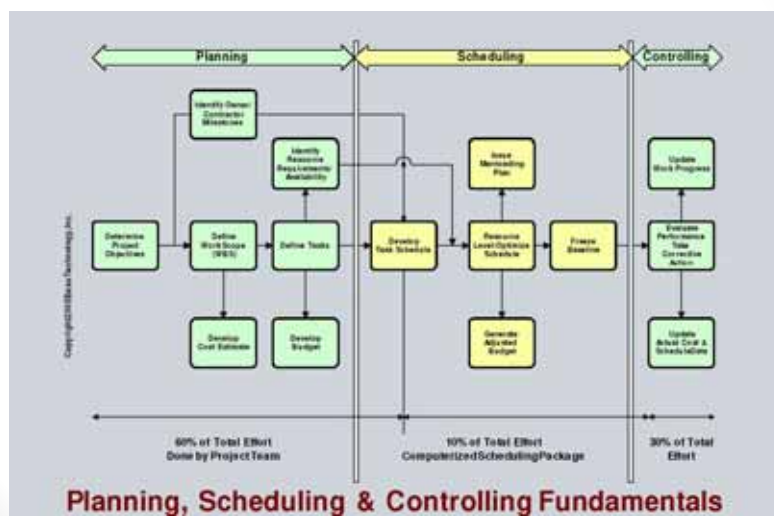
PLANNING & SCHEDULING

Process Map Overview



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PLANNING & SCHEDULING PROCESS



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PURPOSE OF PLANNING & SCHEDULING

- **Planning:** *To review job requirements & responsibilities so that an acceptable course of action (the “plan”) may be agreed upon to perform project in an optimum manner*
- **Scheduling:** *To implement project plan & monitor progress toward desired results*
- **P&S Professional:** *Provides assistance to project management team in developing, monitoring & updating a cost & resource loaded project plan so that efficient execution is achieved*

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WHY PLANNING AND SCHEDULING

Planning is **NOT** Scheduling
Scheduling is **NOT** Planning



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PLANNING OUTLINES

1. Benefits of Planning & Scheduling
2. Planning versus Scheduling
3. Input / Data for Planning
4. Phased Approach to Execution
5. Developing & Using WBS in Planning
6. Planning for Non Logic-Driven Schedules
7. Planning for Logic-Driven Schedules

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PLANNING & SCHEDULING BENEFITS

- Improves overall project execution
 - Make assumptions about future for action today
 - Cost & schedule budget monitoring & control
 - Safety planning & control
 - Delay avoidance & mitigation
 - Risk avoidance & management
 - Communications tool for all stakeholders
 - Manage scarce / expensive resources effectively
 - Improves productivity

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PLANNING & SCHEDULING BENEFITS

- **Improves overall project execution**
 - Forecasts results based on trends observed
 - Anticipates problems / identifies solutions
 - Cost & schedule contingency identification & control
 - “What If” analysis
 - Accountability
 - Lessons Learned



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PLANNING VS. SCHEDULING

- **PLANNING** comprised of key functions:
 - Developing WBS & identifying activities
 - Identifying key/critical constraints & interfaces
 - Constructability study & pre-planning
 - Understanding & incorporating project objectives into plan
 - Determining resource availability
 - Determining suitable project management program / tools
 - Establishing metrics for reporting & success

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PLANNING VS. SCHEDULING

- **PLANNING** comprised of key functions:
 - Site survey (if appropriate) to assess local constraints/issues
 - Coordination with estimators/engineers on scope details
 - Working with project manager to understand funding constraints & contract strategy
 - Assess known risks for individual activities or project/schedule milestones

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PLANNING VS. SCHEDULING

- **SCHEDULING** comprised of key functions:
 - Defining & developing activities from planning stage
 - Estimating activity durations / manning levels
 - Developing project specific logic diagram
 - Assessing impacts of risks & resource constraints
 - Developing equipment / material delivery times
 - Assessing critical path & float

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PLANNING VS. SCHEDULING

- **SCHEDULING** comprised of key functions:
 - Assessing overall schedule probability
 - Producing schedule that communicates to all participants
 - Advising project management of conflicts to plan
 - Ensure schedule & milestones can be properly stated
 - Supports Earned Value Management (EVMS) reporting
 - Assessing & reporting status, progress, float, & criticality

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Planning

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SCHEDULING BEGINS WITH PLANNING

- Well thought out plan is key to successful schedule development / implementation
 - Identify / Set goals & objectives
 - Define scope, responsibilities & priorities
 - Identify & plan resources
 - Identify work processes & procedures
 - Prepare resource, cost & schedule estimates
 - Establish budgets for monitoring & control
 - Establish team & align members
- *Establish a planning culture*

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Major Elements of Planning

- Summarizing Goals
- Identifying Scope of Work
- Time Planning
- Cost Planning
- Resource Planning
- Quality Planning
- Change / Contingency Planning
- Review / Test / Revise or Update

AACE RP 14R-00
Responsibility & Required Skills for a Project
Planning & Scheduling Professional

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Results of Good Planning

- Basis for team development, alignment, communications & problem resolution
- Identifies risk & potential mitigation plans
- Identifies management focus needs
 - Management by exception
- Forms basis for scheduling
 - Baseline development
 - Monitoring
 - Forecasting
 - Replanning to accommodate change

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Why Planning Works

- Old saying still applies:
 - PLAN THE WORK -- WORK THE PLAN!***
 - First Plan, then & only then, Scheduling
 - 60% is just good Planning*
 - 40% is just good Scheduling*
 - 100% of the rest is good Communications*
 - Make your & your team's life easier:
 - PLAN, PLAN & REPLAN!***

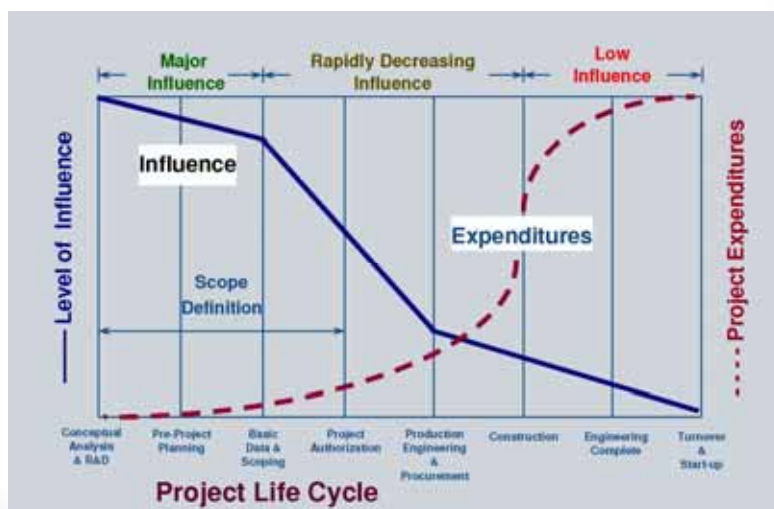
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Program vs. Project

	Project	Program
<i>Project</i>	<i>A "one-off" endeavor</i>	
<i>Program</i>		<i>A related grouping of endeavors</i>
General Planning	Begins with scope definition and evolves with project execution	Summary Level initially, rolled up from individual projects as program evolves
Financial Planning	Scope driven	Business / Operations management driven
Resource Planning	Scope driven	Business / Operations management driven
Operational Planning	Scope Driven; Change Management Controlled	Business / Operations management driven
Change Management	Key to Project Success; Impacted by Stakeholders	Business & Operations
Risk Management	Scope driven; Impacted by Stakeholders	Business & Operations
Communications	Timely & Clear Information to wide variety of needs	Key to Stakeholder Involvement & Team Approach
Scheduling	Detailed for execution & summary for reporting	Communicating to Senior Management & Stakeholders

(27)

Opportunity for Influence



(28)

Process Map



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Example Question: Planning

- Which of the following is a true statement regarding planning vs. scheduling?
 - a) Planning can begin at the same time as scheduling.
 - b) Scheduling determines what work needs to be completed.
 - c) Planning defines the scope, responsibilities and priorities.
 - d) Scheduling determines how the project objectives will be met.

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Example Question: Planning

- Which of the following documents is most likely to be of LEAST value when planning a contractor's baseline critical path schedule for construction of a high rise building on a remote South Pacific resort island for a private developer? Contract has been awarded.
 - a) Specifications – as found in contract documents
 - b) Local government's report on future resort projects on island
 - c) International Building Codes – as referenced in contract documents
 - d) A project-specific geotechnical report

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Example Question: Planning

- To plan a project, the project professional will
 - a) Use delivery date / project due date to determine estimated project cost
 - b) Use total project estimated cost to determine delivery / project due date
 - c) Use deliverable description / scope of work to estimate project's total estimated cost & overall duration
 - d) Use deliverable description / scope of work to calculate quality that must be achieved to define project success

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INPUT / DATA

- **Input is driven by Output Required / Desired**
 - Minimum requirements → Mandatory
 - Optimum requirements → Enhances success
- **Contract is baseline for planning**
 - Understand “Contract Documents”
 - Scope of Work → Change Management
 - Contract terms & conditions
 - *Risk shifting & mitigation*
 - Scheduling & Reporting requirements
 - Augmented with proposal, estimate & other pre-contract execution documents to integrate internal assumptions

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Establish a Planning Culture

- **Proactive, hierarchical structure encompassing:**
 - Policies & procedures
 - Standards of Practice
 - Operational plans
- **Benefits**
 - Clear scope of work prevents gaps in coverage
 - Teams encourage innovation & continuous improvement
 - Provides communication clear conduit to all stakeholders
 - Provides baseline for monitoring & control
 - Post-completion reviews improve future endeavors

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Planning Tools

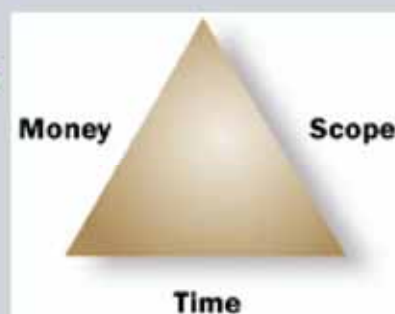
- Policies & operating procedures
- Model plans to adapt to current project
- Checklists to prevent gaps in coverage
- Historical databases cataloging experience
- Codes of accounts structured to aid in monitoring, updating progress & forecasting
- Benchmark studies of best practices & projects
- Commercial handbooks & software programs

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Planning – The Project Triangle

• PCTS Relationship

- Performance
- Cost/ Resources
- Time
- Scope of Work



You can pick any three!

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Stakeholders Input & Feedback

- All stakeholders have separate goals & objectives
- Stakeholder demands & influences have a significant impact to means & methods along with productivity
 - All ultimately drive price & completion



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Example Questions: Stakeholders

- Which of following is NOT normally considered a project stakeholder?
 - a) project supplier to a subcontractor
 - b) client or owner
 - c) project consultant / engineer
 - d) non-governmental organizations (NGOs)
 - e) local news media

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Example Questions: Stakeholders

- **Stakeholders of a project**
 - a) Have final say over all key aspects of project deliverables
 - b) Are only certain members of the project team
 - c) Approve all progress updates & periodic payments
 - d) Influence how project deliverable definition statements / scope of work requirements are crafted
 - e) Participate in contract negotiations

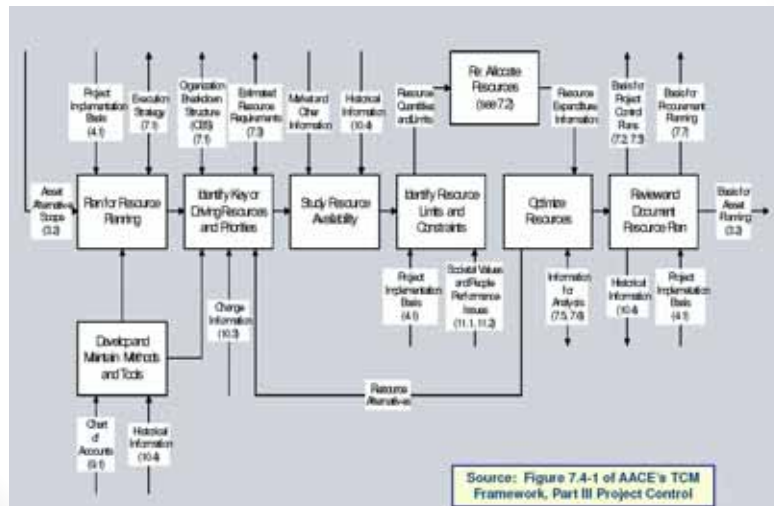
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RESOURCE CONSIDERATIONS & CONSTRAINTS

- **Consider from many perspectives:**
 - How much money will be available
 - How many people will be available
 - How much equipment will be available
- **Resources Planning:**
 - Identify key or driving resources & priorities
 - Study resource availability
 - Identify resource limits & constraints
 - Optimize resources
 - Review & document resource plan
 - Develop & maintain historical database

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RESOURCE PLANNING FLOWCHART



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Planning Inputs & Outputs

- **Inputs**

- Project planning basis
- Resource quantities/expenditure information
- Organization breakdown structure (OBS)
- Execution strategy
- Asset alternative scope
- Chart of accounts
- Societal values & performance considerations
- Historical project information
- Information for analysis
- Changes

- **Outputs**

- Resource availability & limitations
- Basis for project control plans
- Basis for asset planning

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Example Question: Planning Input

- Which *should not* be a reason why superintendents & subcontractors are included during planning phase?
 - a) They have more immediate “buy-in” to project plan
 - b) Planning phase is theoretical exercise & input not needed until execution phase
 - c) Accuracy of resultant plan is improved through “brainstorming”
 - d) Management expectations regarding plan are transmitted to team (alignment)

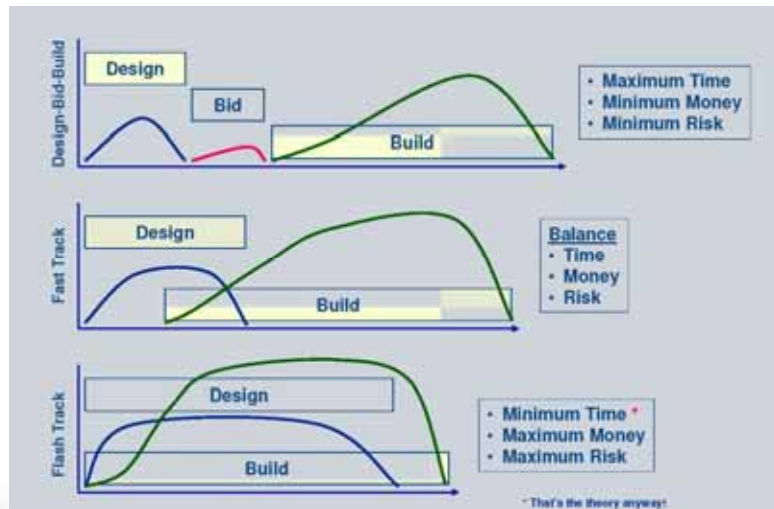
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PHASED EXECUTION APPROACH

- Most projects executed in phases which become planning basis
- For example:
 - Typical Engineer-Procure-Construct (EPC) project, phases include:
 - *Feasibility*
 - *Design Package*
 - *Project Execution*
 - Project Delivery Method influences planning approach

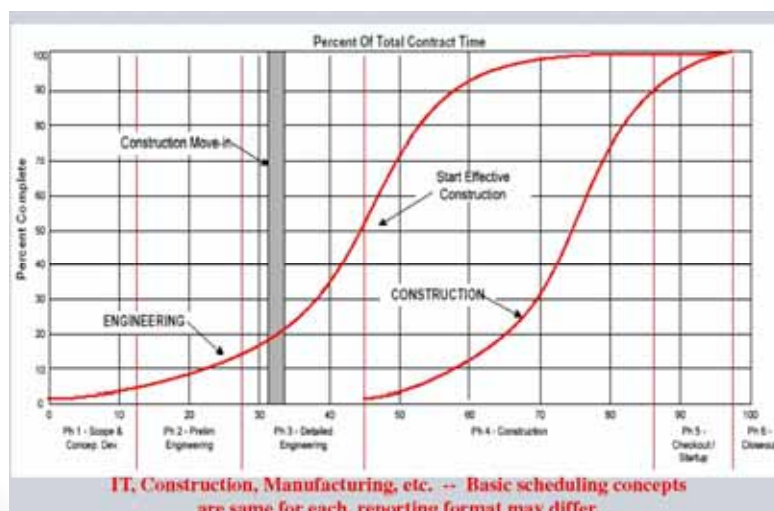
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Design-Bid-Build -> Fast Track / Design Build -> Flash Track



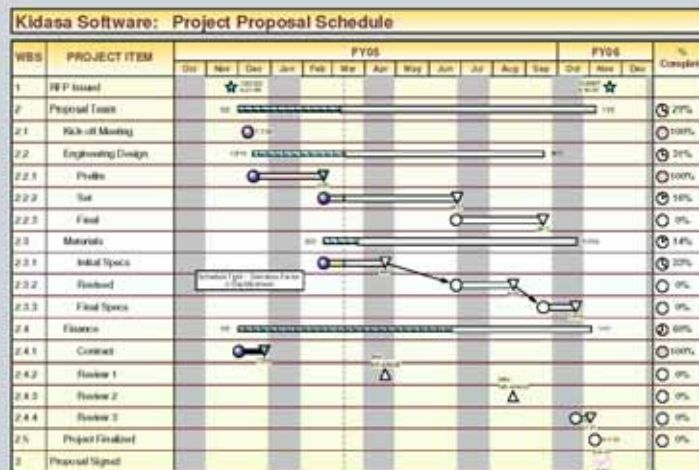
[45]

EPC Projects (Design-Build)



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Baseline Plan



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Example Question: Phased Execution

- Which project delivery system can be interpreted as an early application of “fast-tracking” a construction schedule?
 - a) Construction Management / as agent
 - b) Design-build
 - c) Design-bid-build
 - d) Negotiated select team method
 - e) None of the Above

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Work Breakdown Schedule

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Work Breakdown Structure (WBS)

- **Hierarchical decomposition of project scope**
 - Defines & displays all work to be performed
 - Avoids omission of key project activities
 - Divides complex project into manageable units
- **Provides framework to:**
 - Define specific tasks from which schedules can be developed
 - Facilitate communication
 - Allow integration of project plans
 - *Schedule*
 - *Resources*
 - *Cost*

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WBS Development

- WBS should be developed interactively with all members of the project team
 - “Post-it method”
- Basic Techniques:
 - Top-down
 - Bottom-up
 - Template-based from similar projects
- Whichever technique utilized, end result must be project-specific & complete



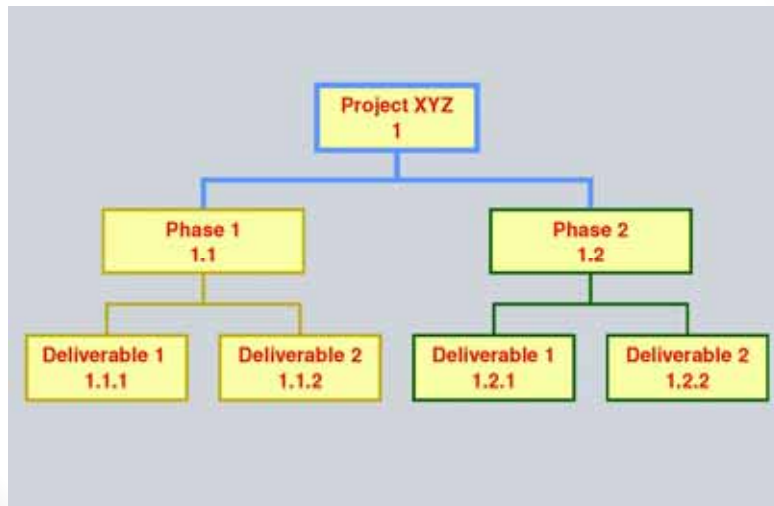
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WBS Development

- Rollup & Summarization
 - Balance between:
 - Complexity required for control
 - Simplicity required for accurate progress reporting
- Code / chart of Accounts
 - Alpha-numeric reflection of hierarchical relationship between WBS elements
 - Contract may dictate using part or all of client's specific coding structure for cost & schedule control
 - Contractor(s)' coding structures may be standardized for collection of historic cost data
 - Does not need to reflect ultimate work sequencing

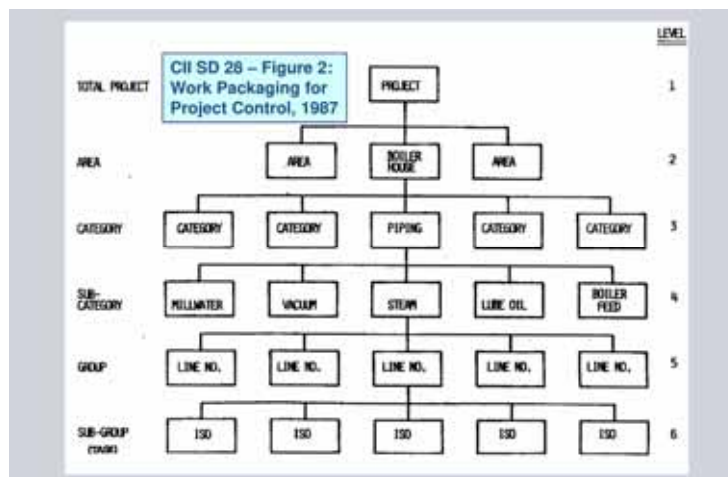
[52]

WBS Structure Example



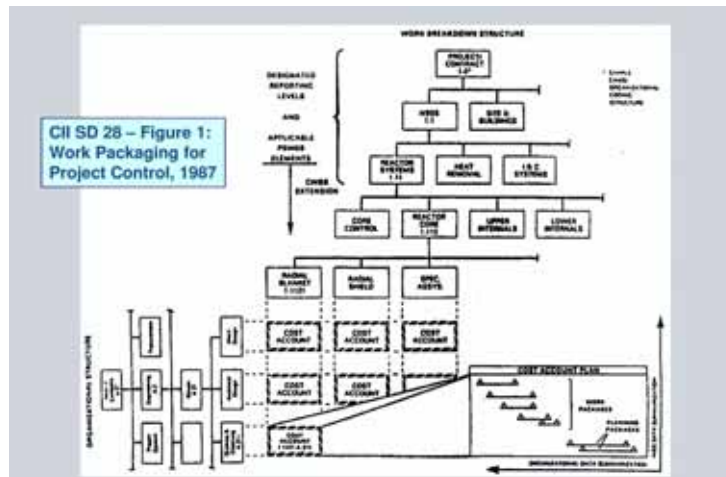
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WBS Levels Illustrated



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WBS - OBS - Schedule Relationship



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WBS Issues

- **Difference between WBS “work package” & “cost account”**
 - A work package is a WBS element where resources/costs can be reasonably estimated & budgeted
 - A cost account is a WBS element where actual costs will be collected & forecasted

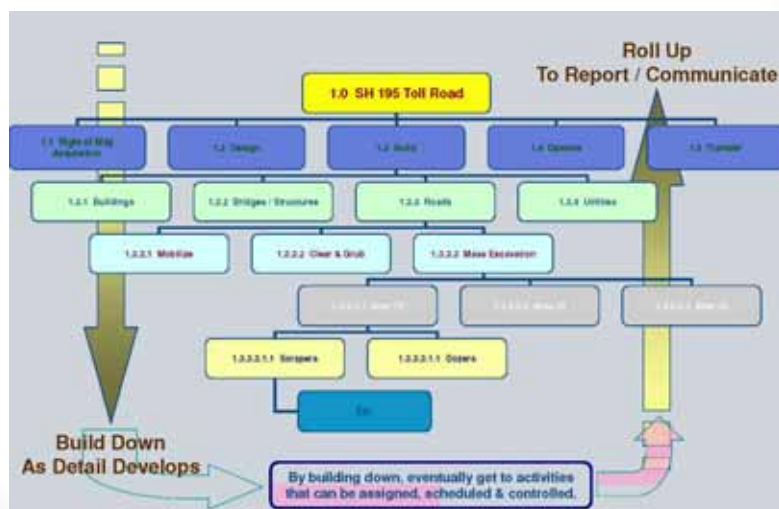
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Developing a Better WBS

- **Recommended Practices:**
 - **Should be structured in accordance with how work will be managed**
 - *Combination of “phase-based” & “deliverable-based”*
 - **Levels of detail relate to complexity/risk involved for each sub-element**
 - *Number of levels may be different for different sub-elements*
 - **Should take into account:**
 - *Technical performance parameters*
 - *Project organization*
 - *Contract funding*
 - *Configuration management*

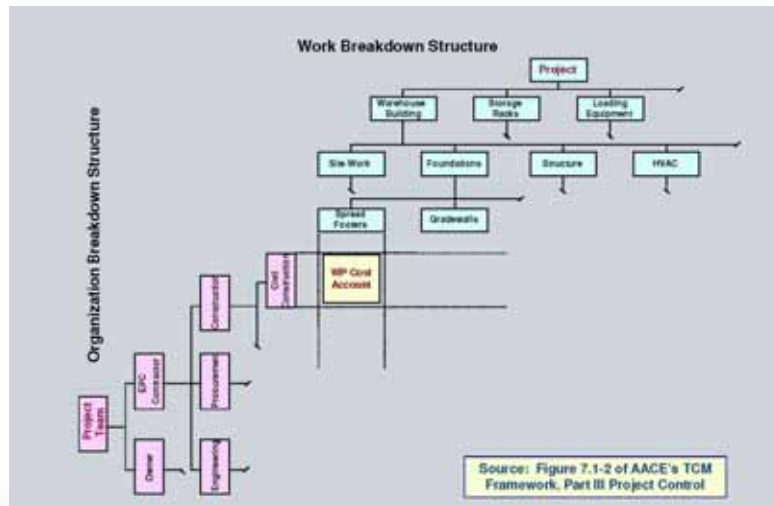
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WBS Development & Use



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WBS & OBS Relationship



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WBS Issues

- At what levels of WBS should “work package” & “cost/control account” reside?

– Two schools of thought

- *Work packages are lowest level of the WBS, which then become activities to be scheduled*
 - Cost accounts are at a level above work packages
- *Work packages are lowest level of WBS, but more detailed schedule activities are developed below WBS*
 - Work packages may be used as cost accounts

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Example Question: WBS

A Work Breakdown Structure (WBS)...

- a) Is derived from project schedule network / logic diagram
- b) Is derived from conceptual cost estimate of project
- c) Always has Five (5) basic levels
- d) Is structure by which project scope is divided into manageable components

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Specifications

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OUTPUT / DELIVERABLES

- **Schedule Scope of Work**
 - Results in schedule specification that represents client's desire for what is to be reported
- **Specification considerations**
 - One size does not fit all types of projects or contracts
 - Read & understand Contract requirements
 - May define requirements in excruciating detail
 - *Level of detail considerations*
 - Client/owner review & acceptance issues

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Developing Specifications

- **Goal should be for project planning requirements to be “scalable”**
 - Size & complexity of project
 - Type of contract
 - Type of project
 - Time constraints
 - *Internal*
 - *External*



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Specifications Components

- **Define need for project scheduling**

- **Owner Perspective:**

- *Ensure that contractor's plan meets owner's goals & objectives*
 - *Monitor contractor's execution plan & progress*
 - *Basis to exert control when schedule is not met*
 - As allowed by contract terms

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Specifications Components

- **Define need for project scheduling**

- **Contractor Perspective:**

- *Define plan to meet contract requirements*
 - *Define means & methods*
 - *Integrate subs & suppliers into overall plan*
 - *Provide baseline from which to control work*

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Specifications Considerations

• Who is responsible for project schedule?

– Contractor prepares & maintains schedule

- *What about subcontractors?*
- *Is a dedicated scheduler required?*



– Owner reviews, approves (explicitly or not) or accepts & monitors schedule

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Specifications Considerations

• Is a “logic-driven” schedule always required?

– Small projects

- *May not need a logic-driven schedule*
- *A simple bar chart may suffice*

– Complex Projects

- *Necessitate logic-driven schedules*
- *At a minimum need a bar chart*
- *Provide field staff with clarity & level of detail to plan & manage work on a daily basis*

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Specifications Details

- **Specification elements may include:**
 - **Planning & scheduling requirements & purpose**
 - **Parties' use of schedule(s)**
 - **Reporting requirements**
 - *Periodic reporting capabilities / requirements*
 - Level(s) of detail
 - **Schedule development & initial submission requirements**
 - **Phasing requirements, interim milestones & final completion details**

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Specifications Details

- **Specification elements may include:**
 - **Periodic updating requirements**
 - **Basis for periodic payment applications**
 - **Scheduler's experience & qualifications**
 - **Software compatibility requirements**
 - **Updating for scope changes, delays & impacts**
 - **Use in claims & disputes**

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Specifications Issues

- **Schedule should show:**
 - How sequencing is affected by phased completion & turnover
 - Interface & sequencing of separate contracts or contractors
 - Work performed by owner or others
 - **Contract limitations:**
 - *Milestones,*
 - *Work day / week restrictions*
 - **Interface with QC/QA**
 - *Inspections*

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Specifications Issues

- **Schedule should also show:**
 - Limitations by owner occupancy & use
 - **Site restrictions**
 - *Access Restraints*
 - **Resource limitations / availability**
 - **Weather & seasonal limitations & requirements**
 - **Provisions for scope changes**
 - **Submittal & review process**
 - **Safety considerations**
 - **Start-up & commissioning process**

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Potential Specifications Conflicts

- Reasonableness of schedule
 - Can schedule actually be used to run project?
- Approval / non-approval of schedule
- Failure to involve major trade contractors
- Vague & ineffective updated procedures
- Submission, approval & incorporation of:
 - Early completion schedules
 - Logic revisions
 - Time extension requests / changes

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Advanced Planning Topics

- Simulation
 - Sophisticated What If Planning & Risk Analysis
 - Balancing Time, Money, Resources, Scope & Risk
- 3D CADD Modeling
 - Smart CADD (Resources & Cost Tags)
 - Planning to reduce interferences & rework
 - Value Engineering
- 4D Planning & Scheduling
 - Integrating Time Planning & CPM into 3D CADD
 - Improves execution of complex & evolving designs
 - Constructability Planning & Reviews
 - Defines Who does What, When & Where
- 5D Planning & Scheduling
 - Fully integrated / updated time & cost into 3D CADD model

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Scheduling

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SCHEDULING OUTLINE

- ✓ Essence, need for & uses of scheduling
- ✓ Schedule stakeholder perspectives
- ✓ Schedule specifications development & use
- ✓ Input / Data used in schedule model building
- ✓ Creating schedule models
- ✓ Bar charts & PDM logic networks
- ✓ Schedule calculations & considerations
- ✓ Resource scheduling
- ✓ Change management & schedules
- ✓ Updating schedules for progress & forecasting
- ✓ Schedule Recovery & Acceleration
- ✓ Schedule levels & reporting output & deliverables

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ESSENCE OF SCHEDULING

- Scheduling is nothing more than good model building
 - Based first & foremost on solid plan
 - No plan, then don't start scheduling!
 - Not exact representation of how work is planned or will be executed
 - Identifies "When"
 - Based on Plan's "What," "How" & "Where"



- Key characteristics:
 - Elastic
 - Sensitive
 - Complete
 - Robust
 - Understood
 - Properly Used

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Integrated Planning & Scheduling

- Scheduling, part of iterative planning process: **modeling**, executing, monitoring, forecasting, replanning & reporting

AACE's TCM
Framework
PDCA Cycle



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Schedule Development

- **Schedule Development is a detail oriented process:**
 - Identify project activities
 - Estimate activity durations
 - Identifying relationships between activities (logic ties)
 - Assign resources responsible for accomplishing activities
 - Calculate activity start & finish dates
 - Review & analyze schedule



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SCHEDULING METHODOLOGIES

- **Effective project management involves:**
 - Planning
 - Organizing
 - Controlling time & cost
- **Scheduling forces:**
 - Quantification of discrete effort
 - Placement of tasks in proper relationship
- **Scheduling methodologies**
 - Non logic-driven
 - Logic-driven



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Basic Schedule Types

- **Non Logic-driven**
 - **Gantt Chart:** Time scaled bar chart
 - **Milestone Chart:** Event oriented bar chart
 - **Line of Balance / Linear Scheduling**
 - Typically horizontal/linear projects (highway, pipeline, underground utilities) or manufacturing resources
 - Repetitive processes
- **Logic-driven (Network Diagrams):**
 - **Deterministic:** Critical Path Method (CPM)
 - **Probabilistic:** Project Evaluation & Review Technique (PERT)

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Schedules: What's the Purpose?

- **Do projects always require a logic-driven schedule?**
 - **Requirement is often project-specific (horizontal vs. vertical)**
 - Civil Works, Highway, Pipelines → Linear Scheduling, Line of Balance, Bar Charts
 - Building Construction, Complex Phasing, Multiple Projects → Logic Driven / CPM Schedules
 - **Owner must make decision early**
 - **Customized, fit for purpose, specifications are key**
 - Coordination of resources, trades & phases?
 - How important is time (early completion) versus cost?
 - What level of information is really required?
 - Reporting: Who gets What & When?
 - Analyzing & Controlling: What really works?

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STAKEHOLDER'S PERSPECTIVES

- Stakeholders
 - Input during Planning
 - Feedback during Scheduling
- Stakeholder control is key success element
 - Will have profound impact on ultimate success of project
 - Requires proactive management via proper level & detail of communications
 - Prevent stakeholder interference



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Stakeholders: Contractors

- Perspectives
 - Plan work to meet contract requirements using available resources
 - *Means & Methods*
 - Monitor work progress of subs & suppliers against baseline / target schedule(s)
 - Periodically update schedule; report progress internally & externally; forecast trends analyzed
 - Control the work
 - *Reverse or improve on negative trends by shifting/ adding resources or changing means & methods*
 - Change management; aid in claims & disputes



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Stakeholders: Subcontractors & Vendors

• Perspective

- Should timely review & accept or reject contractor's schedule submittals
 - *Should not abdicate responsibility*
- Analyze critical path changes
 - *Both in progress updates & in claims & disputes*
- May fail to contemporaneously review schedule updates in detail
 - *Fails to take appropriate action*
 - *May not keep sufficient detailed records to verify accuracy of schedule updates*
- May allow update process to become primarily a monthly payment / draw tool



[85]

Stakeholders: Owners

• Perspective

- Establish overall schedule requirements, interface requirements & constraints & final completion date
- Monitor & oversight of contractor's progress
- Exert limited control of contractor (by contract)
- Analyze critical path changes in claims & disputes



[86]

Example Question: Schedule Development

- Which best defines steps for schedule development?
 - a) Define activities, Establish activity durations, Implement activities, Monitor activity results
 - b) Defining activities, Connect activities with logic, Establish activity durations, Calculate start & finish dates
 - c) Defining activities, Sequence activities, Establish activity durations, & Execute activities
 - d) Sequence activities, Connect activities with logic relationships, & Establishing activity durations
 - e) Define activities, Execute activities & Reporting activity results

[87]

Schedule Inputs

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[88]

INPUT / DATA

- **Input is driven by Output Required / Desired**
 - **Minimum requirements** → **Mandatory**
 - **Optimum requirements** → **Enhances success**
- **Schedule Development**
 - **Considerations:**
 - *Contract Terms & Conditions*
 - *Contract Scope of Work*
 - *Company / Organization Project Controls Policies & Procedures*



[89]


INPUT / DATA

- **Contract Terms & Conditions**
 - **Define client/owner's expectations for:**
 - *Schedule model development*
 - *Review & acceptance*
 - *Updating for progress*
 - *Reporting trends & future performance*



[90]

INPUT / DATA

- 
- **Contract Scope of Work**
 - Defines minimum acceptable scheduling mechanics & reporting details
 - Basis for planning & model building, to include identification of
 - *Deliverables*
 - *Milestones, timing, phasing & sequencing requirements*
 - *Resource limitations & available work hours/week/shifts*
 - *Interface points / requirements*

[91]

INPUT / DATA

- 
- **Company / Organization Project Controls policy & procedures**
 - *Going beyond Contract requirements*
 - *Consideration for systems, procedures & PM software tools used*

[92]

INPUT / DATA

- **Cost Estimates/Preliminary Budgets**
 - Define overall & detailed budget
 - Means & methods assumptions
 - Labor & equipment resource planning considerations
 - Phasing (EPC – Design/Construct cycle & internal phases)
 - Establishes baseline productivity assumptions
 - Drives individual activity durations & ultimately critical path
 - Defines indirects / time sensitive assumptions
 - Drives planned overall duration (short/long schedules)
 - Provides basis for measurement
 - Cost & Schedule performance baseline indices



{ 93 }

Why do Projects Fail?

- **Project Plans & Schedules fail for a wide variety of reasons**
 - Root cause can often be found to have been at beginning of Planning Process
- **Typical reasons for failure include:**
 - Egos, personalities, & poor mix of people skills
 - Corporate goals not understood
 - Poor cost estimates
 - Insufficient data & analysis during plan development
 - Planning checklists & systematic procedures not followed
 - Milestone dates not understood, communicated or followed
 - People & resources constantly changing
 - Specifications & scope of work not understood/used
 - Staffing requirements not understood or ignored
 - Poor communication between client & contractor



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CREATING A SCHEDULE

• Activities Definition *

- Start at summary level of WBS & work down to lowest reasonable progressing & control level
- Start with Summary Level & evolve to Detailed Activity & Logic Level (definitions) as execution & contracting plans merge
- Balance desire for minute detail with need for a model that allows for:
 - *Reporting/communicating to all levels & stakeholders*
 - *Accommodates change*
 - *Allows for effective trending & controlling*

AAACE RP 23R-02
Planning & Scheduling –
Identification of Activities

* **NOTE: Identification vs. Definition in P&S**

[95]

CREATING A SCHEDULE

• Activity Characteristics

- Consume Time
- Usually consume resources
- Have a definable start and finish
- Are assignable
- Are measurable

[96]

Example Question: Schedule Development

- Source of primary information that defines scope of work relied upon to create a schedule model?
 - a) Contract specifications
 - b) Contract special conditions & specifications
 - c) Pre-bid site visit and planning meetings
 - d) Contract provisions that define scope along with contractor's execution plan & related assumptions

[97]

Schedule Activities

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[98]

Schedule Activities Types

- Terminology, meanings, & schedule calculations are software - specific

- **Not all software tools calculate schedule using same algorithms**

- *Especially when lags & constraints applied*
- *Experiment to understand how tool works*
- *Be careful on projects where differing tools / versions are used collaboratively*



[99]

Examples: Activities Types

- **Primavera activity types:**

P6 & higher

- *Task Dependent*
- *Resource Dependent*
- *Start & Finish Milestone*
- *Level of Effort*
- *WBS Summary*

- **Microsoft Project activity types**

- *Fixed Duration*
- *Fixed Units*
- *Fixed Work*

- **Terminology varies with software**



[100]

Schedule & Activity Durations

- **Project scope & model objectives define units of time in schedule**
 - **Hours & Minutes**
 - *Typically very short duration, high activity projects*
 - Fire rebuild; plant turnaround; managing an emergency room
 - **Days**
 - *Calendar Days*
 - *Work Days*
 - Pipeline; Highway; Weather sensitive repetitive work
 - Standard work days / shifts; Specified completion milestones
 - **Weeks / Quarters / Years**
 - *Long term efforts / programs*

[101]

DEVELOPING DURATIONS

- **Estimating activity durations**
 - **Difficult & often subjective**
 - *Quantity of work may be variable or hard to define*
 - **Productivity rate should be based on historical data (averages)**
 - *Use past experience or estimate / schedule database*
 - *Typical work vs. special project conditions*
 - Overtime, shifts, etc.
 - *Estimator's & scheduler's bias considerations*
 - *Means & methods defines basic productivity*
 - *Historical data will include "normal" learning curve, rework & errors*

[102]

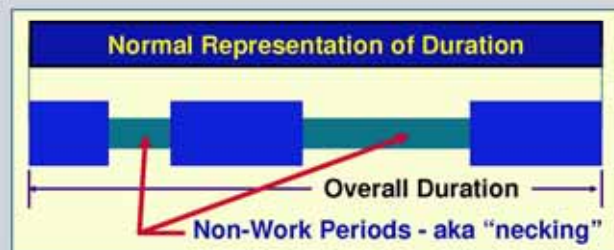
DEVELOPING DURATIONS

- **When initially establishing Activity Durations**
 - Evaluate each activity independently
 - Assume normal labor levels, material & equipment resource availability
 - Assume a normal work day or week/calendar
 - Disregard time/milestone constraints
 - Use consistent time units (hours, days, weeks)
 - Use historical productivity & durations as guide
 - For continuous production activities, identify level of effort & resource loading
 - *Level of Effort = Duration x Resource*

[103]

Understanding Activity Durations

- **What does activity duration really mean?**
 - Overall duration vs. exact time required
 - Resource utilization issues
 - Substantial vs. exact Start/Stop dates



[104]

DEVELOPING DURATIONS - CPM

- **Deterministic (CPM)**

- **Starting point is single-point estimate of duration**

- *Assumes unconstrained & unlimited resources*
 - *Does not include risk or contingency*
 - *Scheduler's bias or influence from project team to pre-determine durations should be resisted*

- **Apply known constraints & resource availability**

- **Examine individual activity duration estimates**

- *May need to split into more controllable durations*
 - *On average duration equal to one (1) update period **
 - *Durations less than 150% of time between periodic updates*
 - *If update every 4 weeks, then max significant activity duration less than 6 calendar weeks*

* Issues of External (Monthly) / Internal (Weekly) Updates

[105]

Example Question: CPM Durations

- **Estimating an activity's duration may include all of the following, EXCEPT _____**

- Using a historical estimating database for gross unit rates – e.g. Mhr / LF of 24" dia. Pipe
- Establishing composite crews & estimating their aggregate productivity for the scope of work
- If activity is off the critical path, establish an arbitrary duration & then plan to staff at level necessary to complete timely
- Examine activities outside of schedule model to estimate duration based on previous work history

[106]

Example Question: Durations

- **When using a detailed estimate as basis for work package/activity durations, what element does not need to be identified before an activity duration can be calculated?**
 - a) **Hours in a standard work day**
 - b) **Estimated labor-hours**
 - c) **Estimated cost**
 - d) **Projected crew size**

[107]

Example Question: Durations

- **If a detailed estimate is not available to assist in the formulation of activity durations but unit quantities have been identified, what information can be utilized to estimate work package / activity durations?**
 - a) **The Eichleay formula**
 - b) **Indirect cost reports**
 - c) **Historical production rates**
 - d) **Time impact analysis**

[108]

Example Question: Durations

- If the control estimate assumes that 480 hours will be expended on Activity 1650, *Grout Pumps*, with a crew makeup of 1 foreman, 2 carpenters & 2 laborers working a 9 hour day, what is the estimated duration for that activity?
 - a) 13 work days
 - b) 12 calendar days
 - c) 11 work days
 - d) 10 work days

[109]

ACTIVITY SEQUENCING

- **Input**
 - Activity lists
 - Product / equipment descriptions
 - Mandatory & discretionary dependencies
 - External requirements & interfaces / dependencies
 - Milestones
 - Constraints & assumptions
 - Known risks
- **Tools used include**
 - Schedule / network templates
 - Bar charts & logic networks developed in brainstorming sessions
- **Output**
 - Detailed, first pass schedule model
 - Documented constraints, assumptions, identified risks

AACE RP 24R-03
Planning & Scheduling –
Developing Activity Logic



[110]

Developing Activity Sequences

- **Logic Considerations:**
 - **Physical relationships**
 - *Activities that must be linked to accomplish the work*
 - **Safety relationships**
 - *Activities that must be linked to avoid unsafe conditions*
 - **Resource relationships**
 - *Activities that are linked to utilize a certain crew or equipment*
 - **Preferential relationships**
 - *Preferences to sequence the work*
 - Integrate subcontractors efficiently into the work flow
 - Smooth / Level resources
 - *Means & methods*

[111]

Soft vs. Hard Logic

- **Hard Logic**
 - **Relationships applied to chains of activities involving well-defined work**
 - **Interrelationships well known & accurately modeled**
- **Soft Logic**
 - **Relationships applied to chains of activities involving preferred work sequences, but not absolutely required as modeled**
 - *May compromise schedule model in terms of flexibility*
 - *May be viewed by Owners as "Preferential Logic" with negative connotations*
 - "Means & Methods" issues

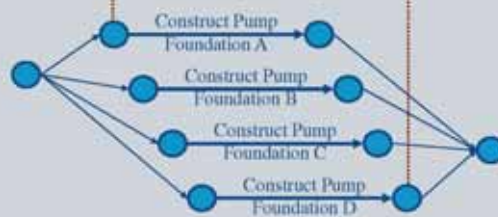
[112]

CPM Model Detail Evolution

• Initial – *Summary Level Detail*



• Detailed – *Evolving Logic*



[113]

Duration & Sequence Issues

- Majority of schedule misunderstandings related to activity durations & sequence of work required for successful completion
- Contractor reliance on its plan to complete work with staffing & sequence of trades as-bid
- “Means & Methods” misunderstandings & disagreements often result in contract disputes

So ... What is the Solution?



[114]

Schedule Basis Documentation

- **Documentation of activity risk, constraints & assumptions is key to success**
 - **Must be updated throughout life of project**
 - **Communications tool to transfer knowledge from planners to schedulers to management to client**
 - *A "meeting of the minds" – common understanding of parties*
 - *With time passing, memories fade & opportunities lost*
 - **Fixes scope basis understandings for**
 - *Earned Value, progress measurement basis*
 - *Proper change management*
 - *Resolving claims & disputes*



[115]

Schedule Types

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[116]

NON LOGIC-DRIVEN SCHEDULES

• Bar / Gantt Charts

- Most common form of expressing time / summary activity (implied) relationships
- Often includes graphical representation of resource information
- Does not normally show relationships between activities
- By themselves do not provide true / full picture of critical path
- Normally does not depict float
- Often used for short "windows" of time
- Provides good overview of project status & needs

[117]

Bar / Gantt Charts Advantages

- Plan, schedule & progress all depicted graphically on a single chart
- Easily read
- Simple way to schedule small undertaking
- Summary display of detailed plans & schedules
- Best used for management briefings

[118]

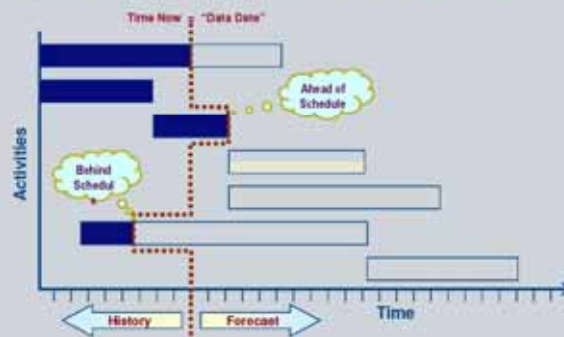
Bar / Gantt Charts Disadvantages

- Planning & scheduling considered simultaneously
- Insufficient detail for timely detection of slippages to critical & near critical paths
- Dependencies not adequately shown
- Difficult to determine how activity progress delays affect project completion
- Difficult to establish & maintain for large projects

[119]

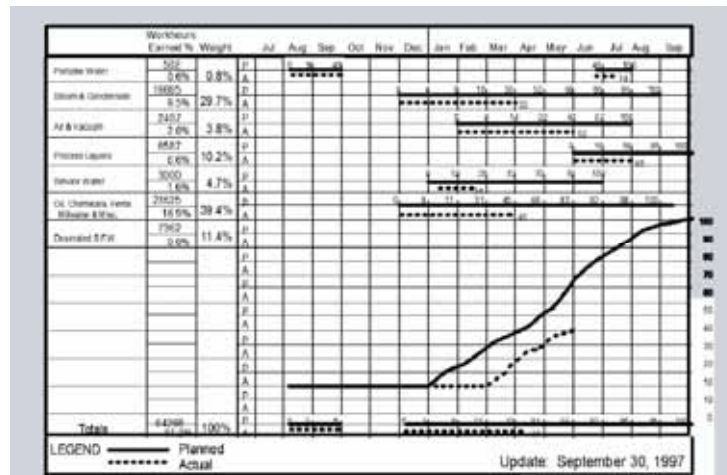
Gantt Chart Example

- Best used at extremes of project management:
 - In field, allows crews to plan & execute work
 - Management, to review, analyze & exercise control



[120]

Example of Combined Data Charts



[121]

NON LOGIC-DRIVEN SCHEDULES

• Linear Schedules *

- Best when highly repetitive, linear work flow
 - Constrained resources requiring no overlap / conflicts
 - Pipelines, highways, masonry, etc.
- Same crew makeup moves continuously/linearly
- Rate of progress easily tracked (LF of pipe/hr)
- Tracks continuous & repetitive activities
- Used to plan
 - Crew location & reuse as work flow progresses
 - Identifies timing & speed of resource utilization

* Sometimes referred to as Line of Balance (Mfg), Vertical Production Method, Time-Space Planning or Repetitive-Unit Construction

[122]

Linear Advantages

- **Less complex & easier to create than networks**
- **Production oriented**
- **Graphical charts rich with data**
 - **Production rates (slope of lines)**
 - **Activity durations**
 - **Resource Assignments & Crew Flow**
 - **Dates (calendar or work day)**
 - **Potential conflict points**
 - *Between activities with differing production rates*

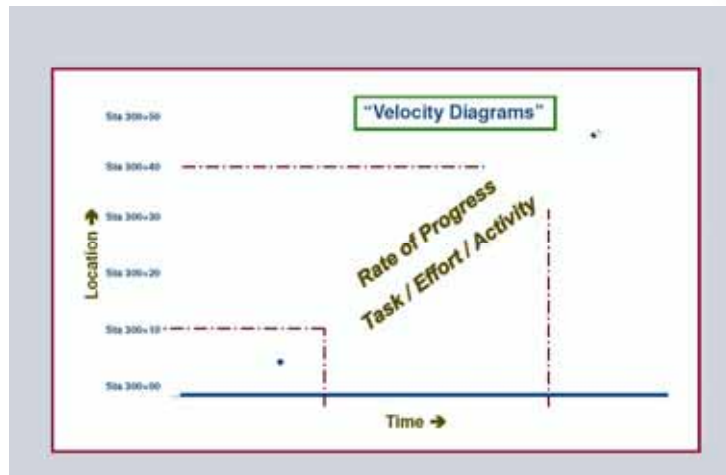
[123]

Linear Disadvantages

- **Only works for repetitive work flow type projects**
 - **May only be appropriate for portions of complex projects**
- **Less effective on more complex linear projects**
 - **Many locations with different phasing requirements**
- **Difficult to depict both horizontal & vertical progress within single schedule**
 - **Many complex projects have 3 dimensions**
 - *Time*
 - *Horizontal location*
 - *Vertical location*
- **No distinct identification of Critical Path**

[124]

Linear / LOB Schedules



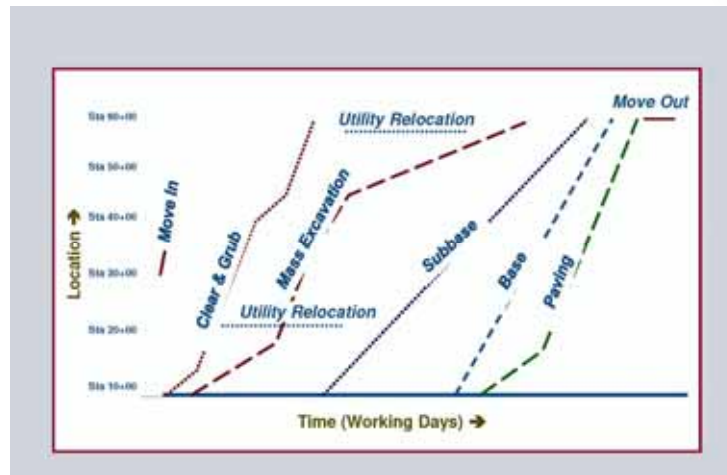
[125]

LOB Planning Process

- Identify "standard" crew makeup
 - Mix of craft & supervisory personnel
- Determine crew function / scope
 - Defines typical aggregate productivity
- Sequence of trades
 - By work type & / or location
- Routing / phasing around site(s)
 - Typically constrained by contract requirements
- Analyze buffers between trade crews
 - Optimum & minimum required

[126]

Roadwork LOB Summary Schedule



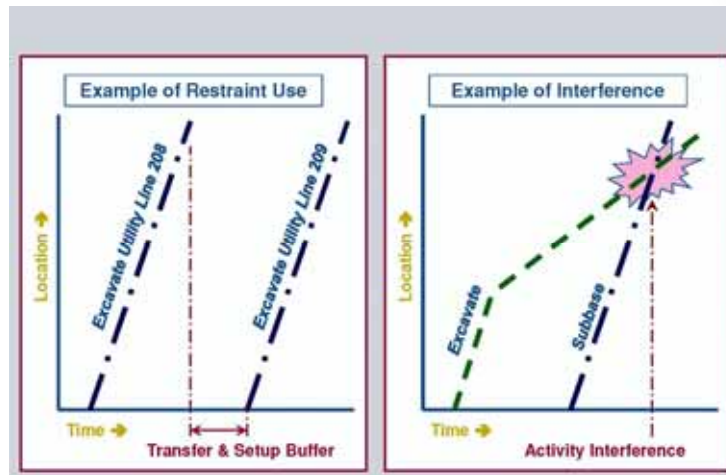
[127]

Analyzing LOB Schedules

- **Critical Activities**
 - Focus on tasks / activities with least slope
 - Focus on reducing task / activity durations
- **Look for future interference / conflicts**
 - Is time buffer between activities accurate & sufficient?
- **Is “straight line” work progress model an accurate depiction?**
 - Location challenges change
 - Learning curve effect
 - Seasonal variations
- **Phases / Elements of non-linear work may justify CPM modeling**

[128]

LOB Scheduling Issues



[129]

Example Question: Linear Schedules

- When planning a project that is best suited to use a linear or LOB schedule, what is NOT a consideration?
 - a) Resources necessary to do work
 - b) Flow of crews throughout project
 - c) Rate of progress of work types relative to each other
 - d) Assigning float values to specific items of work

[130]

Milestone & Specialty Schedules

• Milestone Schedules

– Outlines critical dates

- *NTP*
- *Procurement*
- *Phase start & end*
- *Deliverables*
- *Interface dates*
- *Testing & Turnover*
- *Startup & Commissioning*



[131]

LOGIC-DRIVEN SCHEDULES

• PERT & CPM

- Focuses on “critical” & “near-critical” paths/work flows throughout life cycle of projects
- Intent is improvement of accuracy & credibility of scheduling/forecasting
- Complexity & features used should be governed by project-specific requirements
 - **Basic:** *Network logic applied to activities*
 - **Typical:** *Multiple date & resource calendars used in semi-manual mode*
 - **Advanced:** *Resource-leveling & risk analysis fully incorporated*

[132]

Schedule Networks: *PERT*

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[133]

PERT

- **PERT** → Project Evaluation & Review Technique
 - **Logic-driven, variable (probabilistic) durations**
 - *Based on original 1956 DuPont CPM efforts using ADM*
 - 1958 US Navy Polaris Missile Program
 - **Event oriented vs. activity orientated CPM**
 - *Best suited for R&D type projects, those with evolving technology, or significant uncertainty*
 - **Uses multiple time estimates for durations**
 - *For traditional CPM, many fail to understand & communicate true variability of activity durations*
 - **Goal is probability determination that project will be completed by a certain date**

[134]

PERT Schedule Mechanics

- **Requires three time estimates for each activity**
 - **Optimistic (a)**
 - **Most Likely (m) [Duration value used for CPM]**
 - **Pessimistic (b)**
- **Single point “expected activity duration” used to perform traditional CPM schedule calculation**
- **Statistical analysis then performed on activities comprising critical path to calculate either:**
 - **Probability project will be completed by certain date**
 - **Completion time associated with pre-determined level of risk**
 - *E.g. P80 nomenclature = 80% Probability of meeting Date XYZ*

[135]

PERT Activity Durations

- **PERT**
 - Estimate expected activity durations:**
 - $(TE) = (a + 4m + b)/6$**
 - TE = Expected duration (workdays)**
 - a = Optimistic duration for activity (workdays)**
 - m = Most likely duration for activity (workdays)**
 - b = Pessimistic duration for activity (workdays)**

[136]

DEVELOPING DURATIONS - PERT

- **Probabilistic (PERT)**
 - Starts with **single-point duration estimate**
 - *Assumes unconstrained & unlimited resources*
 - Determine “**Most Likely**” duration based on **available resources & constraints**
 - Evaluate risk & opportunities to “**Most Likely**” duration to calculate “**Pessimistic**” & “**Optimistic**” durations
 - *Use brainstorming session with key project participants to refine duration estimates*

[137]

Example Question: PERT Durations

- From following table of activity information, what is duration of critical path? All activities linked in series with a Finish-Start relationship with a one (1) day lag.
Project work week is 5 days.
- a) 36 work days
 - b) 33 work days
 - c) 49 calendar days
 - d) 46 calendar days

Activity	Duration – Calendar Days		
	Optimistic	Most Likely	Pessimistic
A	3	7	12
B	15	16	20
C	6	9	11

[138]

In Class Exercise

- Using PERT Calculation Method solve the following: (Hint remember the formula and solve for the variable)

Activity	a	b	m	TE
100	3	9	21	?
200	24	30	60	?
300	24	33	54	?
400	21	24	33	?
500	9	12	27	?

[139]

Schedule Networks: *CPM*

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[140]

Network Schedules

- **CPM → Critical Path Method**
 - First formalized by DuPont & Remington Rand in early 1950s
 - Initially used to manage construction efforts on industrial projects
 - Now for just about any type of finite-duration endeavor across many industries & organizations
 - Sophisticated Schedule Models with Cost, Resources & Risk analysis capabilities
 - Applies logic ties to project activities to create a model of the execution plan
 - Model can then be used to identify "critical" work elements that should be focus of planning & control

[141]

Logic Diagrams (CPM Schedules)

- In simple terms: **Add logic ties to bar charts**
 - Intelligence: *What if & updating*
 - Computerization: *Model Building*
- Macro vs. Micro detail: **The "Model"**



[142]

CPM Networks – Basic Functions

- **CPM helps define the following:**
 - **Overall time to complete project (longest path)**
 - **Expected start & finish dates for each activity**
 - *Early Dates & Late Dates*
 - **Which activities / chains of activities are critical**
 - *Must be started & finished as scheduled to allow timely project completion*
 - *Also identifies "near critical path" activities that must be monitored & managed to same level as critical path activities*
 - **Identifies "float" for critical & non-critical activities**
 - *How much can an activity slip before it becomes critical & delays completion date(s)?*

[143]

CPM Advantages

- **Identifies activities that control overall completion**
 - **Critical & Near Critical paths control completion**
- **Determines shortest time for project completion**
 - **Evaluation of "what-if" scenarios**
 - **Solves Time / Cost conundrum**
- **Identifies critical activities (cannot be delayed)**
 - **Focus on what's important at any given time**
- **Shows available float for non-critical activities**
- **Allows resource-loading & leveling / smoothing**
- **Allows monitoring & control of "fast-track" projects**

[144]

CPM Disadvantages

- Only as good as effort put forth to properly model execution plan
- Can be difficult to properly update
- Can be easily misused
- Can lead to a false sense of security
- Actual project conditions may necessitate significant model modifications to accurately reflect changing reality

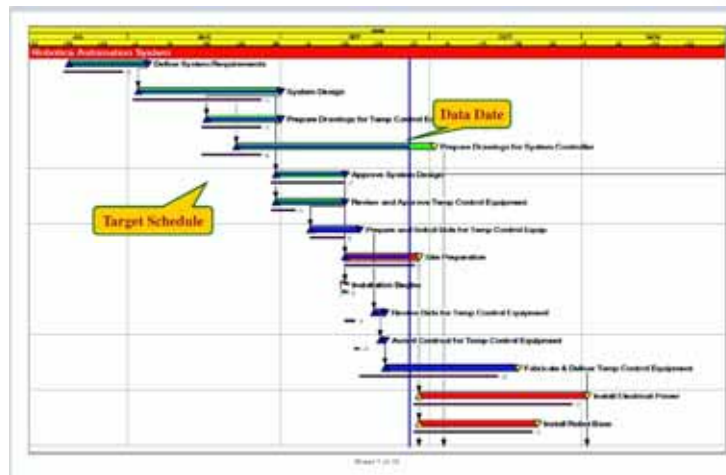
[145]

CPM Bar Chart Graphics: A Caution

- CPM typically displayed in bar chart format
 - Logic diagrams are too complex to use effectively as a management communications tool
- Must understand bar chart basis
 - Is there true logic underlying graphic?
 - At best, only general depiction of critical path
 - Float & resource flow not normally shown
 - Coding & filtering can skew presentation
 - Summary vs. detailed format
 - Macro view for trending & forecasting
 - Micro view for control of daily/weekly activities

[146]

Network / CPM Schedules



[147]

CPM – Today’s “Global Solution”

- Today’s sophisticated CPM (project management) software tools allow for:
 - Detailed WBS communications (reporting) to all levels of the project & stakeholders
 - Cost & Resource planning, tracking & controlling
 - Earned Value progress tracking & forecasting of integrated cost & schedule performance
 - Statistical risk analysis to integrate cost & schedule contingency estimating / forecasting

[148]

Critical Path Method (CPM)

- **Two basic methods of analysis:**
 - **PDM -- Precedence Diagramming Method**
 - *aka Activity On Node (AON) Method*
- **PDM primary method used**
 - **Typical PDM based software:**
 - *Primavera Project Management (P6)*
 - *Microsoft Project*
 - *Asta Powerproject*
 - *Deltak OpenPlan*

[149]

PDM -- Precedence Diagramming

- **Activities vs. Events**
 - **Activities consume time & resources**
 - *Procuring, Constructing, Testing, Turnover & Use*
 - **Events are zero duration & do not consume resources**
 - *NTP, Project Acceptance, Project Completion*
- **Activities may reflect a composite of crews & equipment, taking place over an extended period**
 - **May only formally model first start & final completion of individual activity**
 - *In reality may include several intermittent stops & restarts*
 - **Use of individual work calendars & splitting activities**

[150]

PDM -- Precedence Diagram

- **PDM activities comprised of**
 - **Activity description**
 - **Node represents activity**
 - **Arrow representing relationship / dependency**
 - **Point indicating direction of relationship / dependency**



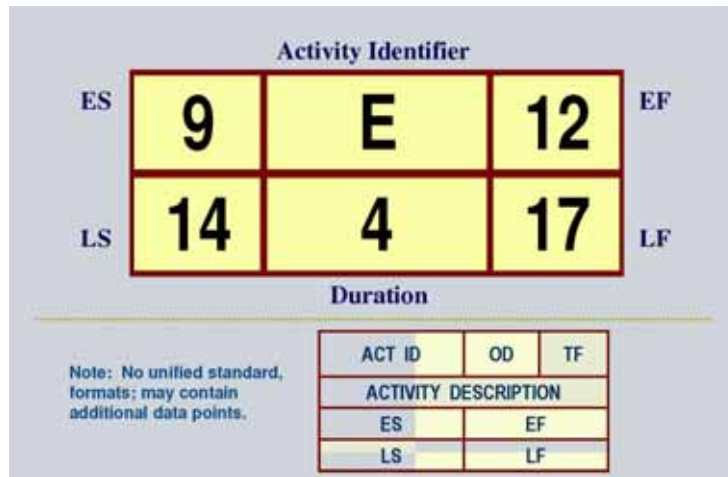
[151]

PDM -- Precedence Diagramming

- **Network rules:**
 - **Activities are represented by boxes or nodes that are assigned properties of activity they represent**
 - **Precedences are shown by arrows that have both direction & time properties**
 - *Precedences consist of two parts*
 - A relationship
 - A lag value or constraint

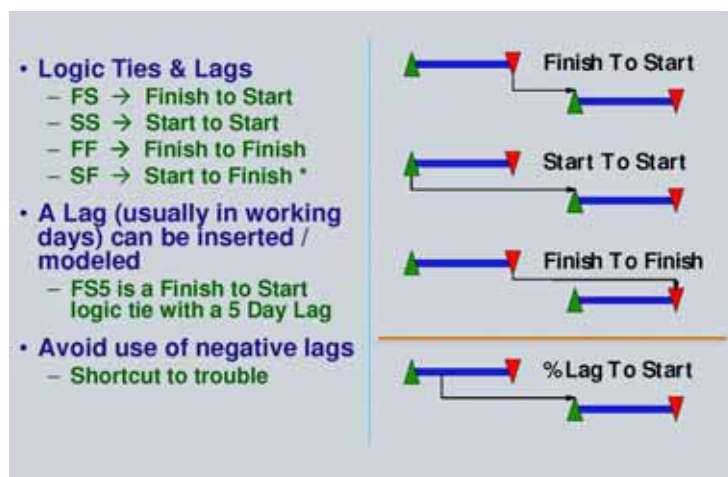
[152]

PDM Activity Notations



(153)

PDM - Creating Relationships



(154)

PDM – Level Of Effort Activities

- Allows flexible reporting & summarizing
- Spans two activities
 - May include a number of other activities
- Measures total elapsed time of covered activities
- “Level of Effort” (LOE) in Primavera P6



[155]

MOST WIDELY USED CPM FORMATS

- Time-Scaled Network Diagram
 - From PDM logic networks
 - May show part or all of logic ties & constraints
- Primavera’s “bar chart” with relationships shown is actually a form of time-scaled network diagram
- “Fenced Bar chart”



[156]

Calendars

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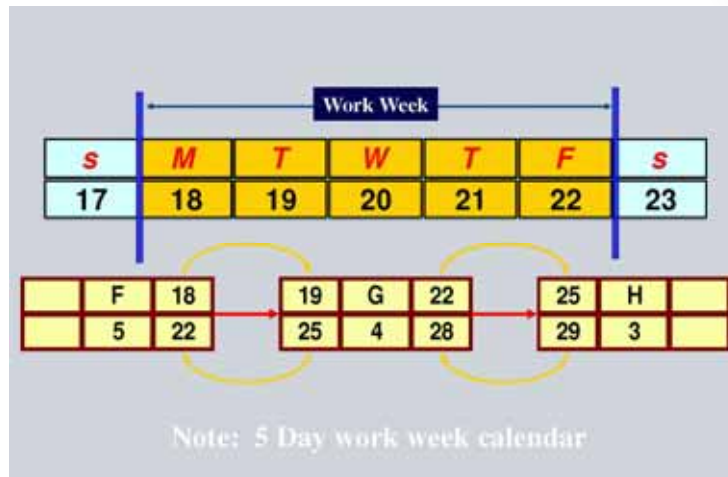
[157]

Work Calendars

- **Work Calendar development important to successful network diagrams**
 - **Standard workweek calendar**
 - *4 Day, 5 Day, 6 Day, 7 Day*
 - **Holidays / Non-Work Periods**
 - **Expected historical weather limitations**
 - **Contract time charges**
 - *Working day vs. calendar day*

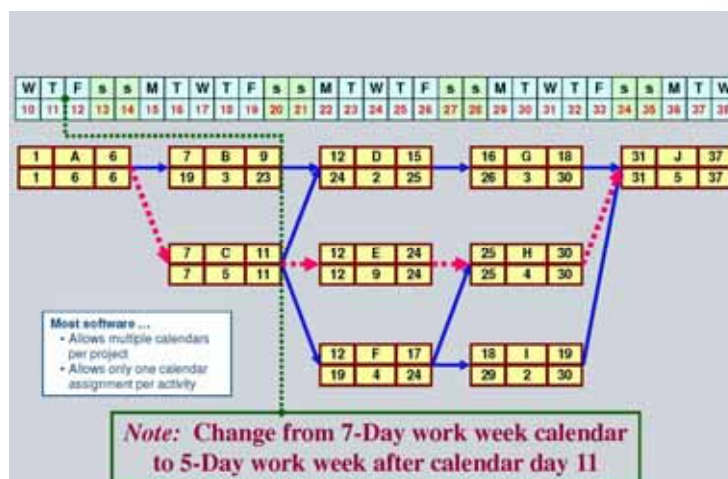
[158]

Calendar Conventions



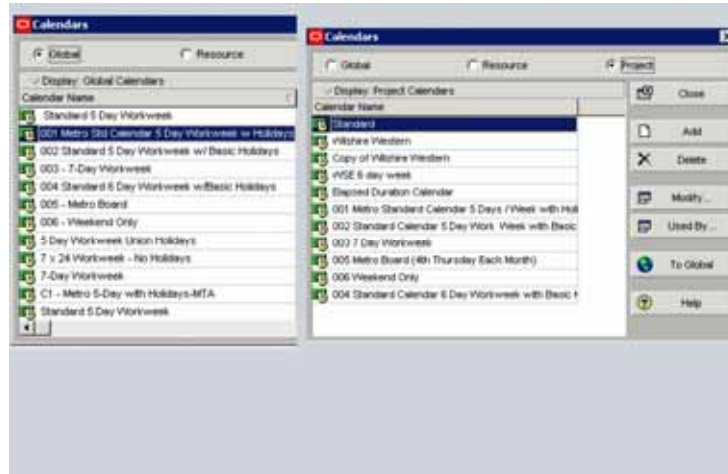
[159]

Work Day Change Example



[160]

Calendars [P6 Example]



[161]

Resource Calendars

- **Resource calendars further refined to allow for maximum & leveled productivity**
 - **Labor/crew availability**
 - **Equipment availability**
 - **Bulk materials delivery & use rates**
 - **Cash flow limitations**

[162]

Example Question: Calendars

- **What would be an example of a schedule activity that would be assigned a “calendar day” calendar?**
 - a) **It is never appropriate to assign “calendar day” calendars to activities**
 - b) **Concrete pouring**
 - c) **Concrete forming**
 - d) **Concrete curing**

[163]

Example Question: Calendars

- **Which method is reasonable for including a normal amount of weather days in a project schedule?**
 - a) **Limit the number of working days during weather season using a weather calendar**
 - b) **Add a percentage of time to duration of each weather sensitive activity to account for weather**
 - c) **Estimate total impact of normal weather days & add a contingency activity at end of project to account for normal weather**
 - d) **All of the above**
 - e) **Only a) & c)**

[164]

Schedule Calculations

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[165]


CPM Schedule Calculations

- **Schedule mathematics**
 - **Complicated by logic ties, lags, constraints on dates & resources**
 - **Understand start date for calculations.**
 - *Day "1" or "0"?*
 - *End-of-Day calculations: Start on day "1"*
 - Beginning-of-Day calculations: Start on day "0"
 - **Combination Convention:**
 - Activities should start at beginning of first schedule workday
 - Activities should finish at end of last schedule workday

[166]

CPM Schedule Calculations

- **Forward Pass** 
 - Defines Critical Path / Longest Path
 - Defines Early dates for activities

- **Backward Pass** 
 - Defines Late dates for activities
 - Defines Float values for activities & chains of activities

[167]

CPM Schedule Calculations

- **Each activity has four time values:**
 - **Early Start (ES)**
 - *Earliest possible time activity can begin based on network logic*
 - **Early Finish (EF)**
 - *Earliest possible time activity can finish based on network logic*
 - **Late Start (LS)**
 - *Latest possible time activity can start without delaying project completion*
 - **Late Finish (LF)**
 - *Latest possible time activity can finish without delaying project completion*

[168]

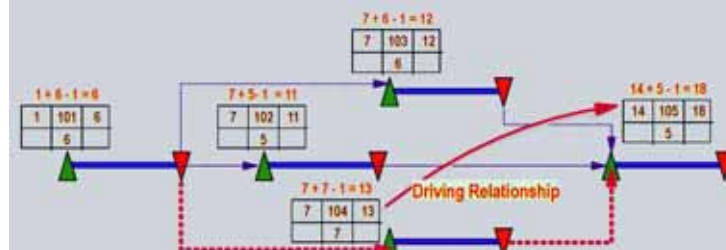
Forward Pass

- Provides: **Early Dates & Critical Path**
- Calculations
 - Early start time of one (1) is assigned to first activity in network
 - Each activity begins as soon as its predecessor activities finish
 - Early start of an activity is equal to largest of early finish times of activities merging that activity
 - Early finish of an activity is equal to early start plus its duration
 - Minus one (1) for calendar convention

[169]

Forward Pass Example

- Calculates Early Start (ES) & Early Finish (EF) of each activity
 - Time begins at "Time 1" & defines ES of 1st activity
 - Activities begin day after finish of predecessors
 - EF time of Activity = ES + Activity Duration - 1



[170]

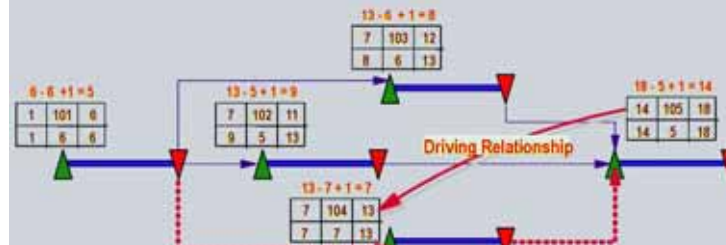
Backward Pass

- Provides: *Late Dates & Float Values*
- Calculations
 - Latest allowable finish time for last activity in network is set equal to its early finish time
 - All activities finish as soon as all successor relationships have been satisfied
 - Late finish of an activity is equal to smallest of late start times of activities bursting from activity in question
 - Late start of an activity is equal to its late finish minus its duration
 - Plus one for calendar convention

[171]

Backward Pass Example

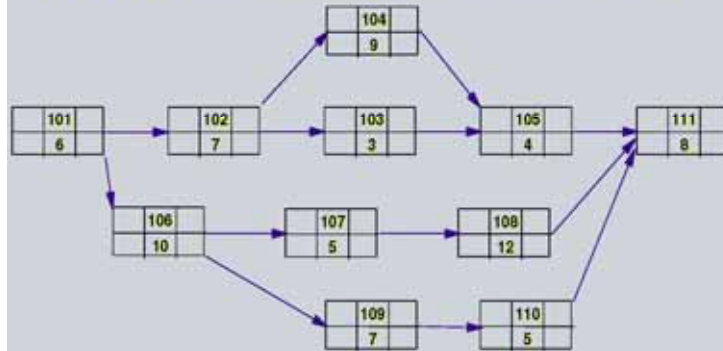
- Calculates Late Finish (LF) & Late Start (LS) of each activity
 - Begin with terminal activity of network
 - Activities finish day before start of predecessors
 - LF time of Activity = LS - Activity Duration + 1



[172]

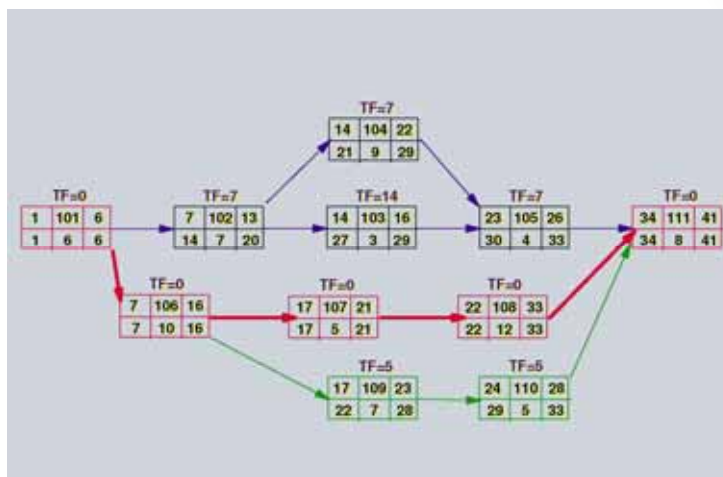
Example Question: Calculations

- Calculate ES, EF, LS, LF & Float
- What are Critical Path & "Near Critical" Paths?



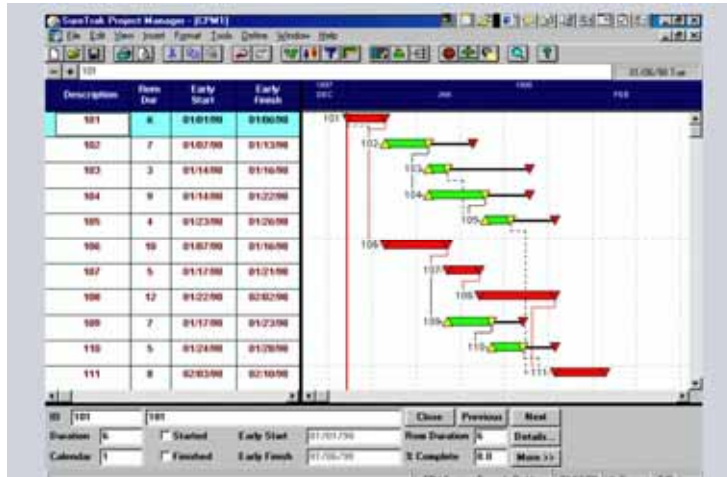
[173]

Example Question: Solution



[174]

Example Question:
Solution in Primavera SureTrak



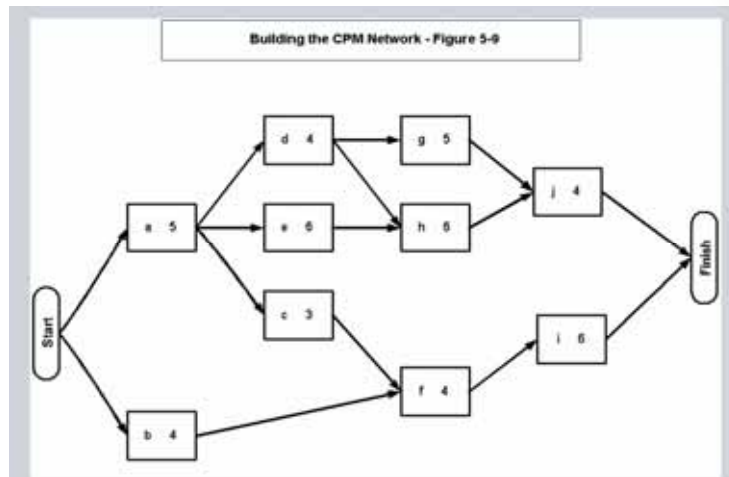
[175]

In-Class Exercise

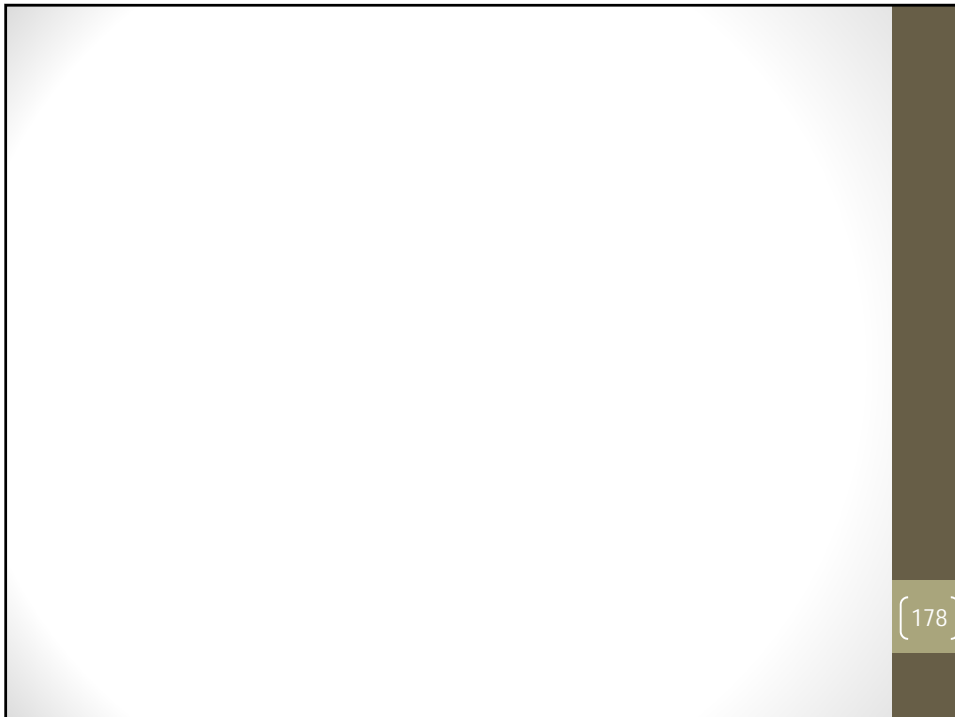
Activity	Predecessors	Duration
a	---	5
b	---	4
c	a	3
d	a	4
e	a	6
f	b,c	4
g	d	5
h	d,e	6
i	f	6
j	g,h	4

[176]

Draw Logic Diagram & Calculate Float



[177]



[178]

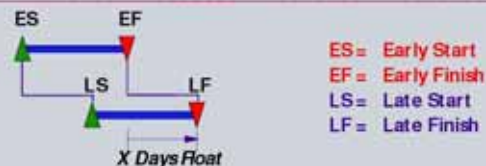
Understanding Float

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[179]

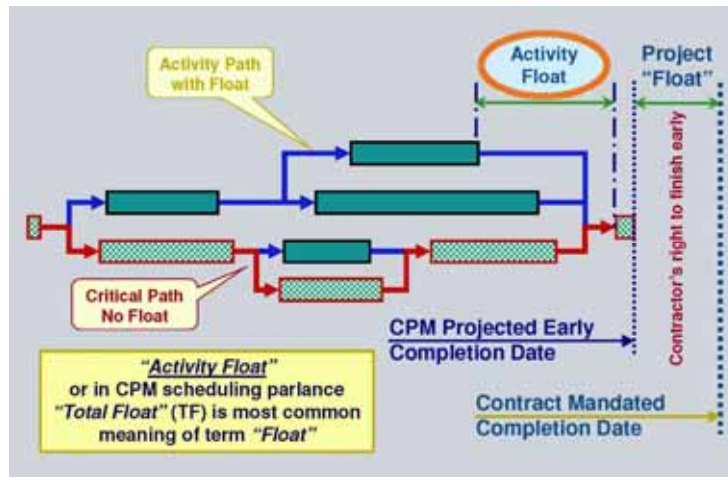
Float Values Defined

- **Total Float (TF):** Amount of time an activity may be delayed before affecting project's finish date
 - $TF = LF - EF$, or $LS - ES$
- **Free Float (FF):** Amount of time an activity may be delayed without delaying early start of successor activities
 - $FF = ES_{\text{Successor}} - EF_{\text{Predecessor}}$
 - $FF \leq TF$



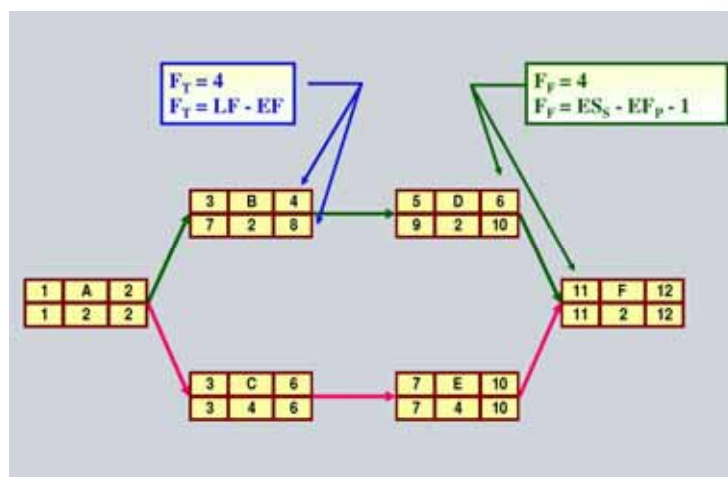
[180]

What is Float?



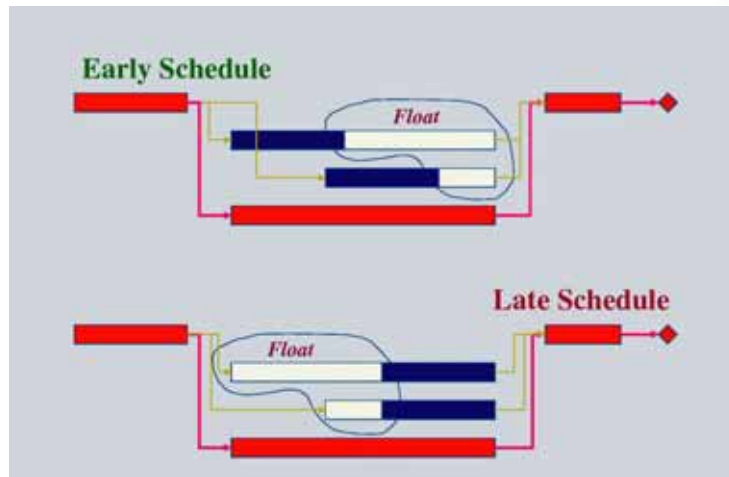
[181]

Float Calculations



[182]

Float : Early & Late Schedules



[183]

Float : Early & Late Schedules



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Common Float Issues

- **Float values**

- **“Positive” Float means**

- *Activity can be delayed*

- **“Negative” Float means**

- *Activity is, or will be, started / completed late*

- *May exist due to a “constraint”*

- Progress less than planned on related activities

- Constrained activity dates / calendars / resources

- *Indicates activities / paths for management focus*

- **Not all paths have consistent float values**

- *Gaps / Discontinuities may be caused by*

- Multiple calendars

- Out of sequence progress

- Date constraints

[185]

[186]

Common Float Issues (Continued)

- **Why is Float important?**
 - Float represents the time available to mitigate risk within a chain of related activities
 - Float expires & cannot be reclaimed
 - *Cannot be "banked" e.g. Weather Delay clauses*
 - Allows for the prioritization of activities & resources in a dynamic & changing environment
- **Who owns "Float"?**
 - Read your contract (very carefully)!
 - *Preferential Logic, Float Banking, Suppression & Sequestering*
 - Quite often, jointly owned
 - "Critical Path Float" vs. "Project Float"
 - Document & communicate

[187]

Common Float Issues (Continued)

- **Float is Not**
 - Time for others to use for decision delay
 - Time for work that should have been done earlier to circle back & finish
- **During periodic updates & evaluation, examine Float for**
 - Is plan / "Model" still valid?
 - Are resources available & properly utilized?
 - Are remaining risk issues covered by float?

[188]

Other Float Values

- **Academic values, rarely used on projects**
 - **Could be indicative of activity / project disruption**
- **Interfering Float**
 - **Amount of time activity's early start can be delayed without delaying project completion, but will delay succeeding activity(ies)**
 - *aka "Shared Float" with other activities*
 - $IntF = TF - FF$
- **Independent Float**
 - **That which is "owned" exclusively by that activity**
 - *Not available for use by other activities*
 - *aka "Safe Float"*
 - $IndF = ESSuccessor - LFPredecessor - Duration$

[189]

Example Question: Float

- **When analyzing a CPM schedule within a particular chain of activities, what do differing total float values indicate?**
 - a) **Schedule has too little detail to reflect an accurate critical path**
 - b) **Certain activities on critical path have no successors or predecessors**
 - c) **Some activities are date constrained**
 - d) **Schedule is projecting an "on-time completion"**

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Understanding Constraints

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Types of Constraints

- **Allow representation of actual work requirements & limitations**

- **Date constraints**

- *Start On / Finish On / Expected Finish*
- *As Late As Possible*
- *Mandatory Start / Mandatory Finish*
- *Start on or Before / Start on or After*
- *Finish on or Before / Finish on or After*

- **Beware of overuse & misuse!**

- **Sequestering float**

- *Masking / 'Pre-Consuming'*

[192]

Date Constraints [P6 Example]

Status

Started 14-Jan-14 Duration %

Finished Suspend

Exp Finish Resume

Constraints

Primary < None > Secondary

Date

- < None >
- As Late As Possible
- Mandatory Start
- Start On
- Start On or After
- Start On or Before

[193]

Critical Path
Longest Path

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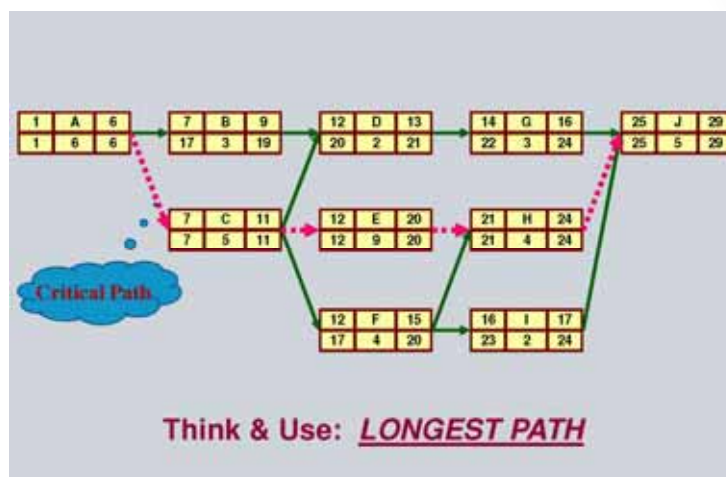
[194]

Critical Path

- **Chain of logically related activities that control completion** (longest path(s))
 - Defines project duration
 - Critical path is series of activities with least amount of total float [can be +, -, or 0]
 - Constraints & calendars can create discontinuous values
- Overall duration reduction (“crashing”) achieved by shortening length of CP
 - Re-sequencing critical activities to be concurrent (“fast-tracking”)
 - Reducing critical activity durations

[195]

Critical Path through Network



[196]

Critical Path Concepts

- **Critical vs. "Near-critical"**
 - **Critical path(s) are those that have Zero (0) or largest negative (-) total float**
 - **"Near-critical" paths/activities are those that have minimal total float**
 - *Important because CPM schedule is at best a model*
 - Inaccuracies, while not fatal, may result in the overlooking or failing to control "near-critical" paths
 - *Small delays to "near-critical" paths can quickly result in their becoming actual driving critical path*
 - *Failure to incorporate "big picture" may result in micromanagement & wrong focus*
 - **Manage to near critical paths**

[197]

Longest versus Critical Path

- **Is there a difference?**
 - **Constraints & multiple Calendars when modeling introduce Float value / path discontinuities**
- **Focus on Longest Path analysis**
 - **Software issues**
 - *Sort by TF versus LP reports*
 - *Retained Logic & Progress Override calculation modes*
 - *"Continuous" & "Interruptible" activity duration modes*
 - **May require manual analysis**
 - *Identify "Driving Relationships"*
 - *Identifying Near-Critical LPs*
 - **Multiple contract mandated Milestones**
 - *May result in a "false" Longest Path*

[198]

Example Question: Critical Path

- When reviewing the critical path, which of the following statements is false?
 - a) A network can have multiple Critical Paths
 - b) Critical Path can be one intermittent path that spreads out into a number of critical paths in a project
 - c) Critical paths must contain a continuous chain of activities
 - d) There must be a least one Critical Path from first to last activity in project
 - e) Critical Path establishes minimum overall project duration

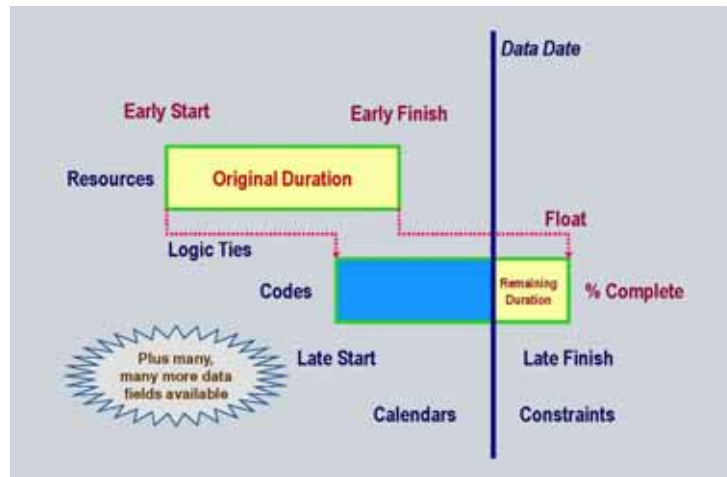
[199]

CPM Models as Databases

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CPM Data: A Peek Below the Water Line



[201]

CPM Database Sophistication

- **Many data fields w/in each activity record**
 - Calculated Dates
 - Float
 - Durations
 - % Complete
 - Logic Ties
 - Constraints
 - Resource Data
 - Tag / ID Data
- **Primavera includes many more data fields**
 - Sophisticated calculated fields

[202]

P6 Coding & User Defined Fields

Activity Code	Code Value	Description
Prog	M	LA County Metropolitan Transportation Authority ...
Proj	WS	Westside Subway Edension Project
SECTION	1	Section 1
EPC FTA Categories	20.03	Underground station, stop, shelter, mall, terminal, ...
EPC Metro Summary	C	Construction
EPC Cost Center	8510	CONSTRUCTION CONTRACTS/PROCUREMENT
SUB SECTION	LB	La Brea Station
Master Schedule Linked-METRO	Rail-CONST	Rail - Construction
EPC Project Number	865518	Westside Edension
EPC Distribution	LIN	Linear
Project Name	WEST	Westside Subway Edension

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P6 WBS “Module”

WBS Code	WBS Name
Westside - Current	Westside W/W to La Cienega Schedule - Section 1
Westside - Current.1	Milestones & Key Dates
Westside - Current.2	Project Planning & Development
Westside - Current.3	Engineering
Westside - Current.4	Right-of-Way (ROW)
Westside - Current.5	Owner Furnished Equipment
Westside - Current.6	Construction
Westside - Current.7	Start Up
Westside - Current.8	Project Close-Out

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Schedule Quality Analysis

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[205]

Schedule Model Quality Analysis

- **Baseline Review of a Schedule:**
 - Is schedule really *complete*?
 - Are activity *durations reasonable*?
 - Are activity *relationships complete*?
 - Are activity *relationships valid*?
 - Is the project *calendar(s) correct*?
 - Does overall *schedule duration fit contract*?
 - Are *contractual milestones met*?
- **If not why not?**
 - Document *purposeful deviations*

[206]

Reviewing Baseline Schedule

- Review predecessor / successor logic
- Verify Baseline matches Bid assumptions
- Ensure Baseline incorporated into subcontracts as appropriate
- Clarify Scope, Details & Responsibilities

[207]

Schedule Model Quality Analysis

- Carefully test for credibility & usability
 - Is critical path reasonable?
 - Predetermined vs. developed from plan analysis results
 - Are there multiple critical paths?
 - Why & what does this mean for controlling the work
 - What activities create near critical paths?
 - Could NCPs be true critical path
 - How does work & resources flow?
 - Truly achievable, work for all involved
 - Are there conflicts between concurrent activities?
 - Resource availability, overloading or interface issues
 - Is there an excessive amount of work at any time?
 - Plans for occasional overtime & weekend work to accommodate?
 - Are there sufficient resources to support concurrent activities?
 - Training & learning curve considerations
 - Have subcontractors & suppliers committed to schedule?
 - Not just their part, but overall interface of all involved
 - How has normal weather been addressed in schedule?
 - Weather calendars, weather contingency activity, etc.

[208]

Schedule Model Quality Analysis

Continue checking for credibility & usability

- Check for logic errors (loops, etc.), coding, & summarization methodology
 - *Don't blindly rely solely on computer results*
- Document assumptions, deviations, & changes
 - *Continuous updating during project*
- Review in detail project specifications & scope of work requirements to ensure plan meets specifications
 - *Don't perpetuate previous oversights, errors*

NOT A TRIVIAL TASK!

[209]

Model Quality Analysis

Prepare for Monitoring, Reporting & Analysis

- Develop implement & continuously quality check plans for
 - Observing & capturing actual progress
 - Periodic reporting / communicating
 - Analyzing progress & forecasting
 - Change implementation / replanning

[210]

Documenting Schedule Basis

A Graded Approach

1. Scope of Work
2. Work Breakdown Structure
3. Key assumptions and constraints
4. Issues & Impacts (Risk)
5. Inclusions & specific Exclusions
6. Schedule Change Order Process
7. Integration & Progress Reporting Process
8. Key Procurements and Submittals

[211]

Horizontal Traceability

- Logically tied & progress driven effort drives remaining duration
- Modeled in correct order of execution
- WBS / Control Accounts provide logical sequence & resource work flow
- Reverse planning review to remove redundant / non-essential logic in predecessors
- Identifiable logic path(s) that results in deliverable / end item
- Critical / driving path(s) checked in forward & reverse "walk"

[212]

Vertical Traceability

- **IMP – Integrated master Plan (not time phased) – integrates with Baseline**
 - **Program events; Significant Accomplishments; Accomplishment Criteria**
- **SOW / SOO – Statement of Work / Objectives**
- **OBS & WBS**
- **Control Account**
- **Work Package**
- **Schedule Levels / Hierarchy**

[213]

SCHEDULING PITFALLS

- **Successful scheduling is not solely dependent on validity of data & inherent planning process**
- **A well-planned project often fails due to poor schedule implementation**
- **Take care to avoid common pitfalls**
 - **Poorly defined activities & structure**
 - **Inadequate work package definitions**
 - **Inappropriate level of scheduling detail**
 - **Poor duration estimating**
 - **Poor updating procedures & lack of information**
 - **Long information processing time**
 - **Failure to full disseminate proper information**
 - **Application of hard logic to a soft logic situation**



[214]

SCHEDULING PITFALLS

- **Develop checklists to continuously validate schedule at all phases**
 - Does it violate basic planning/scheduling principles?
 - Does it make sense & agree with how project will actually be built?
 - *Answer may change over time*
 - Is the model properly constructed?
 - Will WBS & level structure provide summarization & reporting capabilities to satisfy all stakeholder's?
 - Is updating complete & accurate to left & right of data date?
 - *Capture actual starts, finishes & logic changes?*
 - *Properly estimate remaining duration & trends?*
 - Check sensitivity & accuracy issues for proper change management analysis & reporting

[215]

Example Question: Scheduling Issues & Pitfalls

- **Which of following IS NOT an issue or drawback to basic critical path method scheduling?**
 - a) Uses estimated activity durations with a single point value
 - b) Assumes that all resources are unlimited
 - c) Defines work flow & interdependencies between individual activities
 - d) Allows for use of summary or hammock activities to analyze & report at various levels

[216]

Resource Scheduling

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Resource Scheduling

- **Project resources include:**
 - Personnel
 - Support equipment & tools
 - Permanent raw materials & installed equipment
 - Expendable supplies
- **Cost/resource-loading & leveling**
 - Important resources to plan & track
 - Labor hours
 - Quantities of major materials / equipment
 - Baseline for earned value tracking & trend analysis

[218]

Resource Leveling

- **Resource leveling**
 - When “over allocations” occur, project network is revised through “leveling”
 - Attempts to keep requirements for a project resource as constant as possible over project duration
 - Adjust start & finish dates of activities to take availability into consideration
 - **Leveling Methodologies:**
 - **Time constrained: Fixed end date**
 - Necessary resources must be acquired in order to complete project on time
 - **Resource constrained: Fixed resources**
 - Adjusts project duration based on resources available

[219]

Resource Allocation

- **As model is refined, available resources allocated based on availability / plan**
 - As resource allocation is modeled, schedules transition from “Early Start” only basis to “Managed Start” basis
 - Smooths resource utilization
 - Balances float utilization
 - Near Critical Paths become management focus
 - **Primary elements of allocation**
 - Equipment
 - Labor
 - Material
 - **Resource utilization curves used to identify inconsistencies & interferences**

Beware of “preferential logic” or “manipulation” allegations. Requires narrative explanation to defend choices & reasoning.

[220]

Resource Leveling Benefits

- Good practice, as resources often limited in quantity & quality
- Trend analysis & forecasting
 - Resource profiles
 - Resource usage
- Highlight resource implications on schedule
- Basis for improved scheduling decisions
- Effects of resource limitations
 - Consumable resources
 - Non-consumable resources
- Reduces extreme fluctuations

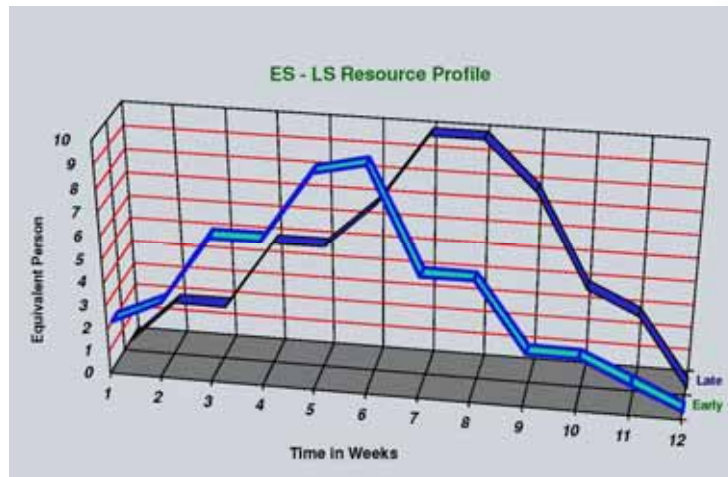
[221]

Resource Leveling Benefits (continued)

- Leveling
 - Adapts plan to planned Maximum or Minimum limits
 - “Smooth” highs & lows, providing a relatively constant demand on resources
 - Maintains a higher level of productivity
 - Minimizes overcrowding & premium pay / second shift work arounds
 - Minimizes unnecessary float consumption by focusing work on early dates

[222]

Example of Resource Profile



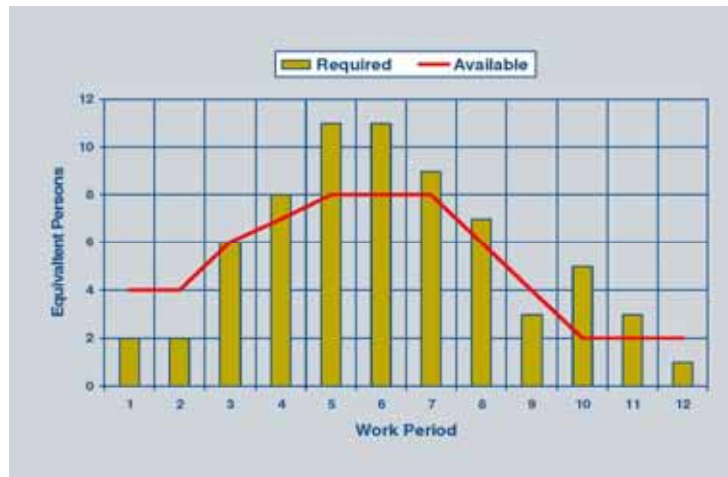
(223)

Example of Resource Leveling



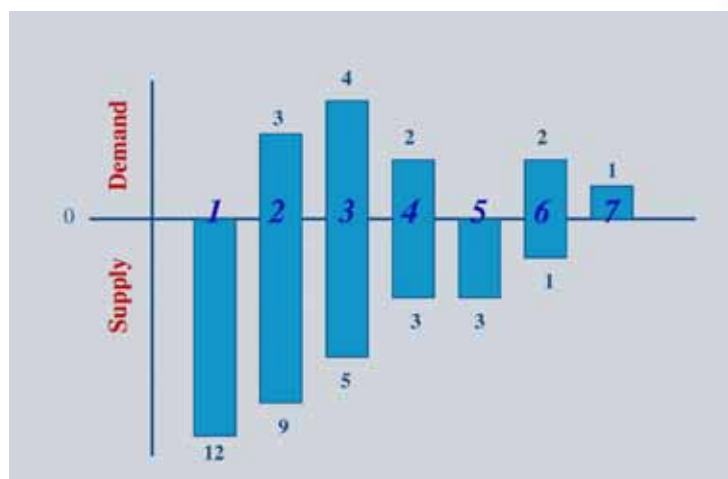
(224)

Non-consumable Resources



[225]

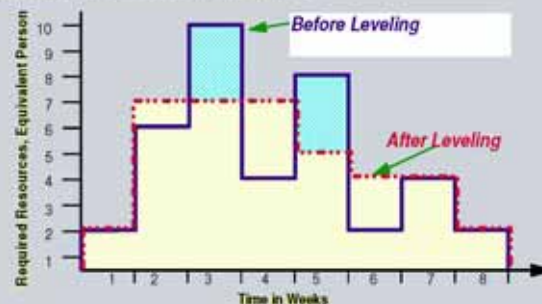
Consumable Resources



[226]

Resource Modeling / Analysis

- Typical CPM schedule not resource loaded to detail necessary to create fully accurate model
 - Most often “manually” leveled / smoothed
- Resource calendar use allows constraints to “level” & “smooth” resource utilization



[227]

Example Question: Resource Leveling

- Longest path calculates to 140 work days using unconstrained average 350 workers. Standard work week is 4-12 hour days, with no holidays. Work area constraints lead to productivity losses of a minimum of 20% when more than 200 people on site. What is leveled overall project duration using average 200 workers?
 - 400 calendar days
 - 140 work days
 - 245 work days
 - 429 work days

[228]

Schedule Updating & Maintenance

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Schedule Maintenance

• Updating & Tracking Progress

– Reasons for updating

- *Reflect & evaluate current project status*
- *Keep schedule relevant as effective management tool*
 - Correctly predicting completion date
- *Document & support actual performance*
 - Create accurate historical record
- *Record unplanned events to document changes, delays & impacts*
 - For some contracts, a formal requirement

– Updating vs. Status Definitions

[230]

Schedule Maintenance

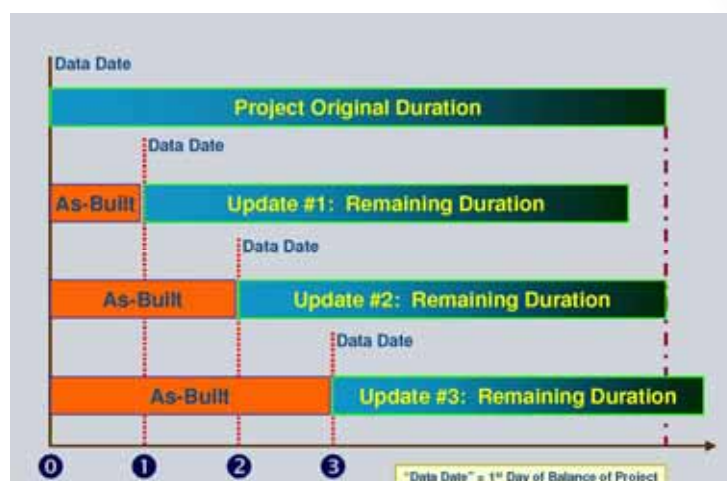
• Frequency of Updates

– Determined by:

- *Specification requirements*
 - Often concurrent with periodic pay application process/summary reports (typically monthly)
- *Project complexity*
 - As often as necessary to efficiently manage project
- *When unexpected events occur*
 - During periods of multiple changes or delays, may be wise to update more frequently

[231]

Data Date Concepts



[232]

Progress / Updating the Schedule

- **Collection & use of actual progress details**
 - **Organizational procedures for measuring & documenting progress**
 - *Unit rates: e.g. MHR/LF of small bore pipe*
 - *Actual Start & Finish [Substantial Start / Finish]*
 - *Activity statusing (% complete)*
 - *Actual logic flow*
 - **Calculate/forecast to completion**
 - *Estimated Remaining Duration [Analysis vs Auto-Calculation]*
 - *Percent complete vs. remaining duration estimate*
 - **Changes to Means & Methods**
 - *Logic Changes*
 - *Resource utilization changes*
 - *Scope changes*

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Updating Considerations

- **Report progress & trends**
 - **Just the facts, please!**
 - **Do not imply precision where none exists**
- **Forecast to completion**
 - **Document assumptions & changes**
 - *Schedule update narrative & supporting documents*
 - *Contract requirements & organizational practices*
 - *Primavera P6 Notebooks*
- **Always update 'Left of Data Date'**
 - **As-Built condition is important**
 - *To understand trends & forecast future*
 - *Accurately model full measure of change*
 - *In a dispute, becomes important history*

234

Updating Procedures

Six basic steps in updating a schedule

1. Gather activity status information
2. Determine schedule status
3. Analyze schedule status
4. Modify & revise schedule
5. Analyze updated schedule
6. Implement updated schedule

[235]

Updating Procedures

Step 1: Gathering actual progress data

- *Unit rates: e.g. MHR/LF of small bore pipe*
- *Actual Start & Actual Finish dates*
- *Remaining durations of work started*
- *Percent % complete*
 - % complete can be measured by:
 - » Quantity of work in place
 - » Amount of time expended
 - » Cost incurred
 - » Resources used
- *Actual logic flow*

[236]

Updating Procedures

Step 2: Determine Schedule Status

- *Calculate / forecast to completion*

Step 3: Analyze Schedule Status

- *Basis for evaluating schedule?*
- *Planned completion date?*
- *Critical path shifted & how?*
- *Float trend changes & why?*
- *Weather as a factor for any activities?*
- *Trends worth watching?*
- *Changes since the last update?*

[237]

Updating Procedures

Step 4: Modify & Revise schedule (as necessary)

- *Revise schedule logic*
- *Revise activity durations*
- *Resource utilization changes*
- *Add & delete activities*
- *Add scope revisions & changes*
- *Address out of sequence progress (as-built logic)*

Step 5: Review & analyze updated schedule

- *Determine that it is complete & accurately reflects how work will be actually carried out*
- *Update schedule basis documentation*

Step 6: Implement updated schedule

[238]

Reviewing Schedule Updates

- **Analyzing Updated Schedules:**
 - Remaining duration vs. percent complete
 - Owner review & accept or reject with comments
 - How should parties deal with negative trends?
 - Compare schedule updates for hidden "Gotchas"
 - Look at trade / subcontractor staffing & flow
 - Immediate, short & long term trends / issues
 - Develop "Top Ten List" for primary focus
 - Analyze critical path(s) & near-critical paths
 - What are positive & negative trends?

[239]

Example Question: Schedule Maintenance

- **Updating a CPM schedule is a two step process that incorporates recording actual progress with**
 - a) Estimating original durations for schedule activities
 - b) Creating a comprehensive work breakdown structure
 - c) Defining a logic network diagram
 - d) Calculating a forecast of completion for project

[240]

Example Question: Schedule Maintenance

- If an activity has an original duration of 10 days & 10 days of progress recorded, but activity not yet complete. Which method(s) could give most accurate % complete?
 - a) $\text{Work in Place/Planned Work Quantity} \times 100$
 - b) $\text{Time expended/planned activity duration} \times 100$
 - c) $\text{Cost incurred/Planned Activity Budget} \times 100$
 - d) $\text{Man-hours used/Planned Man-hours} \times 100$
 - E) All of the above

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Earned Value Considerations

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Earned Value Considerations

- **Earned Value Management System (EVMS)**
 - “**Earned value**” is the yardstick by which to measure both cost & schedule performance
 - *Common unit of measure is utilized for both*
 - Dollars
 - Labor Hours

[243]

Earned Value Terminology

- **Budget at Completion (BAC)**
- **Planned Value: PV (BCWS)**
 - **Time-phased budget**
- **Actual Cost: AC (ACWP)**
- **Earned Value: EV (BCWP)**
 - **Value of work physically completed**
 - *EV = % Complete x BAC*
- **Estimate to Complete: ETC**
- **Estimate at Completion: EAC**

[244]

Earned Value Terminology

- **Three standard measures of project status**
 - **Budgeted Cost of Work Scheduled (BCWS)**
 - *Same as Planned Value (PV)*
 - *Time phased budget*
 - **Budgeted Cost of Work Performed (BCWP)**
 - *Same as Earned Value (EV)*
 - *Value of work physically completed*
 - **Actual Cost of Work Performed (ACWP)**
 - *Same as Actual Cost (AC)*
 - *Actual Expended*

[245]

Earned Value Calculations

- **Budgeted Cost of Work Scheduled = BCWS**
BCWS = PV = (PS) (BCW)
PS = Percent Scheduled
BCW = Budgeted Cost of Work
- **Budgeted Cost of Work Performed = BCWP**
BCWP = EV = (PC) (BCWS)
PC = Percent Complete
BCW = Budgeted Cost Work
- **Actual Cost of Work Performed = ACWP = AC**
Obtained for accounting system

[246]

EV Activity Statusing Methods

1. Units complete

– **Units complete/total number of units**

- *For clearance of 100 acres,
10 acres cleared = 10% complete*

2. Incremental milestones

– **A pre-determined percent complete is assigned for each milestone or deliverable**

Milestone	Overall % Complete
Complete site visit	5
Complete work plans	30
Complete field work	80
Complete final report	100

[247]

EV Activity Statusing Methods

3. Start / Finish

– **50 / 50**

- *50% granted to start work on activity &
50% when activity complete*

– **0 / 100**

- *Full completion credit only when subtask
fully complete*

4. Supervisor Opinion

– **Most subjective method**

[248]

Example Question: EV Work Progress

- Of four methods for measuring work progress contained within EVMS which is most subjective?
 - a) Supervisor opinion
 - b) Start/finish
 - c) Incremental Milestone
 - d) Units completed

[249]

Schedule Variance/Index Calculations

- **Schedule Variance: SV**
 - Difference between earned & planned values
 - $SV = EV - PV$
 - Positive is favorable (ahead of schedule)
 - Negative indicates behind schedule

[250]

Schedule Variance/Index Calculations

- **Schedule Performance Index: SPI**
– Variance expressed as a factored index

$$SPI = EV/PV$$

$$SPI = \frac{BCWP}{BCWS}$$

> 1.0 is favorable

< 1.0 indicates behind schedule

- How do these relate to potential schedule slippage?

[251]

Schedule Variance/Index Calculations

- **Cost Variance = CV**
 $CV = BCWP - ACWP$

- **Cost Variance % = CVP**
 $CVP = CV / BCWP$

- **Cost Performance Index = CPI**
 $CPI = BCWP / ACWP$

[252]

EV Trended Forecasting

- **Unfavorable variances must be weighed in conjunction with analysis of critical path**
 - **May be related to non-critical activities**
 - *Early or late dates*
 - **Trended schedule forecasting more applicable for specific project scope elements/work packages**
 - **Art vs. science when using early / incomplete data**
 - *Must catch early, analyze & take action early when that action can be effective & least costly*
- **Similar to EAC for cost, schedule variances can be used in “trended” forecast of duration**
 - **Estimated Duration = Original duration / SPI**
 - *Straight line forecast vs. non-linear trends to achieve*

[253]

Example Question: Schedule Maintenance

Activity has original duration of 10 days & 10 days of progress recorded against it. Activity not yet complete. Which method(s) could give most accurate % complete?

- a) **Work in Place/Planned Work Quantity x 100**
- b) **Time expended/planned duration x 100**
- c) **Cost incurred/Planned Budget x 100**
- d) **Man-hours used/Planned Man-hours x 100**
- e) **All of the above**

[254]

Example Question: Updating for Progress

When updating schedule for progress, which is least important for achieving an accurate forecast of final completion?

- a) Establishing a data date
- b) Estimating individual activity remaining duration based on trends observed
- c) Inputting as-built logic changes into schedule model
- d) Updating schedule model to account for changes to means & methods of work remaining to be accomplished

(255)

Example Question: Work Progress

Of recognized methods for measuring work progress contained within an EVMS, which is most objective?

- a) Supervisor opinion
- b) Start/finish
- c) Units completed
- d) Incremental Milestone

(256)

Change Management

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(257)

Change Management

- **Change is inevitable**

- **Keys to successfully managing change**

- *Identifying (notice) that it is occurring/has occurred*
- *Take steps to manage & document impacts*
- *Follow through is key*

- **Must continually update all data points**

- *Most PM software tools have many ways to document & account for change (which too often are not used)*

- **If CPM not revised to reflect change, then loses credibility/usability for all stakeholders**

- *No longer able to accurately monitor progress & trends*
- *No longer able to accurately forecast future*
- *Often leads to abandonment of tool*

AACE RP 52R-06
Change Management & Forecasting –
Time Impact Analysis
As Applied in Construction

(258)

Change Management

- **Primary focus: Scope Monitoring & Control**
 - Observe trends (+ / -)
 - Analyses
 - Forecasting
 - Reporting Communicating NOTICE
- **Project Change Management Processes**
 - Deviations
 - Variances
 - Trends
 - Changes
 - Corrective Action

**Must be fully integrated
into Planning &
Scheduling processes**

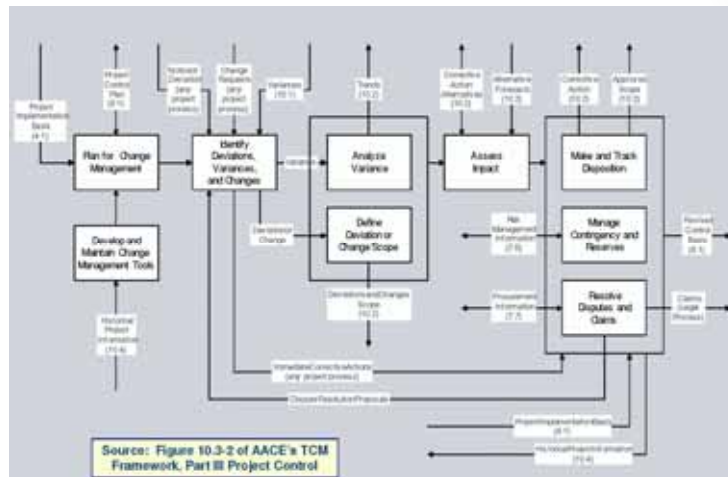
(259)

Change Management / Control Outputs

- **Documentation**
 - Documentation of assumptions is key when undergoing change (singular or continuing)
 - Coding & logs in project management software tool
 - Change logs: Trends, Deviations, Changes, Budget Shifts
 - Track history, time & cost & resolution
 - Progress tracking spreadsheets & databases
 - Feed progress data into project schedule model
 - Periodic schedule updates
 - Corrective action plans / forecasts
 - Revised project controls basis / target schedules
 - Historical project information & lessons learned
 - Requires proper root cause analysis to be meaningful

(260)

Schedule Change Control



[261]

Schedule Control

• Goal is to proactively influence factors that create or impose schedule change

Step 1

Identification / Notice of change

Step 2

Documentation of change

Step 3

Management of change to mitigate impacts

Step 4

Resolve change orders, disputes & claims in a timely manner



[262]

Example Question: Change Control

• **Tools & techniques of change management & change control**
DO NOT include

- a) **CPM schedule software programs**
- b) **Lessons Learned**
- c) **Earned Value analysis**
- d) **Performance measurement reports**

[263]

Schedule Levels

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[264]

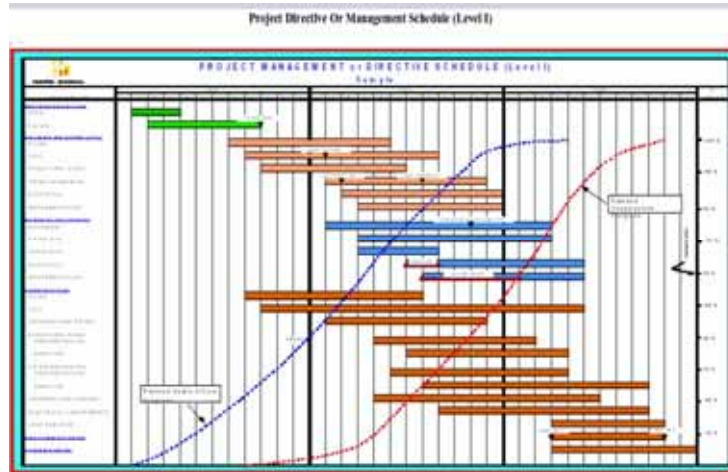
Schedule Levels of Detail / Filtering



[265]

[266]

Management Summary



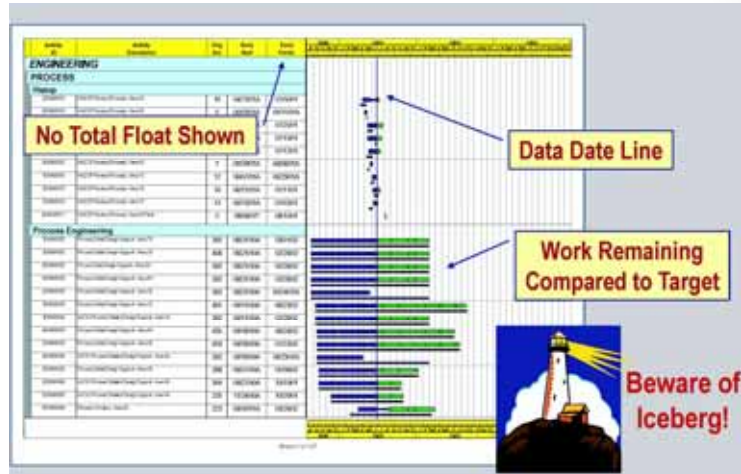
(267)

Level II Schedule Example - 1/2



(268)

Level II Schedule Example - 2/2



[269]

Schedule Forecasting

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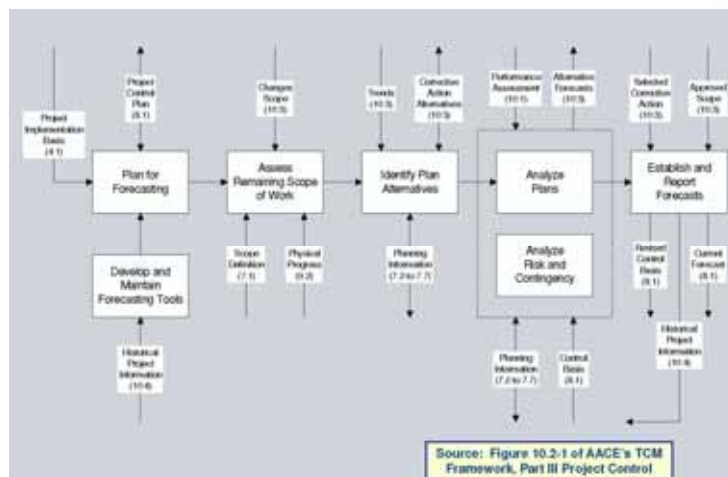
[270]

Progress & Trend Forecasting

- **Forecasting is process of evaluating plan & control baselines against ongoing project performance to understand trend indications, along with planned mitigations & incorporation of changed execution plans**
 - **Must be proactive & systematic**
 - **Baseline / target is static until new baseline established & well documented by all**
 - **Assess scope, schedule, budget, resources & risks**
 - *As impacted by a deviation, trend, change request or opportunity*
 - **Supports change management process**
 - **Reporting properly is key success element**

[271]

Process Map for Forecasting



[272]

Inputs & Outputs of Forecasting

- **Inputs**
 - Project Implementation Basis
 - Project Control Plan
 - Project Control Basis
 - Scope Definition
 - Changes in Scope
 - Physical Progress
 - Trends
 - *Changes / deviations observed, but not yet categorized*
 - Corrective Actions
 - *Alternatives considered & those selected*
 - Planning Information
 - Approved Scope Changes
 - Historical Project Information
- **Outputs**
 - Revised Project Control Plan
 - Planning Information
 - Corrective Action Alternatives & Recommendations
 - Alternative Forecasts
 - Project Controls Basis
 - Historical Project Documentation

[273]

[274]

Example Question: Forecasting

- When analyzing forecast to completion resulting from a schedule progress update, what are different total float values along critical path an indication of?
 - a) Certain activities in critical path have no successors
 - b) Schedule has too much detail to reflect an accurate critical path
 - c) Different calendars assigned to certain activities in critical path
 - d) Schedule is projecting an “on-time completion”

[275]

Example Question: Forecasting

- When updating a schedule for progress, which is least important for achieving an accurate forecast of final completion?
 - a) Establishing a data date
 - b) Estimating individual activity remaining duration based on trends observed
 - c) Inputting as-built logic changes into schedule model
 - d) Updating the schedule model to account for changes to means & methods of work remaining to be accomplished

[276]

Example Question: Forecasts

- **Periodic forecasts are best performed when**
 - a) **as directed by client**
 - b) **bi-weekly**
 - c) **quarterly**
 - d) **when change or risk is encountered**

[277]

Schedule Compression & Acceleration

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[278]

Schedule Compression

- Many reasons for need to compress schedule
 - Contract calls for completion date earlier than plan / schedule provides
 - Financial incentives (**contractual & internal**) to complete early
 - Recovery from critical path delays
 - Scope increase/change otherwise delays completion, with desire to maintain original completion date(s)
 - Directed acceleration to finish earlier than planned
 - Constructive acceleration (**contractual issue**)
- Planners & schedulers must know how to properly analyze & perform schedule crashing
- Acceleration often becomes a contractual issue

[279]

Schedule Compression

- Some critical path activities may jeopardize target project completion
- Recovery methods
 - Revise FS schedule logic to SS
 - *Overlapping activities*
 - Change work methods
 - Increase resources
 - Use multiple shifts
 - Use overtime
- Analyze compression plan to verify that it achievable
- Recovery attempts often come at price of lower productivity



[280]

Schedule Compression

- **Differentiation of these Schedule Terms**

- **Schedule Compression**

- *Shortening critical path by*

- Resequencing work
 - Change work methods
 - Increase resources
 - Use multiple shifts
 - Use overtime

- **Schedule Acceleration**

- *Requirement to complete performance earlier than scheduled*

- Constructive Acceleration
 - Directed Acceleration

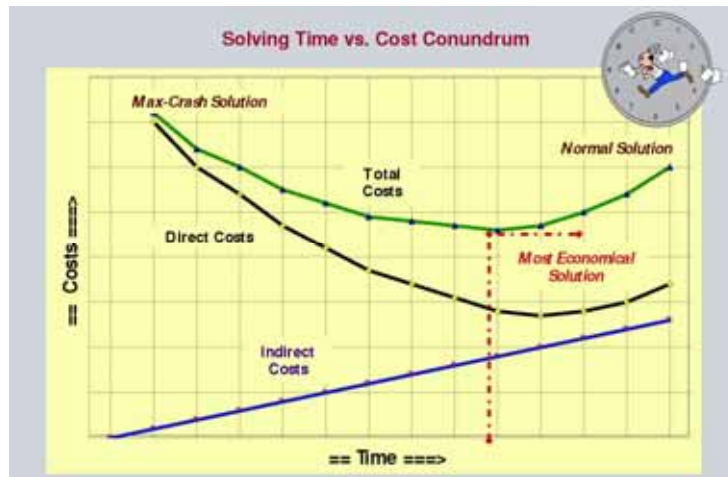
- **Schedule Crashing**

- *Decrease activity or project duration by increasing resources*

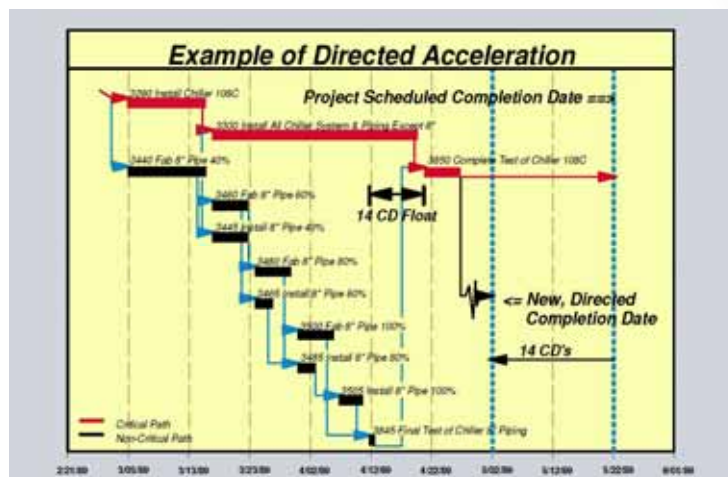
[281]

[282]

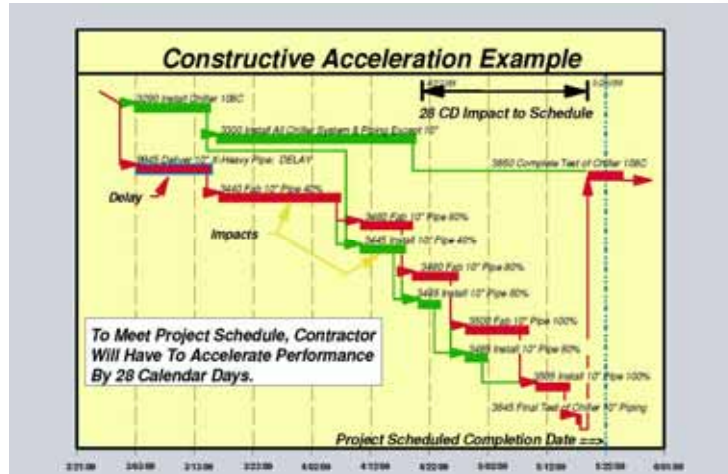
Crashing Analysis



Directed Acceleration

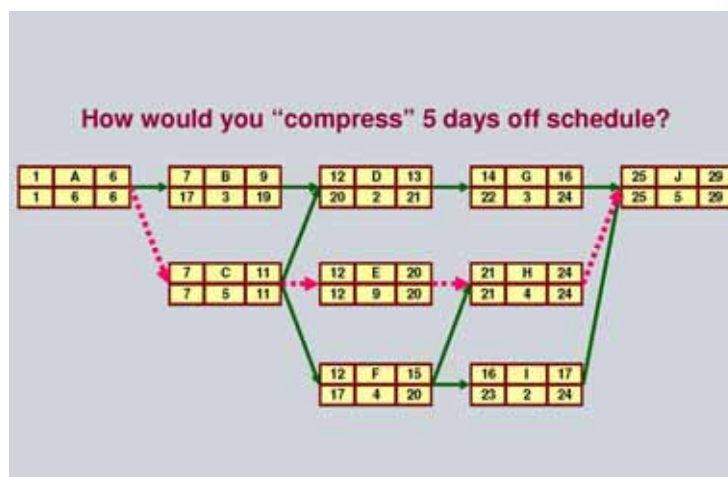


Constructive Acceleration



285

Example: Acceleration



286

Example Question: Acceleration

- To crash a schedule begin by reducing durations of activities with:
 - a) Most total float (TF)
 - b) Most free float (FF)
 - c) Least free float
 - d) Least amount of total float
 - e) Greatest cost per day

[287]

Schedule Delays

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[288]

Identifying & Documenting Schedule Change

- **Change vs. Delay vs. "Elongation"**
 - **Change**
 - *Revised or Added Scope*
 - *Change in execution plan*
 - **Delay**
 - *Partial or Full Suspension of Work*
 - *On or off Critical Path*
 - *Duplicative and / or Concurrent Delay*
 - *Pacing*
 - **"Elongation"**
 - *Productivity*
- **Early Identification & Early Addressing**
- **Documentation**
 - **Internal & External**

[289]

Analyzing Schedule Delays

- **Time Impact Analysis (TIA)**
 - **Multiple meanings & uses**
 - *Often Contract imposed methodology*
 - **See RP 52R-06 & TCM Framework**
- **TIA Process Model Delay with Fragnet (standalone)**
 - **Identify Appropriate Schedule Update**
 - **Insert Delay Fragnet with Zero (0) delay durations into schedule & recalculate CPM**
 - *If Recalculated schedule dates do not match original schedule*
 - *Revisit Fragnet to understand & revise as appropriate*
 - **Account for & understand any concurrencies & mitigations**
 - **Apply actual or forecast delay durations & recalculate**
 - **Analyze delay periods & impacts to project**
 - **Multiple delay and / or disruption may require multiple TIA analysis Fagnets – such as "windows" type analysis**
- **Excusable & Compensable: *Contracts Issues***

[290]

Time Impact Analysis (TIA)

- **Goal is to analyze & communicate critical path schedule delays contemporaneously**
 - Enter delays as activities/“fragnets” into periodic schedule updates
 - Recalculate to determine if delay results
 - If so, analyze for causation
 - Assign responsibility
 - Communicate to Owner in update narrative
 - Update schedule basis documentation

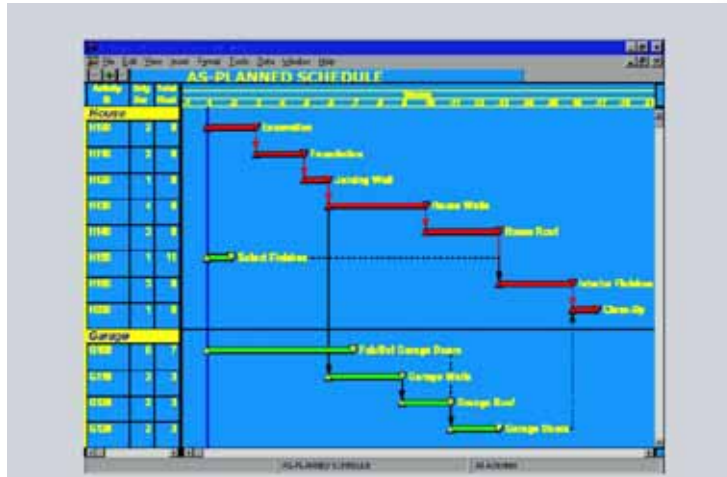
[291]

Time Impact Analysis (TIA)



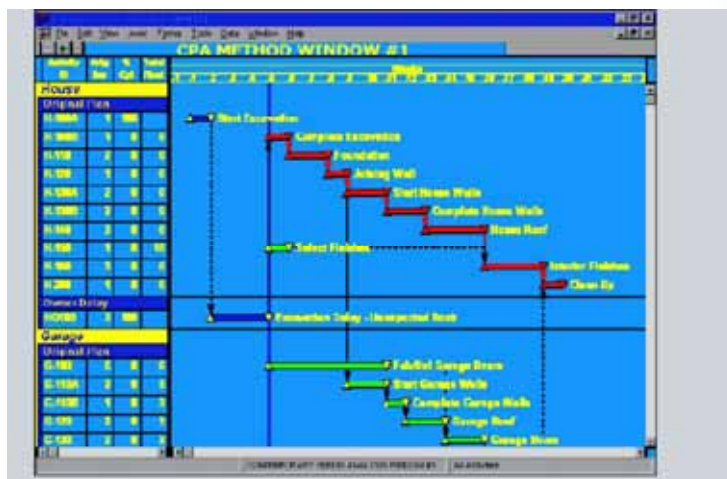
[292]

Time Impact Analysis (TIA)



293

Time Impact Analysis (TIA)



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Time Impact Analysis (TIA)

UPDATE NUMBER	SCHEDULE DATE (WEEK NO.)	PROJECT COMPLETION (WEEK NO.)	SLIP DURING PERIOD	DELAYS			REMARKS
				NON EXCUSABLE	EXCUSABLE NONCOMPENS	EXCUSABLE COMPENSABLE	
6	8	16	8	7	7	0	
7	1	10	1	0	0	1	Unforeseen Site Conditions

[295]

Reporting Status & Forecasting

- **Organizational needs & Contract requirements**
 - Must accommodate contract requirements
 - Must be useful in the field
 - May place limitations on information provided client
 - *Cost reimbursable vs. lump sum contract issues*
 - Electronic files vs. paper reports
- **Requires combination of tabular reports & graphics**

[296]

Example Question: Changes & Delays

- Practice of inserting delays or changes into a CPM schedule as fragnets & analyzing it for changes / impacts to overall project duration is referred to:
 - a) “But-for” scheduling
 - b) Collapsed as-built scheduling
 - c) Impacted as-planned scheduling
 - d) Time impact analysis

[297]

Control Inputs, Tools & Techniques

- Input
 - Project Implementation Basis
 - Deviation, Trend & Change notices / request documentation
 - Variances
 - Baseline / target schedule
 - Progress & performance reports
 - Schedule control / management plan
 - Corrective action alternatives & forecasts
 - Risk management information
 - Historical project information

[298]

Control Inputs, Tools & Techniques

• Tools & Techniques

- Change management practice & procedures
 - *Company & contract requirements*
- Project management software / databases
- Planning to accommodate, mitigate, work around change
- Performance measurement against baseline / target
 - *Earned value or Variance analysis*
 - *Rebaselining or reforecasting*

[299]

Example Question: Baselines

- A baseline plan / schedule is developed and revised
 - a) Never more than once during lifetime of project
 - b) Every month during regular progress update cycle
 - c) Might be updated several times during course of project
 - d) Will be changed only if cost estimate changes
 - e) Is updated quarterly regardless of ongoing issues or lack of issues on project

[300]

Example Question: Recovery Plans

- **A project recovery plan / schedule becomes necessary when ...**
 - a) **Cost budget is changed**
 - b) **Any time client asks for it**
 - c) **Project misses its cost or schedule targets**
 - d) **Every time a Change Order is agreed to by Client**
 - e) **Project anticipates missing cost or schedule targets**
 - f) **Both C & E**

[301]

Schedule Reporting

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[302]

CPM Schedule Reporting

How good are your Communications Skills?

- **Understand & listen to your audience**
 - **Client needs vs. stated 'gotta have'**
 - *Client monitors for contract compliance*
 - **Contractor's project staff**
 - *Project management personnel*
 - *Field / execution staff*
 - **Subcontractor & suppliers**
 - *They only see part of the picture*
 - *They need to provide schedule input*
- **Less is often more**

(303)

OUTPUT / DELIVERABLES

- **Reporting to stakeholders**
 - **Proper & accurate reporting key to success**
 - **Reliable, proactive information allows better trend management & mitigates time & cost impact**
 - **WBS & schedule level definitions implemented in schedule makes reporting:**
 - *Repeatable with consistent format & output*
 - *Places correct information in easily digested format to appropriate audience*
 - *Provides basis for simple trend observations that allow management of positive & negative trends*

(304)

Reporting to Stakeholders

- **Schedule “Report” is a Review Package**
 - **Contract often defines minimum & form**
 - *Confirm conformance*
 - *Organizational norms*
 - **Sanity check**
 - *Evaluate data integrity*
 - *Validate execution model going forward*
 - **Trends observed, forecast & recommendations**
 - *Track & report variances on key statistics*
- **Requires a “flexible” solution**
 - **Fit for purpose**
 - **Evolves, but only with management approval**

[305]

Why Important to Management?

No surprises allowed!

- If project is in distress, senior management wants (demands!) to be first to know
- The boss won't shoot messenger, only LATE reporting messenger!
- Boss controls resources
- Stockholder accountability is their job/future!



[306]

Reviewing Schedules

- **Key Schedule Analysis focus areas**
 - **Critical and Near-Critical Paths**
 - **Milestone (Contract & float)**
 - **Out of Sequence Progress**
 - *Indicator of plan being followed / achieved*
 - **What has changed in update?**
 - **Narrative**
 - Should be more informative than actual schedule analysis
 - **Schedule logic & activities**
 - FS changed to SS / FF
 - Duration changes
 - **Claim Digger & Schedule Analyzer type tools**

307

Variability, Risk & Credibility



308

Report, Advise & Decide

- **Scheduler**
 - Provides data points for Management team to understand trends & forecast presented in progress report
- **Management**
 - Decides to take specific actions to mitigate negative trends & capitalize on positive aspects
- **What if update shows late completion?**

[309]

Example Question: Reporting to Management

- **When reporting progress to upper level management, how can schedule organized based on project's WBS be useful?**
 - a) Schedule can be converted from ADM to PDM
 - b) Schedule can be manipulated to hide negative aspects
 - c) Schedule can be summarized to intermediate levels of detail
 - d) Schedule can only be "crashed" if organized by WBS

[310]

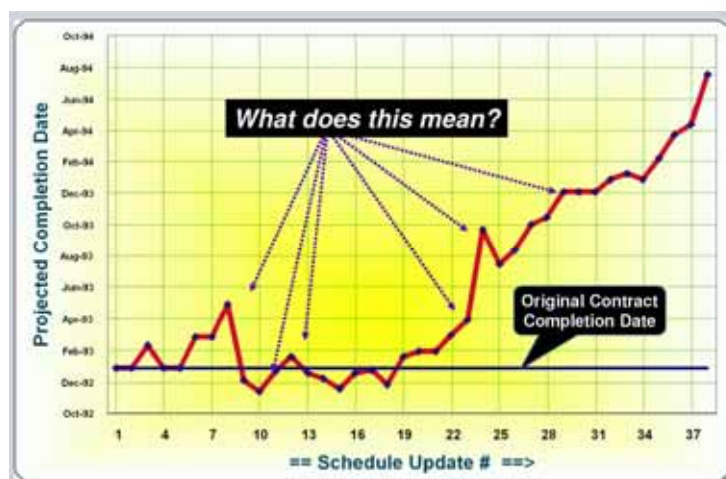
Credibility in Planning & Scheduling

**How close to
bull's-eye
are your
schedule predictions?**



{ 311 }

What's Going On Here?



{ 312 }

Use following table / data to answer questions

Use following table / data to answer questions

ID	Description	Duration	Relationship
1010	NTP – Notice to Proceed	Milestone	No other activity can start until NTP issued
1020	Mobilize to Site	20 WD	Succeeds finish of Activity 1010
1030	Bid / Select Subcontractor	30 WD	Succeeds finish of Activity 1010
1040	Owner Equipment Delivered	40 WD	Succeeds finish of Activity 1010 by 10 days
1050	Construct Foundations	25 WD	Succeeds finish of Activity 1020 & 1030
1060	Install Equipment	20 WD	Succeeds start of Activity 1020 by 10 days Succeeds finish of Activity 1040 Predecessor See Finish to Finish w/ 1050 Successor See Finish to Start w/ 1080
1070	Hookup / Install Controls	15 WD	Succeeds start of Activity 1060 by 10 days
1080	Startup & Test Equipment	10 WD	Succeeds finish of Activities 1060 & 1070
1090	Mechanical Completion	Milestone	Succeeds finish of Activity 1080
1100	Commission Equipment	15 WD	Succeeds finish of Activity 1090
1110	Final Completion	Milestone	Succeeds finish of Activity 1100

WD = Work Days 5 Day Work Week NTP Issued Monday, 3/05/07

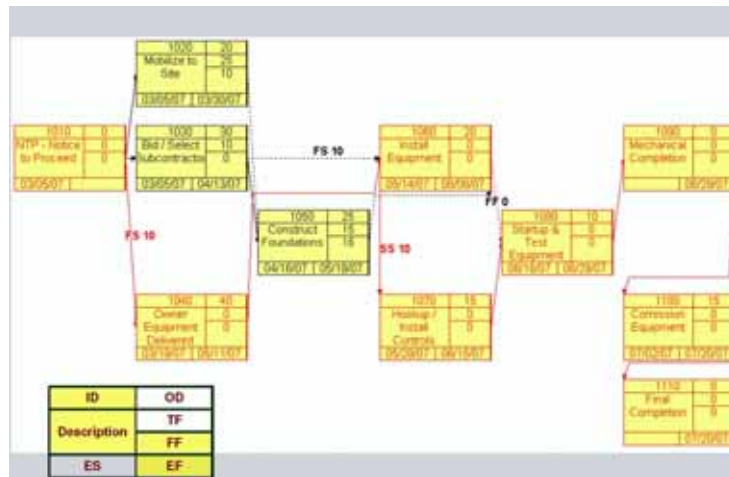
313

Example: Scenario Questions

- **Draw a CPM network diagram**
 - Use PDM format to show ID, Desc, OD, TF, FF, ES & EF
 - Prepare a Time Scaled Bar Chart for schedule & delay analysis as needed to aid in problem solution
- **Determine:**
 1. What is overall duration of project in
 - Work Days
 - Calendar Days
 2. Identify all Non-Critical Path Activities
 3. Identify TF & FF for each activity
 4. If completion of Activity 1030 is delayed by 20 Calendar Days, determine ES of Activity 1070 & FF of Activity 1020
 5. Given 25 WD delay to Activity 1040, what can be done to maintain as-planned final completion date?
 - Identify potential actions & associated issues / risks

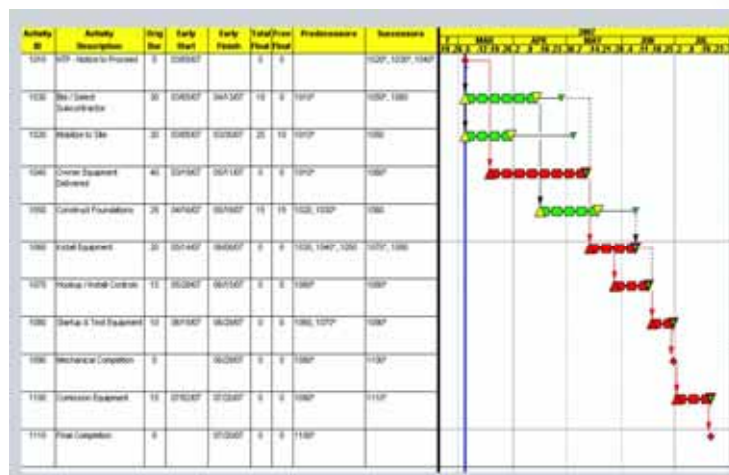
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Example: PDM Diagram – TF & FF



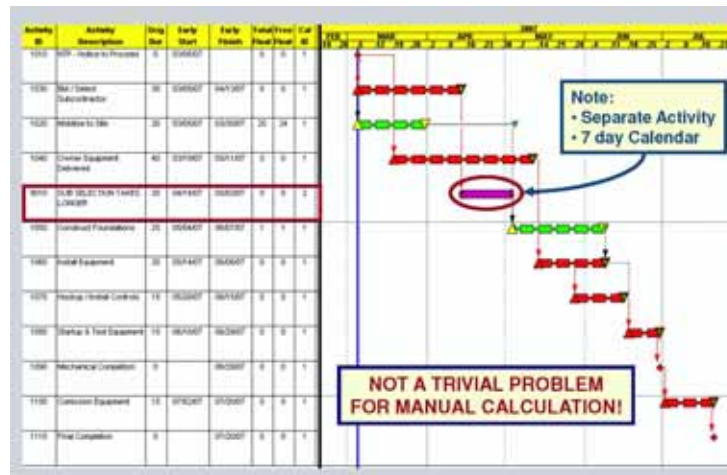
315

Example: CPM Network Solution



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Example: Delay Chart



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Example: Answers

- Overall duration: Monday, 3/05 – Friday, 7/20/07
 - Calendar Days = 138 CDs [7/20 – 3/05 + 1]
 - Work Days = 100 WDs [138 - 19 weekends @ 2 days each]
 - [Or CP = 40 + 20 + 15 + 10 + 15 WDs]
- Non-C. P. Activities: 1020, 1030 & 1050
- TF & FF for each activity: See PDM Diagram
- Delayed Activity 1040: See Delay Chart
 - ES Activity 1070 = 5/28/07
 - FF Activity 1020 = 24 Work Days
- Options / Risks: Must be reasonably achievable
 - Reduce durations of activities on Critical Path
 - Add resources & re-sequence work
 - Increase workweek from 5 to 6 or 7 days per week
 - Re-sequence / Fast Track work
 - Reduce Start LAG durations to follow-on activities
 - Added resources may introduce disruptions
 - Learning curve, inefficiencies, low labor productivity, etc.

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Example: Communications Problem

- **Assume preceding example problem**
 - **Prepare a one page (typewritten, single-space) memo to management of:**
 - *Problem / issue statement*
 - *Schedule Analysis*
 - *Recommended course of action(s) to maintain original schedule*
 - *Identify risks associated with proposed actions*
 - *Identify mitigation strategies*
 - *Identify, if needed, any additional monitoring & control activities needed going forward*

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