# نحوه برآورد مدت زمان فعالیت‌ها در پروژه

(بر اساس اسنادی از AACE و AGC و PMI)


**ارائه دهنده:**

سید محمدرضا علوی‌پور

(PhD, PMP, CMIT)

CMAA Authorized Trainer

دانشگاه Illinois Tech آمریکا

# What we will learn?

- Durations basics
- Time unit selection
- Estimating activity durations
- Example activity duration calculation
- Resource availability
- Factors affecting productivity
- Sources of quantity and productivity
- Activity duration assumptions

# What we will learn?

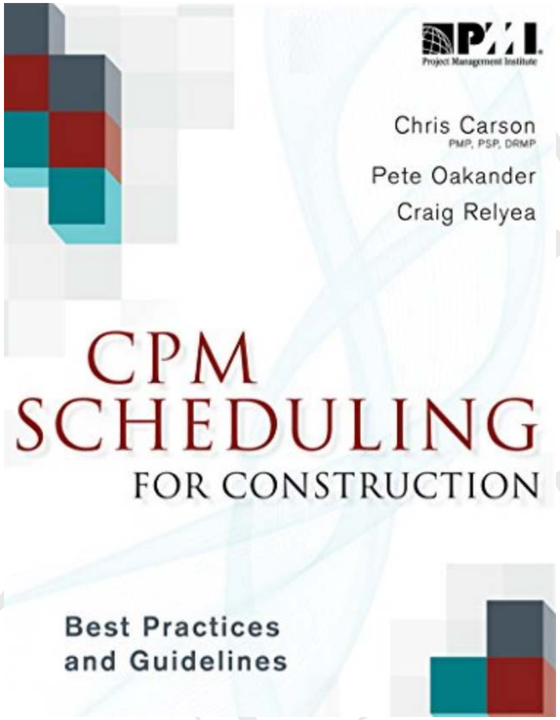
- AACE Purpose and Overview
- AACE RP
  - Introduction
  - Phase I – Determine Unconstrained Activity Durations
  - Phase II – Adjust Activity Duration Based on Constraint Impact or Other Limiting Factors
  - Phase III – Revise Original Activity Durations to Meet Project Requirements
  - Calculating Remaining Durations
  - Duration Relationship with Actual Start and Finish Dates
  - Risk and Activity Duration Variability
  - Contract/Scheduling Specifications Requirements
  - Software Issues
  - Calculating Original Durations Using the Approved Estimate

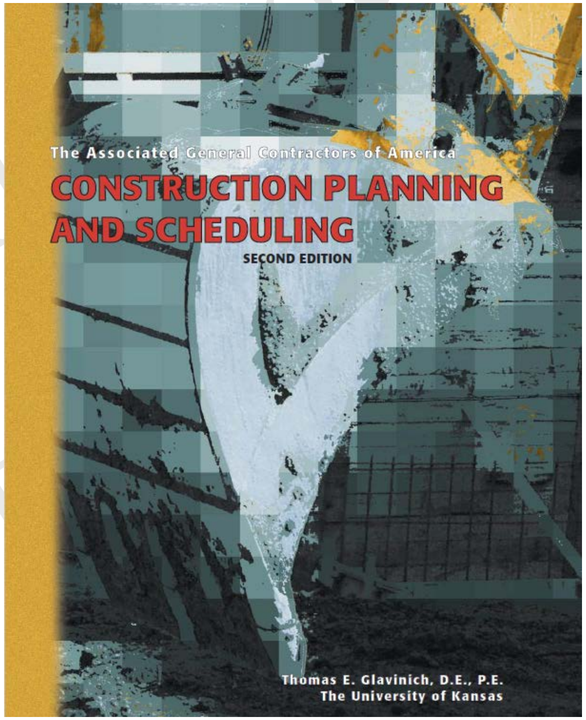
# What we will learn?

- Improving Duration Accuracy
- Duration Verification
- Participation In Duration Review

# Reference

# Primary references

# Other references


# Durations Basics

ACEMI

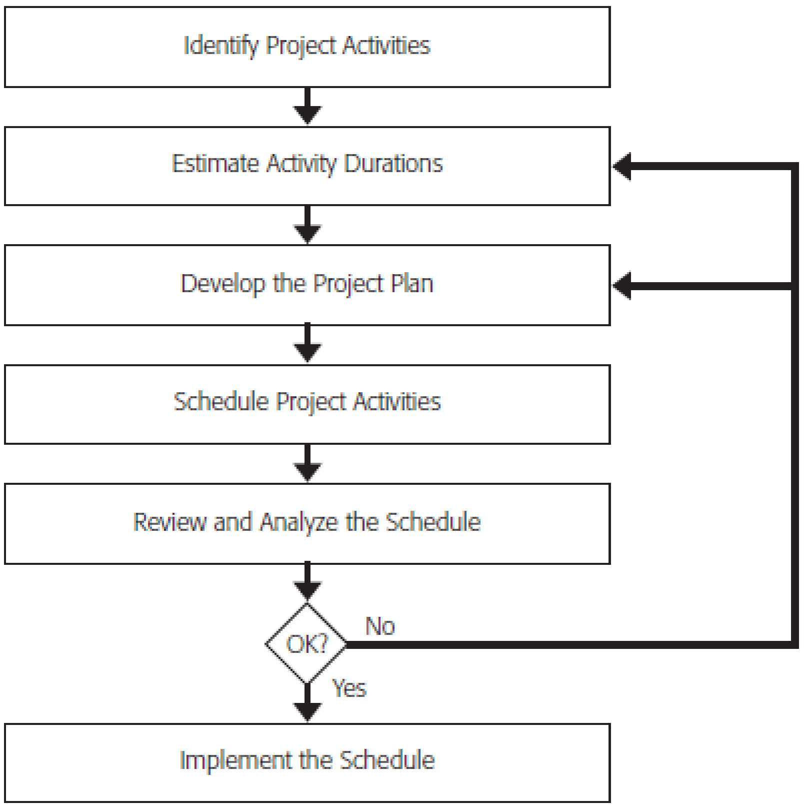
# Definitions

- Activity durations, along with logic,

  are the **basic building blocks** of any schedule.

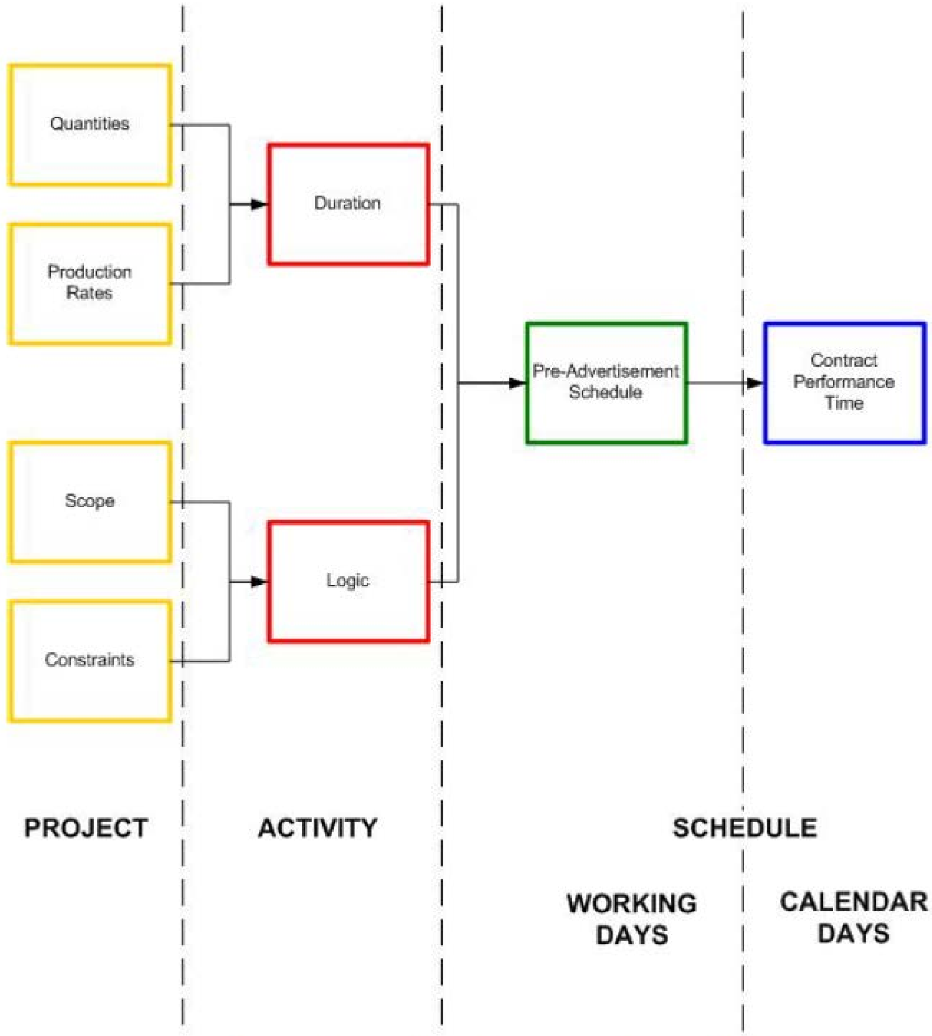
- The **scheduler** should be aware of
  1. the methods available to estimate activity durations, and
  2. how the method used will **influence the accuracy** of the schedule over the life of the project.

# Definitions




The Planning and Scheduling Process

# Definitions




. General Contract Time Determination Process flowchart

# Definitions

- Durations are **simply estimates** of the period of time to perform the work assigned to each schedule activity, **typically measured in days**.

- At **higher level summary schedules**, durations can be measured in weeks or even months.

- At the **other end of the spectrum**, a **very detailed schedule** to control a **relatively short project** or **specific phase** of a project could measure durations in hours.

- But use of **days to measure durations** is by far the **most common** planning unit.

# Original vs. remaining durations

- Most scheduling software will use, calculate, and display an activity's original duration and remaining duration.
  - The **original duration** is the number of days (or other unit of measure) **initially assigned** to a given activity.
  - Once an activity has **started**, and the **start date has been actualized** in the schedule,

    the **remaining duration** will be displayed as **the number of days (or other unit of measure)** remaining to finish that activity.

    - ✓ The **remaining duration** will either be
      1. **manually entered** during the schedule update, or
      2. **calculated if** the percentage complete is **linked** to remaining duration and

         **entered during** the schedule **update** (software dependent).

# Risk management perspective

- From a **risk management perspective**,

  **durations** carry a certain **amount of uncertainty** in their values,

  so durations would **more appropriately** be modeled on probability distributions.

  - This is related to the range of production rates that could be assigned to **tasks** based on
    - individual talents,
    - project conditions,
    - climate, and
    - a number of other considerations.

# Risk management perspective

- Traditionally,

  **outside of CPM scheduling**,

  there are **several methods** used to deal with this concern and **produce** probabilistic calculations of durations.

- In a CPM schedule, **durations** are typically deterministic, using a **single value**.

# Deterministic schedule methods

- **One of the reasons** that deterministic schedule methods seem to **work reasonably** well is the self-correcting nature of the **project controls effort**.

- If there is a **good analytical process** in place during the routine schedule updates, any **stacking of pessimistic durations** will be identified in the update analysis, and **corrective actions** will be taken to bring the project **back onto schedule.**

# Time Unit Selection

ACEMI

# Introduction

- **Activity durations** can be expressed in any **convenient time unit**, **depending on**
  1. **when** the schedule is prepared in the project life cycle and
  2. the **objective** of the scheduling effort.
- **Time units** used for construction planning and scheduling can include any of the following:
  - Years
  - Months
  - Weeks
  - Days
  - Hours

# Years

- For **very large construction projects** that have a long planning, design, and construction period,

  **early project schedules** may have activity durations expressed in years or fractions of a year.

- In the **early stages** of a large project, there may **not be enough information** to develop a **detailed schedule** with **smaller time units**.
  - *For example, the development of a large, multi-building commercial development or a planned residential community might have a schedule with durations expressed in years showing the phases of development.*

- **Large construction projects** such as power plants, dams, and highways could also have early schedules **expressed in years.**

# Months

- A schedule with activity durations expressed in **months** may also be **appropriate** in the **early stages** of a construction project.
- A construction schedule expressed in months could be **prepared** during the conceptual stages of a project to mark **milestones** that need to be met in order to complete the **project on time**.
  - *For example, during the early stages of a construction project the construction manager may develop master schedule in months to alert the project team as to*
    - ✓ *when design packages need to be completed,*
    - ✓ *procurement of long-lead items should be started, and*
    - ✓ *major construction activities will be finished.*

# Weeks

- A **construction schedule** expressed in **weeks** and developed in the **early stages of a project**

  can provide the **framework** for the developing a **more detailed schedule** as construction progresses.

- The **project team** can **gradually** divide the **summary activities** in the **construction schedule**

  into **greater detail** for the day-to-day planning and management of the project.

# Days

- **Days** are the **most common** and **convenient time unit** for planning and scheduling **most construction projects**.
- Estimating activity durations in days allows the **start and finish of activities** to be scheduled by **calendar date**,

  which takes into account rest days and holidays when **no work** is planned.
- Additionally, time in most construction contracts, subcontracts, and supply agreements is expressed in **days and dates.**
- When the schedule time unit is days, it is **easier to incorporate** the ter**ms of these agreements** into the project schedule.

# Hours

- **Hours** can also be used to plan and schedule complex, short-duration construction projects that must be completed by a specified time.
- Normally, schedules with activity durations expressed in hours involve the **shutdown** of a **process** or **system** to make modifications or perform **maintenance** when it is **imperative** that the **process or system be back** in operation at a specified time.
  - *For example, the replacement of a facility's electrical service might be scheduled in hours starting Friday evening to ensure that the facility is back in operation at the start of business on Monday morning.*

# Time unit selection

- In fact, **different time units** may be used for **different schedules** as the project develops and **becomes more defined**.
  - In the early stages of the project, activity durations may be expressed in **years or months.**
  - For detailed planning and scheduling of construction operations, activity durations expressed in **weeks** or **days** could be used.
  - Additionally, for critical short-term construction processes, activity durations may be expressed in **hours**.

# Time unit selection

- In **addition to different schedules** used at different points in the project life cycle, **different time units** may be used for **schedules generated** from the master construction schedule for **specific users**.
  - *For example, summary schedules in years, months, or weeks might be developed from the master construction schedule in days for informing upper management, the owner, or the designer of the status of the project.*
- Similarly, **short-interval schedules** in days or hours can be developed from the **master construction schedule** for managing day-to-day construction operations at the site.

# Time unit selection

- As **noted above**, the day is the **most common time unit** used in construction planning and scheduling.
  - For this reason, activity durations will be expressed in days throughout the remainder of this course.

# Time unit consistency

- **All activities** in a **construction schedule** must have their durations expressed in the **same time unit.**
- **Different time units cannot** be intermixed in the same construction schedule.
- If a **construction schedule** uses the **day as its time unit** and
  an **activity** has an estimated duration less than a full day,
  then that **activity's duration** must be rounded up to a **full day**
  **before** being included in the schedule.

# Time unit consistency

- Similarly, **activities** with durations expressed in weeks, months, or years must be **converted to days** **before** being **included in a construction schedule** **using days** as its base time unit.

# Estimating Activity Durations

# Estimating Method

- The PMBOK® Guide recognizes **three methods** for estimating deterministic schedule activity durations,

  useful for **progressively** elaborated schedules such as those **developed early** in the project and **updated** as **design** is **advanced**.

# Estimating Method

- The methods are:
  - **Expert judgment.**
    - ✓ Relies on **knowledge** of **prior similar project durations** to inform estimates for the **current project**,

      more of a **"gut check"** on durations that may be **estimated** or **validated** by other methods that follow.

# Estimating Method



- The methods are:
  - **Analogous estimating.**
    - ✓ When **detailed information** about a project is **limited**,

      using **parameters** from previous similar projects can be used to estimate the current project durations;

      some schedulers will derive **“rules of thumb”** or other guidelines for **common activity durations** based on **past performance**,

      **not as accurate** as other methods and

      **typically** used in **earlier phases** of a project.

ACEMI

# Estimating Method

- The methods are:
  - **Parametric estimating.**
    - A **more quantitative approach** that yields **more accurate durations**, by using known quantities and historical production rates to calculate durations;

      **general contractors** with history in self-performed work and records of trade subcontractor past performance often use **this method**,

      but it **still** requires assumptions or data on **available resources** to **apply the production rates** to the project quantities.

# Estimating Method

- **Recommended Practice No. 32R-04**, “Determining Activity Duration” (AACE International, 2012) suggests that there are **three phases** to determining durations:
    1. determining unconstrained activity durations,
    2. adjusting activity duration based on constraint impact, and
    3. revising activity original durations to meet project requirements.

- These **phases are described in detail** in the Recommended Practice, and the concept is **very useful as an approach** to deterministic duration estimating.

# Estimating Method

- **This estimating** of durations for the official project schedule,

  the **baseline or as-planned**, becomes **more detailed**, requiring **reasonable calculations.**

- Once production rates and quantities are established to calculate the durations,

  it is **important to ensure** that the production rates are based on

  1. available resources and
  2. spaces.

- **Without** taking into account available resources to perform the activities, and

  **without** consideration of the available spaces in which to work,

  **estimates of durations** are **not appropriate** and may **not be reasonable**.

# Estimating Method

- The **duration** of an activity is a **function** of
  1. the amount of work that **must be accomplished** and
  2. the rate at which **work can be accomplished**.

- Simply stated, the **duration** of an activity is the quantity of work **divided** by the production rate.

# Estimating Method

- The **basic formula** for estimating activity durations is as follows:

$$\textit{Activity Duration} = \textit{Work Quantity} \,/\, \textit{Production Rate}$$

# Work Quantity Defined

- The **work quantity** is

  the **amount of work** that must be accomplished

  as **defined** by the **construction documents**.

- The **quantity of work** is expressed in some measurable quantity such as

  the **amount** of

  materials or the equipment that need to be **installed**.

- The **quantity of work** includes

  all work that is necessary to **complete the scope** of work

  **defined** by the **activity**.

# Work Quantity Defined

- The **quantity of work**

  may **not be expressed** in the exact quantity of materials and equipment,

  such as the number of **concrete masonry units** that **must be installed**.

  - Instead, the **quantity of work** might be expressed in terms of some other measurable quantity such as

    number of **square feet of masonry wall** completed.

- This quantity will then **serve as a basis** for

  **measuring progress** and could include

  the **installation** of related materials such as

  reinforcing steel and filler in the case of masonry wall.

# Production Rate Defined

- The **production rate** should be the **planned average** daily production rate based on
  1. the available resources and
  2. the environment within which the work will be performed.
- The **production rate** includes **not only** the productive time associated with a **particular activity**

  but also idle and non-productive time associated with
  1. the movement and setup of equipment,
  2. break times,
  3. expected equipment downtime for maintenance and repair, and
  4. other expected downtime.
- When estimating a production rate, resource availability and other factors affecting productivity need to be considered

# Example Activity Duration Calculation

# Introduction

- The **accuracy** of activity duration estimates is **very important**.
- **Activity durations** in conjunction with **activity logic** form the **basis** for performing **network schedule calculations**.
- **Inaccurate** activity durations can **affect**
  1. the integrity of the network schedule and
  2. its usefulness as a management tool.
- **Care** must be taken by the **scheduler** when estimating activity durations to ensure that they reflect the planned means and methods of performing the activity and anticipated conditions at the **project site**.

# Introduction

# Introduction

- As discussed, there are **two elements** that go into calculating activity durations, work quantity and production rate.

# Quantity of work

- The **quantity of work** is normally defined by the contract documents and is a **constant**.
  - The contractor has **little if any control** over this element.

- The **quantity of work** is usually taken **directly** from the plans and specifications when performing **quantity takeoffs** for the **bid estimate**.

# Production rate

- The **production rate**, on the other hand, is **not a constant** and can be **affected** by a number of factors both **within** and **beyond** the contractor's control.
  - A number of these factors were discussed in this section.

- **These factors** should have been taken into account by the **estimator** **when preparing** the bid estimate in **determining** the type and amount of labor and equipment required to perform **each project activity**.

# Preparing a detailed bid estimate

- In **preparing a detailed bid estimate** for a project, required labor, material and installed equipment, and production equipment for each activity are usually **estimated based** on planned means and methods for accomplishing the work.
- This information is **often not carried** over to the planning and scheduling of the project **once the contract** is awarded.
  - Instead, **activity durations** are estimated by project personnel based on **past experience** or other **available information**.
    - ✓ **Ignoring** the **detailed analysis** of the project performed by the estimator in **preparing the bid** overlooks a **valuable information source** that can be very useful in estimating activity durations

# Time and cost

- Time and cost are **related to one another** in the performance of any construction activity, and **both are a function** of the type and quantity of **resources** used.
  - **Resource usage** is the **basis for estimating both** activity time and cost.
- After contract award, the **bid estimate normally** becomes the **basis** for the project **budget**.

*Why the bid estimate should be checked before using as a basis for project schedule?*

# Quantities of labor, materials, and installed equipment

- **Quantities** of labor, materials, and installed equipment and production equipment included by the **estimator** can be **converted into** daily production rates that **relate** schedule to budget.
  - *For example, a particular building requires the installation of 1500 grid ceiling-mounted, 2’ x 4’, 4-lamp, fluorescent fixtures evenly distributed between five floors for 300 fixtures per floor.*
  - *When **preparing the bid estimate** for this activity, it was **estimated** that an **electrician** could install 10 fixtures per day.*
  - *Following award of contract, **detailed** activity planning determined that a **crew of six electricians** would be **best** for installing the **fluorescent fixtures** on **each floor.***

# Quantities of labor, materials, and installed equipment

- **Using** the bid estimate data and the planned crew size, the scheduler is able to **estimate** the production rate for the **planned crew** as follows:

$$\text{Production Rate} = \left(\frac{10 \text{ Fixtures}}{1 \text{ Electrician-Day}}\right)(6 \text{ Electricians})$$

$$= \frac{60 \text{ Fixtures}}{\text{Day}}$$

# Quantities of labor, materials, and installed equipment

- The **estimated duration** for the **installation** of fixtures on each floor of the building can **now be calculated** as follows:

$$\text{Fixture Installation Duration} = \left(\frac{300\ \text{Fixtures}}{\text{Floor}}\right)\left(\frac{1\ \text{Workday}}{60\ \text{Fixtures}}\right)$$

$$= \frac{5\ \text{Workdays}}{\text{Floor}}$$

- Therefore, the **estimated activity duration** for the installation of fluorescent fixtures on each floor of the building would be **five workdays**.

# Finalizing estimate

- This **simple example** illustrates how duration estimates can be **derived** from bid estimate data.
- The **same care** and **attention** to detail that is put into estimating activity costs when bidding a project should be put **into estimating activity durations** when planning and scheduling the project after contract award.
- Forms similar to the one **shown Figure 3-1** can be developed by the contractor to **help** organize and document **activity duration estimates**.
- The **amount of detail and information** contained in the form will **vary** from **contractor to contractor** depending on need.
  - However, as a **minimum**, this form should **provide the contractor** enough information so that there is a **record** as to how activity durations were estimated and how these durations relate to the project budget.

ACEMI

# Finalizing estimate

| ACTIVITY | | BUDGET REFERENCE | WORK QUANTITY | | PLANNED PRODUCTIVITY (Workday/Unit) | ESTIMATED ACTIVITY DURATION (Workdays) |
|---|---|---|---|---|---|---|
| NUMBER | DESCRIPTION | | AMOUNT | UNITS | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Figure 3-1
Activity Duration Worksheet

# Finalizing estimate

- **Establishing** a relationship between an activity's duration and budget can be accomplished in a **number of ways**, for example, with a **simple line-item code** that **cross-references** the schedule activity to a budget line item.
- A **more effective** and **useful way** of relating the project schedule and budget is through the contractor's project cost accounting system.
- **Most contractors** have a project cost accounting system in place that is **tailored** to their **specific** work and informational needs.
- **Tying** the project schedule to the project cost accounting system will provide **additional information** that can be used **to better monitor and control** the activity during construction.

# Recommended practice

- The **Best Practices** section lists the **generally accepted methods** to use for estimating activity durations.

# Recommended practice

- **Additional considerations** regarding activity durations include:
  - **Maintaining** uniform activity durations during **early stages** of project schedule development can **simplify the process** as the **schedule is expanded** in level of detail.

# Recommended practice

- **Additional considerations** regarding activity durations include:
  - A **good guide** for the **maximum duration** of an activity is to **limit** it to half or the full reporting period **between schedule updates**.
    - Frequently, **updates** are required on a **monthly basis**, which would indicate a **maximum activity duration** of about 10 to 20 working days.

# Recommended practice

- **Additional considerations** regarding activity durations include:
  - **Feedback** from trade or project supervision that is closest to **those actually performing** the work is excellent input to schedule productivity,

    in this case to **estimate** activity durations,

    based on their **detailed** trade-specific knowledge and past experience.
  - Use of **experienced** general contractor and trade subcontractor superintendents and foremen can **improve the accuracy** of schedule duration estimates.

# Recommended practice

- **Additional considerations** regarding activity durations include:
  - **Once** the durations are **estimated** in compliance with **best practices**, the **individual** activity **durations** should be **reasonable** and **appropriate**.
    - ✓ However, this does **not guarantee** a reasonable and appropriate **schedule** because it **only addresses** the use of resources on **each activity**, **not necessarily all activities** planned to perform at the **same time**.

# Recommended practice

- **Additional considerations** regarding activity durations include:
  - It is **vital to examine** the issue of concurrent activities because the durations of each activity will require **concurrent resource use**.
  - This is also **true for spaces**; each trade individual needs a certain amount of **space for**
    1. materials storage,
    2. tool storage, and
    3. work.
  - The **available spaces** for **work** will **limit**
    1. the number of individuals, as well as
    2. the number of trades

    that can work at the **same time** in **each space**.

ACEMI

# Recommended practice

- **Additional considerations** regarding activity durations include:
  - As a result of this issue, trade and space stacking are **common causes** or symptoms of **inappropriate** or **unreasonable schedules**,

    so the **quality control verification** for the baseline or as-planned schedule should include a **review** of **available resources** of concurrent activities.

# Recommended practice

- **Additional considerations** regarding activity durations include:
  - Review of the total number of crews and individual resources in the early and late date sorts of the schedule will help improve the **reasonableness** of the plan.

# Resource Availability

# Resource Availability

- The **key to estimating** activity durations is the availability of resources.

  These resources include:

  1. Labor
  2. Equipment
  3. Material
  4. Subcontractors and
  5. suppliers

ACEMI

# Resource Availability

- Most activity durations are **resource driven**, and activity duration estimates need to be based on **available resources**.
- If duration estimates are **not resource based** for the particular project, they **may not be valid**, resulting in distortion of the schedule.

# Resource Availability

- As a general rule, the **more resources available**, the **less time** it takes to perform an activity.
- The **time-resource trade-off** and its relationship to construction planning and scheduling course,

  which provides **addresses** schedule <u>compression</u> and <u>decompression</u> through **resource application**.

# Factors Affecting Productivity

# Factors Affecting Productivity

- In addition to the availability of labor, equipment, materials, and subcontractors, there are a **number of other factors** that can have an impact on an activity's duration.
- These **factors** affect resource productivity and must be **considered when estimating** an activity's duration.
- The second step in estimating activity durations is to adjust productivity to account for special conditions associated with a **particular project**.

# Factors Affecting Productivity

- **Factors** affecting **resource productivity** include:
  1. Nature of the work
  2. Resource productivity
  3. Management skill
  4. Material and equipment availability
  5. Seasonal conditions
  6. Work restrictions
  7. Quality of work
  8. Concurrent activities

# Nature of the Work

- The **nature of the work** will affect resource productivity and needs to be taken into account when estimating activity durations.
  - For example, **labor productivity** should **increase** as **experience** is gained for repetitive tasks.
    - ✓ Activities **composed** of repetitive tasks should benefit from
      1. the increased task productivity and
      2. have decreasing activity durations.

# Resource Productivity

- Labor and equipment productivity are **not constant** and can vary significantly from
  1. project to project and
  2. location to location.

# Resource Productivity

- **Labor productivity** is a function of a number of factors, including
  1. training,
  2. experience,
  3. motivation, and
  4. labor restrictions.

# Resource Productivity

- **Equipment productivity** is primarily a **function** of
  1. operator skill, but can also be affected by
  2. equipment maintenance policies,
  3. age, and
  4. site conditions.
- The **impact** of anticipated labor and equipment productivity needs to be **factored** into estimated activity durations.

# Management Skill

- The **ability of the management team** to plan, organize, and execute the work is an important factor in estimating activity durations.
- Management skill is **key to the successful completion** of any construction project.
- The effective and innovative application of **available resources** can have a significant impact on **activity durations** and needs to be accounted for in the construction scheduling process.

# Material and Equipment Availability

- **Material and equipment availability** can affect labor and equipment productivity and **ultimately** activity duration.
- **Sufficient** material and equipment must be **available to support** planned production rates.
- Insufficient quantities of material and equipment can lead to **lost productivity** and **idle resources**.
- Similarly, a large inventory of materials and equipment at the site can cause **congestion** and lower productivity.
- Material and equipment **deliveries** to the site need to be carefully planned and scheduled so as to **balance**
  1. production needs with
  2. available laydown and storage space

# Material and Equipment Availability

- When estimating activity durations, the **ability of the supplier** to provide sufficient materials and equipment to the site to **support** the planned production rate needs to be considered.
- Estimating activity durations **based solely** on available labor and equipment may result in **optimistic durations** that **cannot realistically** be attained because of a lack of materials and equipment.
  - For example, it does **not good to estimate** the duration for **pile driving** using **two crews**

    **if** the pile supplier can provide **only enough piles** to support **one crew**.

# Material and Equipment Availability

- In **addition to supplier production capacity**, other factors that could affect material and equipment availability should also be considered.
  1. Raw material availability,
  2. credit restrictions, and
  3. transportation bottlenecks

  may also affect material and equipment availability.

# Seasonal Conditions

- **Construction productivity** is affected by weather conditions.
- Labor and equipment productivity usually **drops** in both hot and cold weather.
- In addition, **construction materials** become **more difficult to work** with in extreme weather conditions, requiring special protection from the elements and greater attention.
- This **decrease in productivity** results in construction activities taking **longer** than would ordinarily be expected in milder weather and needs to be accounted for in planning and scheduling activities.

ACEMI

# Seasonal Conditions



- **Construction** is a **highly seasonal** business, and the amount of seasonal fluctuation varies from location to location.
- The impact of seasonal fluctuation on activity planning and scheduling depends on the **type of construction activities** being undertaken.
- The **primary cause** of construction seasonality is weather, and

  there are **construction techniques** that can be used to **cope with adverse** weather conditions.

# Seasonal Conditions

- **Rather** than **rejecting out-of-season** construction, the construction firm should
  1. analyze local weather conditions and
  2. consider the potential impact on the availability and cost of labor, equipment, and materials.
- **Carefully planned** and executed out-of-season construction may **cost less than anticipated** and provide the contractor with a **competitive advantage** in a particular locale.

# Work Restrictions

- **Work restrictions** can be imposed by the
  1. construction contract,
  2. local customs,
  3. laws,
  4. labor agreements, and
  5. physical conditions.

# Work Restrictions

- **Some examples** of work restrictions that could affect activity durations are as follows:
  - Hours of the day when work can be performed;
  - Material delivery and movement restrictions;
  - Security requirements for labor;
  - Load limits on floors and elevators;
  - Zoning ordinances that restrict the erection and operation of temporary construction and plant facilities;
  - Provisions of labor agreements; Building codes and regulations; and
  - Safety requirements for protecting the general public, workers, and work in progress.

# Quality of Work

- When estimating activity durations, the **specified quality** of work in place needs to be considered.
- In general, the more exacting the quality and the tighter the tolerances, the **longer it will take** to complete the work.
  - *For example, the placement and finishing of a super-flat concrete floor for an automated warehouse will take longer than a normal warehouse floor built to standard industry tolerances.*

# Concurrent Activities

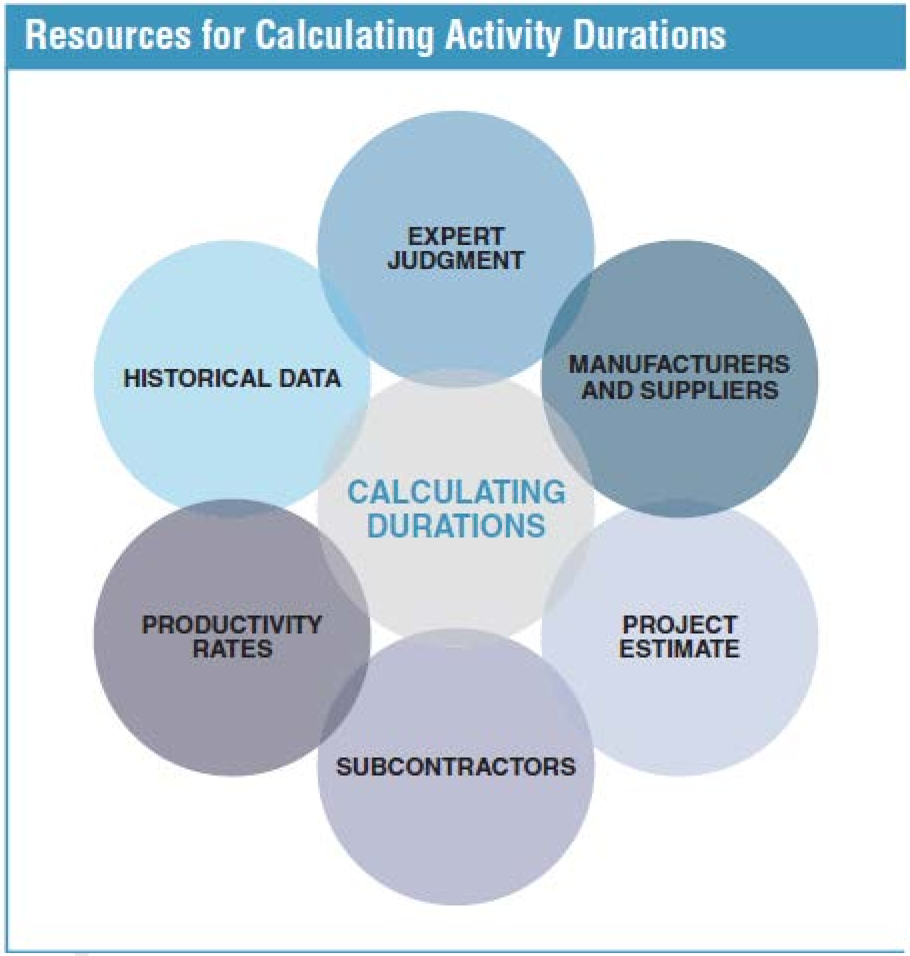
- The type and number of construction activities being **carried out simultaneously** at the **construction site** can affect productivity.

- **Interference** between activities being carried out in close proximity to one another slows production.

- **Interference** between concurrent activities needs to be considered when estimating activity durations.

# Sources of Quantity and Productivity

# Sources of Quantity and Productivity



# Sources of Quantity and Productivity

- **Sources** of quantity and productivity data include:
  - Quantity takeoff;
  - Bid estimate;
  - Past experience;
  - Outside information;
  - Estimating guides;
  - Industry and trade organizations;
  - Manufacturers, fabricators, and
  - suppliers; and
  - Specialty contractors.

# Quantity Takeoff

- The **quantity takeoff** provides **information** on the quantity and type of materials and equipment that will be **incorporated** into the construction project, and usually serves as the **basis for the bid estimate**.
- Since the **length of time required** to perform a particular task is a function of the amount of work,
  the **quantity takeoff** is a **good source** for the raw data necessary for estimating activity durations.

# Bid Estimate

- When estimating activity durations it is very important that the **duration estimates** are based on **available resources**.
- Normally, **detailed** construction **planning and scheduling** occurs after contract award.
- The **best source** of planned resources for a project is the bid estimate, on which the **bid project budget** will be based.
- The **bid estimate** includes **assumptions** regarding
  - crew sizes and makeup,
  - construction means and methods,
  - equipment types and spreads,
  - subcontractors and suppliers, and
  - planned duration for major equipment.

# Bid Estimate

- **Estimate data** prepared during the **bid period** should provide planned man-hours and equipment hours that can be used to **estimate activity durations**.
  - *For example, the bid estimate may include a line item for the leasing of a tower crane on a high-rise building.*
    - ✓ This estimate would be based on the **length of time** the **tower crane** is planned to be **used at the site**.
    - ✓ **Failure** to consider this time could **result in substantial overruns** on this **line item** that could impact the cost of the **overall project**.

ACEMI

# Bid Estimate

- Similarly, the **quantity** of equipment planned in the bid estimate needs to be considered **when estimating** activity durations.
- As noted above, the **duration** of a construction activity is **dependent** on the amount of resources dedicated to that activity.
- If the **bid estimate assumed** that there would only be one pile driver on site,
  - then the pile-driving activity duration should **not require** the **use of two pile drivers.**
- The **scheduling of additional resources** above and beyond that included in the bid estimate could result in unnecessary cost overruns

  if the **additional productivity gained** is not necessary to maintain the planned schedule.

ACEMI

# Past Experience

- **Past experience** is a **valuable source** of duration estimate data.
- **Unlike** research and development endeavors,

  which require **duration estimates** for activities that have never been **performed before**,

  construction activities normally have been **performed many times before** with the same crews, equipment, and materials.
- While **each** construction project is **unique**,

  **seldom** is the **contractor faced** with a construction activity that has **never been performed before.**

# Past Experience

- At times, the **contractor** is faced with a project that requires the **installation of new**
  materials and equipment,
  means and methods, or
  the use of different construction equipment.
  - However, the contractor can **still draw on past experience** to develop **reasonable durations** for the activity.
- While the **contractor's past experience** may **not be an exact match** to the current activity,
  the contractor may be **able to draw upon other similar experiences** to develop a reasonable duration estimate for the activity.

# Outside Information

- In **addition to experience**, the contractor can use information from outside sources when estimating activity durations.
- Information on **activity productivity** is compiled by many public and private groups associated with the **construction industry**.
- This information can be very **helpful in estimating** activity durations, but the contractor must be **very careful in how it is used**.
- Using **published information**

  **without considering** the conditions and assumptions on which the information was based can be **very risky** and result in a **distorted project** schedule

  if estimated activity durations are **too short or too long**.

# Estimating Guides

- **Estimating guides** provide a variety of information that may include the **estimated labor and equipment units** required to complete an activity, and

  are **an outside source** that can be used to estimate activity durations.

- **Most published** estimating guides also provide the crew makeup and equipment used in developing the labor and equipment **units**,

  which are very helpful in **determining the applicability** of the information to the **specific** construction project being planned and scheduled.

# Estimating Guides

- **Estimating guides** can also be very helpful to the contractor **when moving into a new market area**.
- **Different geographic locations** have varying skill levels and production rates.
- Normally, **estimating guides** provide adjustment factors for moving from one **geographic area to another**.
- **These productivity rates** can be used to **adjust estimated durations** for the new location.
- Again, it is important that the **contractor understand** the information provided in the estimating guide, and this information should be **just one input** to any productivity adjustment made; any **major adjustments** in productivity should be **verified** with other sources in addition to the estimating guide.

# Industry and Trade Organizations

- Industry and trade organizations can also be a **valuable source** of productivity information

  that can be used when estimating activity durations.

  Industry and trade organizations can sometimes provide productivity information on different means and methods and for different geographic areas.

# Manufacturers, Fabricators, and Suppliers

- Manufacturers, fabricators, and suppliers can **provide delivery information** that is **critical** to the effective planning and scheduling of construction projects.
- **Failure to consider** the time required to design, fabricate, and deliver necessary materials and equipment can result in problems during construction and delays in planned performance.
- The **duration of activities** associated with the **procurement of equipment** and **materials** must be considered when planning and scheduling construction projects.

# Manufacturers, Fabricators, and Suppliers

- **Manufacturers, fabricators, and suppliers** can also provide information regarding the time required to install or erect
  - **supplied equipment** and **materials** and
    - **necessary start-up** and **testing operations** that need to be considered and incorporated into the construction planning and scheduling process.

# Manufacturers, Fabricators, and Suppliers

- Information provided by **manufacturers, fabricators, and suppliers** can be very helpful in estimating activity durations during the construction planning and scheduling process.
- It is very important, however, that the contractor consider this **information** in conjunction with past experience with

  **similar equipment and materials** as well as

  **input from specialty contractors** who may be responsible for installing the materials and equipment.

# Specialty Contractors

- **Specialty contractors** usually perform work and employ means and methods that are **unique** to their specialty, and should be **consulted regarding** the activity durations for which they are **responsible**.
- Additionally, in **preparing their bid estimate**, **specialty contractors** normally make **assumptions** regarding the timing and intensity of their work effort on a **particular project**.
- **Failure of the contractor** to **consult** with specialty contractors regarding the time required to perform their work could **result** in estimated activity durations that are too short or too long for the scope of work defined by a particular activity.

# Activity Duration Assumptions

# Activity Duration Assumptions

- **Once** the initial activity duration is **estimated**, the **initial duration estimate** can be **modified** to address the unique characteristics of a **particular project.**

- **Methods** for
  1. **identifying** activity and resource conflicts and
  2. **adjusting** schedule parameters to accommodate time constraints

  were addressed in Planning and Scheduling Course.

# AACE
# Purpose and Overview

ACEMI

# Purpose of This RP

- This recommended practice (RP) for Determining Activity Durations is intended to provide a guideline and a resource, **not to establish a standard**.
- As a recommended practice of AACE International, it provides guidelines for the project scheduler to
  1. **determine** schedule activity durations and
  2. **understand** the limitations and assumptions involved in such determination as part of

     the total cost management (TCM) project planning, scheduling forecasting, and change management processes (7.2).

# Purpose of This RP

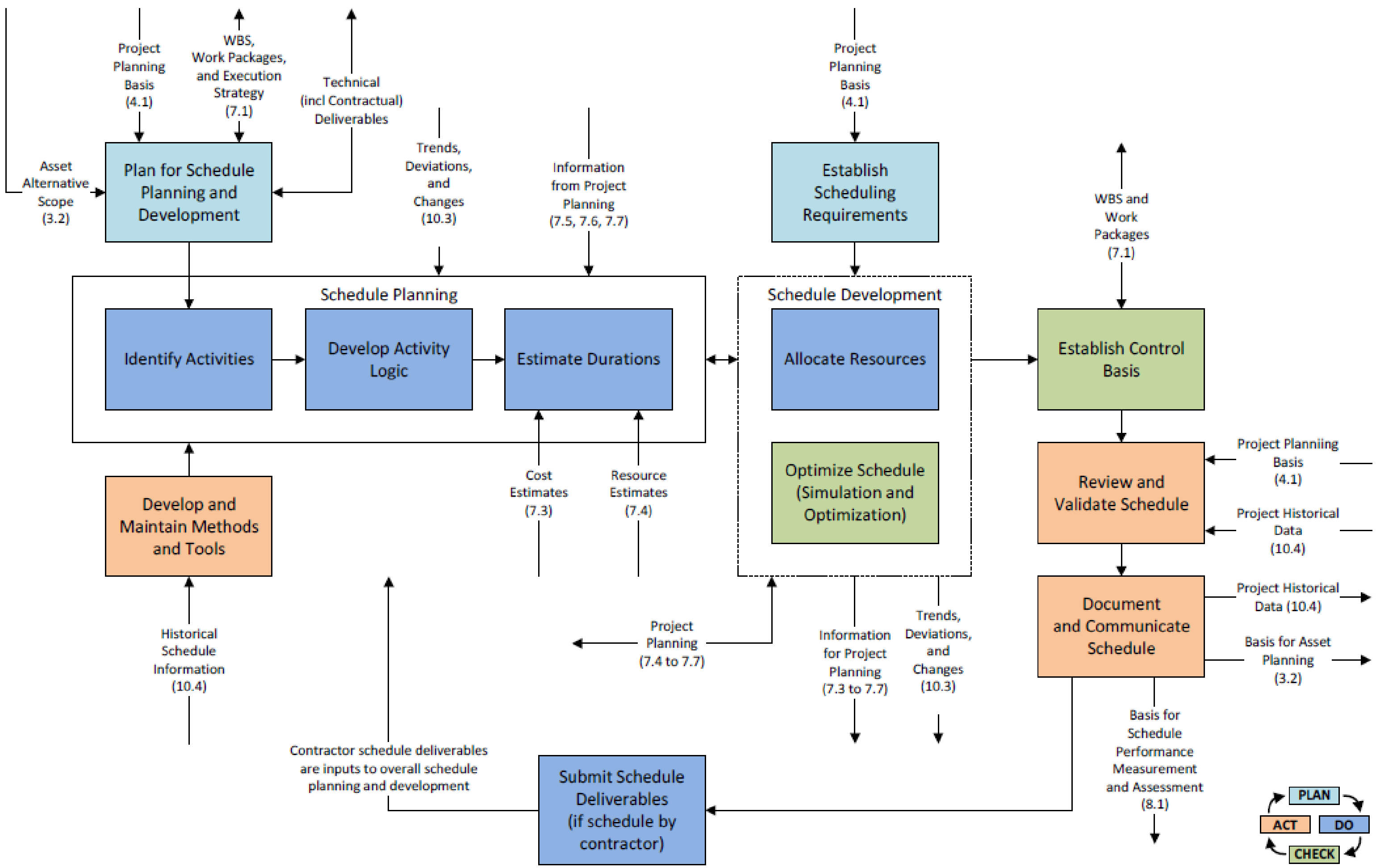



**Figure 7.2-1 Process Map for Schedule Planning and Development**

# Purpose of This RP

- This recommended practice provides information about
  1. **determining** the **original durations** for activities for developing the project schedule and
  2. **general considerations** related to the establishment of **remaining durations** while **updating** the project schedule.
- **Specific considerations** regarding the topic of establishing the activities **remaining durations** for schedule performance assessment are **not within the scope** of this RP.
  - Therefore, the **information presented** here generally applies to determining original activity durations; and

    **general considerations** for the establishment of **remaining durations** be provided **only as appropriate**.

# Purpose of This RP

- This **recommended practice** offers methods for determining original activity durations **through**
  1. the analysis of past project data with
  2. anticipated future performance data.

- It also incorporates an **iterative effect-analysis** of <u>constraints</u> on activity duration.

# Estimating basics

- **Many methods** have been used to determine schedule activity duration estimates; the number of continuous work periods required to complete an activity.
- Critical path method (CPM) is a **deterministic network model** that uses a **single** duration estimate,

  whereas program (or project) evaluation and review technique (PERT) is a **probabilistic** or **stochastic network** model that uses three duration estimates.

# Estimating basics

- In **either** of those methods the activity **duration is still an estimate** of the continuous time (in work-units) required to **perform the work** of an activity.

- This estimate normally takes into consideration the **nature** of the work and the resources needed to **complete an activity**; and

  it may also need to consider productivity impacts and nonstandard production rates needed to meet the **constraints** of a project.

# Estimating basics

- **Duration estimates** are typically made **through**
    1. the comparison of actual data with anticipated performance, and
    2. an effective analysis of constraints on activity duration.
- **Accurately estimating** activity durations is essential to developing schedules for which project milestones and completion dates can realistically be achieved.
- It is important to **estimate**
    1. **durations** that are realistic given the work to be done,
    2. the **resources** to be made available, and
    3. other influences and constraints on performance.

# Estimating basics

- Two performance areas are considered when estimating an activity's duration:
  1. past performance and
  2. expected future performance.
- From **past performance** the scheduler can
  1. **review** actual durations of similar activities **completed in the past** and
  2. **apply** professional judgment for **anticipated future** performance.
- This establishes a **basis for determining** an activity's duration,

  but does **not consider constraints** that may keep the activity from being completed within the planned time frame.

# Estimating basics

- There will be **some activities** for which there are **no past performance measures** to rely upon (e.g., in new technology, or work not performed in recent years).
  - If the organization does **not have prior experience** in the work activity there may be industrial databases or other resources to rely upon.
  - An **alternative** is to use the **PERT method** as described above.

# Critical path method

- Traditionally, the **Critical Path Method** uses deterministic (no randomness) values when applying activity durations.
- The Critical Path Method calculates the **longest path** of the project, establishing the earliest and latest dates that each activity can start and finish.
- The forward pass calculation allows you to determine the earliest start dates, while the backward calculation allows you to determine the latest dates.
- The forward and backward calculation allows you to identify the critical activities based on the total float.
- The "Total Float" represents the schedule flexibility and is measured by subtracting early dates to late dates of path completion.
- Total Float is the defining core of the Critical Path Method.

# PERT method

- The **PERT Method** or **Project Evaluation Review Technique** is a method to analyze the set of project activities that allows for **randomness** by introducing **uncertainty** to activity duration estimates.
- This is completed by determining the **expected time** for each activity.
- The following identifies the typical **PERT calculation**.

# PERT method

- $TE = (O + 4M + P) \div 6$

  Where:

  - TE = Expected Time
  - O = Optimistic Time (minimal amount of time)
  - M = Most Likely Time (the best estimated time)
  - P = Pessimistic Time (maximum amount of time)

ACEMI

# CPM and PERT method

- The CPM and PERT models can be **used in conjunction** with each other to develop an improved Critical Path that addresses **uncertainty**.

- Both the CPM and PERT models can be represented as Gantt or network diagrams.

# Realistic original durations

- Determining **realistic original durations** for schedule activities is essential for proper schedule development.
  - There is always a **chance** that **target** project milestone dates are not achievable given the scope of work to be performed and the resources made available.
  - **Realistic durations** should be utilized **even if** the **dates derived** from the time estimates do not meet target project requirements.

# Realistic original durations

- If the **target milestone dates** are **not in-line** with realistic project requirements,

  the **professional scheduler** should not reduce durations to fit the **target dates**

  **unless** explicit schedule adjustments have been **approved** that will provide

  more resources,

  reduce scope, or

  allow for some realistic alternative approach (e.g., parallel activities).

# AACE
# Recommended Practice

## (Introduction)

# Introduction

- This RP has been organized as follows:
    1. Phase I – Determine unconstrained activity durations
    2. Phase II – Adjust activity duration based on constraint impact
    3. Phase III – Revise activity original durations to meet project requirements
    4. Determining activity duration - flowcharts

# General guidelines for estimating a schedule’s activity duration

1. *Duration = Quantity of work / work units per time period.*

- Quantity of work is a function of the definition or scope of the activity.
- Work units per time period is commonly referred to as the production rate.

# General guidelines for estimating a schedule's activity duration

2. **Duration** is typically specified in **rounded continuous working time periods** in the unit common to the activity, e.g. hours, days, weeks, years, etc.

- Generally, durations are **rounded up** to the **next whole unit**,

  **even when the estimated** duration is **less than ½ a work unit** (e.g., if estimated duration calculates to 1.25 work days, it is rounded up to 2 work days).

# General guidelines for estimating a schedule’s activity duration

3. There are **some activities** which need to be **measured in calendar time periods** rather than **working time periods** (e.g., the time for curing of concrete).

# General guidelines for estimating a schedule's activity duration

4. Durations should be **estimated** using an analytical and systematic method

# General guidelines for estimating a schedule's activity duration

5. Activity or resource **calendars** should be used to **model constraints** related to a **particular time range** (e.g., winter, dry, or wet seasons)

so that the **effect on activity duration** does **not persist**

if the **activity slips** into or out of the **affected period**.

- *For example, if a project's start date slips 6 months, and an activity originally scheduled in the summer now occurs in the winter, the appropriate calendars will automatically adjust the activity's duration.*
- **Major shifts** in **start dates** should be reviewed with the **responsible performing organizations.**

# General guidelines for estimating a schedule's activity duration

6. The **basis** of activity duration **estimates** should be **identified as a part** of the <u>overall schedule basis documentation.</u>

# AACE
# Recommended Practice

## (Phase I – Determine Unconstrained Activity Durations)

# Phase I – Determine Unconstrained Activity Durations

1. The **approved project (baseline) estimate** can be used to determine unconstrained **original durations**.

- For **details** concerning **this process**, please refer to the **Supplemental Calculations** section of this **recommended practice**.

# Phase I – Determine Unconstrained Activity Durations

2. **Historical data** consists of actual duration data from **similar**, **previous projects** that can be used to estimate how long an activity may take in the **future**.

- **AACE RP 114R-20 Project Historical Database Development**, provides further information.
  - For example, historical project data provides that for a particular activity:

# Phase I – Determine Unconstrained Activity Durations

| Project Name | Completed Activity | Average Actual Duration (Days) |
|---|---|---|
| Completed Project 1 | Issue Purchase Req. | 10 |
| Completed Project 2 | Issue Purchase Req. | 5 |
| Completed Project 3 | Issue Purchase Req. | 8 |
| Completed Project 4 | Issue Purchase Req. | 6 |

**Table 1 – Sample Historical Project Data**

# Phase I – Determine Unconstrained Activity Durations

2. **Assume** that these **actual average** **activity durations** are normally distributed, and compute a confidence interval on the **mean duration**.

- This is **better than** just **taking an average** since it gives a **range of values** instead of a single number.
  - The **confidence interval** for the above example would be **roughly 7 days ±2 days**.
    - ✓ This means that the **next duration** could be anywhere from **5 to 9 days**.

# Phase I – Determine Unconstrained Activity Durations

2. **Assume** that these **actual average** **activity durations** are normally distributed, and compute a confidence interval on the **mean duration**.

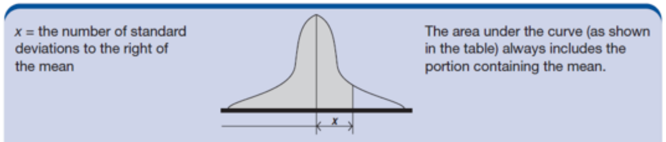
- This calculation gives the **shortest** and **longest** probable original activity durations **based on historical data**.
- Any **analysis of historical data** requires normalization for scope and other characteristics that may affect the data.
- **Refer to statistical texts** to understand data analysis, and the confidence level (and risk) associated with **these types of calculations.**

# Phase I – Determine Unconstrained Activity Durations



## What if delay may occur to activity durations – Method 2: Bell-shaped curve

### Area Under a Standard Normal Curve




| x | .00 | .01 | .02 | .03 | .04 | .05 | .06 | .07 | .08 | .09 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | .50000 | .50399 | .50798 | .51197 | .51595 | .51994 | .52392 | .52790 | .53188 | .53586 |
| 0.1 | .53983 | .54380 | .54776 | .55172 | .55567 | .55962 | .56356 | .56749 | .57142 | .57535 |
| 0.2 | .57926 | .58317 | .58706 | .59095 | .59483 | .59871 | .60257 | .60642 | .61026 | .61409 |
| 0.3 | .61791 | .62172 | .62552 | .62930 | .63307 | .63683 | .64058 | .64431 | .64803 | .65173 |
| 0.4 | .65542 | .65910 | .66276 | .66640 | .67003 | .67364 | .67724 | .68082 | .68439 | .68793 |
| 0.5 | .69146 | .69497 | .69847 | .70194 | .70540 | .70884 | .71226 | .71566 | .71904 | .72240 |
| 0.6 | .72575 | .72907 | .73237 | .73565 | .73891 | .74215 | .74537 | .74857 | .75175 | .75490 |
| 0.7 | .75804 | .76115 | .76424 | .76730 | .77035 | .77337 | .77637 | .77935 | .78230 | .78524 |
| 0.8 | .78814 | .79103 | .79389 | .79673 | .79955 | .80234 | .80511 | .80785 | .81057 | .81327 |
| 0.9 | .81594 | .81859 | .82121 | .82381 | .82639 | .82894 | .83147 | .83398 | .83646 | .83891 |
| 1.0 | .84134 | .84375 | .84614 | .84849 | .85083 | .85314 | .85543 | .85769 | .85993 | .86214 |
| 1.1 | .86433 | .86650 | .86864 | .87076 | .87286 | .87493 | .87698 | .87900 | .88100 | .88298 |
| 1.2 | .88493 | .88686 | .88877 | .89065 | .89251 | .89435 | .89617 | .89796 | .89973 | .90147 |
| 1.3 | .90320 | .90490 | .90658 | .90824 | .90988 | .91149 | .91309 | .91466 | .91621 | .91774 |
| 1.4 | .91924 | .92073 | .92220 | .92364 | .92507 | .92647 | .92785 | .92922 | .93056 | .93189 |
| 1.5 | .93319 | .93448 | .93574 | .93699 | .93822 | .93943 | .94062 | .94179 | .94295 | .94408 |
| 1.6 | .94520 | .94630 | .94738 | .94845 | .94950 | .95053 | .95154 | .95254 | .95352 | .95449 |





## What if delay may occur to activity durations – Method 2: Example

- The estimate from the **masonry contractor**, and the estimate from the **carpet installer was 20 days**.
- Both used data on **seven prior projects** that were **similar** to the one being constructed.

| | Masonry Data | | Carpet Data | |
|---|---|---|---|---|
| Project # | Duration (Dur) | (Dur-Mean)$^2$ | Duration (Dur) | (Dur-Mean)$^2$ |
| 1 | 14 | 36 | 18 | 4 |
| 2 | 17 | 9 | 21 | 1 |
| 3 | 27 | 49 | 19 | 1 |
| 4 | 16 | 16 | 22 | 4 |
| 5 | 18 | 4 | 17 | 9 |
| 6 | 25 | 25 | 22 | 4 |
| 7 | 23 | 9 | 21 | 1 |
| | $\text{Sum}_1 = 140$ | $\text{Sum}_2 = 148$ | $\text{Sum}_1 = 140$ | $\text{Sum}_2 = 24$ |
| | $\text{Mean}_1 = 20$ | $(\text{Sum}_2/n-1)^{1/2} = 4.97$ | $\text{Mean}_1 = 20$ | $(\text{Sum}_2/n-1)^{1/2} = 2$ |
| | $n = 7$ | Std. Dev. = 5 (approx.) | $n = 7$ | Std. Dev. = 2 |

- **95 percent confident**, the estimate must be **1.645 standard deviations** beyond the mean.
  - About 28 days for the masonry work (20 + 1.645 * 5 = 28.2).
  - About 23 days (20 + 1.645 * 2 = 23.3) for carpet.

ACEMI

# Phase I – Determine Unconstrained Activity Durations

3. **Professional judgment** may be used to **help determine** an activity's estimated duration.

- Often, **key project team members** can provide their **experience related to particular types of work** activities.
- Their knowledge may reveal that doing work in <u>certain geographical areas </u>or under <u>specific climatic conditions </u>generally takes **shorter or longer** than anticipated.
- Using the **opinion** of an experienced professional helps to identify **non-typical conditions** to consider when assigning original durations to those activities.

# Phase I – Determine Unconstrained Activity Durations

4. The **original activity durations** may be dependent on the **level of the schedule** being produced.

- *For example, in a Level 1 schedule the duration for an activity may be based upon historical information as described above;*

  *while for a Level 2 schedule, the duration may be calculated using a more detailed method as described in the Supplemental Calculations below.*

# Phase I – Determine Unconstrained Activity Durations

- **Any or all of these methods** can be determined using single-point estimate durations or other stochastic techniques, such as PERT.

# Phase I – Determine Unconstrained Activity Durations - Flowcharts

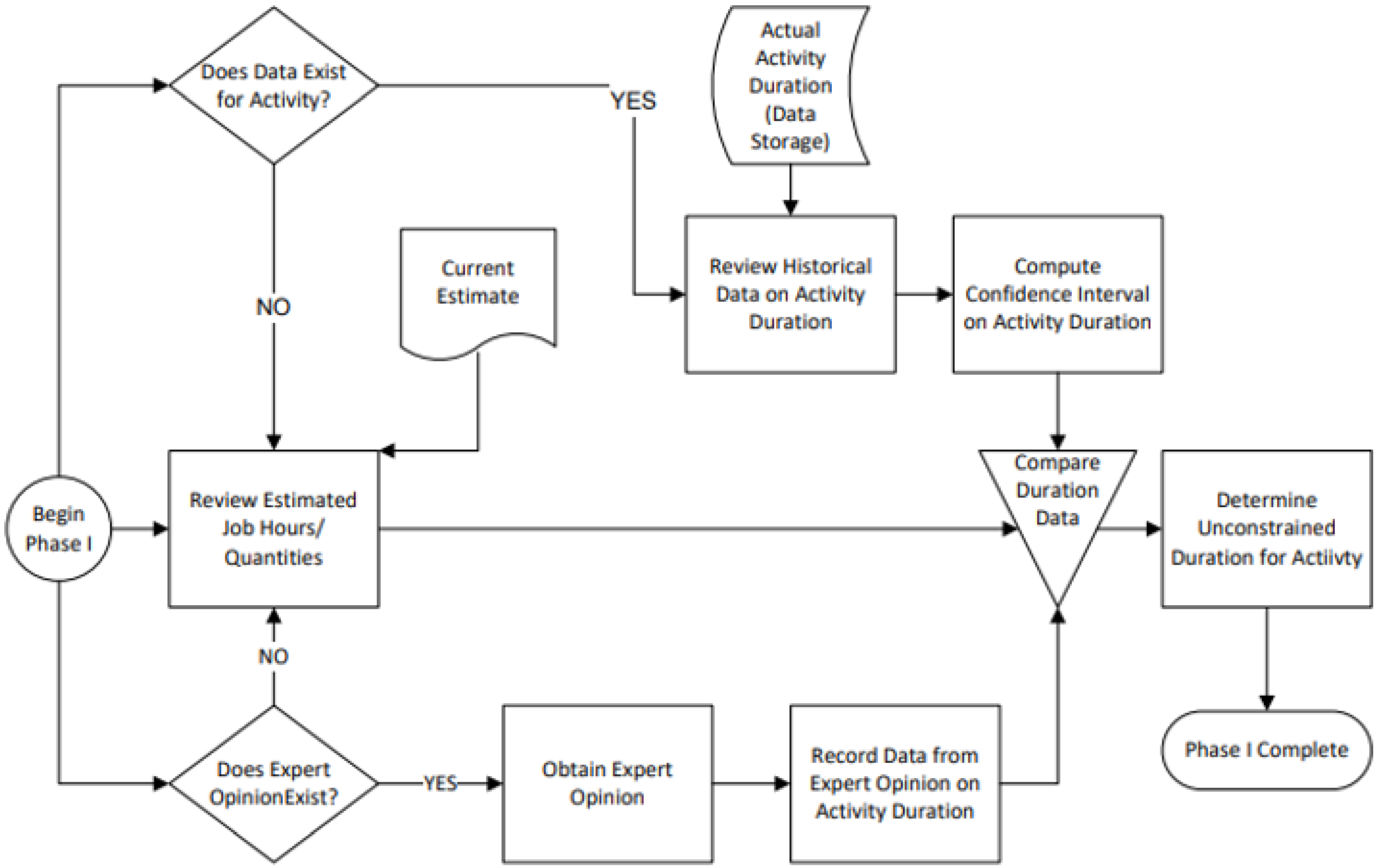
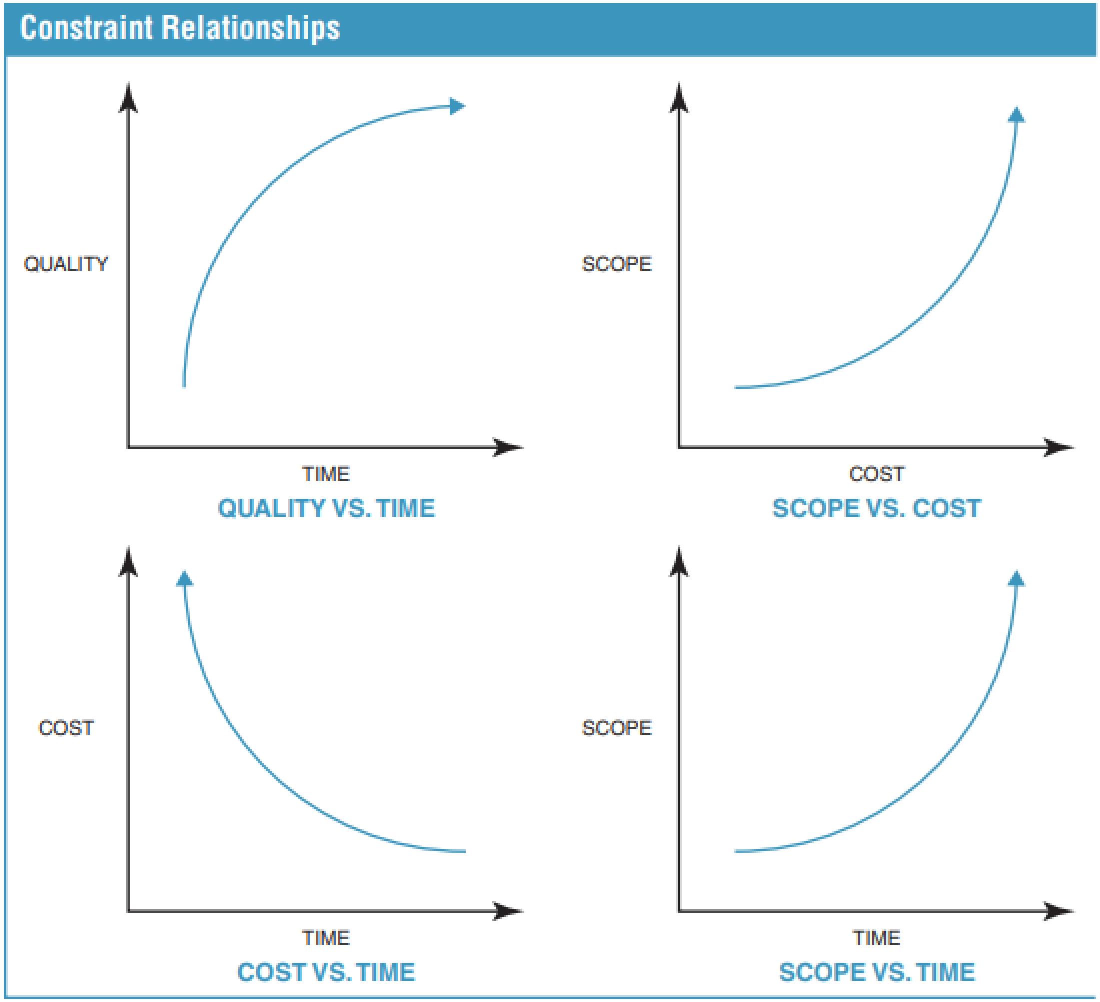



**Figure 1 – Phase I: Determine Unconstrained Activity Durations**

# AACE
# Recommended Practice

## (Phase II – Adjust Activity Duration Based on Constraint Impact or Other Limiting Factors)

# Phase II – Adjust Activity Duration Based on Constraint Impact or Other Limiting Factors



# Phase II – Adjust Activity Duration Based on Constraint Impact or Other Limiting Factors

- Once a well thought out and developed plan has been prepared using the **unconstrained activity durations** determined in Phase I, and

  the **scheduler** has understood the dynamics and the effect that activity durations have on the **plan as a whole**,

  **then the scheduler** should proceed to consider any effects that constraints or other limiting factors (e.g. site, location, seasons, etc.) might have on the activity durations.

# Phase II – Adjust Activity Duration Based on Constraint Impact or Other Limiting Factors

- The **impact of constraints** must be considered and accounted for when estimating activity duration.
- Some constraints may only affect **certain activities** and not others.
- This recommended practice suggests **creating a list of possible constraints**.
- The list should include any known or anticipated constraints that could adversely affect activity duration.
- The list should then be cross referenced against **each activity** to determine if the **constraint** could **potentially affect** that particular activity.

Factors to consider may include (but are not limited to):

# Phase II – Adjust Activity Duration Based on Constraint Impact or Other Limiting Factors

- Resource availability
- Factors affecting productivity
- Contract requirements and restraints
- Nature of the work / scope of work
- Labor and equipment productivity
- Means and methods planned
- Permit and local ordinance requirements and restrictions
- Management skill / constraints
- Material and equipment availability
- Seasonal / location considerations

# Phase II – Adjust Activity Duration Based on Constraint Impact or Other Limiting Factors

- Work restrictions (union vs. non-union, work rules and constraints, length of workday, # of work-shifts per day, etc.)
- Quality of work (contract specifications requirements)
- Subcontractor and vendor considerations
- Engineering deliverables / client, third-party influences and deliverables
- Fast-tracking / concurrency of work

# Phase II – Adjust Activity Duration Based on Constraint Impact or Other Limiting Factors

- If the constraint has the **potential to affect** an activity,

  the **scheduler should create** a calendar that takes into consideration the constraints that affect any of the activity's resources or scope.

- **Not all constraints** can be modeled through resource and activity calendars.
- In such instances, it is **critical** to fully document all

  1. assumptions and
  2. activity duration modifications.

- The **scheduler** should note that some activities may be **inherently fixed in duration**, and therefore un-adjustable.

# Phase II – Adjust Activity Duration Based on Constraint Impact or Other Limiting Factors

- An **example of a constraint** might be equipment availability.
  - *Suppose a portion of a project includes machining secondary parts on an existing milling machine during the month of January.*
  - *It is also known that January is generally a high production time and that the milling machine generally runs high priority parts during this period.*
  - *Since not all of the parts may be run at once, the scheduler should assign a calendar to the resources or the activities associated with this section of the work.*
- As a side note, the **scheduler might also consider** rescheduling these activities during a **less busy** production time.

# Phase II – Adjust Activity Duration Based on Constraint Impact or Other Limiting Factors - Flowcharts

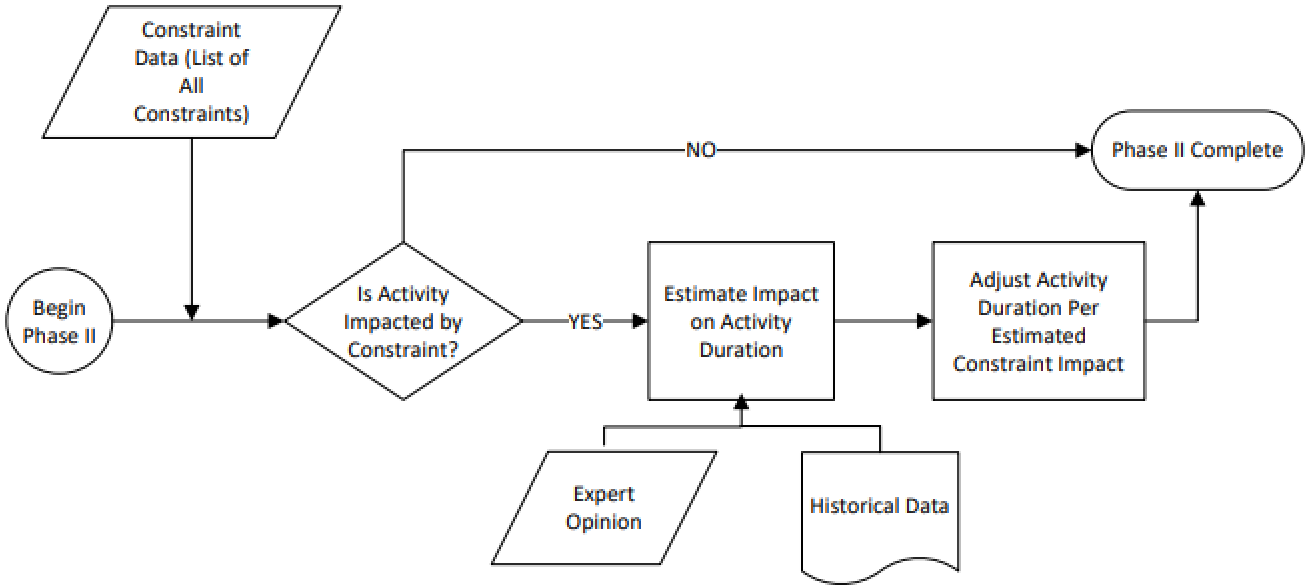



**Figure 2 – Phase II: Adjust Activity Duration Based on Constraint Impact**

# AACE
# Recommended Practice

## (Phase III – Revise Original Activity Durations to Meet Project Requirements)

## Phase III – Revise Original Activity Durations to Meet Project Requirements

- Once **realistic original durations** (whether constrained or unconstrained) are determined for each activity,

  the **scheduler must examine** whether project requirements or milestones can be met as modeled.

- A **project requirements list** should be developed that **contains**
  1. all milestone dates that **must be met**, as well as
  2. all known contract and permit restraints.

- These requirements may include customer incentives based on **good performance** or **required completion dates** of **deliverables**.

# Phase III – Revise Original Activity Durations to Meet Project Requirements

- If all project requirements and milestones are **met**, the **schedule is ready** for final project team **review** and **approval**.
  - However, **if certain activities** **prevent** the project from achieving required milestone dates,

    the **scheduler should work** with the project team to **identify** realistic and achievable actions needed to allow **durations to be reduced** so that these important dates may be **met**.
    - Such **actions may be** to
      1. reduce scope (de-scoping),
      2. add resources (crashing),
      3. schedule activities in parallel (fast-tracking) or
      4. other changes to schedule logic.

## Phase III – Revise Original Activity Durations to Meet Project Requirements

- If **schedule adjustment** is necessary to **accomplish milestone dates**,

  the **scheduler** should create a corrective action list that contains **all feasible actions** that may be used to **decrease** an **activity's duration**.

  - **Activity durations** should **not** be reduced unless project management **approves** the required actions.

- Specifically, activity durations should **not be reduced** just to meet owner / contractual constraints,

  but **recommendations** should be made as to **identify** the required modifications to **realistically shorten** durations.

# Phase III – Revise Original Activity Durations to Meet Project Requirements



- **Examples** of corrective actions for schedule **compression** include:
  1. more intensive use of existing resources (scheduled overtime),
  2. adding resources, and/or
  3. offering schedule incentives to key suppliers or subcontractors.

  Other examples of corrective actions might be to

  - parallel similar work activities or
  - increase crew size

  to **potentially reduce** the time required for completing an activity.

## Phase III – Revise Original Activity Durations to Meet Project Requirements

- The **scheduler** is **advised** to **analyze** all activities on
  1. the critical path(s),
  2. near-critical path(s) and
  3. large float path(s)

  to **determine** **how** those activities that are not on the critical path(s) may be **interrupted** to

  **allow** for orderly crew resource flow to **meet the requirements** of the project requirements without large swings in **required resources**.
- **Any modifications** to reduce activity durations may be associated with **additional risk** or **potential rework**.

## Phase III – Revise Original Activity Durations to Meet Project Requirements

- If **corrective actions** to reduce schedule impact the estimated cost, the **cost** should be **reflected** in the basis of estimate.
  - The **scheduler** should understand and take into account the **trade-offs** between cost and schedule in any **revisions to activity durations** and seek project team **approval**.

# Phase III – Revise Original Activity Durations to Meet Project Requirements - Flowcharts

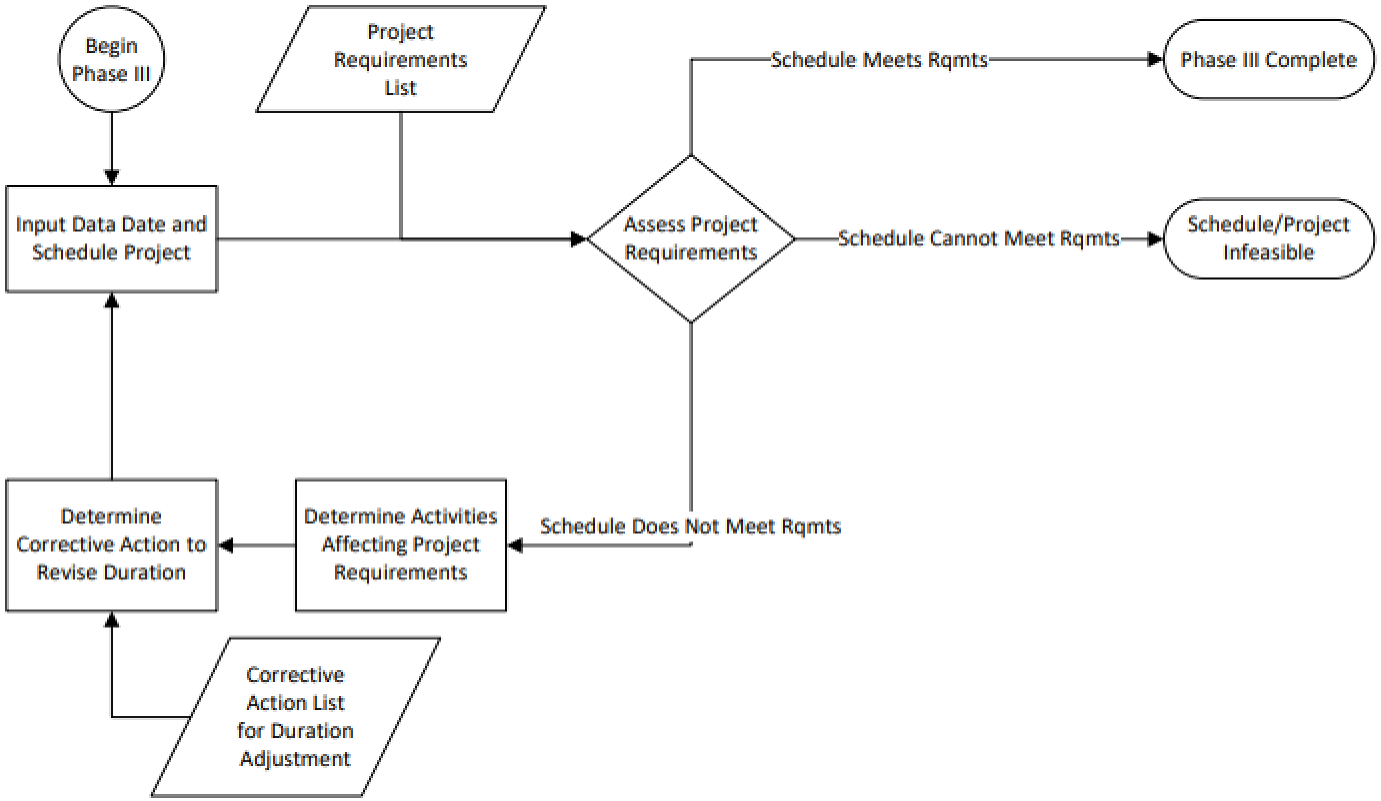



**Figure 3 – Phase III: Revise Activity Durations to Meet Project Requirements**

# AACE
# Additional Information to consider

## (Calculating Remaining Durations)

# Calculating Remaining Durations

- The phases described in this RP **also apply** to the process of **establishing** remaining durations **when**
  1. **updating** a schedule or
  2. **preparing** a forecast or schedule to complete.

- **Previous period's data** should be evaluated to **establish patterns** in activities durations.

# Calculating Remaining Durations

- When **evaluating** remaining durations, the **rules for updating actual dates** should be reviewed.
- Basically, **every start and finish date** before (to the left of) the data date should be an **actual date**; and

  there should be **no actual dates after** (to the right of) the data date.
- If the scheduling **software does not enforce** these rules,

  then **error filters** should be **created to highlight** these conditions for **correction prior** to estimating remaining durations.
- It is also **recommended** that the **entry of actual dates** be validated and **not assumed** to **occur as planned**.

# Calculating Remaining Durations

- If **no other information** is available to the scheduler one alternative is to use a **variation to the Blinders Method**.
  - This method assumes a **straight line progress**.

# Calculating Remaining Durations

i. IF: data date (DD) - actual start of the activity (AS) < original duration (OD),

- THEN: remaining duration (RD) = OD - (DD - AS)

# Calculating Remaining Durations

ii. IF: DD - AS > OD,

- ❖ THEN: RD = 1, but should be re-assessed.

# Calculating Remaining Durations

iii. If an AS date is missing and

a valid actual finish of the activity (AF) date is given,

remaining durations and percent completes are ignored and

the revised activity duration is determined on the basis of

1. the AF and
2. the specified duration (original duration is assumed as actual duration).

# Calculating Remaining Durations

v. If AS and AF dates are missing,

the revised activity duration is determined on the basis of

1. the remaining duration and
2. percent complete.

# AACE
# Additional Information to consider

## (Duration Relationship with Actual Start and Finish Dates)

# Duration Relationship with Actual Start and Finish Dates

- The **following conventions** usually **apply when** either actual start (AS) and/or actual finish (AF) dates are **specified** for an activity:

  i. **If both AS and AF dates are specified**,

  the **revised activity duration** is computed as the time period,

  between the AS and the AF,

  **excluding non-working periods** (working time versus calendar time).

# Duration Relationship with Actual Start and Finish Dates

- The **following conventions** usually **apply when** either actual start (AS) and/or actual finish (AF) dates are **specified** for an activity:

    ii. **If AS is specified without an AF**,

    the **revised activity duration** is **computed** as

    the **sum** of the

    1. elapsed duration and
    2. the remaining duration.

# Duration Relationship with Actual Start and Finish Dates

- The **following conventions** usually **apply when** either actual start (AS) and/or actual finish (AF) dates are **specified** for an activity:

  iii. **If AS is specified and both an AF and an RD are missing**, the revised activity duration is **computed** on the basis of

  1. the elapsed duration and
  2. the physical percent complete.

# Duration Relationship with Actual Start and Finish Dates

- The **following conventions** usually **apply when** either actual start (AS) and/or actual finish (AF) dates are **specified** for an activity:

    iv. If AS is specified - and

    AF, remaining duration, or percent complete are not specified –

    the activity duration is **not revised** (it is **assumed** that the activity will be **completed within the original duration** as identified in the baseline schedule).

# AACE
# Additional Information to consider

**(Risk and Activity Duration Variability )**

# Risk and Activity Duration Variability

- **Several alternatives** have been devised to take into **consideration risk** when determining the activity duration.
- As mentioned at the beginning of this RP, PERT is a probabilistic or stochastic network model that uses three duration estimates.

# Risk and Activity Duration Variability

- **Variations** to the **three-point estimate** have been derived using weighted averages for **triangular** and **beta** distributions. For example:

    i. Weighted average using a triangular distribution

    *Duration = (Optimistic Duration + Most Likely Duration + Pessimistic Duration)/3*

# Risk and Activity Duration Variability

- **Variations** to the **three-point estimate** have been derived using weighted averages for **triangular** and **beta** distributions. For example:

ii. Weighted average using an example of a beta (PERT) distribution

*Duration = (Optimistic Duration + 4*Most Likely Duration + Pessimistic Duration)/6*

# Risk and Activity Duration Variability

- The **scheduler needs** to understand the underlying risk associated with any particular method.

# AACE
# Additional Information to consider

## (Contract/Scheduling Specifications Requirements)

# Contract/Scheduling Specifications Requirements

- **Contract scheduling specifications** sometimes require artificial constraints that pre-determine duration **limits**, and minimum or maximum values for an activity duration.

  If this is the case, then the **scheduler must comply** with these requirements.

# AACE
# Additional Information to consider

## (Software Issues)

# Software Issues

- **Not all software uses** the same scheduling algorithm so the scheduler may encounter **different results** from different software.
  - For further information about such considerations see AACE International Recommended Practice No. 29R-03, Forensic Schedule Analysis.

# AACE
# Supplemental Calculations

## (Calculating Original Durations Using the Approved Estimate)

# Calculating Original Durations Using the Approved Estimate

- The estimate can be used as a **basis for determining** an activity's original duration. The **estimate** does **not provide** the production rate or the amount of work required for each activity.
  - Therefore, it is necessary to ensure that the proper resources, and corresponding quantities, are assigned to each activity.
    - ✓ This is the **first step** in using the estimate as a basis for the **original activity** duration.
      - ➢ Based on input from the project team, the **following example table** can be created:

# Calculating Original Durations Using the Approved Estimate

| Design WBS | | |
|---|---|---|
| **Activity 1** | Estimated Hrs to Complete | Crew Size |
| Resource 1 - Civil Eng | 20 | 1 |
| Resource 2 - Mechanical Eng | 100 | 2 |
| Resource 3 – Environmental Eng | 10 | 1 |

| **Activity 2** | Estimated Hrs to Complete | Crew Size |
|---|---|---|
| Resource 1 - Civil Eng | 30 | 2 |
| Resource 2 - Mechanical Eng | 50 | 1 |
| Resource 3 - Environmental Eng | 45 | 1 |

**Table 2 – Sample Calculations**

# Calculating Original Durations Using the Approved Estimate

- Once this **table has been created** for each activity the **duration can be estimated** for the activities using the following **formula**:

$$Duration = \left[\left(\frac{R1\ Total\ Hrs\ for\ activity}{R1\ Crew\ Size\ for\ activity}\right) \Big/ (Estimated\ Workday\ in\ Hrs)\right] \times (R1\ Workload\ Factor)$$

$$+ \left[\left(\frac{R2\ Total\ Hours\ for\ activity}{R2\ Crew\ Size\ for\ activity}\right) \Big/ (Estimated\ Workday\ in\ Hrs)\right] \times (R2\ Workload\ Factor)$$

$$+ \left[\left(\frac{Rn\ Total\ Hours\ for\ activity}{Rn\ Crew\ Size\ for\ activity}\right) \Big/ (Estimated\ Workday\ in\ Hrs)\right] \times (Rn\ Workload\ Factor)$$

Where,

*R1, R2...Rn* = The resources needed to complete each portion of an activity.
*Crew Size* = The number of each resource used to complete the activity.
*Workload Factor* = Reflects workload of each resource. Higher workload factors indicate less productivity and longer activity original durations. Workload factors are typically determined from historical data and experience.

# Calculating Original Durations Using the Approved Estimate

- Using the model described the following table can be obtained.
  - Assumptions for the model are:
    - ✓ Each resource (R1, R2, R3, etc.) work only on their portion of the activity (no cross-trained resources).
    - ✓ Resources DO NOT work in parallel to accomplish the work.
    - ✓ The schedule logic is correct.
    - ✓ One workday equals eight hours.

# Calculating Original Durations Using the Approved Estimate

| Design WBS | | | | | |
|---|---|---|---|---|---|
| **Activity 1** | Estimated Hrs to Complete | Crew Size | Original Duration (Days) | Workload Factor (Number of Units) | New Duration (Days) |
| Resource 1 - Civil Eng | 20 | 1 | 2.5 | 2.0 | 5 |
| Resource 2 – Mech. Eng | 100 | 2 | 6.25 | 3.0 | 18.75 |
| Resource 3 - Env. Eng | 10 | 1 | 1.25 | 2.0 | 2.5 |
| | | | | **Activity Duration** | **26.25** |

| **Activity 2** | Estimated Hrs to Complete | Crew Size | Original Duration (Days) | Workload Factor (Number of Units) | New Duration (Days) |
|---|---|---|---|---|---|
| Resource 1 - Civil Eng | 40 | 2 | 2.5 | 2.0 | 5.0 |
| Resource 2 – Mech. Eng | 60 | 1 | 7.5 | 3.0 | 22.5 |
| Resource 3 - Env. Eng | 40 | 1 | 5.0 | 2.0 | 10.0 |
| | | | | **Activity Duration** | **37.5** |

**Table 3 – Sample Calculations**

# Calculating Original Durations Using the Approved Estimate

- For **resources working** in parallel the **MAXIMUM duration** calculated **between resources** would be used.
  - *For example, the total duration for Activity 1 would be 19 (18.75 rounded) days instead of 27 (26.25 rounded) days. Activity 2 would be 23 (22.5 days rounded) rather than 38 days (37.5 days rounded).*

# Calculating Original Durations Using the Approved Estimate

- **While this model** provides a way to determine **original activity durations**, it should **not be used as the sole basis** for deciding original durations.
- As the **flowchart shows**,

  **all data** should be merged to make a decision on an activity's duration.
- By using **more than one approach** to determine original durations,

  the scheduler can get a **much better idea** of how the work will be performed.
- Ultimately this results in a project schedule which has a **greater opportunity** for **successful completion**.

# Calculating Original Durations Using the Approved Estimate

- As with other duration calculations, attention needs to be paid to the activity or resource calendars.

# Improving Duration Accuracy

ACEMI

# Improving Duration Accuracy

- The **accuracy** of the estimated activity durations can **usually be improved** in the following ways:
  - **Divide** activities into **smaller activities**, which will increase activity detail and duration estimate accuracy.
  - Use **several sources** of productivity information.
  - **Avoid bias** when estimating and assigning activity durations.
  - **Consider** each activity <u>independently</u> and **randomly move around** the schedule.
  - **Don't** follow **specific logic paths**.
  - **Continually review** and **update** activity durations as construction progresses.
  - **Bring the people responsible** for performing the work into the planning and scheduling process by getting input and reviewing estimated activity duration with them.

# Incorporating Weather Into the Schedule

- There are **three methods** for accounting for **normal weather** in the schedule:
  1. **Limit** the number of workdays available during a **particular season** based on experience or **historical weather data**.
  2. **Add** a percentage of time to **weather-sensitive activities** based on the time of year that the activity is planned.
  3. **Estimate** the total impact of weather on activities and **add** time for weather as a **separate activity** during
     1. weather-sensitive periods or
     2. as the final schedule activity

     where the entire project is weather sensitive.

# Duration Verification

# Estimating life cycle

- **Assigning** and **verifying** activity durations during the course of a project can be **split** into three time periods.
- Each of these time periods **requires separate sets of inputs** to successfully accomplish the goals of the procedures.

# Estimating life cycle

- **Pre-Construction**—the utilizing of **historical** achieved data to **plan future performance** on like-scoped activity durations.
- **Pre-Construction and In-Progress Construction**—the checking of data against **project records** or **national clearinghouse information** for **validation** of planned durations.
- **In-Progress and Post-Construction**—the use of comparisons such as **actual** durations versus **original** durations to evaluate the sufficiency of assigned planned durations compared to actual progress on the project.

# Estimating life cycle

- During the pre-construction and planning phases of a project, the assignment of durations to activities that comprise the planned schedule of performance should be based on the **best information available**.
- Frequently, this information should be culled from the **historical record** of **like-scoped performance** on **past projects**.
- When utilizing **past production rates**, it is important to note any **impacts that might have been present** on the project that could have affected the achieved productions rates.

# Estimating life cycle

- Weather, owner-mandated construction limitations (security, time of day, and year restrictions, etc.), and experience learning curves for unfamiliar types of construction all can affect the results.
- Once comfortable with capturing the information present in the historical project information,

  it should be **applied** to planned individual- or crew-hours of performance.
- During pre-construction or actual construction on a project, the **need to verify** durations may arise.

# Estimating life cycle

- **Company-specific** historical productivity records to compare current planned durations **might not exist**.
- **Specialty scopes of work** that are inherent in a project might **not have prior performance records.**
- In these cases the scheduler or estimator can **consult** the **myriad of national** clearinghouse information for similar scope productivity.
  - Resources like R. S. Means, Building Construction Cost Data, or Richardson Construction Estimating Standards, to name a few, show expected productivity rates for specific work scopes.
- This information is usually **presented** in both man-hours and crew-hours.

# Estimating life cycle

- When utilizing this information, it is important to **factor** in the **suggested crew sizes** that are assigned to the **productivity rates**.
- This is evidenced by the relatively static nature of these rates over the **last 20 years of publishing resources** years of publishing resources.

# Estimating life cycle

- Finally, during the post-construction period,

  influences or factors that drove **actual performance** should be

  1. **identified** and
  2. **categorized**

  for the sake of planning **future projects.**

- **Scheduling diagnostics** can be run in order to **find scopes of work** that were **prosecuted** much more aggressively or passively compared to the original planned duration.

- These diagnostics can also be run **during the course** of the project to help explain the **degree** to which impacts are **hampering efforts.**

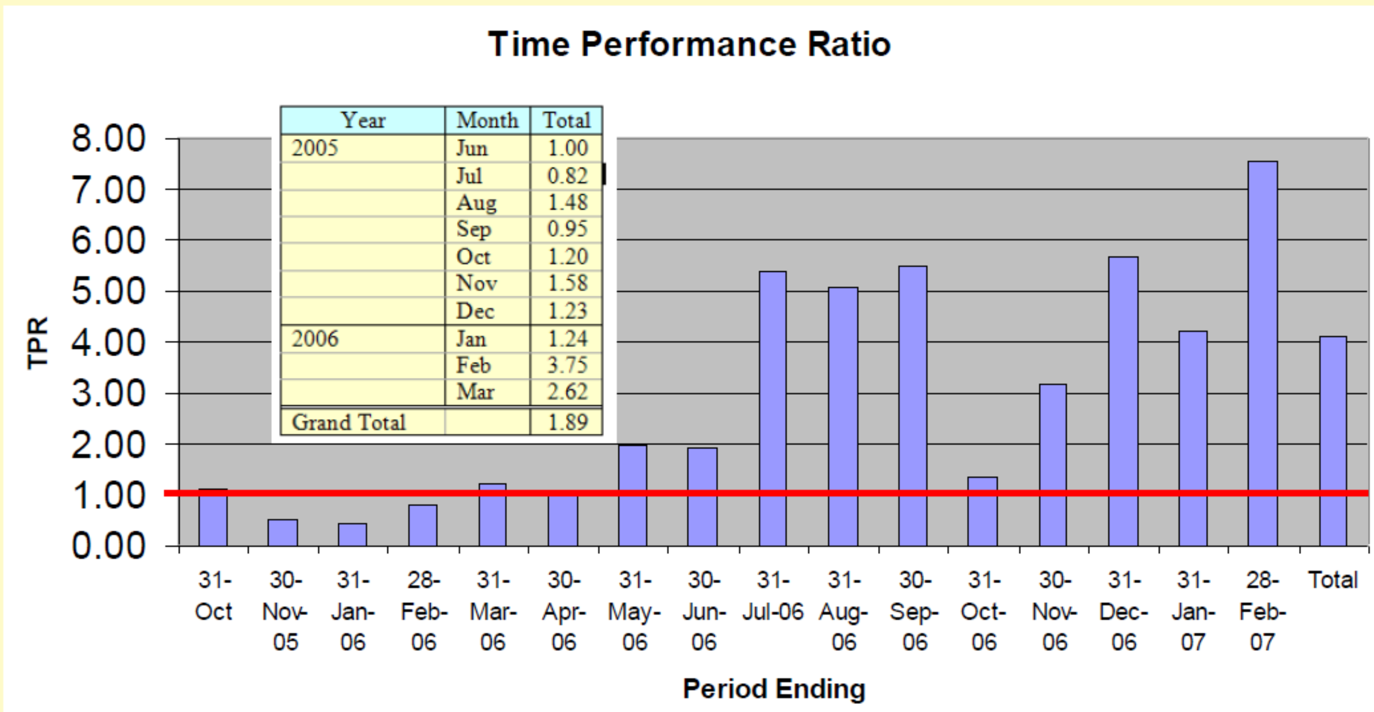
ACEMI

# Time Performance Ratio (TPR)

- One **valuable diagnostic tool** that can be run on durations is a comparison called the **Time Performance Ratio (TPR).**
- The TPR is a **simple mathematical equation** that divides the actual performance time by the planned duration.
- **Activities with TPRs** of **over one** have had their actual performance lag compared to plan, while those with TPRs of **less than one** have actually proceeded **quicker than planned.**
- All activities can then be **categorized by the TPR values**, and the worst performing activities, in terms of actual time compared to plan, can be **investigated for impact causation.**

# Time Performance Ratio (TPR)

- Review (TPR) Time Performance Ratio trending (AD/OD)



| Year | Month | Total |
|---|---|---|
| 2005 | Jun | 1.00 |
| | Jul | 0.82 |
| | Aug | 1.48 |
| | Sep | 0.95 |
| | Oct | 1.20 |
| | Nov | 1.58 |
| | Dec | 1.23 |
| 2006 | Jan | 1.24 |
| | Feb | 3.75 |
| | Mar | 2.62 |
| Grand Total | | 1.89 |

# Time Performance Ratio (TPR)

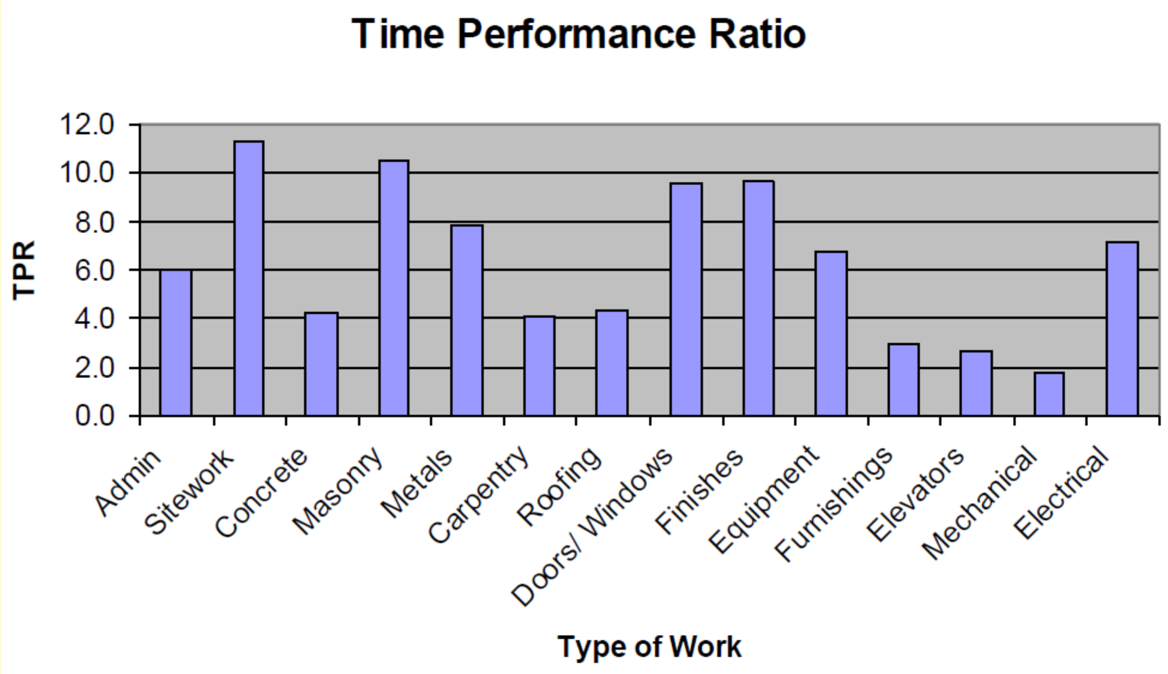
Review (TPR) Time Performance Ratio trending by Milestor
by Responsible Contractor (AD/OD)

**Table #3a, TPR Responsibility Summary**

| Milestone | HB | HBRC | HRU | JCD | WCE | WM | Grand Total |
|---|---|---|---|---|---|---|---|
| 1 | 0.78 | 3.00 | 30.00 | 1.00 | 2.30 | | 4.49 |
| 3 | 1.77 | | 10.75 | | | | 8.51 |
| 4 | 1.67 | | 1.00 | 0.83 | | | 1.03 |
| 5 | 5.83 | | | 0.50 | | 1.00 | 2.33 |
| 70 | 0.86 | 1.00 | | | 1.00 | | 0.99 |
| 90 | | | 1.00 | | | | 1.00 |
| 7A | 8.40 | 0.15 | 1.20 | 1.45 | | | 1.87 |
| 7B | 3.96 | 0.05 | 1.40 | | | | 2.67 |
| 7C | 2.01 | 0.05 | 1.33 | | | | 1.48 |
| 7D | 4.27 | | 0.78 | | | | 2.52 |
| 7E | 2.55 | | | | | | 2.55 |
| 8A | 5.60 | | | | | | 5.60 |
| 8B | 4.19 | | | | | | 4.19 |
| 9A | | | 2.70 | 1.71 | | | 2.32 |
| 9B | | | | 1.01 | | | 1.01 |
| Grand Total | 3.55 | 0.97 | 2.84 | 1.23 | 1.26 | 1.00 | 1.84 |

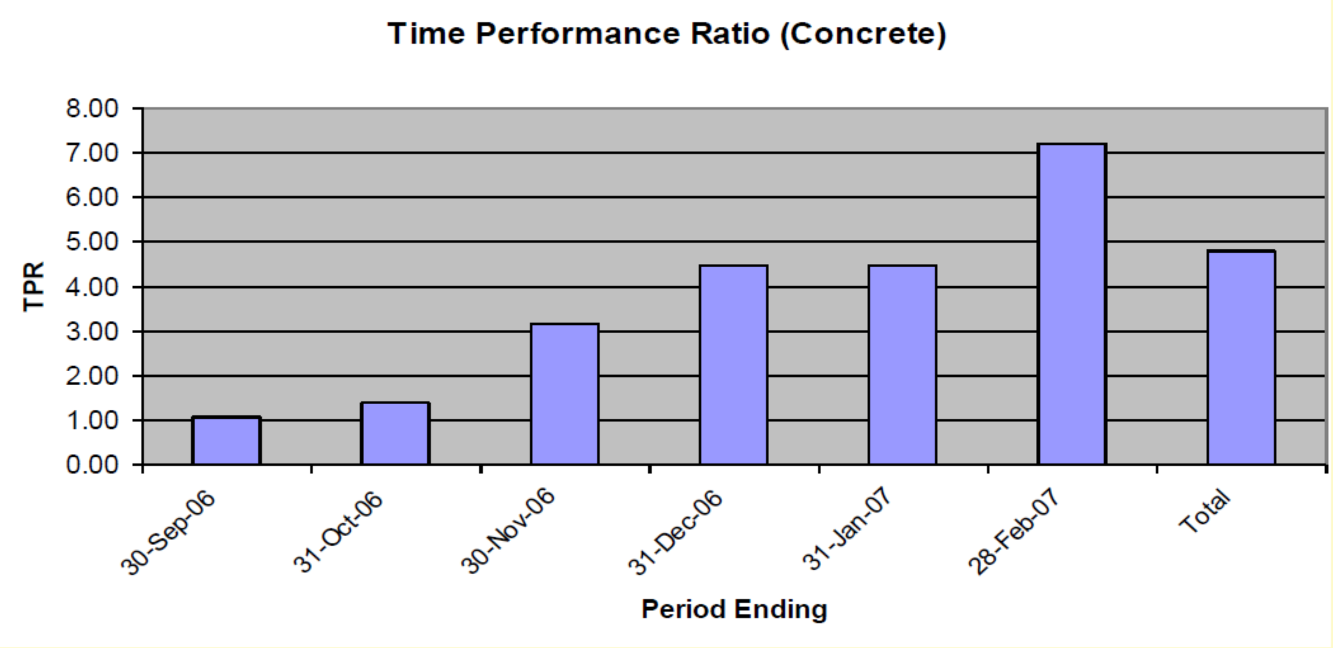
# Time Performance Ratio (TPR)

- Review (TPR) Time Performance Ratio per trade (AD/OD)



# Time Performance Ratio (TPR)

- Review (TPR) Time Performance Ratio trending by trade (AD/OD)



# Time Performance Ratio (TPR)

- **Time Performance Ratio (TPR)** values do not identify any causation,
  **only the results of performance**,
  so they **cannot indicate responsibility** for delays or disruption that might have resulted in poor TPR values.
- **TPR values** are as accurate **as** the actual duration **records**,
  so if non-workdays are **not maintained** in the activity calendars,
  the **actual durations** could be overstated.
- **Software** that allows suspending and resuming of work can help support **more accurate TPR values** if the activities were interrupted.

# Participation In Duration Review

# Participation In Duration Review

- **Estimating activity durations** is an extremely important task in project scheduling which has implications that **affect** the schedule, budget, and perhaps other areas of project objectives.
  - Although it is **usually performed** by the scheduler,

    it requires **input** and **review** from all parties involved in the process.

ACEMI

# Definitions

- Participation in duration review is a **collective effort** by the project management team members for the purpose of **determining** and **verifying** the durations of the activities constituting the project schedule.
- This effort is **managed** by the project scheduler under the **supervision** of the project manager.
- The **scheduler** **coordinates** and **finalizes** this effort,

  with the **final outcome** to be approved by the **project manager** and **project team members**, and

  then **adopted** in the baseline schedule

# Default condition

- **Unless otherwise agreed** upon, it is usually the **responsibility** of the general contractor (GC) to **prepare a schedule** for the project that **meets contractual requirements** such as the project's completion date.
- The **scheduler** **prepares** the schedule using
  1. estimates derived from previous experience,
  2. input from the project management team,
  3. stakeholders, and
  4. third-party references.

# Default condition

- Thus, the **GC** will be **responsible** for
  - the activities' durations in the schedule, as well as
  - the schedule logic and
  - other attributes that collectively lead to the establishment of a project's predicted **completion date** and other **important interim milestones**.

ACEMI

# Best practices

- **Ensuring participation** in duration review should be the **responsibility** of the **scheduler**, who is **responsible for preparing** the project's schedule.
- Project team members are generally of two types:
  1. those who are under the authority and supervision of the **general contractor** (such as self-performing crews and subcontractors), and
  2. those who are not (such as the owner, construction manager, owner's representative, engineering leads, design consultant, and project management consultant).

# Best practices

- For **more appropriate** and **reasonable** schedules, the scheduler needs **active participation** from both groups.
- The **scheduler** **creates** the **draft project schedule** using **tentative durations estimated** as noted earlier.
- The **scheduler** **then meets** with **stakeholders** to discuss relevant activities and agree on reasonable durations.
- **After the completion** of these meetings with **all team leaders**,

  the **scheduler**

  1. **updates** the schedule with these durations and
  2. **recalculates** the **project milestones**, such as substantial or final completion.

# Best practices

- There may be a **need to adjust** some durations or sequencing.
- The **scheduler** would then **hold a meeting** with team leaders for
  - the relevant activities,
  - discuss adjustments, and
  - come up with final durations that are acceptable to all parties.
- Then the **scheduler finalizes** the schedule and **sends** copies to **all team members** to ensure agreement.
- Once the scheduler has the **consent** of all team members, and all quality control checks have been **completed**, it is **submitted to the owner for approval**.
- **Once approved**, the schedule officially becomes the **baseline or as-planned schedule** used for the purpose of monitoring and control.

# Best practices

- The **scheduler** would **conduct** the duration review meetings and could **incorporate** use of a duration factor or duration constraint checklist.
- This list includes **factors** that **may influence** the durations of activities.
- These factors can be **grouped under major categories** such as

  *weather, soil, work location/height, type of management (QA/QC program), equipment, labor skill, job site condition, and others.*
- The group labeled **"weather"** could include

  *temperature, humidity, precipitation, wind, lightning, and visibility (fog, smog, sand storms).*
- This **checklist** could be used to help **ensure that constraints** that might affect durations are considered during the estimate and verification.

# Best practices

- The adjustment and fine-tuning of activities durations in the schedule may take a few **iterations** and **some negotiations** between the scheduler and other team members in order to arrive at **durations acceptable** to all parties and to the contractual obligations.
- In some cases, the **durations supplied** by team members may be **reasonable** but will **not result in a timely completion** of the project.
- The **scheduler then** would **review** the areas where the draft schedule does not comply with **contractual requirements** and **project needs**, and
  - **adjust the schedule** with **input from team members** by fast-tracking or compressing relevant activities.
    - The draft will **need team approval** before finalization.

ACEMI

# Best practices

- There are **other important factors** the **scheduler must** take into consideration:
  - **Every duration change** will likely result in the **change of the timing** of other succeeding activities.
    - There can be a **domino effect** any time an activity's duration is **changed**.
    - The **impact must be assessed**, and

      relevant team leaders **informed**,

      **prior** to **finalization** of the schedule.

ACEMI

# Best practices

- There are **other important factors** the **scheduler must** take into consideration:
  - When an **activity is shifted** in time, even if its own duration is not changed, it may have an **impact** on the work plan and budget.
    - When such **shifting is significant**, it can **change the conditions** under which the activity is performed.
      - ✓ *For example, weather conditions may change, the rain season may start, or daylight hours may increase or decrease.*
    - This **emphasizes the need** for appropriate **weather planning.**
    - **Shifts** may **also affect the work plan** of the team leader and the allocation of subcontractor resources

# Best practices

- There are **other important factors** the **scheduler must** take into consideration:
  - When the **scheduler feels** that the **duration of an activity** is unreasonably large or has a high level of uncertainty,

    it is recommended that such activity be **broken down** into several activities

    that allow **more control** and **more certainty** in determining their duration.

## Best practices

- There are **other important factors** the **scheduler must** take into consideration:
  - **When determining** durations, the **team should not** be too optimistic or pessimistic.
    - ✓ The **chosen durations** should reflect the **best information available** at the time of schedule development.

# Best practices

- The scheduler should **avoid**:
  - **Determining** activity durations for work performed by other team members **without consultation**.
  - **Ignoring factors** that may influence activity durations (the checklist mentioned above).
  - **Ignoring** the **cost impact** of **changing** activity durations and/or timing.
  - **Failing** to **assess** and take into consideration the domino effect of a **change** to activity durations on other activities.
  - **Failing** to **solicit input** and **feedback** from team members and team leaders for **suggestions** to achieve the objective.
  - **Failing** to **communicate** and **document** this process clearly and properly.

# Topics Not Covered in This Course

# Topics Not Covered in this course

- **Execution Plan** – **Relationship** between **original** activity durations and the **specific** execution plan of the project.
- **Resources** – Effect on activity durations by **resources** used to execute the work.
- **Schedule and Estimate** – Activity durations are related to the project **cost estimate**, and the **link** between estimate and schedule should be documented.

# Topics Not Covered in this course

- **Contingency** – **Normally** original activity durations do **not have a contingency** included.
  - Nevertheless, if **individual** or **global contingencies** are applied they are **thoroughly documented**.
  - Uncertainty for an **independent single activity** has been addressed in the **PERT discussion**, however schedule contingency as a whole (and Monte Carlo simulations) are **not addressed** in this RP.

# Topics Not Covered in this course

- **Work-Breakdown Structure** – Activity duration **linkage** to the work-breakdown structure.
- **Updates or Acceleration** – Activity durations need to be addressed **when updating** a schedule for progress or if there is a need to accelerate or crash original durations.
- **Schedule Basis Documentation** – The methodology, assumptions, variability, risk, etc. **associated with the estimation** of activity durations should be described in the **schedule basis documentation**.

# موسسه مهندسی و مدیریت ساخت علوی پور (ACEMI)


دفتر آموزش

تهران، بلوار فردوس شرق، مجتمع آبگینه، طبقه سوم اداری، واحد C42

+۹۸ ۲۱ ۴۶ ۱۰۰ ۴۵۰

+۹۸ ۲۱ ۴۶ ۱۰۰ ۴۴۵

www.dralavipour.com

info@dralavipour.com

@acemi_social

@alavipour_pm

@IRANACEMI

@alavipour_pm


ACEMI