

The background of the cover is an abstract composition of 3D cubes in various shades of blue, green, and yellow. A single, transparent yellow cube in the center-right area is illuminated from within, casting a bright glow. A thin white diagonal line runs from the top left towards the bottom right, passing behind the main title.

# AACE<sup>®</sup> INTERNATIONAL CERTIFIED SCHEDULING TECHNICIAN<sup>™</sup> PRIMER ■ FIRST EDITION

The logo for AACE International, featuring the word "AACE" in a large, bold, blue sans-serif font. A small globe icon is integrated into the letter "A". Below "AACE", the word "INTERNATIONAL" is written in a smaller, blue, sans-serif font.

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# **AACE<sup>®</sup> International's Certified Scheduling Technician (CST) Primer**

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First Edition

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# **AACE<sup>®</sup> International's Certified Scheduling Technician (CST) Primer**

*First Edition*

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## **Introduction to the Certified Scheduling Technician (CST) Primer**

The **Certified Scheduling Technician (CST) Primer** has been prepared by the AACE International, Education Board to support personal study for those seeking apprentice certification in scheduling.

Thank you for choosing to use this on-line document. The AACE Education Board trusts that it meets your needs and expectations.

If you have any suggestions for material to be added to the Primer or corrections that need to be addressed, please e-mail your suggestions to: AACE International, Attention: Education Board Chair at: [edchair@aacei.org](mailto:edchair@aacei.org).

Much of the material presented in the **Certified Scheduling Technician (CST) Primer** is drawn directly from the **AACE International Planning and Scheduling Professional (PSP) Certification Study Guide** [First Edition]. In some cases the quoted material may be slightly altered, usually in verb tense, so that the material is in format with the overall intent being represented in this Primer. A second addition that occasionally occurs is the addition of new “bullet list items” to add appropriate material of interest. Where a major change appears it is noted by this indicated: [Changed from P&S-SG].

We recommend that you begin your use of the Primer by reviewing the section: *“Use of the Scheduling Primer and Access to Other Selected AACE International Materials.”*

Thank You





## **Use of the Certified Scheduling Technician (CST) Primer and Access to Other Selected AACE International Materials**

### **Use of the Certified Scheduling Technician (CST) Primer**

The **Certified Scheduling Technician (CST) Primer** has been prepared by the AACE International's Education Board to support personal study for those seeking Apprentice Certification in scheduling.

The Primer is a support tool for your use in preparing to take the certification examination for a Scheduling Technician.

The Primer provides:

- A brief introduction to some of the key considerations in scheduling that a scheduler commonly encounters.
- A compendium of important aspects for preparing a Critical Path Method [CPM] schedule for construction and industrial applications.
- A compendium of common terms that the scheduler should fully understand by the examination candidate.

There are also several things that the Primer is not intended to accomplish. It has not been developed to:

- Be a teaching tool for those not familiar with CPM scheduling and/or not having considerable experience in the processes of developing a schedule. And,
- It is not all inclusive, but a refresher overview intended to aid the examination candidate in developing the skills to be ready to sit for the certification examination.

At various places in the text, boxed material is presented. These boxes are guides to activities and actions that will support use of the **Certified Scheduling Technician (CST) Primer**. An active example of a box-information-format follows:

The AACE International Education Board welcomes suggestions for improving this edition of the **Certified Scheduling Technician (CST) Primer**.

Send your suggestions, by email, to: [edchair@aaacei.org](mailto:edchair@aaacei.org)

**Access to Other Selected AACE International Materials**

AACE International makes available to the general public a number of its publications at no cost. These include:

- **AACE International Recommended Practices:** This is a set of over 40 in-depth documents, representing detailed studies of various topics important to the profession of cost engineering. Those with particular interest to scheduling and schedule management have been cited in the Bibliography for this monograph.

**AACE International Recommended Practices**

Definition from the Association website

[Edited]

The **AACE International Recommended Practices** (RPs) are intended to be the main technical foundation of our educational, and certification products and services.

The RPs are a series of documents that contain valuable reference information that has been subject to a rigorous review process and recommended for use by the AACE International Technical Board.

AACE's RPs are frequently quoted and referred to in all facets of industry.

- **TCM Framework:** This document develops flow diagrams for many aspects of the cost engineering profession.

**The TCM Framework**

Definition from the Association website

[Edited]

Total Cost Management (TCM) is a systematic approach to managing cost throughout the life cycle of any enterprise, program, facility, project, product or service. The **TCM Framework: An Integrated Approach to Portfolio, Program and Project Management** is a structured, annotated process map that for the first time explains each practice area of the cost engineering field in the context of its relationship to the other practice areas including allied professions.

TCM is a continuing effort to promote best practices for cost and management professionals.

**To Register and Gain Immediate On-Line Access**

Go to the AACE International home-page at: [www.aacei.org](http://www.aacei.org).

Use the “Search” option and type in, “*Recommended Practices*.”

Log in using the “New Visitor Registration” form. This will give you immediate access to the **AACE International Recommended Practices** and **TCM Framework** for your use.

If you have any difficulties in accessing AACE International resources that are available on-line, contact the association staff: On-Line at: [www.aacei.org](http://www.aacei.org), by telephone at: 1-304-296-8444, or at: 1265 Suncrest Towne Centre Drive, Morgantown, West Virginia 26505-1876

**CST Certification Requirements and Process**

The prospective Certified Scheduling Technician (CST) should know all requirements for earning the credential. This will allow the most efficient use of time to improve one's knowledge, skills, and abilities.

For the most current information regarding the eligibility requirements and application and payment for this certification, visit the AACE website at [www.aacei.org](http://www.aacei.org) under the Certification section.

**Examination Format**

The exam is delivered through computer based testing (CBT) and consists of multiple choice questions. The examination is open book, allowing candidates to bring the **Certified Scheduling Technician (CST) Primer** to use during examination. Programmable or pre-programmed calculators (including those with financial functions) are also permitted.

For the latest information regarding the CST exam format or recommended resources, visit the AACE website at [www.aacei.org](http://www.aacei.org) under the Certification section.

## **Chapter I**

# **Scheduling Overview**

### **Introductory Information**

Much of the information in this chapter is expository. However, some of the material has direct citation. This information is sourced as follows: Chapter 2: “*Scheduling*” of **Planning and Scheduling Professional (PSP) Certification Study Guide**. The style of the annotation is: [P&S-SG: (plus - page number)].

### **Overview**

The material in this chapter provides overviews of important topics related to the skills that a scheduling technician needs to develop. Specific information about the broader aspects of the scheduling process and developing a schedule are presented in the following two chapters.

Each candidate seeking Certified Scheduling Technician (CST) certification will have different established educational and experience credentials. No two individuals can possibly have the same backgrounds in their work experiences. With this in mind, it is appropriate to point out that this primer provides an overview of important topic areas that every scheduler should have knowledge of prior to seeking certification. Some of the areas of interest presented will be fully familiar to you and others will be new areas of interest.

All the issues covered by this text are considered appropriate for examination questions for the certification examination. The body of questions from which your examination is built will change with each examination. Therefore, you should expect that not all the material in this primer will be covered on your particular examination.

The Certified Scheduling Technician (CST) examination also is based on the simpler forms of contract construction. That is, a bid and awarded contract based on issuance of plans and specifications with a fixed duration of time.

There are broad aspects of scheduling that are not covered in this primer as they are beyond the scope of the technician. However, you should be aware that they too, are important parts of the scheduling process and will become important later in your career. These aspects of scheduling will not be covered in the examination process, unless encountered on the most fundamental basis and then usually in conjunction with other concepts. They include:

- Contracts
- Constructability
- Resources
- Risk and Recovery Planning
- Cost/Resource Loading
- Cost and Resource Management
- Schedule Change Management

- Acceleration
- Variances and Trends
- Recovery Schedules, And,
- Alternate Types of Schedules (Linear, Critical Chain, Etc.).

### **Planning for the Scheduler**

Planning and scheduling is a concept in construction and process management that go together like “reading and writing” or “cake and ice cream.” They cannot be separated one from the other. However, the parts of planning associated with the work of a scheduling technician can be discussed as a unit of information.

Within construction and process management there are several types of planning. They include:

- Conceptual Planning;
- Planning in Design; and,
- Construction Planning.

Only construction planning, which is an element of your Certified Scheduling Technician (CST) examination, will be discussed in this primer.

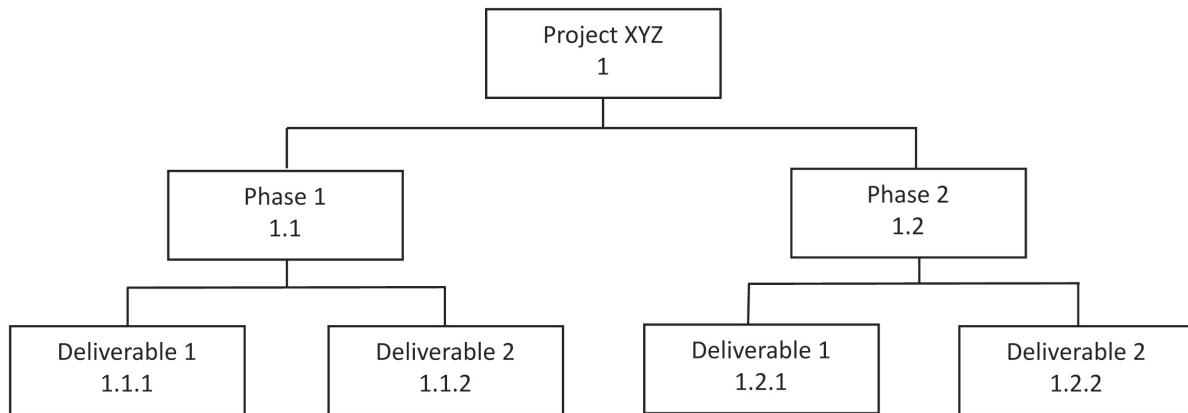
Construction Planning is that planning required to:

- Develop and document the Work Breakdown Structure [WBS].
- Establish the schedule specification for the project.
- Identify stakeholders.
- Define a list of deliverables.
- Define the work to be performed.
- Estimate work durations.
- Create the baseline schedule.
- Collect and report schedule progress. And,
- Present period and special purpose reports. [Changed from P&S-SG]

### **Work Breakdown Structure**

The Work Breakdown Structure [WBS] is a hierarchy division of the work scope elements of a project to be performed. The function of the WBS is to divide the scope of work into manageable parts that correspond to key deliverables, phases, or milestones with the intent to avoid the omission of key elements and assist in the communication of cost, schedule, quality, and resource performance data to stakeholders.

The WBS is product-oriented or process-oriented. Defining the WBS, like all tasks in the planning process may be dynamic, cyclical, and iterative. [P&S-SG: 88 and 89]



**Figure 1—Sample WBS Structure**

### Schedule Specification

The schedule specification states the planning and scheduling requirements and purposes; level of detail required; reporting periods and capabilities; minimum and mandatory scheduling tools; initial schedule development, submission, phasing and milestone; changes; claims and disputes; scheduler experience and qualification; and other requirements that the owner-client deems appropriate for the specific project. [P&S-SG: 146]

You, as a member of a scheduling team, may well be involved in some or all of the development of these criteria for a schedule and schedule implementation.

Specifically, the purpose of a scheduling specification is to identify minimum requirements for:

- Key milestones and overall contract duration.
- Required phasing and sequencing.
- Contractor's plan, means and methods.
- Cost and resource loading and reporting.
- Subcontractor and supplier integration.
- Plan and schedule basis documentation.
- Owner and client requirements, such as goals and objectives, ability to monitor the contractor, and control required when progress fails to meet contractual milestones and requirements.
- Schedule types and levels to be used and maintained.
- Reporting requirements: levels, frequencies, and formats. And,
- Scheduling software programs that are allowed, preferred, or required.

[P&S-SG: 148]

Material on creating a baseline schedule, collecting and accounting for progress, and reporting are discussed in Chapters III and IV.

This short overview has provided a brief summary of planning in construction with an emphasis on the detail that will be involved in competent planning, as a part of the scheduler's responsibilities.



### **Stakeholders**

Stakeholders are entities with an interest in the particular effort being undertaken. For a construction project, a stakeholder is any entity that has an issue with the project. In process management, a stakeholder is one who is concerned with the process being undertaken.

Stakeholders are composed of any interest group with an interest in the project. By this, they may be positive supporters of the project or have a deleterious issue to undertake. Any stakeholder's interest may be short-term or last the duration of the project. To provide a complete list of stakeholders would be difficult, however a list of types of stakeholders includes:

- Individuals.
- Small and/or large groups of individuals either associated or not.
- Social and/or political organizations.
- Federal, state, and or local government entities.
- Professional individuals and/or groups. This may include:
  - ✓ Architects, engineers, surveyors, planners, etc., either involved or not in the design and implementation of the project. And,
  - ✓ Outside professionals supporting the projects such as: those responsible for site analysis to include archeological or mineral evaluations, testing during all phases of the work, and outside overview, etc.
- The owner and/or association of owners whose interest may not always be mutually inclusive.
- Contractors and subcontractors.
- Suppliers. And,
- Tradesman and tradesmen's organizations, such as labor unions.

Looking more fully at who the different stakeholders are in the construction arena, they generally include two classes that are broken down into their respective areas of interest. The two classes are:

- External to the project; And,
- Internal to the interests of the project.

External stakeholders come to the project with an interest and/or objective that must be understood and addressed by the internal stakeholders.

Stakeholder interests change with the various stages of the project. Failure to consider an appropriate issue at its appropriate time in the development and implementation of the project will only cause problems. An overlooked issue may cause the time and effort, of a later discovery, to delay ongoing work. Attempting to hide a stakeholder's issue, without addressing it, bodes well for no one.

The project scheduler will be involved in addressing stakeholder issues. Many stakeholder issues may be long solved before the scheduler becomes active in project development, but certain elements of the schedule planning process may raise previously unaddressed and/or new issues. Evaluating plans in the process of developing schedules, or integrating materials and or costs, may show new and not previously considered issues that bring their interest representatives to the front. The schedule planning and development process is always a problem solving process, requiring the settlement of stakeholder concerns.

The second area where a project scheduler may find his or her skills at stakeholder amelioration is in the project update process. Every update is a compromise aimed at reflecting the best possible presentation of the “truth,” represented by what is shown in the field. Solving the problems that arise in accumulating data and presenting solutions is the scheduler’s primary responsibility. Doing so in a presentation that fully reflects the facts on-the-ground is not always easy, most assuredly when the news is not “good news” for all parties with a stake in the particular situation. Determining alternatives for a problem is often a responsibility of the scheduling team.

### **The Scheduler’s Interest in Time**

Time has two main interests for the scheduler: First is effective use of the scheduler’s own time, and secondly, is how the scheduler represents time in his or her products.

Time is the one resource than cannot be saved. The scheduler is always at the mercy of the calendar. This process involves not just the one time responsibilities of creating a baseline schedule, but also the routine processes of periodic updates. Not covered by these routine processes, but of importance, are the time required for special issues—such as addressing and solving changed conditions, latent or patent, and also determining and building acceptable alternatives to a myriad of field problems that occur on every project.

Key to the presentation of time in project scheduling is planning for its presentation. This includes effectively responding to time considerations and constraints laid out in the contract documents. Also of importance is the creation of consistent and universally recognized time formats and calendars in the development of schedules.

Such items as seasonal conditions, estimating weather, weekend and holiday interruptions to work are important considerations. Some projects use other considerations of time: locales in international countries and/or extended religious rituals or holidays may affect work. Transportation of labor to the work site over long distances may affect the time on-the-job site.

If these time considerations and/or constraints are not effectively considered in developing a schedule, the merits and validity of the schedule come into question. Fully understanding these considerations builds reliable and usable products to guide the construction effort.

### **The Scheduler’s Responsibility for Effective Project Documentation**

The owner and the contractor, much less the end users, rely on being able to turn to the construction documentation to preserve their stakeholder interests in the project. Effective project documentation makes this process easy, useful, and effective. The responsibility for much of the periodic documentation rests with the scheduling team and schedulers.

Effective project documentation is a learned, organizing skill. It takes effective, concise oral presentation skills, with an ability to “think on your feet,” to move forward in the construction industry. Advancement also requires a well defined and developed written communication ability. These skills form themselves not only orally and in writing, but also in the ability to quickly and artfully draw concepts which present an accurate communicative sketch to the skilled interpreter who can turn the idea into a finished product for design or schedule use, and a sketch that will show the novice a representation of an idea.

Project documentation also includes designing and using a system to complete various scheduling materials, such as: (product, submittals, correspondence, drawings, samples, test results, schedules, and all other forms of contract documentation), in such a manner as to be readily retrievable. Use of the project documentation is only valuable when, after each use, it can be quickly found and meaningfully used by the scheduler and others.

### **The Scheduler's Career Path**

The scheduler's career path begins with education and experience. Sitting for and passing an introductory certification examination and gaining certificate as a Certified Scheduling Technician (CST) demonstrates possession of fundamental skills.

Putting this fundamental knowledge to work increases and develops skills in the construction or process industries. The skills in communicating and schedule management, as an individual scheduler or a team member, open many doors and opportunities to advance in the industry of your choice. Once you pass the CST exam and after several years of professional on the job experience, taking the next step and gaining certification as a Planning and Scheduling Professional (PSP) can become an achievable goal.

Schedulers with continuing education can move up within their work environment or open their own enterprise. An understanding of the fundamentals of schedule development, schedule management, and scheduling skills should provide any practitioner with much career satisfaction.

The Certified Scheduling Technician (CST) certification lays the foundation for further advancement in your career. It also may lead you to seeking other certifications offered by AACE International. These include:

- Planning and Scheduling (PSP) certification; or,
- Certified Cost Professional (CCP)

## **Chapter II**

# **Scheduling Principals**

### **Introductory Information**

Elements for developing a schedule are presented in this chapter. This information is drawn from: *Chapter 2: “Scheduling”* of the **Planning and Scheduling Professional Certification Study Guide**. The style of the annotation is: [P&S-SG: (plus: page number)].

At the end of each segment in this discussion, the appropriate page annotation to the Study Guide or other source is provided.

### **Schedule Documentation**

#### **Schedule Basis Documentation/Baseline Documentation [General]**

The baseline schedule documentation is recorded from the assumptions, constraints, and operational parameters—as well as from the contract and supplementary documentation—that goes into development of the baseline schedule.

The baseline schedule documentation includes a short narrative that describes baseline schedule development, the critical path, and key characteristics of the schedule model. Each stakeholder’s input and assumptions are clearly identified.

The baseline schedule provides the documentation and foundation for schedule change or delay and impact identification and management. As such, it is important to create necessary documentation so that at a later date the schedule basis can be clearly understood by all. Any changes in the schedule that result in significant variance from the baseline schedule may be traced to this document and the proper schedule adjustment developed and incorporated.

When it is necessary to develop a revised baseline schedule, the revised schedule must include the supporting documentation to support the changes made to the schedule. The schedule basis is contemporaneously updated throughout the life of the project. [P&S-SG: 206]

#### **Schedule Maintenance/Controlling**

Schedules are maintained to report progress and to forecast trends, progress, and completion. Schedules are used to control successful execution.

A schedule models the plan using resources and execution strategy to meet project objectives. The schedule must accommodate and account for change as it occurs.

Periodic updates are undertaken to measure actual progress achieved. Information obtained in the updating process, along with trend analysis and forecast of future progress, is reported to stakeholders. Included within these progress updates is schedule maintenance to account for nominal changes to the execution plan.

When conditions and assumptions upon which the schedule was based significantly change, the schedule must be re-examined and updated, as necessary, to develop a new baseline for measuring further progress. Depending upon the nature of change necessitating a new baseline, the schedule model may undergo a complete rebaselining or just a significant revision.

As a project is executed, periodic progress reporting, change management, and schedule updating and forecasting—with reporting to stakeholder—becomes the ongoing work of the scheduler. The schedule is usually updated on a periodic, contractually stipulated timeframe and provides a basis for tracking progress, for use as a management tool, for recording and supporting actual performance, and for providing documentation for changes, delays and impacts. [P&S-SG: 210]

### **Baseline Schedule**

The baseline schedule derives from a schedule model to meet the project execution plan and achieve management approval for use as a baseline for project execution. It reflects the intended workplan of the contractor.

The baseline schedule is used to measure progress and identify trends and changes. Analysis of the updated schedule against the baseline will show the impact of any milestones or completion date variances.

The baseline schedule identifies the initial critical path and provides the basis for measuring progress and schedule deviation.

The baseline schedule will be the foundation for cash flow planning, resource managing, trending for cost and schedule forecasting, and reporting. [P&S-SG: 214, with modifications]

### **Tracking Schedule Progress**

The means, methods, and techniques used to report progress are essential elements to the updating process. The process of identifying update input, logic changes, reporting periods and actual dates for beginning and completing activities is critical to accurate schedule progressing. The scheduler must include such requirements into schedule analysis, forecasting, and reporting.

The scheduler is responsible for and should be aware of how and is responsible for the different scheduling software functions when progress is updated and the software programs perform their unique schedule calculations. [P&S-SG: 218]

### **Schedule Change Management**

Suspension, delay, and disruption encountered during the project are all elements of change and must be integrated into the schedule model. Such issues may result from scope change, a change in circumstances, or outside influences on work progress. Analyses of these events drive the development of alternatives.

Owners and outside stakeholders may cause either positive or negative change. Either have impact on the current or baseline schedule.

As appropriate, the “plan for change management” may need to be adapted to circumstances that develop during the implementation of the project.

When much change occurs on a project, reporting against the original or baseline [model] may become difficult and impractical, thus requiring a new baseline. It is important that policies and procedures are in place to accurately evaluate and implement progress. The schedule must be able to not only analyze and document the changed work, but also do the same for the impact of change on unchanged work. [P&S-SG: 228 & 229]

#### **Schedule Maintenance Feedback**

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. [P&A-SG: 240]

While it is the scheduler's responsibility to report on conditions, it is the responsibility of the project management team to negotiate and resolve them.

#### **Schedule Output And Deliverables**

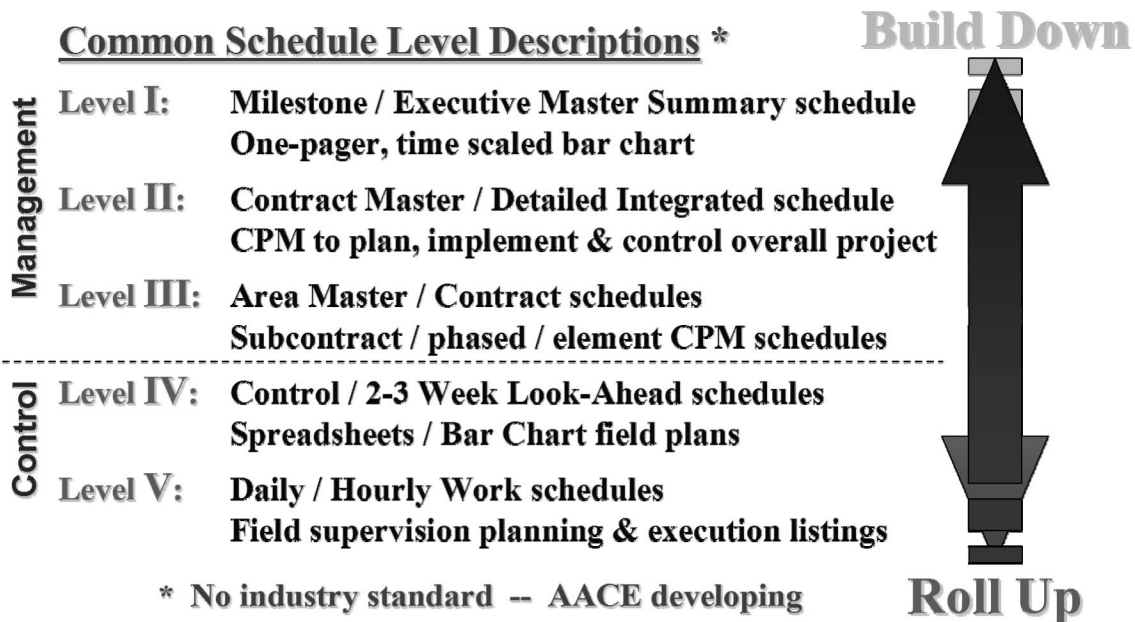
The schedule output and deliverables consist of:

- control level schedules;
- variances and trends;
- schedule analysis;
- schedule forecasts;
- constructability review;
- progress reports and reviews;
- recovery schedules; and
- management summary. [P&S-SG: 244]

#### **Control Level Schedules**

It is important to understand the various levels of summarization and their respective for managing the schedule and reporting to a variety of stakeholders. CPM analysis is required to ensure that the summary or other type schedule correctly reflects its intended purpose.

Different levels of schedule may be used at different phases or periods in the project depending on the scope and the requirements to report the schedule to the stakeholders.



**Figure 2—Schedule Levels of Detail/Filtering**

### **Variances and Trends**

As the schedule is updated and compared against a baseline schedule, schedule variances and trends are identified and analyzed. If the variance or trends fall within certain thresholds, they should be noted and observed for further variances. If the variances or trends fall outside accepted norms, corrective action or recovery plans and alternatives should be developed, communicated, concurred, and implemented.

Thresholds are levels or limitations that have been determined as guidelines for the project team to identify potential concerns or issues that require actions to keep the project on schedule.

Variances and trends provide the basis for revisions to the project control plan, corrective actions, alternatives and recommendations, or potential changes in scope. [P&S-SG: 252, with modifications]

### **Schedule Analysis**

For network activity schedule models, schedule analysis will identify float values for critical non-critical activities, determine implications of “what-if” scenarios, and monitor and control the schedule sensitivity to changed conditions.

The scheduler’s review and analysis needs to be careful and thorough, since the schedule may be difficult to assess or status. The scheduler must understand the manual calculation process of forward and backward passes and the process used by the computer scheduling program to support examination and analysis of critical points in the schedule.

To properly understand critical path analysis it is important to understand the mechanics of the software that is used to model and analyze the schedule.

A properly developed and understood critical path analysis is a valuable tool for the project team. The process assists the team in developing and publishing recovery or work-around alternatives to minimize the adverse impact of changes and delays. [P&S-SG: 256, with modifications]

#### **Schedule Forecasts**

Forecasts are vital planning information for project control, in order to develop corrective action alternatives and recommendations. Once the forecast is accepted by stakeholders, it becomes the basis for developing an updated baseline for monitoring and controlling projects. [P&S-SG: 266]

#### **Management Summary**

The goal of [management summary] reporting is to give brief, concise, and accurate overviews of status. Since management does not have the time to look through the detail, consistently presented summary information using key metrics is provided, so there are no surprises during the course of a project.

Summary information is valuable for management, since it assists them in making decisions about resources and risks, and it aids in the broader aspects of decision-making. [P&S-SG: 288]





## **Chapter III**

# **Elements of a Basic Schedule**

### **Introductory Information**

Elements for developing a schedule are presented in this chapter. This information is drawn from: Chapter 2: “Scheduling” of the **Planning and Scheduling Professional Certification Study Guide**. The style of the annotation is: [P&S-SG: (page number)].

At the end of each segment in this discussion the appropriate page annotation to the Study Guide or other source is provided.

Each section of the **Planning and Scheduling Professional Certification Study Guide** includes topical questions for self-study. These questions are specific to the Study Guide. They will give the candidate for certification an indication of the types of questions which might appear on the certification examination.

### **Principles Used in Developing a Schedule**

#### **Concepts**

Key considerations [of scheduling] are:

- Schedule results from the plan.
- Scheduling is both cyclical and iterative. And,
- Scheduling is dynamic.

Schedules are developed at various points in the planning process. Schedules are maintained to report progress, and forecast trends, work progress and completion.

The schedule models the plan and the cost estimate using resources and execution strategy to meet the project objectives. The schedule must accommodate and account for change as it occurs.

The key characteristics of a successful schedule include elasticity, sensitivity, completeness, robustness, and clarity for all stakeholders. [P&S-SG: 130]

#### **Schedule Development**

Once the project is defined and the contract awarded, a detailed schedule of the work is developed for the purpose of monitoring, controlling, and reporting the project time commitments.

Schedule development consists of two (2) main sections:

### **Input and Data**

- ✓ define schedule scope;
- ✓ work breakdown structure;
- ✓ schedule specification;
- ✓ feedback from stakeholders; and,
- ✓ cost estimate model.

### **Creating Schedule**

- ✓ types of schedule;
- ✓ activities;
- ✓ durations;
- ✓ relationships;
- ✓ constraints and calendars;
- ✓ cost and resource loading;
- ✓ schedule quality analysis, compliance review; and,
- ✓ schedule basis documentation. [P&S-SG: 132, with minor modifications]

Understanding the range of elements for the project is the first key requirement in the development of the schedule scope. The process requires explicit and detailed knowledge of the scope of work, scheduling tools' requirements and limitations, and the ability to communicate the plan into a workable schedule. [P&G-SG: 139]

### **Schedule Specification**

The purpose of a scheduling specification is to identify minimum requirements for:

- Key milestones and overall contract duration.
- Required phasing and sequencing.
- Contractor's plan, means and methods.
- Cost and resource loading and reporting.
- Subcontractor supplier integration.
- Plan and schedule basis documentation.
- Owner and client requirements, such as goals and objectives.
- Schedule types and levels to be used and maintained.
- Reporting requirements: levels, frequencies, and formats. And,
- Scheduling software programs that are allowed, preferred, or required.

[P&S-SG: 146] [NOTE: An overview has not been provided for all of these schedule specification requirements in this text. The listing is provided so that a coherent outline is presented.]

### **Feedback From Stakeholders**

Understanding the interests of the respective stakeholders, in developing the schedule, ensures that the schedule will be inclusive, encompassing, and responsive to the stakeholders and the intent of the work under contract.

There are two general classes of stakeholders. They are:

**External stakeholders**

- Owner.
- Local political and community interests.
- Permitting and code enforcing entities. And,
- Owner's users and customers.

**Internal stakeholders**

- Prime contractor and project management contractor.
- Principal subcontractors.
- Second tier of subcontractors.
- Suppliers.
- Installers. And,
- Startup, testing, and compliance support personnel. [P&S-SG: 162]

**Types of Schedules**

Types of schedules commonly used. Some of these types of schedules are no longer commonly used. However, this list represents styles of scheduling used over the history of the industry. The types include:

- Bar charts (sometimes referred to as Gantt charts).
- Critical Path Method (CPM).
  - ✓ Precedence diagram method (PDM).
- Program Evaluation and Review Technique (PERT).
- Linear schedule.
- Line-of-balance.
- Rolling wave.
- Milestone. And,
- List Critical Chain. [P&S-SG:163]

At key times in the life of a project, the type of schedule may change from one format to another. Types of schedules used during the life cycle of the project may include:

- milestone;
- phase;
- area;
- process system;
- task lists:
  - ✓ work activity;
  - ✓ punch list;
  - ✓ commissioning;

- ✓ inspection;
- ✓ submittals; and,
- ✓ request for information.
- Control level. [P&S-SG: 162]

### Data Elements and Supporting Information for Building a Basic Schedule

#### Activities

The scheduler must understand the definition of an activity as the plan or phase that is converted into a schedule model. The schedule models the scope of work to be performed and is made up of activities, which reflect items of direct work or indirect work support. Each activity is an individual element of work that becomes logically linked to other activities to form the schedule.

An activity has multiple components. Consider that an activity is the equivalent of a record in a database. Each record has multiple fields of data that define activity scope and characteristics for reporting and management of the work. The minimum components for an activity are:

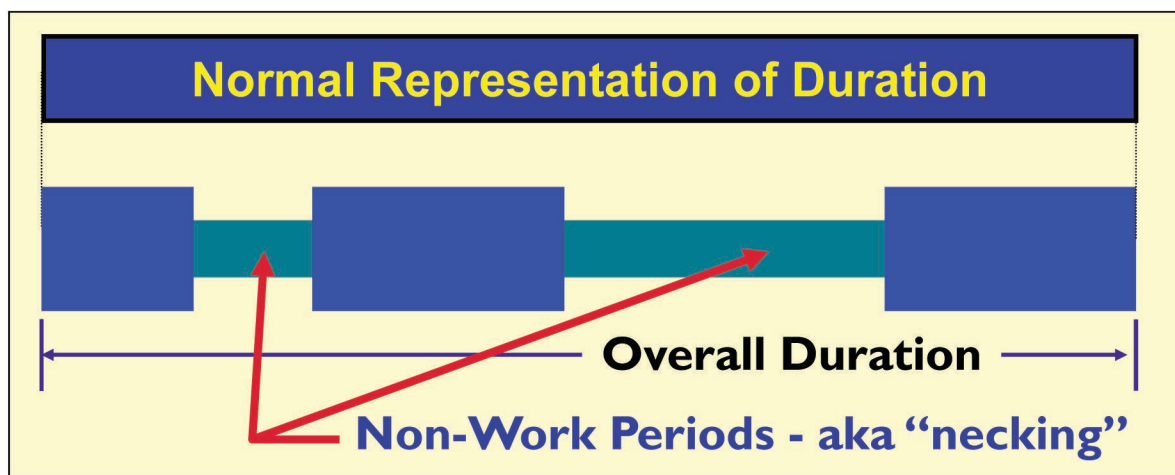
- A unique alphanumeric identifier.
- A unique descriptive name, optimally phased as verb-object. And,
- A workday duration.

Individual activities have relationships and may have other attributes, such as:

- Cost and resource loading. And,
- Constraints. [P&S-SG: 168]

#### Durations

Duration is the overall estimated working time in which an activity is planned to be completed. This time unit ignores planned breaks, holidays, or weekends. This becomes the “original duration” for an activity and is an assigned element of the activity. Duration often includes multiple work elements within the activity scope. [P&S-SG: 174]



**Figure 3—Understanding Activity Durations**

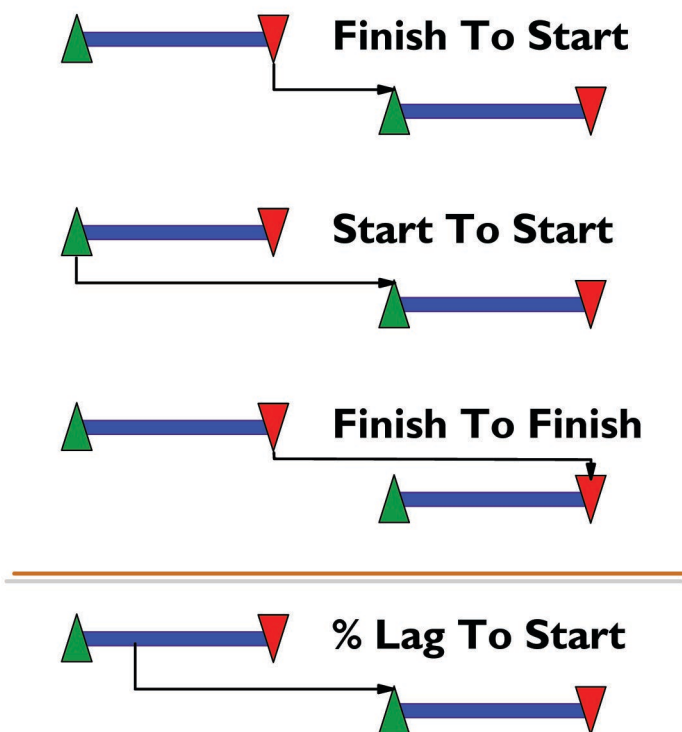
### **Relationships**

The scheduling process requires that activities be logically linked to form a network schedule model. The network model is a representation of the project teams' plan to accomplish the work in a mutually exclusive and interconnected manner so that the program/project is brought to a successful completion.

Ordinarily, each activity should have a predecessor and successor activity, with the exception of the first and last activities. The first activity will have one or more successor activities. The last activity will have one or more predecessor activities. Relationships provide a logical link or connection between two or more activities in a schedule. When a chain of activities of the longest duration are linked together, they define the critical path in the project schedule.

The project team [scheduler] should understand how various types of relationships affect the schedule model and the data that it reports. Nesting and grouping of activities is a functional part of scheduling and models how work is actually performed. [P&S-SG: 180, with minor adjustments]

How about a discussion of physical (hard) versus preferential (soft) logic?



**Figure 4—Logical Relationships**

### **Constraints and Calendars**

Constraints take many forms.

Constraints are any factors that affect the start, finish, or duration of an activity and the criticality of the project. Factors may include, but are not limited to, calendars, date restraints, and external [constraints] such as resources, weather, or that are physical in nature.

Constraints may have an impact on the calculation of the critical path and the scheduler should understand how various scheduling software packages calculate dates, float, and the critical [path], based on the constraints identified and input into the schedule.

Calendars are how critical path method (CPM) turns an activity's duration into assigned dates, and thus determines overall duration. Calendars are sequences of actual time developed for functional purposes. Calendars may vary depending on the purpose for which the calendar is assigned. There may be multiple calendars contained within a project schedule model. Examples include:

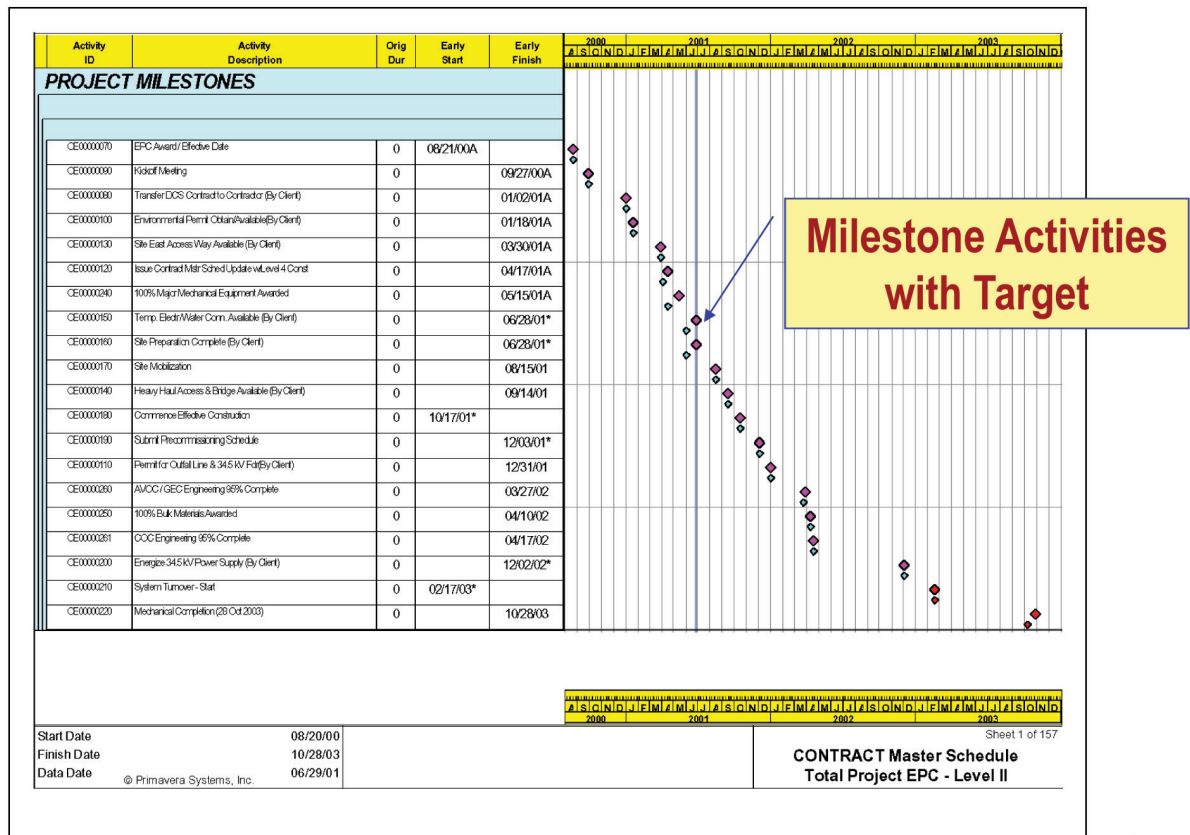
- global (7 day);
- workday;
- resource;
- weather, environmental, and seasonal; and,
- contractor or owner-constrained.

Calendars may have an impact on the calculation of the critical path and the scheduler should be aware and understand how various scheduling software package calculate dates, float and the critical path based on the identified calendars and their input into the schedule. [P&S-SG: 186]

## Milestones

Milestones are zero-duration key events that the project team must determine and incorporate into the schedule as it is developed.

Milestones for a project may be an imposed or contractual requirement (often with related bonus and penalty provisions) or an internal metric for progress of the project in part or whole. However, in all cases, schedule milestones should be agreed upon by all stakeholders prior to approval of the project baseline schedule.



**Figure 5—Milestone Schedule Example**



## **Appendix A**

### **Schedule and Scheduling Terms**

This section of the **Certified Scheduling Technician (CST) Primer** provides a word list source for schedule and scheduling specific terms for your reference. All of the terms are drawn from the **AACE International Recommended Practice No. 10-S90, *Cost Engineering Terminology***.

This Recommended Practice is regularly updated. It is available on-line to both members and non-members. Non-members must create an account in order to be able to use this and other AACE Recommended Practices.

These terms represent the most commonly used concepts likely to be encountered by a scheduling technician. For access to the full definitions, go directly to the **AACE International Recommended Practice No. 10-S90, *Cost Engineering Terminology***, by clicking: <http://www.aacei.org/resources/rp/>

**A**

Acceleration  
Activity  
Activity Attributes  
Activity Bar  
Activity Calendar  
Activity Code  
Activity Cost  
Activity Definition  
Activity Description  
Activity Duration  
Activity Duration Estimating  
Activity Relationship  
Activity Sequencing  
Activity Total Slack  
Activity Splitting  
Activity Status  
Activity Times  
Activity type  
Actual Finish Date  
Actual state Date  
Arrow Diagram  
Arrow Diagramming Method (ADM)

**B**

Backward Pass  
Bar Chart  
Baseline  
Baseline Schedule  
Basis  
Beginning (Start) Node of Network

**C**

Calendar  
Calendar Unit  
Calendar Start Date  
Cash Flow  
Cash Flow Management  
Code  
Code of Accounts (COA)  
Contract Completion Date  
Contract Dates  
Contract Master Schedule  
Contract Plan  
Contract Work Breakdown Structure (CWBS)

Constraint  
Cost Codes  
Crash Duration  
Crashing  
Critical Path  
Critical Path Analysis  
Critical Chain Method  
Critical Path Method (CPM)  
Critical Relationship  
Critical Sequence  
Cycle Time

**D**

Data Date  
Date Constraint  
Delay  
Discretionary Dependency  
Duration

**E**

Earliest Expected Completion Date  
Early Dates  
Early Finish (EF)  
Early Start Time (ES)  
Early Start (ES)  
Earned Value (EV)  
Economic Return  
Effective Date of the Agreement  
Effort  
Effort Remaining  
End Activity  
Errors and Omissions  
Escalation  
Estimate  
Estimated Completion Date  
Event  
Event Name  
Event Number  
Event Times

**F**

Fast-Track(ing)  
Finish-To-Finish (FF)  
Finish-To-Start (FS)

Finish-To-Start Lag  
Fixed Date  
Float  
Float Path  
Forward Pass  
Fragnet  
Free Float (FF)  
Free Slack  
Front End Loading (FEL)  
Front End Schedule

## G

Gantt Chart\

## H

Hammock Activity  
Hard Logic

## I

In-Progress Activity  
Integrated Cost / Schedule Reporting  
Interface Activity

## J

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## K

Key Activity  
Key Event Schedule  
Key Events

## L

Lag  
Lag Duration  
Lag Relationship  
Lag Time  
Lead  
Lead Durations / Lead Time  
Levels of Schedules  
Level 1—Management Summary Schedule (Level 1 Schedule)  
Level 2—Project Level Schedule (Level 2 Schedule)  
Level 3—Control Level Schedule (Level 3 Schedule)

Line of Balance (LOB)  
Linear Scheduling Method (LSM)  
Logic  
Logic Constraint  
Logic Diagram  
Longest Path (LP)

## M

Manufacturing Resource Planning (MRP II)  
Master Production Schedule (MPS)  
Master Schedule  
Master Schedule Item  
Master Scheduler  
Milestone  
Milestone Dictionary  
Milestone Flag  
Milestone Level  
Milestone Payment  
Milestone Plan  
Milestone Report  
Milestone Schedule  
Multi-Project Scheduling  
Must Finish  
Must Finish By Date  
Must Start

## N

Near-Critical Activity  
Near-Critical Path  
Near-Term Activities  
Negative Float  
Network Float  
Network Scheduling  
Not Earlier Than  
Not Later Than

## O

Open-Ended Activities

## P

Path  
Path Convergence  
Path Divergence  
PDM Arrow  
PDM Finish To Finish Relationship  
PDM Finish To Start Relationship

PDM Start To Finish Relationship  
PDM Start To Start Relationship  
Precedence Diagramming Method (PDM)  
PERT (Project Evaluation and Review  
Technique)  
PERT Analysis  
PERT Chart  
Plug Date  
Predecessor Activity  
Preferential Logic  
Project Float

## Q

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## R

Relationship Float  
Relative Total Float  
Remaining Float (RF)  
Resource  
Resource Allocation Plan (RAP)  
Resource Availability Date  
Resource Availability Pool  
Resource Calendar  
Resource Constraint  
Resource Level  
Resource Leveling  
Resource Limited Scheduling  
Resource Loading / Resource Allocation  
Resource Requirement Planning  
Resource Smoothing

## S

Schedule  
Schedule Compression  
Schedule Contingency  
Schedule Percent Complete  
Schedule Performance Index (SPI)  
Schedule Variance  
Scope

Sequence  
Slippage  
Soft Logic  
Stakeholder  
Stakeholder Analysis  
Start-To-Finish (SF)  
Start-To-Start (SS)  
Start-To-Start Lag  
Subnetwork Float  
Subproject

## T

Task  
Time-Constrained Scheduling  
Time-Limited Resource Scheduling  
Time-Limited Scheduling  
Total Float (TF)

## U

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## V

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## W

Work  
Work Breakdown Structure (WBS)

## X

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## Y

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## Z

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## **Appendix B**

### **Document Comparison Table**

To aid the reader in seeking additional information for further study the following table has been developed for your use.

The table is organized using the major sections of the **Certified Scheduling Technician (CST) Primer** major areas of interest. The second column lists the **Skills and Knowledge of Cost Engineering; edition 5**, chapters that have parallel information. The third column lists the **AACE International Recommended Practices** that have similar, supporting materials.

<b>Certified Scheduling Technician (CST) Primer</b> primary areas of interest	<b>Skills and Knowledge; Edition 5</b> supporting material	<b>AACE International Recommended Practices</b> with supporting material
General References		
<b>Planning and Scheduling Professional (PSP) Certification Study Guide</b> , <i>First Edition</i> , 2008, for print version, various editions in compact disc format.		
		<b>RP 11R-88: Required Skills and Knowledge of Cost Engineering</b>
		<b>17R-97: Cost Estimate Classification System</b>
<i>Chapter I—Scheduling Overview</i>		
<i>Planning for Scheduling</i>		<b>RP 39R-06: Project Planning – As Applied in Engineering and Construction for Capital Projects</b>
		<b>RP 60R-10: Developing the Project Controls Plan</b>
<i>Work Breakdown Structure[WBS]</i>		
<i>Schedule Specification</i>		
<i>Project Documentation</i>		<b>RP 38R-06: Documenting the Schedule Basis</b>
<i>Chapter II – Scheduling Principals</i>		
<b>Certified Scheduling Technician (CST) Primer</b> primary areas of interest	<b>Skills and Knowledge; Edition 5</b> supporting material	Recommended Practices with supporting material
<i>Scheduling Documentation</i>		<b>RP 37R-06: Schedule Levels of Detail; As Applied in Engineering, Procurement and Construction</b>
<i>Schedule Maintenance</i>		
<i>Baseline Schedule</i>		<b>RP 20R-98: Project Code of Accounts</b>

<i>Schedule Change Management</i>		<b>RP 45R-08: Scheduling Claims Protection Methods</b>
<i>Schedule Output and Deliverables</i>		
<i>Control Level Schedules</i>		
<i>Variances and Trends</i>		
<i>Schedule Analysis</i>		<b>RP 49R-06: Identifying the Critical Path</b>
		<b>RP 53R-06: Schedule Update Review: As Applied in Engineering, Procurement, and Construction</b>
<i>Schedule Forecasts</i>		<b>RP 52R-06: Time Impact Analysis: As Applied in Construction</b>
<i>Management Summary</i>		
<i>Chapter III – Elements of a Basic Schedule</i>		
<i>Principals Used in Developing a Schedule</i>		
<i>Schedule Development</i>		
<i>Schedule Specification</i>		
<i>Feedback from Stakeholders</i>		<b>RP 30R-03: Implementing Project Constructability</b>
<b>Certified Scheduling Technician (CST) Primer</b> primary areas of interest	<b>Skills and Knowledge; Edition 5</b> supporting material	Recommended Practices with supporting material
<i>Types of Schedules</i>		<b>RP 27R-03: Schedule Classification System</b>
<i>Data Elements for a Schedule</i>		
<i>Activities</i>		<b>RP 23R-02; Identification of Activities</b>
<i>Durations</i>		
<i>Relationships</i>		<b>RP 24R-03: Developing Activity Logic</b>
<i>Constraints and Calendars</i>		
<i>Milestones</i>		

## **Bibliography**

Following are AACE International sources that are of particular interest to those working in the engineering, construction, and processing industries with responsibilities for scheduling.

### **AACE International Recommended Practices:**

Recommended Practices may be found at the AACE International website. Please use the search feature to locate these documents.

These documents are commonly referred to as: "RP's."

The date of the most current edition is shown on the RP.

RP's represent the technical documentation of the cost engineering profession. They represent the highest level of technical materials for their individual subject matter. However this does not infer that they do not have a great deal of information of interest to the scheduling technician.

These documents will be more and more beneficial as the technician proceeds in the development of a scheduling career.

**RP 10S-90:** *Cost Engineering Terminology*

**RP 13S-90:** *Recommended Method for Determining Building Area*

**RP 14R-90:** *Responsibility and Required Skills for a Project Planning and Scheduling Professional*

**RP 20R-98:** *Project Code of Accounts*

**RP 23R-02:** *Identification of Activities*

**RP 24R-03:** *Activity Logic*

**RP 27R-03:** *Schedule Classification System*

**RP 30R-03:** *Implementing Project Constructability*

**RP 31R-03:** *Reviewing, Validating, and Documenting the Estimate TCM Framework*

**RP 32R-04:** *Determining Activity Durations*

**RP 34R-05:** *Basis of Estimate*

**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 – As Applied in Engineering and Construction for Capital Projects*

**RP 48R-06:** *Constructability Review*

**RP 49R-06:** *Identifying the Critical Path*

**RP 53R-06:** *Schedule Update Review: As Applied in Engineering, Procurement, and Construction*

**RP 60R-10:** *Developing the Project Controls Plan*

**AACE International Publications:**

**Planning and Scheduling Professional (PSP) Certification Study Guide**

**TCM Framework: An Integrated Approach to Portfolio, Program and Project Management**

Privately published professional texts and hand-out materials from seminars or technical programs, from academia and/or professional courses have not been included in this bibliography.

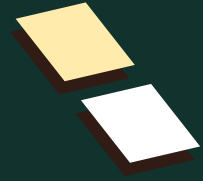
You are encouraged to review these materials as a part of your review for the certification examination for the Certified Scheduling Technician (CST) certification.

The certification examination allows you to use any published materials that you wish to bring into the place of examination.

**List of Versions / Revisions / Changes to the Certified Scheduling Technician (CST) Certification Study Guide**

The revisions and changes to the **Certified Scheduling Technician (CST) Primer** are:

Version Number	Date	Description of Changes
STP-1.0	April 15, 2013	Initial on-line posting.



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