AACE INTERNATIONAL RECOMMENDED PRACTICE

14R-90

REQUIRED SKILLS AND KNOWLEDGE OF PLANNING AND SCHEDULING

AACE INTERNATIONAL

Rev. August 30, 2022

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REQUIRED SKILLS AND KNOWLEDGE OF PLANNING AND SCHEDULING

TCM Framework: General Reference
7.2 – Schedule Planning and Development

Rev. August 30, 2022

Note: As AACE International Recommended Practices evolve over time, please refer to web.aacei.org for the latest revisions.

Any terms found in AACE Recommended Practice 10S-90, *Cost Engineering Terminology*, supersede terms defined in other AACE work products, including but not limited to, other recommended practices, the *Total Cost Management Framework*, and *Skills & Knowledge of Cost Engineering*.

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Disclaimer: The content provided by the contributors to this recommended practice is their own and does not necessarily reflect that of their employers, unless otherwise stated.

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REQUIRED SKILLS AND KNOWLEDGE OF PLANNING AND SCHEDULING

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INTRODUCTION

This recommended practice is intended to serve the following purposes: define the core skills and knowledge a planning and scheduling practitioner is required to have, and in doing so establish the core competencies for the AACE International PSP education and certification programs.

Knowledge is understanding gained through experience or study, while *skills* are abilities that transform knowledge into use. Core competencies are those whose usage is and which AACE International considers as being required for planning and scheduling practitioners to know and use.

This recommended practice (RP) lists the core competencies and provides general performance statements (e.g., "describe", "perform", etc.) to represent the level of proficiency expected in each subject area. These statements are guiding examples only and are presented in a "verb-object" format.

This outline is intended to be a structural foundation for additional planning and scheduling products to be developed by AACE International and will continue to be modified as current practices change.

BACKGROUND

This revision retains most of the content of the previous version and includes information from RP 11R-88, *Required Skills and Knowledge of Cost Engineering.* [1] It also incorporates those elements of the *Total Cost Management (TCM) Framework* [2] that are deemed applicable for a planning and scheduling professional. It provides organization of the subjects aligned with the *TCM Framework*.

TCM provides an integrated structure and organizes the development of RPs. *TCM Framework* Fig 7.2.1 illustrates the process map for schedule planning and development and shows the basic workflow for planning and developing a schedule. This includes planning the project and planning for schedule development, establishing scheduling requirements, identifying activities, developing activity logic, estimating durations, allocating resources, submitting schedule deliverables, reviewing and validating the schedule, documenting and communicating the schedule, developing and maintaining schedule methods and tools, optimizing the schedule and establishing a control basis.

In addition to the *TCM Framework* and the scope of knowledge provided in this document, the following AACE recommended practices are related to the required skills of planning and scheduling:

- RP 20R-03, *Implementing Project Constructability*
- RP 23R-02, *Identification of Activities*
- RP 24R-03, *Developing Activity Logic*
- RP 27R-03, *Schedule Classification System*
- RP 32R-04, *Determining Activity Durations*
- RP 33R-15, *Developing the Project Work Breakdown Structure*
- RP 37R-06, *Schedule Levels of Detail – As Applied in Engineering, Procurement, and Construction*
- RP 38R-06, *Documenting the Schedule Basis*
- RP 39R-06, *Project Planning*
- RP 48R-06, *Schedule Constructability Review*
- RP 49R-06, *Identifying the Critical Path*
- RP 50R-16, *Trending and Forecasting of CPM Schedules*
- RP 54R-07, *Recovery Scheduling – As Applied in Engineering, Procurement and Construction*
- RP 55R-09, *Analyzing S-Curves*
- RP 64R-11, *CPM Schedule Risk Modeling and Analysis: Special Considerations*
- RP 70R-12, *Principles of Schedule Contingency Management*
- RP 90R-17, *Statusing the CPM Schedule – As Applied in Construction*

- RP 91R-16, *Schedule Development*
- RP 109R-19, *Schedule Change Management – As Applied in Construction*
- Any other recommended practice published under TCM Section 7.2.

PURPOSE

The purpose of this recommended practice is to:

1. Identify the applicable skills and knowledge for planning and scheduling practitioners from RP 11R-88 and the core competencies required for the AACE PSP Certification.
2. Establish a planning and scheduling guideline for training and professional development.
3. Provide ethics subscribed to by planning and scheduling practitioners.

This recommended practice is organized in three major sections consistent with the breakdown of traditional planning and scheduling "phases" as shown in Figure 1.

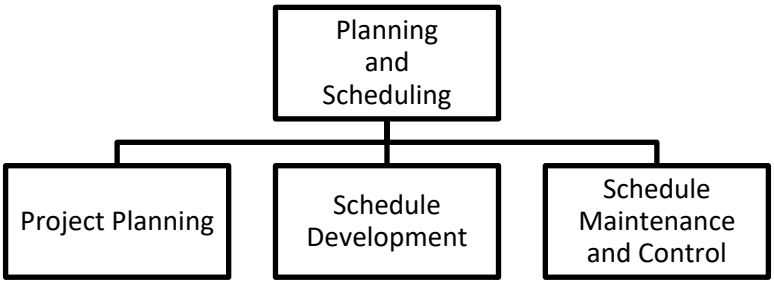

Figure 1: Planning and Scheduling Scope of Knowledge

A planning and scheduling practitioner should understand the core purposes of the scope of knowledge, which are as follows:

1. The purpose of project planning is to establish an acceptable course of action ("plan") to execute a project in an effective manner through the review of project scope and objectives.
2. The purpose of schedule development is to define activities, durations, and relationship logic to implement the project plan.
3. The purpose of schedule maintenance and control is to monitor, update, and communicate the schedule to reflect status and the impact of project changes.
4. The planning and scheduling practitioner provides the project management team with the expertise to plan, schedule, and control the project delivery in the most effective manner.

Planning and scheduling are distinct but related disciplines. Both terms are defined by AACE in Recommended Practice No. 10S-90, *Cost Engineering Terminology* [3]. It is imperative to understand the difference and purposes of these two skills, as described in the *Planning and Scheduling Phases* section below.

PLANNING AND SCHEDULING PROCESS MAP

Figure 2 (*TCM Framework* Fig 7.2.1) illustrates the process map for schedule planning and development and shows the basic workflow based on the plan, do, check, act (PDCA) control cycle.

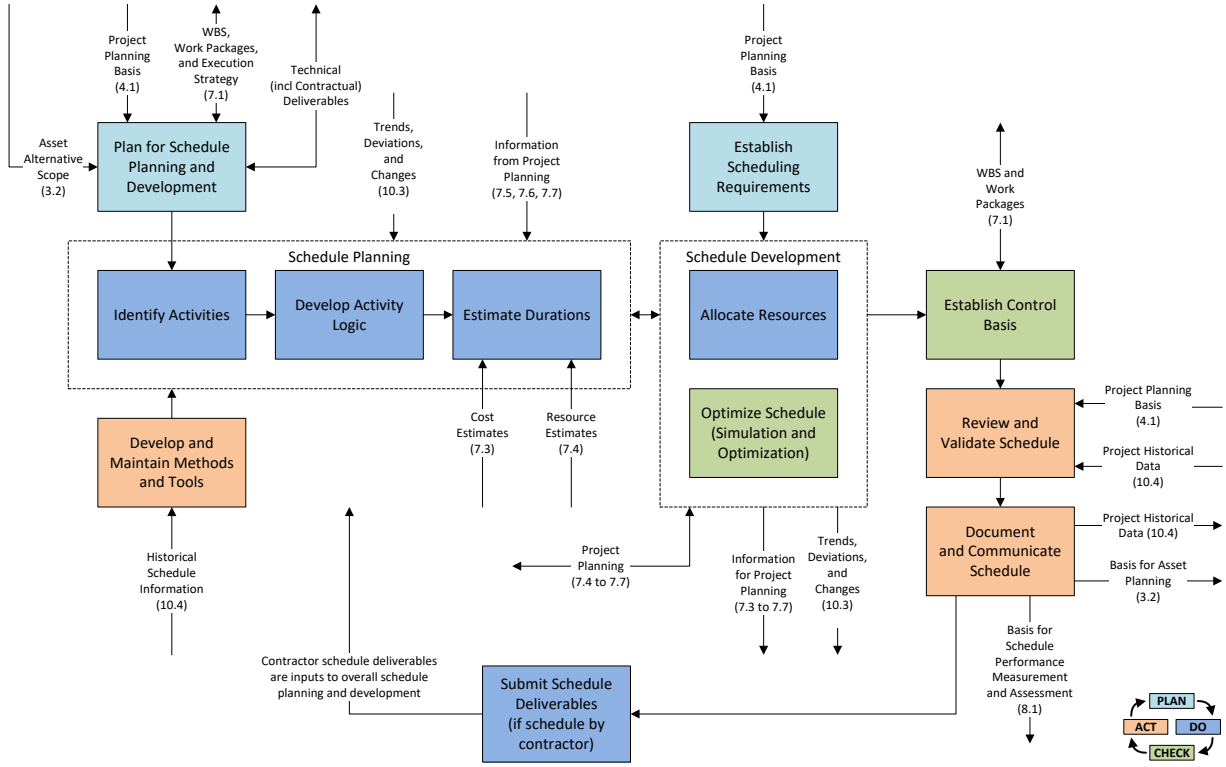

Figure 2. Process Map for Schedule Planning and Development [2]

The schedule planning and development process includes:

- Plan for schedule planning and development (Plan)
- Establishing scheduling requirements (Plan)
- Identifying activities (Do)
- Developing activity logic (Do)
- Estimating durations (Do)
- Allocating resources (Do)
- Submitting schedule deliverables (Do)
- Optimizing the schedule (Check)
- Establishing control basis (Check)
- Reviewing and validating the schedule (Act)
- Documenting and communicating the schedule (Act)
- Developing and maintaining schedule methods and tools (Act)

PLANNING AND SCHEDULING PHASES

Project Planning Phase

Planning, is defined in AACE RP 10S-90 and consists of:

1. Reviewing the scope of work, client requirements, division of responsibility, project objectives and constraints to develop the strategy for effective project delivery. A planning and scheduling practitioner should be able to read the applicable scoping documents (e.g., construction drawings) and understand the applicable sections of contract specifications.

2. Identifying major activities to be performed and the preferred sequence in which they are to be accomplished.
3. Developing an integrated plan to effectively execute the scope of work and meet project objectives.
4. Identifying the cost/schedule/resource aspects of the scope of work.
5. Coordinating the scope of work and planning assumptions with the project management.

Project planning begins early and continues as the project moves through the various phases of the project life cycle from project conception through to project completion, and closeout. Rather than a straight-through process, it is best thought of as a planning cycle.

Most project management professionals agree that there is a basic, five-step process involved in developing a project plan. Essential questions that are answered during the project planning phase include:

- **What?** The project's physical features and technical objectives.
- **How?** Work breakdown structure (WBS).
- **Who?** Resource commitments and organization breakdown structure (OBS).
- **When?** Timeline initially and then the schedule later in the planning process.
- **How Much?** Budget estimate.

Based on these questions, the recommended sequence of actions to develop the project plan are as follows:

1. Define the project scope.
2. Establish the work breakdown structure (WBS).
3. Identify resources and availability (people and capital assets).
4. Establish the timeline and sequence of deliverables.
5. Identify and evaluate constraints related to work hours or contiguous operations.
6. Determine the budget for each component activity, work package, or group of tasks.
7. Identify and evaluate risks.

The final output of the planning process is an optimized project execution plan for the selected alternative that best meets project objectives and goals.

Scheduling Phases

Scheduling is defined in AACE RP 10S-90 and consists of two distinct phases, development followed by maintenance and control.

Schedule Development

The purpose of schedule development is to implement the project schedule by converting the project plan into a logical arrangement and sequence of activities. During the schedule development phase, the planning and scheduling practitioner will interface with, and obtain input from, project personnel for the development of a project schedule that reflects the defined scope of work. The major output/deliverable from the schedule development phase is the project baseline schedule as documented in the schedule basis document. After schedule development is complete, including quality review and stakeholder acceptance of the baseline schedule, then scheduling transitions to the next phase of schedule management and control.

The schedule development phase is outlined as follows:

1. **Initiate a schedule development process that establishes:**
    a. Schedule development process and procedures.

b. Modeling methodologies.
c. Approval and distribution requirements.
d. Process for obtaining project team schedule review and approval.
e. Process for obtaining client approval.

2. Obtain input/data for schedule development from:
a. Stakeholders.
b. Contract schedule specifications.
c. Client requirements.
d. Other requirements.
e. Cost estimate.
f. Output from project planning including:
i. Project scope of work.
ii. Project execution approach/methodology.
iii. Work breakdown structure (WBS).
iv. Project milestones and key events.
v. Activity definitions.
vi. Activity durations.
vii. Logical relationships and sequences.

3. Develop detailed project schedule that meets the client requirements and includes:
a. Entire project scope of work.
b. Schedule hierarchy.
c. Division of responsibility.
d. Optionally, resources and/or costs may be included in the schedule activities. Assigning costs, labor, and equipment to each activity contributes to the determination of progress and resource requirements to meet the project completion date.

4. Review developed schedule including:
a. Quality analysis.
b. Constructability analysis.
c. Compliance with client requirements.
d. Contingency determination and allocation.

5. Schedule development output/deliverables:
a. Baseline schedule.
b. Cash flow.
c. Resource histograms.
d. Documented basis of schedule.

Schedule Maintenance and Control

The purpose of the scheduling maintenance and control phase is to monitor the execution of the project baseline schedule. During schedule maintenance and control, a planning and scheduling practitioner must be able to not only accurately document past progress and model the projected schedule, but also to analyze the current schedule status and provide accurate reporting to the project management team and client. Reporting may include of the following:

- Recording accurate actual progress.
- Assessing actual progress versus planned progress to determine trends and variances.
- Analysis of critical path and near critical activities.

- Schedule change management including recording and assessing the effects of project schedule changes.
- Analysis of schedule trends, risk assessment, and development of options for preventative and corrective actions.
- Forecasts and recovery plan.
- Progress reporting.
- Revising the project plan and project schedule as required.

The schedule maintenance and control phase is outlined as follows:

1. **Implement schedule management and control procedures**
    a. Ensure project scheduling controls are appropriately implemented and maintained as defined in schedule development phase.

2. **Maintaining the schedule by:**
    a. Tracking progress by updating the project schedule on a regular basis to assess actual performance against the plan.
    b. Assessing impacts on the critical path and near-critical activities and report critical work activities to the project manager. A critical work activity is defined in several ways by AACE Recommended Practice No. 10S-90, *Cost Engineering Terminology*.
    c. Monitoring schedule deviations and variances and assist in developing alternative methods for preventative and corrective action.
    d. Performing value analysis upon recommended alternatives to determine cost/benefit tradeoff, and present recommendations to project management.
    e. Revising the schedule as directed by project management and ensure that schedule changes are communicated to all project team members.

3. **Schedule coordination and communication**
    a. Present and answer questions on project plans and schedules at project meetings.
    b. Perform analysis to evaluate alternative plans, work-around courses of action, or otherwise amend, plan, schedule and forecast as directed by project management.
    c. Work in concert with project cost engineers, quantity surveyors, estimators, and material control personnel, to ensure cost and schedule integration.

4. **Schedule change management**
    a. Revise the schedule when an approved change order mandates a change in scope or duration.
    b. Keep time-phased copies of the schedule for historical records as the project progresses.
    c. Provide schedule-related recommendations to the project management team on strategies to recover from project delays or to leverage project improvements and opportunities.
    d. Develop and update the contingency drawdown, reflecting the approved usage of schedule contingency.

5. **Schedule reports and deliverables**
    a. Perform schedule analysis and provide periodic reports of schedule content to the project management team.
    b. Issue status updates and approved revisions of the schedule that reflect work progress and time elapsed.

6. **Project and schedule closeout**
    a. Upon completion of the project, verify that the as-built schedule reflects accurate completion dates for each schedule activity.
    b. Disposition/status all schedule activities to completion.
    c. Provide final schedule report and as-built schedule.

COMPETENCY MODEL

Figure 3 3 illustrates the hierarchal structure of the required skills and knowledge of planning and scheduling. The first level of the structure differentiates between general supporting knowledge used in more than one practice or process, and specific practice knowledge used in specific functions or process steps. Succeeding levels further break down the content to whatever level is appropriate for each competency area. The location of a skill or knowledge competency in the level of the outline does not reflect on its relative importance.

The structure is organized in accordance with the plan, do, check, and act (PDCA) process model that serves as the basis for the *TCM Framework* through which all the skills and knowledge of cost engineering are applied. TCM is not structured by a practitioner's work function. For example, planners and schedulers will not find all required skills and knowledge under one heading. The required competencies of a planning and scheduling practitioner will include elements of planning, measuring, and assessing that are appropriate to the planning and scheduling functions.

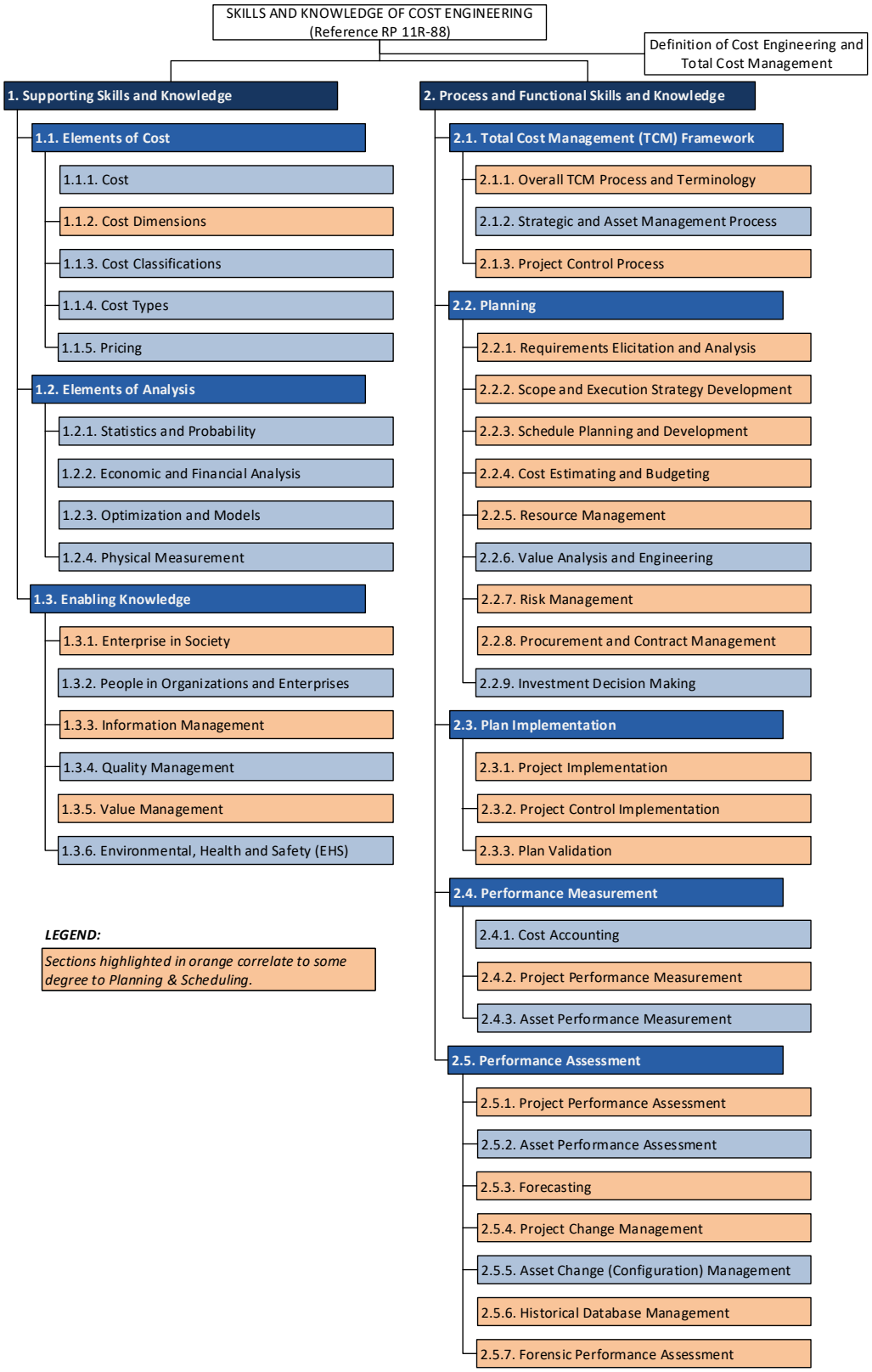

Figure 3. Competency Model relating Planning and Scheduling to Cost Engineering

PLANNING AND SCHEDULING SCOPE OF KNOWLEDGE

The planning and scheduling practitioner should be able to describe, discuss, and/or perform the tasks listed in the following elements of this scope of knowledge. The numbering and structure in this section is based on RP 11R-88 [1]. Not all sections of RP 11R-88 are pertinent to planning and scheduling; thus several are omitted, and the numbering within this section may not be sequential. Sections of RP 11R-88 pertinent to planning and scheduling are further detailed in this section and are also highlighted in orange in Figure 3 above.

1. Supporting Skills and Knowledge

1.1 Elements of Cost

1.1.2 Cost Dimensions

1.1.2.6 Legal

- Be able to explain how cost and schedule analysis practices might differ when applied for forensic purposes versus traditional planning and control purposes.
- **Time impact analysis**: describe the concept related to schedule change.

1.3 Enabling Knowledge

1.3.1 Enterprise in Society

1.3.1.1 Societal Values

- Be able to generally describe societal concerns and needs that should be considered in asset and project planning.

1.3.3 Information Management

1.3.3.2 Databases and database management

- Describe the importance of historical, empirical data and databases to future planning and schedule development.

1.3.5 Value Management

1.3.5.2 Purpose and approach

Value Improvement Practices

- Be able to describe constructability (10S-90) and implement constructability analysis. This value improvement practice includes:
  - ♦ Optimizing the design in consideration of the effective performance of construction activities.
  - ♦ Analyzing alternate materials, unique construction sequencing (i.e., activity logic), and construction technologies.
- Be able to describe manufacturability and implement manufacturability analysis. This value improvement practice includes:
  - ♦ Optimizing product and production system design in consideration of the effective performance of manufacturing and related activities.
  - ♦ Analyzing alternate materials, manufacturing technologies, and standardization (e.g., use common parts for different products).

2. Process and Functional Skills and Knowledge

2.1 Total Cost Management (TCM) Process [2]

2.1.1 Overall TCM Process and Terminology

- Basic Terminology – Be able to explain the following:
  - ♦ Plan-do-check-act (PDCA).
  - ♦ Project.
  - ♦ Portfolios and programs.
  - ♦ Strategic asset.

2.1.3 Project Control Process

2.1.3.1 Basic Purpose of Steps

- Given a representation of the project control process map (or some portion of it); be able to describe the basic purpose of each step and how it relates to the other steps in the map.

2.1.3.2 Earned Value Management Process

- Be able to describe the earned value management process as a specific way of applying the project control process (i.e., in what ways is it specialized).

2.2 Planning

2.2.1 Requirements Elicitation and Analysis

- Inputs to planning:
  - ♦ Describe the characteristics of good requirements for use in project or asset planning.
  - ♦ Explain how requirements for an asset or product might differ from those for a project.
  - ♦ Explain how the cost estimate contributes to the planning and development of the schedule model.

2.2.1.1 Stakeholders/Customers

- Describe how to identify stakeholders and be able to discuss the challenges of eliciting the information regarding needs, wants, or expectations from the various stakeholders.

2.2.1.2 Needs, Wants or Expectations of Stakeholders

- Describe challenges of eliciting this information from various stakeholders.

2.2.1.3 Requirements

- Describe the characteristics of a good requirement for use in asset or project controls planning.

2.2.2 Scope and Execution Strategy Development

2.2.2.1 Asset Scope

- Develop a complete scope description that includes the physical, functional and quality characteristics or design basis of the selected asset investment (functional decomposition).

2.2.2.2 Project Scope

- Develop a complete scope description that includes the work to deliver the project (i.e., project scope – work decomposition).

2.2.2.3 Work Breakdown Structure (WBS)

- Diagram a work breakdown structure (WBS) for a basic scope provided in narrative form to an appropriate level of deliverables.

2.2.2.4 Organizational Breakdown Structure (OBS)

- Diagram an organizational breakdown structure (OBS) for a basic scope provided in narrative form.

2.2.2.5 Work Package

- Be able to Identify/define work packages at an appropriate level of detail.

2.2.2.6 Deliverables

- Be able to identify/define deliverables.

2.2.2.7 Execution Strategy

- Be able to develop a complete execution strategy that includes project goals.

2.2.3 Schedule Planning and Development

2.2.3.1 Schedule Planning

Be able to describe the following planning considerations:

General Terminology

- Stakeholders:
  - Owner/user/operator.
  - Designers/architects/engineers.
  - Contractors/subcontractors/direct hire.
  - Suppliers/vendors.
  - Public agencies.
  - Public groups.
- Resources:
  - People.
  - Equipment.
  - Technology.
  - Capital.
- Project variables:
  - Physical environment.
  - Project delivery methods.
  - Contracting methods.
  - Funding.
  - Labor agreements.

- Constructability assessment.

- Value engineering analysis:
  - Optimize cost.
  - Optimize schedule.
  - Optimize quality.
  - Improve project functions.

Be able to describe the following planning processes:

2.2.3.1.1 Activities

- Be able to define activities and work packages.

2.2.3.1.2 Activity Logic and Logic Diagrams

- Given a series of logic statements, draw a logic diagram.
- Given a soft-logic work package with no strict activity interrelationships, describe ways to schedule this work.
- Be able to determine logical sequences of work packages and activities
  - Describe the various PDM logical relationships and their effective use: (e.g., FS, FF, SF, SS).
  - **Leads and lags**: Discuss any proper use of leads and lags.
  - Describe the difference between hard logic and soft logic.
  - **Preferential logic**: Describe and define.

2.2.3.1.3 Activity Durations

- Describe a process for developing realistic activity durations.
- Understand, identify, and adjust for biases when collecting activity durations from expert judgment and historical data.

2.2.3.1.4 Critical Path

- Describe the critical path (longest path) for the schedule as defined by RP 10S-90.

2.2.3.1.5 Float

- Explain and differentiate between total and free float for the schedule activities.

2.2.3.1.6 Schedule Models

- Precedence diagram method (PDM):
  - Describe the use of this method and be able to model at least one of each relationship type (finish-start, finish-finish, start-finish, and start-start) with lags and identify critical path(s).
  - Using the PDM and given a logic diagram and durations for activities, be able to calculate the early start and finish, late start and finish, and the total and free float times for all activities. Identify the minimum project completion time.

- Bar chart/Gantt chart:
  - Describe the uses of this method and explain the difference between this and a logic diagram.
  - Given network activity durations, early and late start and finish dates, and total float, be able to draw a bar chart based on the early start dates of all activities, and show the total float of activities where applicable.

- Arrow diagram method (ADM): Describe the use of this method and be able to identify critical points.
- PERT chart: Describe the program evaluation and review technique (PERT) method and use.
- Line of balance (LOB): Describe this method and uses.
- Linear scheduling: Describe this method and uses.
- Critical chain: Describe this method and uses.
- Critical path method (CPM) schedule:
    - ♦ Calculate the early and late start and finish times and identify total float.
    - ♦ Given either an ADM or PDM network with activity durations, early and late start and finish times, and total float, analyze and correctly answer questions based on activity and schedule calculations showing early/late start or finish times of all activities, and total float of these activities.

2.2.3.1.7 Historical Data

- Be able to describe the use of historical data in planning.

2.2.3.1.8 Other Concepts

- Explain the process for determining the project phases within the scope of work. As the scope of work is refined, the identification or breakdown of the project scope into various phases may likewise be expanded to fit the project.

2.2.3.1.9 The Transition from Schedule Planning to Schedule Development

- Be able to describe the transition between project planning and schedule development.
- Describe how the project plan is "handed off" and the project schedule is developed during the schedule development phase.
- Demonstrate understanding of the connection between project planning and schedule development: the project planning output provides input/data for schedule development.

2.2.3.2 Schedule Development

2.2.3.2.1 Milestones

- Be able to define milestones and key events.

2.2.3.2.2 Resource Loading

- Be able to allocate resources to activities in a schedule.
- Describe the mechanics of allocating resources:
    - ♦ Labor and equipment loading.
    - ♦ Cost or value loading.
- Explain the concept of cost or value loaded schedules with regard to contracts and schedule control for contracted work.

2.2.3.2.3 Resource Leveling

- Discuss ways to assess resource availability and potential consequences of not making that assessment.
- Discuss resource limits and constraints that may occur or be imposed.
- Describe the process of resource leveling or balancing.

- Be able to explain the differences between forward and backward allocation methods.
- Be able to explain the difference between the terms smoothing and maximum limits.
- Be able to explain the difference between the terms maximum and over-maximum allocation.

- Given a simple PDM network with resource inputs, be able to resource level the network within early and late start limits and draw a histogram of worker-loading for early start, late start, and resource leveled configuration.

2.2.3.2.4 Critical Path

- Be able to identify the critical path (longest path) of the schedule.
- Determine the constraints and potential impacts to critical path, and near critical path work activities.
- Assess the impact to critical path and near-critical activities.
- Report critical work activities to the project manager.

2.2.3.2.5 Other Concepts

- Be able to describe the concept of development by schedule class and level.
- Be able to describe the concept of rolling wave development.
- Describe the role of stakeholder review/feedback in schedule development.
- Be able to describe the following key outputs of schedule development:
  - Baseline schedule.
  - Resource loading curves/work crew and staffing requirements.
  - Expected cash flows based on baseline schedule and control estimate.
  - Stakeholder (internal and external) review and feedback.
- Understand the work breakdown structure (WBS), organization breakdown structure (OBS), and cost breakdown structure (CBS), and their relation to scheduling:
  - Understand WBS and the dependencies among work tasks to enhance team efficiencies.
  - Understand OBS and the dependencies among parts of the organization to enhance team efficiencies.
  - Understand CBS and its relationship to the WBS and OBS.
  - Understand and document schedule change using WBS and OBS concepts.
- Discuss the use of a Monte Carlo simulation model to assess probable project outcomes.

2.2.3.3 Schedule Control Basis

2.2.3.3.1 Schedule Controls Baseline

- Be able to describe the concept of short interval scheduling (SIS) in relation to an overall project schedule control baseline.

2.2.3.3.2 Planned Schedule

- **Project Level Calendars**:
  - Discuss the importance of setting up project specific calendars.
  - Be able to provide examples where the use of multiple project calendars may be necessary.
- **Activity coding**: Describe the use of coding for sorting/selection of activities.
- **Constraints**:
  - Discuss real and mechanical constraints that may be imposed on a schedule.

- ♦ Be able to describe the effects constraints may have on the calculations of early start and finish, late start and finish and total float in a schedule.

2.2.3.3.3 Schedule Basis

- Describe the typical content of schedule basis documentation.

2.2.3.4 Other Concepts

2.2.3.4.1 Programs and Portfolios

- Explain how schedule development might be handled for groups of projects.

2.2.3.4.2 Operations/Production

- Explain how production scheduling differs from project scheduling.

2.2.3.4.3 Schedule Strategy

- Describe the characteristics and risks of a fast-track schedule.
- Describe alternate schedule strategies in response to potential changes and claims that a contractor may apply in developing a network schedule (acceleration, crashing, crunching, etc.).
- Be able to describe the characteristics and risks of just-in-time (JIT) scheduling.

2.2.3.4.5 Schedule Change Management

- For project control, schedule change management refers to the process of managing any change to the scope of work and/or any deviation, performance trend or change to an approved or baseline project control plan.
- Definition: For asset management, schedule change management refers to the process of managing any change to documented information defining the scope of an asset or the basis of measuring and assessing its performance over its life cycle. Change management helps ensure that requirements always address customer needs.

2.2.3.4.8 Schedule Contingency

- Define schedule contingency and what should be included.
- Describe ways schedule contingency can be estimated/established in coordinate with cost control (estimating/budgeting) team members.
- Discuss the relationship between schedule contingency and recovery plans.
- Be able to describe several typical ways that schedule contingency can be assessed.

2.2.4 Cost Estimating Skills and Knowledge

2.2.4.1 General Concepts

- Code of accounts: Describe the characteristics of a good code of account structure and its benefits for both project scheduling and cost control.
- Provide an understanding of how the cost breakdown structure (CBS) for a project is developed during the planning process. The planner-scheduler must understand how the CBS is used for cost accounting and forecasting by management and the field during construction.

2.2.4.2 Processes and Practices

- Understand how aspects of the planning process affect the cost estimate:
    - ♦ Constraints and resource considerations apply during the planning process.
    - ♦ Impacts associated with resource constraints and considerations that influence the timeline and budgeting process.
    - ♦ Concepts of creating budget projections for the major elements to obtain an overall budget for the project.
    - ♦ Contract documents may dictate how and when the cost estimate is developed.
    - ♦ A WBS and OBS are integrated into the cost estimate, and how this integration may form the basis for the schedule model.
    - ♦ Alternatives for resource options are developed and evaluated based on timeline and the projected budget considerations as they evolve during the planning process. This includes value engineering and constructability determinations as well as change or revision to the project.
    - ♦ Schedule risk should be evaluated when the scope of work, project plan, and phase definition develop into the initial cost estimate and schedule models.

2.2.4.3 Cash Flow and Forecasting

- Be able to develop schedule-based cash flow.
- Discuss the effects on planning when cash flow is restricted.
- Discuss the importance of integrating estimating and scheduling practices.

2.2.5 Resource Management

- Describe how the resource management process is tied closely to cost estimating (e.g., quantification) and schedule development (e.g., resource allocation).

2.2.7 Risk Management

2.2.7.1 General concepts

- Risk and uncertainty: Define risk in terms of risk opportunities.
- Risk factors (or drivers) and risk factor properties.
- Deterministic versus probabilistic schedule durations.

Risk management plans:

- Describe how the risk management plan may be used to mitigate risk and ensure recovery throughout the project life cycle.
- Describe the schedule risk assessment process and evaluation of plan feasibility.
- Understand that both risk and changes require recovery plans.

Recovery plans:

- Be able to describe key elements to a recovery plan:
    - ♦ Potential solutions to impacts caused by risk or change.
    - ♦ Understand that change may have either a positive or negative impact on the current plan.

Schedule contingency management:

- Describe the appropriate level of authority for managing schedule contingency.
- Describe typical criteria for its allocation and use of schedule contingency.

2.2.7.2 Practices

- Be able to describe the purpose and mechanics of these risk management process steps:
  - Risk assessment.
  - Risk analysis,
  - Risk factor screening.
  - Schedule risk assessment, (e.g., Monte Carlo).
  - Risk mitigation or acceptance.
  - Risk control.

2.2.8 Procurement and Contract Management

- Contract documents: Explain the importance of the contract in regard to the schedule.

2.2.8.1 Contract Types

- Describe different contract types, advantages and disadvantages of each from the owner and contractor viewpoints including but not limited to:
  - Fixed price.
  - Unit price.
  - Cost-plus (with fixed, incentive, or award fees) .
  - Time and materials (T&M).
  - Guaranteed maximum price.
  - Public-private partnership.
- Describe different project delivery methods:
  - Design-bid-build.
  - Design-build.
  - EPC (engineer-procure-construct)
  - Design-build-operate.
  - Integrated project delivery.
  - Variations of the above.

2.2.8.2 Risk Allocation

- Explain how each contract type allocates risks between the contracting parties.

2.2.8.4 Integrated Project Controls

- Project control baseline:
  - Describe how to integrate the cost and schedule control baselines - establishing effective project control interface (e.g., how to measure progress, integrate schedules, etc.) for each type of contract.

2.2.8.6 Other Concepts

- **Supply chain**: Explain this concept and how it might affect procurement planning.
- Other contracting and procurement concepts:
  - **Schedule of values**: Explain this concept in regard to contracts and schedule control for contracted work.
  - **Cost or value loaded schedules**: Explain this concept in regard to contracts and schedule control for contracted work.

- **Front-end loading (FEL)**: Describe this concept and its benefits in terms of risk management and project control planning.

2.3. Plan Implementation

- Describe the content of the project execution plan also known as: project implementation plan, construction execution plan, task order plan, etc.

2.3.1 Project Implementation

2.3.1.1 Phases and Gates Process

- Describe the typical stages in respect to project planning and funding authorization and the benefits of an established process.

2.3.1.2 Project Implementation Basis or Scope Statement

- Describe the typical information in this deliverable at project initiation and the importance of business and project team agreement and communicating this information to all stakeholders.

2.3.2 Project Control Plan Implementation

2.3.2.1 Control Accounts

- Describe this concept and its content in relation to WBS and earned value application.

2.3.2.2 Project Control Plan and Basis

- Describe the typical information in this deliverable at the start of project execution and the importance of integrating, agreeing on and communicating this information to the project team.

2.3.3. Validation

- Be able to describe and perform schedule quality analysis including:
  - Verify compliance to schedule specification(s).
  - Verify schedule integrity including but not limited to review of open-ended logic, relationships, constructability (means and methods).
  - Describe how the quality and completeness of plans can be assessed before implementation and why the process is important.
  - Explain the value of historical, empirical information.
  - Explain the value of documenting schedule assumptions.
- **Schedule hierarchy**: Describe the levels of schedule detail and their intended uses.

2.4 Performance Measurement

2.4.2 Project Performance Measurement

2.4.2.1 General Concepts

- **Earned Value**: be able to explain the general concept and the importance of and reliable control basis and objective, quantitative physical progress measures.

2.4.2.2 Practices

2.4.2.2.1 Physical progress:

- Explain the general concept for the following methods and, given input information, be able to calculate the following:
    - Units completed.
    - Incremental milestones.
    - Weighted or equivalent units completed.
    - Resource expenditure and/or resources required.
    - Remaining duration.
    - Percentage completed.
    - Judgment.
- Describe how progress is observed, tracked, and used for forecasting in schedule updates.
- Describe how the means, methods, and techniques used to report progress are essential elements to the updating process.
- Describe the process of identifying update input, logic changes, reporting periods, and actual dates for beginning and completing activities.
- Describe how accurate progressing of a schedule forms a basis for competent and accurate forecasting.
- Explain the importance of incorporating the contract requirements for resource, cost and payment loading into the updated schedule model.
- Explain the importance of ensuring change management and historical documentation is accurate to support as-built schedule data.
    - As-built data would include logic changes, actual start and completion information, interruptions and finishes of work activities, along with resource utilization data.
- The scheduler should be aware of how the different scheduling software functions when progress is updated and the software performs their unique schedule calculations.

2.4.2.2.2 Track Resources

- **Labor hours**: be able to explain the advantages and disadvantages of tracking labor hours instead of cost as the basis for earned value
- **Material management and fabrication**: be able to discuss how material progress/status can be measured.
- Understand cost and resource management requirements during the updating and maintenance of the schedule. Cost and resource management includes the collection of actual data, monitoring and analysis through cost, resource leveling, and earned value techniques.
- Understand the how the different scheduling software programs perform cost and resource calculations and leveling.

2.4.2.2.3 Measure Performance (how work is being done)

- Be able to discuss why earned value measures alone have limited value in finding ways to improve performance.
- Be able to discuss the mechanics of the following methods, how they can help find ways to improve performance, and their strengths and weaknesses:
    - Work sampling.
    - Time and motion studies.
    - Time lapse photography and video monitoring.
    - Expediting.
    - Inspection.

- Be able to describe schedule performance procedures and processes.

2.4.2.2.4 Status Schedule

- Schedule progress and status procedures:
  - **Status schedule**: Discuss the various methods and mechanics of statusing and updating a schedule.

2.5 Performance Assessment

2.5.1 Project Performance Assessment

2.5.1.1 General Concepts

- **Schedule performance assessment**: Explain these general concepts:
  - **Schedule variance**: Describe this concept as an empirical difference between actual and planned performance for any aspect of the control plan.
  - **Schedule trends**: Describe the difference between random and non-random variance and how this might influence subsequent control actions and forecasts.

2.5.1.2 Practices for Control Assessment

- Describe practices and methods for assessing and reporting performance (variances and trends) against the following baseline plans:

2.5.1.2.1 Cost

- Be able to describe basic earned value methods.
- Be able to describe and prepare tabular and cumulative distribution charts ("S-curves") for reporting.

2.5.1.2.2 Schedule

- Describe methods to identify variance (e.g., calculate slip, earned value methods, etc.), assess critical path and remaining float.
- Describe performance reporting methods (e.g., schedule plot showing the planned and actual schedule activity status), tables showing a percentage or factor that expresses the extent that the schedule is ahead or behind at given points in time, lists of activities sorted by early start date or total float, etc.).

2.5.1.2.3 Resources

- **Resources/earned value**: Explain the general concept and the importance of a reliable control basis and objective, quantitative physical progress measures.
  - **Labor**: Describe basic earned value methods.
  - **Material and fabrication**: Describe the use of earned value, schedule assessment, material management reports, and so on.

2.5.1.2.5 Other Concepts

- Understand the need to seek and incorporate feedback from stakeholders during the maintenance of a schedule to depict actual conditions, impacts, and delays. This allows all stakeholders the opportunity to "buy in" to the modeled execution plan.
- Describe why the roles, goals, and objectives of each stakeholder should be considered as feedback is gathered.
  - Each stakeholder has an interest in the project and each item of feedback needs to be analyzed and incorporated, as appropriate. This feedback may expose failures in alignment of the

execution plan with stakeholder goals. Such failures to satisfy expectations must be resolved before the misalignments become contractual disputes.

2.5.1.3 Practices for Integrated Earned Value Assessment

- Be able to explain and calculate all the basic earned value measures and indices (planned and/or budget (was BCWS), earned (was BCWP), and actual (Was ACWP), SV, CV, SPI, CPI).

2.5.3 Forecasting

- Describe how the schedule control concepts are applied in the context of work in progress, performance assessment findings, change management, and corrective actions.

2.5.4 Project Change Management

2.5.4.1 Basic Terminology

- Changes: Explain the difference between scope and non-scope changes.
- Discuss the concept of changes and change management in respect to contract agreements.

2.5.4.2 Practices

2.5.4.2.1 Variance or Trend Analysis

- **Trend or variance analysis**: Describe how the schedule control concepts are applied in change management.

2.5.4.2.2 Impact Assessment

- **Time impact analysis**: Describe the concept related to schedule change.
- Understand how to analyze change events to drive development of alternatives.
- Understand the effects that schedule acceleration has on a project.
- Understand various schedule acceleration methods, including:
  - Changes in logic.
  - Changes in construction methods.
  - Duration changes.
  - Adding resources.
- Understand the potential risks of 'crashing' a schedule.

2.5.4.2.3 Make or Track Disposition

- **Corrective actions**: Describe what these are and why they might be needed.
- **Change control procedures**: Describe ways that change management findings and dispositions are recorded, reported, and incorporated in the project control plans.
- Understand schedule change management and the implications change has on a project schedule.
  - It is important that the project team analyze and understand the underlying causes that result in a changed condition. Recommendations for change management and the tracking change over the course of a project are critical techniques.
  - Understand how to integrate suspension, delay, and disruption encountered during the project into the schedule model.

2.5.4.2.4 Manage Contingency Reserves

- Describe methods for managing schedule contingency.
- Describe ways to assess the need for contingency for work in progress.

2.5.6 Historical Database Management

2.5.6.1 Empirical Data

- **Empirical data**: Data that are collected using direct or indirect observation.
- **Lessons learned**: Describe the importance of accurate data collection and the importance of evaluating the project schedule execution experiences for the benefit of future projects.

2.5.6.2 Project Closeout

- **Project closeout**: Describe the mechanics and challenges of closing out a project in respect to project control systems, data, and information.

2.5.7 Forensic Performance Assessment

2.5.7.2 Changes vs. Claims

- Understand that claims may arise from disputed changes.
- Describe the difference between changes and claims (for scope, compensation, relief, damages, delay, or other disagreements).
- Understand claims avoidance or mitigation techniques.

2.5.7.3 Reasons for Contract Changes

- Describe major reasons for contract changes including the role of project scope definition.

2.5.7.4 Types of Schedule Delay with Respect to Contract Changes

- Describe various types of schedule delay in respect to contract changes:
  - Excusable.
  - Non-excusable.
  - Compensable.
  - Non-compensable.

2.5.7.5 Effects of Disputes on Project Performance

- Describe the potential effects of disputes on project performance.

2.5.7.6 Elements of Cost in Context of Disputes and Claims

- Discuss and understand the elements of cost in context of contract schedule disputes and claims (bonds, retainage, performance guarantees, liquidated damages, demurrage, legal costs, etc.).

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