Project Management Professional (PMP)

Section (6)
Project Time Management

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PMBOK 5th. Edition

Project Time Management

- Includes the processes required to manage the timely completion of the project
  - 6.1 Plan Schedule Management
  - 6.2 Define Activities
  - 6.3 Sequence Activities
  - 6.4 Estimate Activity Resources
  - 6.5 Estimate Activity Durations
  - 6.6 Develop Schedule
  - 6.7 Control Schedule

Project Time Management: Processes

- **6.1 Plan Schedule Management:**
  - The process of establishing the policies, procedures and documentation for planning, developing, managing, executing, and controlling the project schedule.
- **6.2 Define Activities:**
  - The process of identifying and documenting the specific actions to be performed to produce the project deliverables.
- **6.3 Sequence Activities:**
  - The process of identifying and documenting relationships among the project activities.

Project Time Management: Processes

- **6.4 Estimate Activity Resources:**
  - The process of estimating the type and quantities of material, human resources, equipment, or supplies required to perform each activity.
- **6.5 Estimate Activity Durations:**
  - The process of estimating the number of work periods needed to complete individual activities with estimated resources.

Project Time Management: Processes

- **6.6 Develop Schedule:**
  - The process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule model.

- **6.7 Control Schedule:**
  - The process of monitoring the status of project activities to update project progress and manage changes to the schedule baseline to achieve the plan.

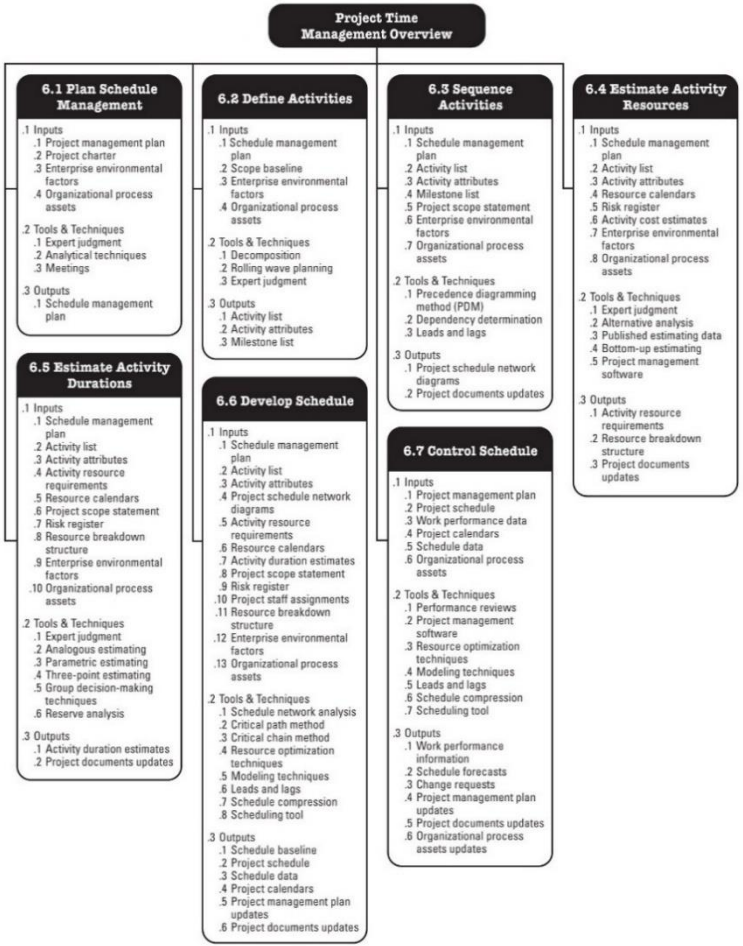


Figure 6-1. Project Time Management Overview

6.1 Plan Schedule Management (PG: Planning)

- The process of establishing the **policies**, **procedures**, and **documentation** for planning, developing, managing, executing, and controlling the project schedule.

- The key benefit of this process is:
  - Provides guidance and direction on how the project schedule will be managed throughout the project.

6.1 Plan Schedule Management (PG: Planning)

- The schedule management plan is:
  - A component of the project management plan.
  - May be formal or informal, highly detailed or broadly framed.
  - Based upon the needs of the project.
  - Includes appropriate control thresholds.
  - Defines how schedule contingencies will be reported and assessed.
  - May be updated to reflect a change in the way the schedule is managed.

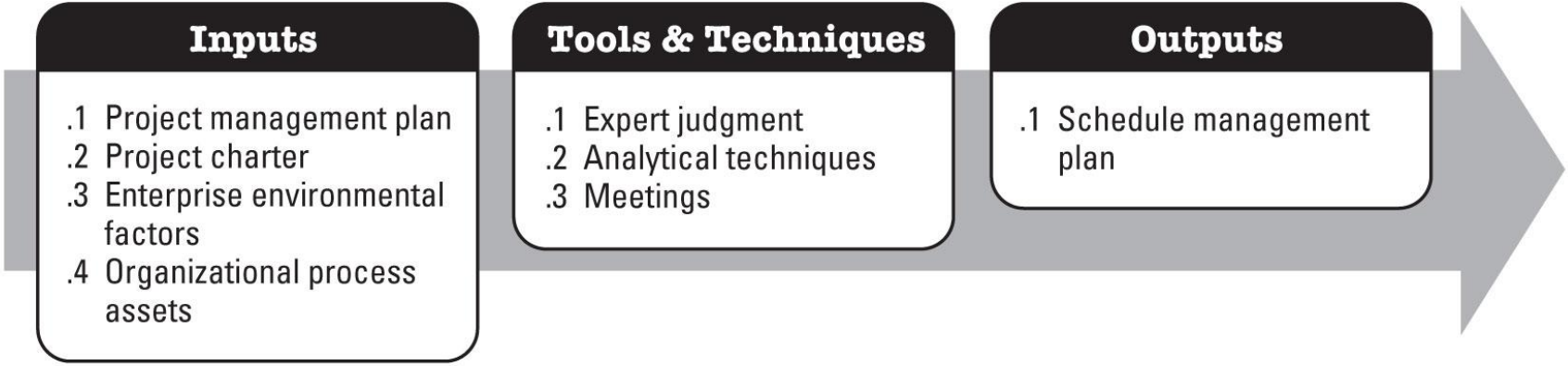


Figure 6-3. Plan Schedule Management: Inputs, Tools & Techniques, and Outputs

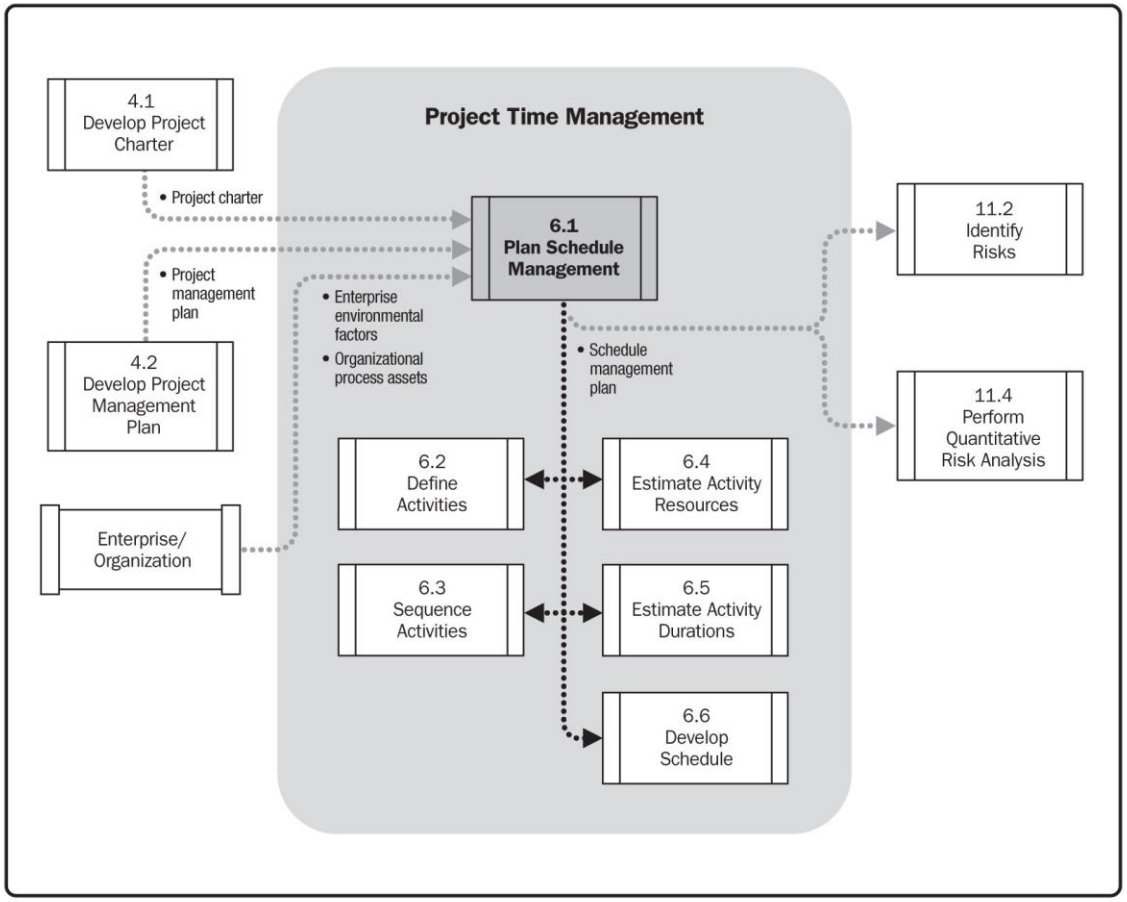


Figure 6-4. Plan Schedule Management Data Flow Diagram

6.1 Plan Schedule Management: Inputs

- 6.1.1.1 Project Management Plan (Out: 4.2)
  - The project management plan contains information used to develop the schedule management plan which includes, but is not limited to:
    - Scope baseline: The scope baseline includes the project scope statement and the work breakdown structure (WBS) details used for defining activities, duration estimation, and schedule management
    - Other information: Other scheduling related cost, risk, and communications decisions from the project management plan are used to develop the schedule.

6.1 Plan Schedule Management: Inputs

- 6.1.1.2 Project Charter (Out: 4.1)
  - The project charter defines the summary milestone schedule and project approval requirements that will influence the management of the project schedule.

6.1 Plan Schedule Management: Inputs

- 6.1.1.3 Enterprise Environmental Factors (EEFs)(Out: 2.1.5)
  - The enterprise environmental factors that influence the Plan Schedule Management process include, but are not limited to:
    - Organizational culture and structure can all influence schedule management
    - Resource availability and skills that may influence schedule planning
    - Project management software provides the scheduling tool and alternative possibilities for managing the schedule
    - Published commercial information, such as resource productivity information, is often available from commercial databases that track
    - Organizational work authorization systems

6.1 Plan Schedule Management: Inputs

- 6.1.1.4 Organizational Process Assets (OPAs) (Out: 2.1.4)
  - The organizational process assets that influence the Plan Schedule Management process include:
    - Monitoring and reporting tools to be used
    - Historical information
    - Schedule control tools
    - Existing formal & informal schedule control related policies, procedures & guidelines.
    - Templates & Project closure guidelines
    - Change control procedures
    - Risk control procedures including risk categories, probability definition and impact, and probability and impact matrix.

6.1.2 Plan Schedule Management: Tools and Techniques

- 6.1.2.1 Expert Judgment
  - Expert judgment, guided by historical information, provides valuable insight about the environment and information from prior similar projects.
  - Expert judgment can also suggest whether to combine methods and how to reconcile differences between them.
  - Judgment based upon expertise in an application area, Knowledge Area, discipline, industry, etc., as appropriate for the activity being performed, should be used in developing the schedule management plan.

6.1.2 Plan Schedule Management: Tools and Techniques

- 6.1.2.2 Analytical Techniques
  - The Plan Schedule Management process may involve choosing **strategic options to estimate and schedule** the project such as:
    - Scheduling methodology
    - Scheduling tools & techniques
    - Estimating approaches
    - Formats
    - Project management software.

6.1.2 Plan Schedule Management: Tools and Techniques

- 6.1.2.2 Analytical Techniques (Cont.)
  - The schedule management plan may also detail ways to fast track or crash the project schedule such as undertaking work in parallel.
  - Organizational policies and procedures may influence which scheduling techniques are employed in these decisions, Techniques may include:
    - Rolling wave planning (Section 6.2.2.2)
    - Leads and lags (Section 6.3.2.3)
    - Alternatives analysis (Section 6.4.2.2)
    - Methods for reviewing schedule performance (Section 6.7.2.1)

6.1.2 Plan Schedule Management: Tools and Techniques

- 6.1.2.3 Meetings
  - Project teams may hold planning meetings to develop the schedule management plan.
  - Participants at these meetings may include the project manager, the project sponsor, selected project team members, selected stakeholders, anyone with responsibility for schedule planning or execution, and others as needed.

6.1.3 Plan Schedule Management: Outputs

- 6.1.3.1 Schedule Management Plan
  - A component of the project management plan that establishes the criteria and the activities for developing, monitoring, and controlling the schedule
  - The schedule management plan may be formal or informal, highly detailed or broadly framed, based upon the needs of the project, and includes appropriate control thresholds.

6.1.3 Plan Schedule Management: Outputs

- 6.1.3.1 Schedule Management Plan:
  - Example, the schedule management plan can establish the following:
    - Project schedule model development
    - Level of accuracy
    - Units of measure
    - Organizational procedures links
    - Control thresholds

6.1.3 Plan Schedule Management: Outputs

- 6.1.3.1 Schedule Management Plan:
  - Example, the schedule management plan can establish the following:
    - Rules of performance measurement: Earned value management (EVM) rules or other physical measurement rules of performance measurement are set. For example, the schedule management plan may specify:
      - Rules for establishing percent complete
      - Control accounts at which management of progress and schedule will be measured
      - Earned value measurement techniques
      - Schedule performance measurements
    - Reporting formats
    - Process descriptions

6.2 Define Activities (PG: Planning)

- The process of **identifying** and **documenting** the specific actions to be performed to produce the project deliverables.
  - Defining and planning the schedule activities such that the project objectives will be met.
  - The Create **WBS** process identifies the deliverables at the lowest level in the WBS-the work package.
  - Work packages are typically decomposed into smaller components called activities that represent the work effort required to complete the work package.

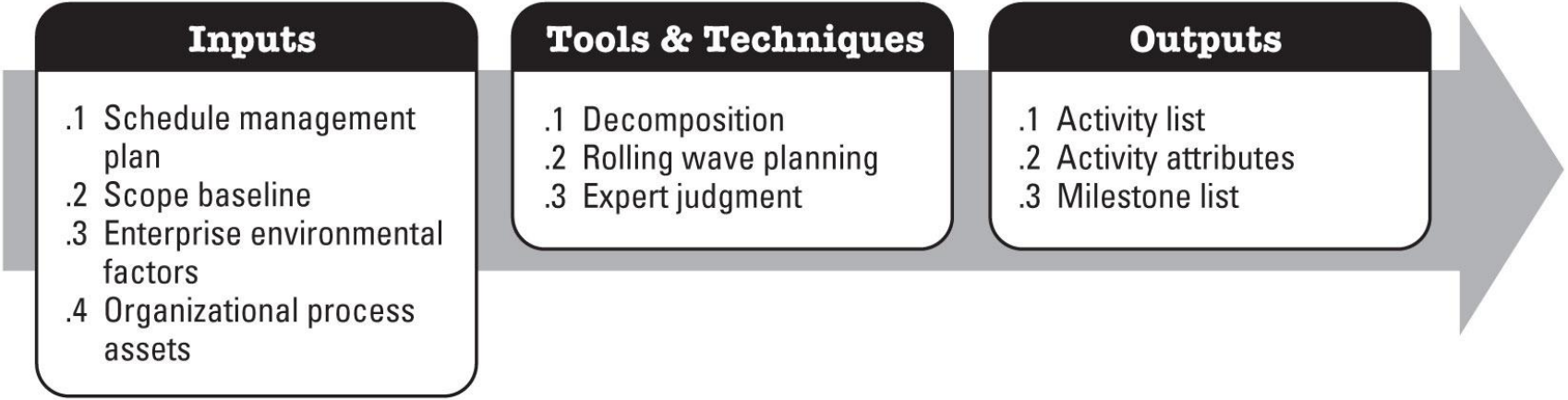


Figure 6-5. Define Activities: Inputs, Tools & Techniques, and Outputs

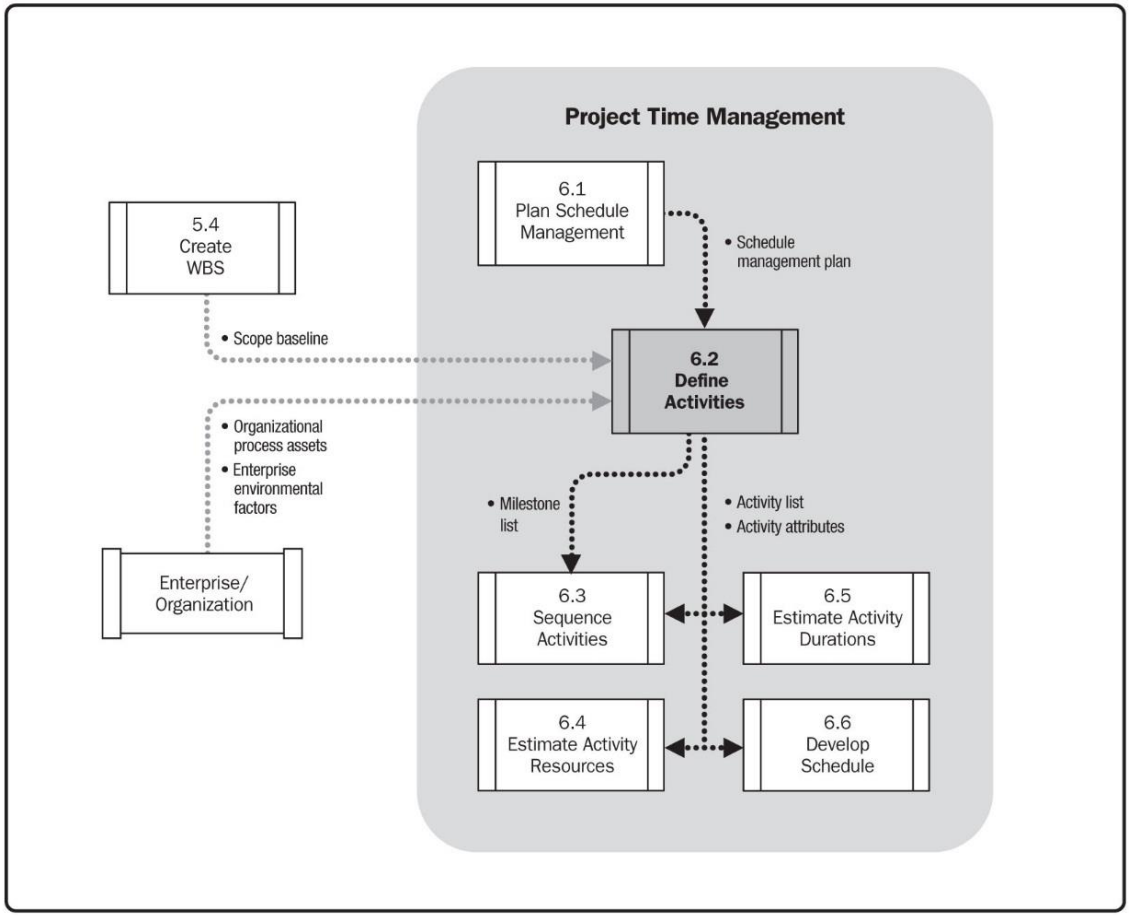


Figure 6-6. Define Activities Data Flow Diagram

6.2.1 Define Activities: Inputs

- 6.2.1.1 Schedule Management Plan (Out: 6.1)
  - A key input from the schedule management plan is the prescribed level of detail necessary to manage the work.

6.2.1 Define Activities: Inputs

- 6.2.1.2 Scope Baseline (Out: 5.4)
  - The project WBS, deliverables, constraints, and assumptions documented in the scope baseline are considered explicitly while defining activities.

6.2.1 Define Activities: Inputs

- 6.2.1.3 Enterprise Environmental Factors (EEFs) (Out: 2.1.5)
  - Enterprise environmental factors that influence the Define Activities process include:
    - Organizational cultures and structure
    - Published commercial information from commercial databases
    - Project management information system (PMIS)

6.2.1 Define Activities: Inputs

- 6.2.1.4 Organizational Process Assets (OPAs) (Out: 2.1.4)
  - The organizational process assets that can influence the Define Activities process include:
    - Lessons learned knowledge base containing historical information regarding activity lists used by previous similar projects
    - Standardized processes
    - Templates that contain a standard activity list or a portion of an activity list from a previous project
    - Existing formal and informal activity planning-related policies, procedures, and guidelines, such as the scheduling methodology, that are considered in developing the activity definitions.

6.2.2 Define Activities: Tools and Techniques

- 6.2.2.1 Decomposition
  - A technique used for dividing and subdividing the project scope and project deliverables into smaller, more manageable parts.
  - Activities represent the effort needed to complete a work package.
  - The Define Activities process defines the final outputs as activities rather than deliverables, as done in the Create WBS process (Section 5.4).
  - The activity list, WBS, and WBS dictionary can be developed either sequentially or concurrently, with the WBS and WBS dictionary as the

6.2.2 Define Activities: Tools and Techniques

- 6.2.2.2 Rolling Wave Planning
  - **An iterative planning technique** in which the work to be accomplished in the near term is planned in detail, while the work in the future is planned at a higher level.
  - It is a form of **progressive elaboration**. Therefore, work can exist at various levels of detail depending on where it is in the project life cycle.
  - During early strategic planning, when information is less defined, work packages may be decomposed to the known level of detail.

6.2.2 Define Activities: Tools and Techniques

- 6.2.2.3 Expert Judgment
  - Project team members or other experts, who are experienced and skilled in developing detailed project scope statements, the WBS, and project schedules, can provide expertise in defining activities.

6.2.3 Define Activities: Outputs

- 6.2.3.1 Activity List
  - The activity list is a comprehensive list that includes all schedule activities required on the project.
  - The activity list also includes the activity identifier and a scope of work description for each activity in sufficient detail to ensure that project team members understand what work is required to be completed.
  - Each activity should have a unique title that describes its place in the schedule, even if that activity title is displayed outside the context of the project schedule.

6.2.3 Define Activities: Outputs

- 6.2.3.2 Activity Attributes
  - Activities, distinct from milestones, have durations, during which the work of that activity is performed, and may have resources and costs associated with that work.
  - Activity attributes extend the description of the activity by identifying the multiple components associated with each activity.
  - Activity attributes can be used to identify the person responsible for executing the work, geographic area, or place where the work has to be performed

6.2.3 Define Activities: Outputs

- 6.2.3.3 Milestone List
  - A milestone is a significant point or event in a project. A milestone list is a list identifying all project milestones and indicates whether the milestone is mandatory, such as those required by contract, or optional, such as those based upon historical information.
  - Milestones are similar to regular schedule activities, with the same structure and attributes, but they have zero duration because milestones represent a moment in time.

6.3 Sequence Activities (PG: Planning)

- The process of **identifying** and **documenting** relationships among the project activities.
  - The key benefit of this process is that:
    - it defines the logical sequence of work to obtain the greatest efficiency given all project constraints.
    - Every activity & milestone except the first and last should be connected to at least one predecessor with:
      - Finish-to-start
      - Start-to-start
    - and at least one successor with:
      - Finish-to-start or
      - Finish-to-finish

6.3 Sequence Activities (PG: Planning)

- Notes:
  - Logical relationships should be designed to create a realistic project schedule.
  - It may be necessary to use **lead** or **lag** time between activities to support a realistic and achievable project schedule.
  - Sequencing can be performed by using:
    - Project management software.
    - Manual techniques.
    - Automated techniques.

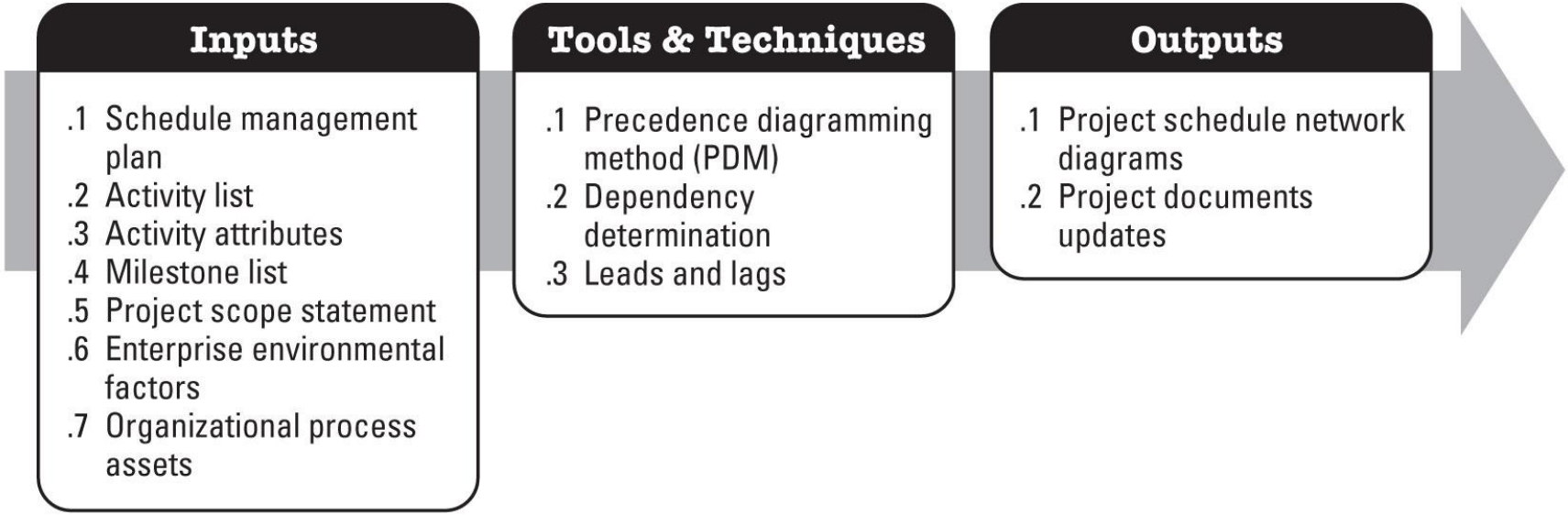


Figure 6-7. Sequence Activities: Inputs, Tools & Techniques, and Outputs

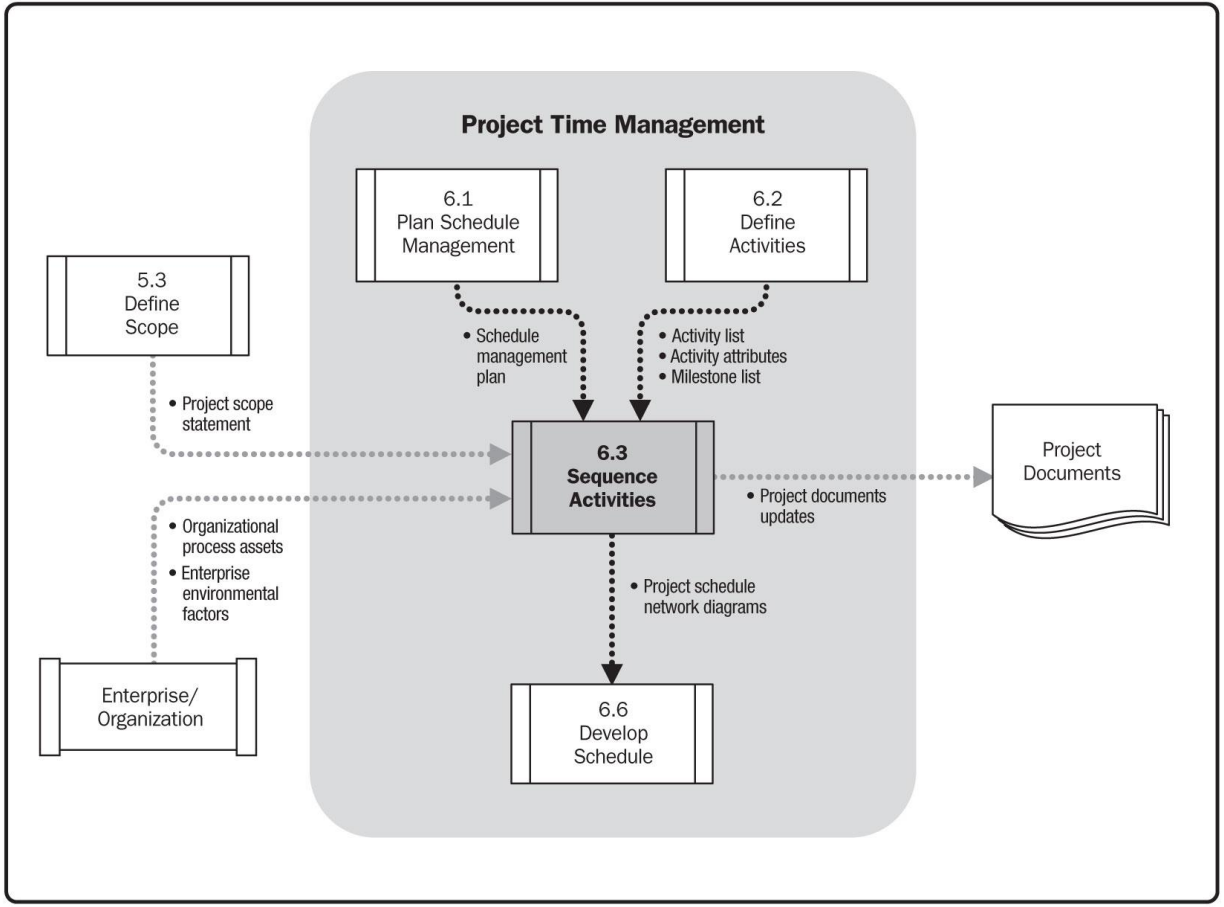


Figure 6-8. Sequence Activities Data Flow Diagram

6.3.1 Sequence Activities: Inputs

- 6.3.1.1 Schedule Management Plan (Out: 6.1)
  - Identifies the scheduling method and tool to be used for the project, which will guide how the activities may be sequenced.

- 6.3.1.2 Activity List (Out: 6.2)
  - Contains all schedule activities required on the project, which are to be sequenced.
  - Dependencies and other constraints for these activities can influence the sequencing of the activities.

6.3.1 Sequence Activities: Inputs

- 6.3.1.3 Activity Attributes (Out: 6.2)
  - Activity attributes may describe a necessary sequence of events or defined predecessor or successor relationships.

- 6.3.1.4 Milestone List (Out: 6.2)
  - The milestone list may have scheduled dates for specific milestones, which may influence the way activities are sequenced.

6.3.1 Sequence Activities: Inputs

- 6.3.1.5 Project Scope Statement (Out: 5.3)
  - Contains the product scope description, which includes product characteristics that may affect activity sequencing
  - Other information from the project scope statement including:
    - Project deliverables
    - project constraints
    - project assumptions

6.3.1 Sequence Activities: Inputs

- 6.3.1.6 Enterprise Environmental Factors (Out: 2.1.5)
  - Enterprise environmental factors that influence the Sequence Activities process include:
    - Government or industry standards,
    - Project management information system (PMIS),
    - Scheduling tool, and
    - Company work authorization systems.

6.3.1 Sequence Activities: Inputs

- 6.3.1.7 Organizational Process Assets (2.1.4)
  - The organizational process assets that can influence the Sequence Activities process include:
    - Project files from the corporate knowledge base used for scheduling methodology,
    - Existing formal and informal activity planning-related policies
    - Procedures & guidelines, such as the scheduling methodology that are considered in developing logical relationships, and
    - Templates that can be used to expedite the preparation of networks of project activities.

6.3.2 Sequence Activities: Tools and Techniques

- 6.3.2.1 Precedence Diagramming Method (PDM)
  - A technique used for constructing a schedule model in which activities are represented by nodes and are graphically linked by one or more logical relationships to show the sequence in which the activities are to be performed.

    - **Activity-on-node (AON)**
      - One method of representing a precedence diagram.
      - This is the method used by most project management software packages.

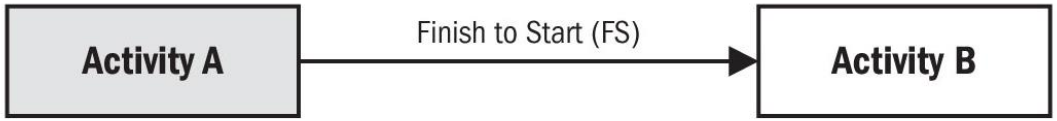
6.3.2 Sequence Activities: Tools and Techniques

- 6.3.2.1 Precedence Diagramming Method (PDM) (Cont.)
  - PDM includes four types of dependencies or logical relationships.
    - **A predecessor activity** is an activity that logically comes before a dependent activity in a schedule.
    - **A successor activity** is a dependent activity that logically comes after another activity in a schedule.

6.3.2 Sequence Activities: Tools and Techniques

6.3.2.1 Precedence Diagramming Method (PDM) (Cont.)

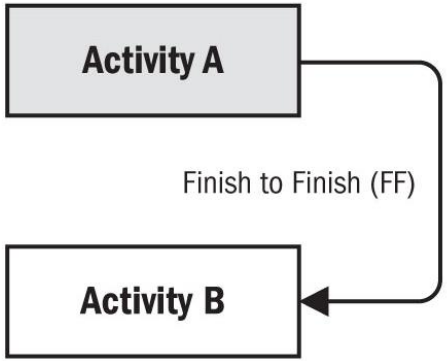
- **Finish-to-start (FS):**
  - A logical relationship in which a successor activity cannot start until a predecessor activity has finished.
  - Example: The awards ceremony (successor) cannot start until the race (predecessor) has finished.



6.3.2 Sequence Activities: Tools and Techniques

6.3.2.1 Precedence Diagramming Method (PDM) (Cont.)

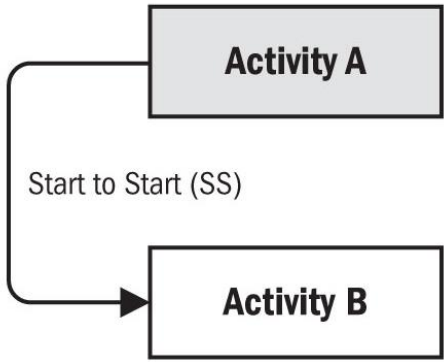
- **Finish-to-finish (FF):**
  - A logical relationship in which a successor activity cannot finish until a predecessor activity has finished.
  - Example: Writing a document (predecessor) is required to finish before editing the document (successor) can finish.



6.3.2 Sequence Activities: Tools and Techniques

6.3.2.1 Precedence Diagramming Method (PDM) (Cont.)

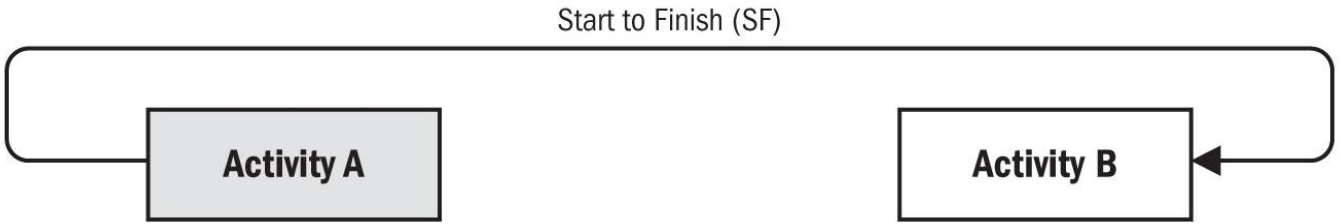
- **Start-to-start (SS):**
  - A logical relationship in which a successor activity cannot start until a predecessor activity has started.
  - Example: Level concrete (successor) cannot begin until pour foundation (predecessor) begin



6.3.2 Sequence Activities: Tools and Techniques

6.3.2.1 Precedence Diagramming Method (PDM) (Cont.)

- **Start-to-finish (SF):**
  - A logical relationship in which a successor activity cannot finish until a predecessor activity has started.
  - Example: The first security guard shift (successor) cannot finish until the second security guard shift (predecessor) starts.



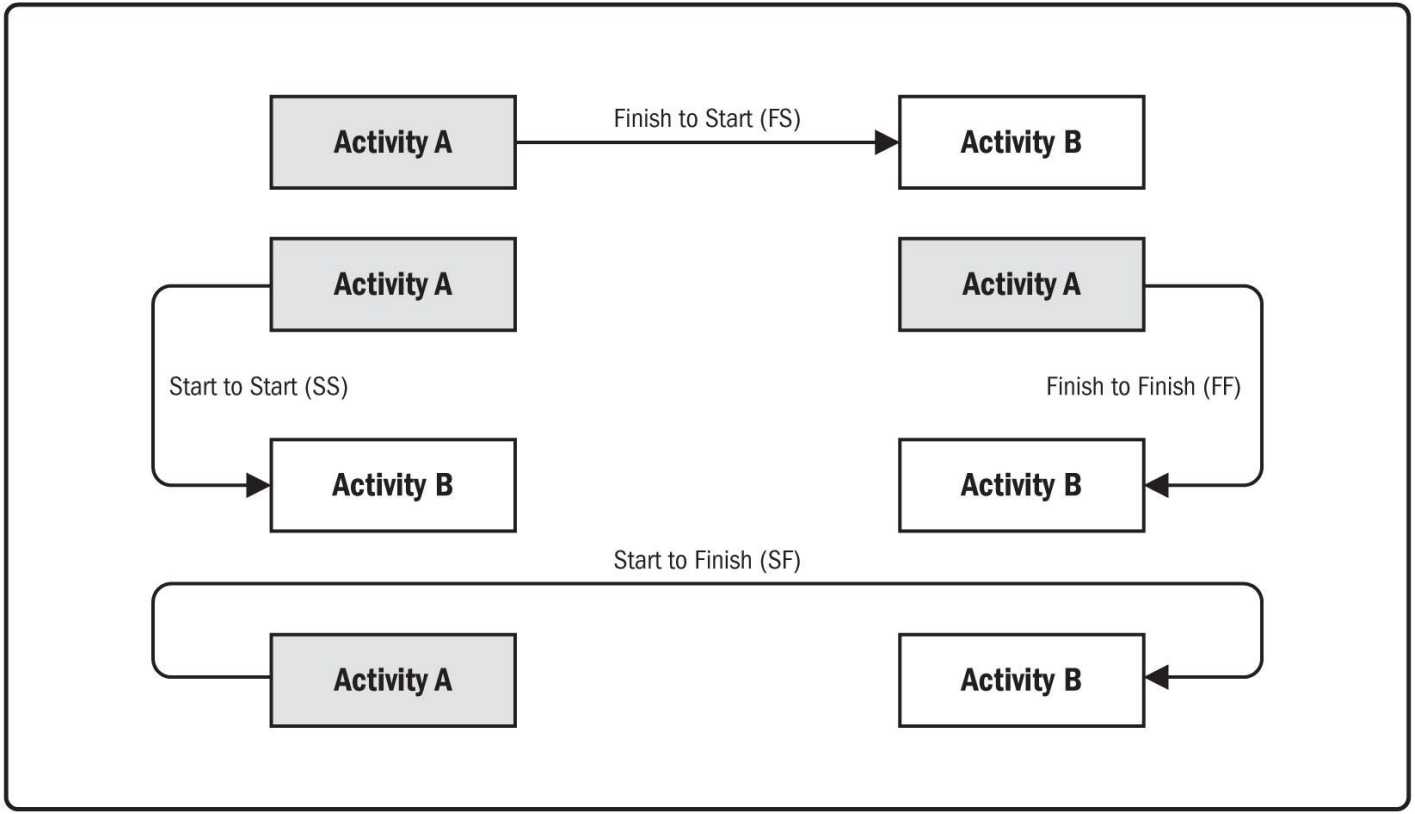


Figure 6-9. Precedence Diagramming Method (PDM) Relationship Types

6.3.2 Sequence Activities: Tools and Techniques

- 6.3.2.2 Dependency Determination
  - Dependencies may be characterized by the following attributes: mandatory or discretionary, internal or external.
    - Dependency has four attributes:
      - Mandatory dependencies
      - Discretionary dependencies
      - External dependencies
      - Internal dependencies

6.3.2 Sequence Activities: Tools and Techniques

- 6.3.2.3 Leads and Lags
  - A lead
    - The amount of time whereby a successor activity can be **advanced** with respect to a predecessor activity.
    - Example:
      - A project to construct a new office building, the landscaping could be scheduled to start two weeks prior to the scheduled punch list completion.
      - This would be shown as a finish-to-start with a two-week lead as shown in Figure 6-10.
  - Lead is often represented as a negative value for lag in scheduling software.

6.3.2 Sequence Activities: Tools and Techniques

- 6.3.2.3 Leads and Lags
  - A lag
    - The amount of time whereby a successor activity will be **delayed** with respect to a predecessor activity.
    - Example
      - A technical writing team may begin editing the draft of a large document 15 days after they begin writing it.
    - Lag can also be represented in project schedule network diagrams

6.3.2 Sequence Activities: Tools and Techniques

- 6.3.2.3 Leads and Lags

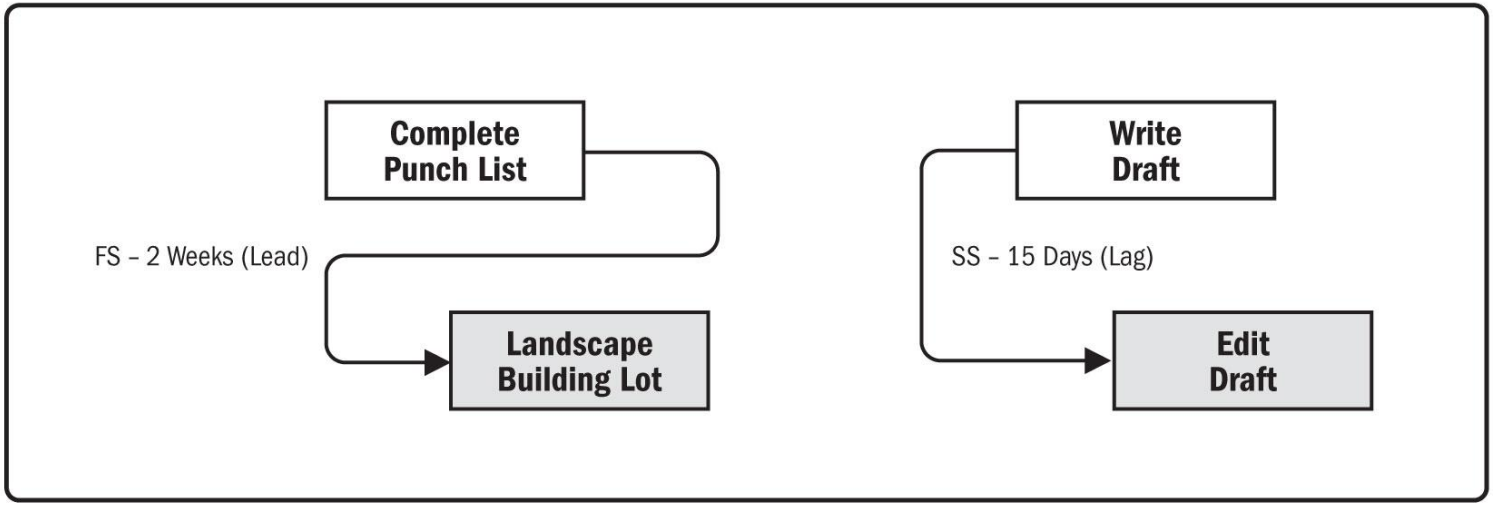


Figure 6-10. Examples of Lead and Lag

6.3.1 Sequence Activities: Outputs

6.3.3.1 Project Schedule Network Diagrams

- A graphical representation of the logical relationships, also referred to as dependencies, among the project schedule activities.

- Notes:
  - A project schedule network diagram is produced manually or by using project management software.
  - It can include full project details, or have one or more summary activities.
  - A summary narrative can accompany the diagram and describe the basic approach used to sequence the activities.
  - Any unusual activity sequences within the network should be fully described within the narrative.

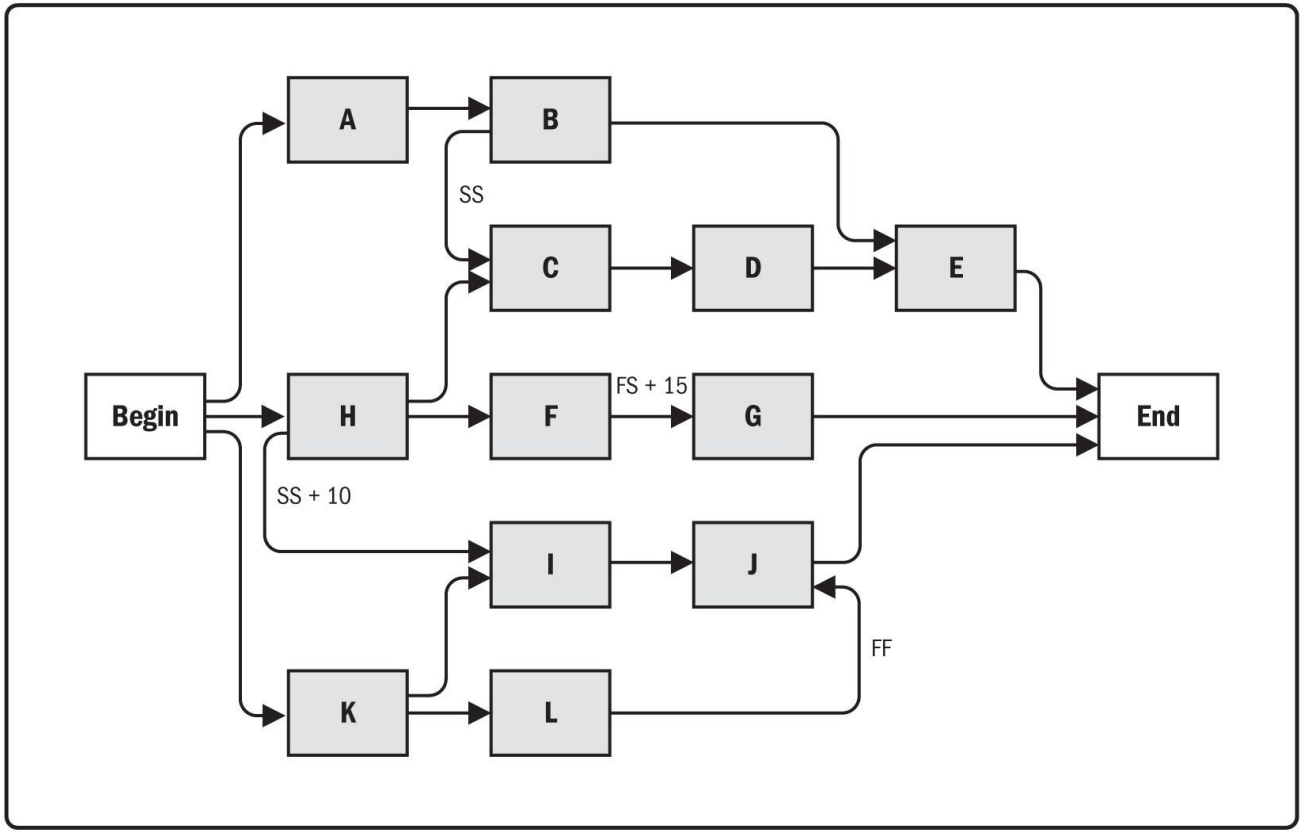


Figure 6-11. Project Schedule Network Diagram

6.3.1 Sequence Activities: Outputs

- 6.3.3.2 Project Documents Updates
  - Project documents that may be updated include, but are not limited to:
    - Activity lists
    - Activity attributes
    - Milestone list
    - Risk register

6.4 Estimate Activity Resources (PG: Planning)

- The process of **estimating** the **type** and **quantities** of material, human resources, equipment or supplies required to perform each activity.
  - The key benefit of this process is that it identifies the type, quantity, and characteristics of resources required to complete the activity which allows more accurate cost and duration estimates.
  - The Estimate Activity Resources process is closely coordinated with the Estimate Costs process.

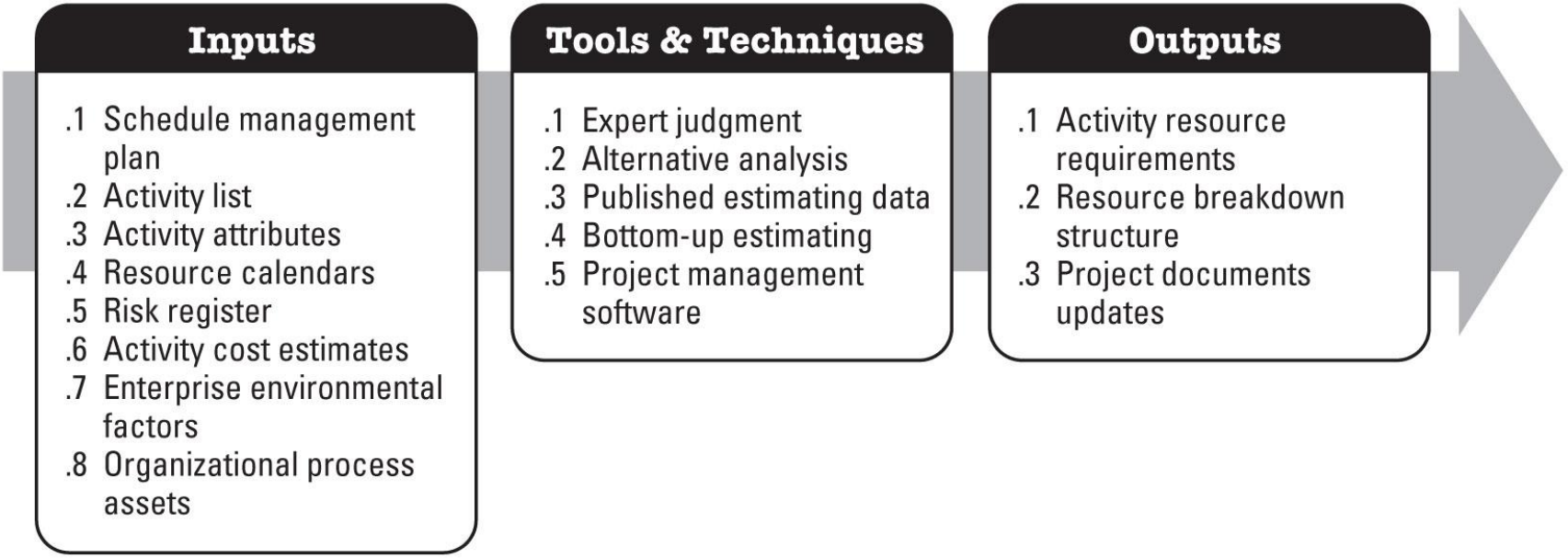


Figure 6-12. Estimate Activity Resources: Inputs, Tools & Techniques, and Outputs

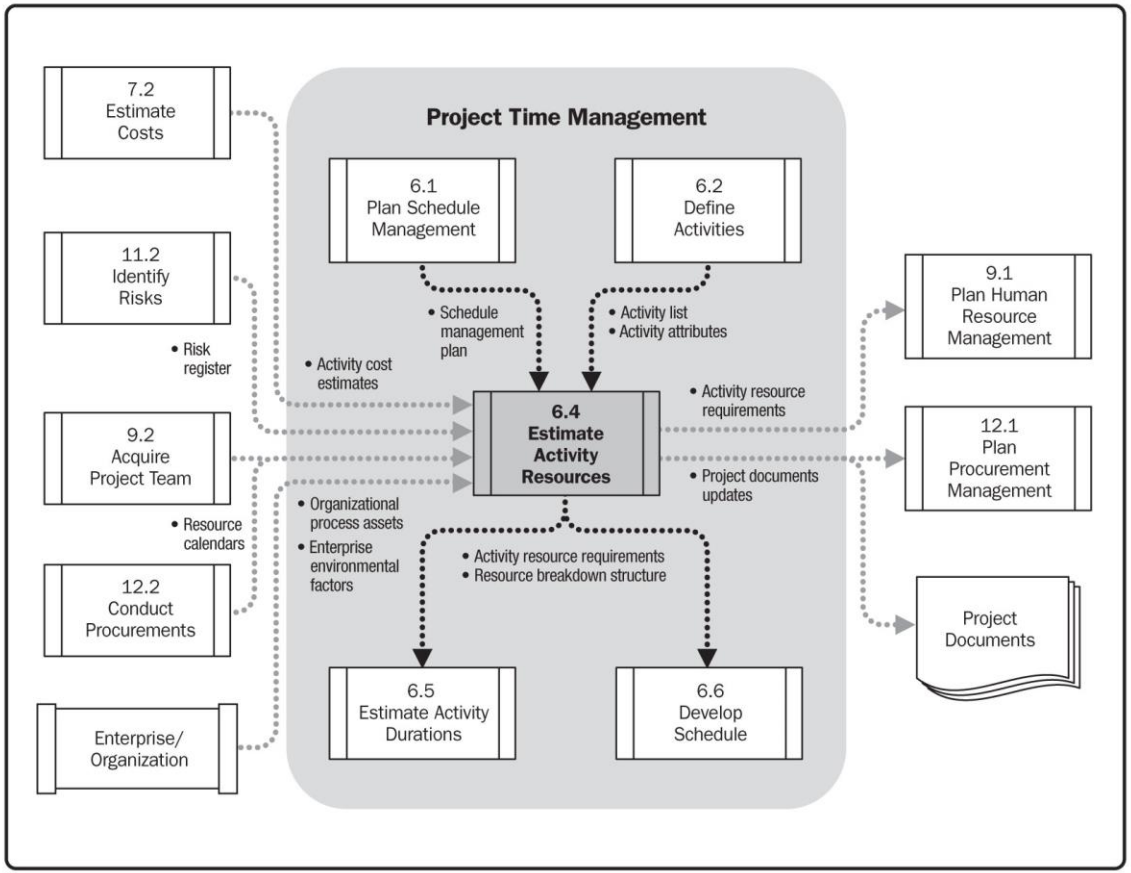


Figure 6-13. Estimate Activity Resources Data Flow Diagram

6.4.1 Estimate Activity Resources: Inputs

- 6.4.1.1 Schedule Management Plan (Out: 6.1)
  - The schedule management plan identifies the level of accuracy and the units of measure for the resources to be estimated.
- 6.4.1.2 Activity List (Out: 6.2)
  - The activity list identifies the activities which will need resources.
- 6.4.1.3 Activity Attributes (Out:)
  - The activity attributes provide the primary data input for use in estimating those resources required for each activity in the activity list.

6.4.1 Estimate Activity Resources: Inputs

- 6.4.1.4 Resource Calendars
  - A calendar that identifies the working days and shifts on which each specific resource is available.
  - Information on which resources are potentially available during a planned activity period, is used for estimating resource utilization.

6.4.1 Estimate Activity Resources: Inputs

- 6.4.1.5 Risk Register
  - Risk events may impact resource selection and availability. Updates to the risk register are included with project documents updates
  - Described in Section 11.5.3.2, from Plan Risk Responses.

- 6.4.1.6 Activity Cost Estimates
  - The cost of resources may impact resource selection.

6.4.1 Estimate Activity Resources: Inputs

- 6.4.1.7 Enterprise Environmental Factors
  - Influence the Estimate Activity Resources process include, but are not limited to, resource location, availability, and skills.

- 6.4.1.8 Organizational Process Assets
  - Influence the Estimate Activity Resources process include:
    - Policies and procedures regarding staffing.
    - Policies & procedures relating to rental & purchase of supplies & equipment
    - Historical information regarding types of resources used for similar work on previous projects.

6.4.2 Estimate Activity Resources: Tools and Techniques

- 6.4.2.1 Expert Judgment
  - Assess the resource-related inputs to this process.
  - Any group or person with specialized knowledge in resource planning and estimating can provide such expertise.

- 6.4.2.2 Alternative Analysis
  - Many schedule activities have **alternative methods** of accomplishment.
  - They include using various levels of resource capability or skills, different size or type of machines, different tools (hand versus automated), and make-rent-or-buy decisions regarding the resource

6.4.2 Estimate Activity Resources: Tools and Techniques

- 6.4.2.3 Published Estimating Data
  - Several organizations routinely publish updated production rates and unit costs of resources for an extensive array of labor trades, material, and equipment for different countries and geographical locations within countries.

6.4.2 Estimate Activity Resources: Tools and Techniques

- 6.4.2.4 Bottom-Up Estimating
  - A method of estimating project duration or cost by aggregating the estimates of the lower-level components of the WBS.
    - When an activity cannot be estimated with a reasonable degree of confidence, the work within the activity is decomposed into more detail.
  - The resource needs are estimated.
    - These estimates are then aggregated into a total quantity for each of the activity's resources.
  - Activities may or may not have dependencies between them that can affect the application and use of resources.

6.4.2 Estimate Activity Resources: Tools and Techniques

- 6.4.2.5 Project Management Software
  - Project management software, such as a scheduling software tool, has the capability to help plan, organize, and manage resource pools and develop resource estimates.
  - Depending on the sophistication of the software, resource breakdown structures, resource availability, resource rates, and various resource calendars can be defined to assist in optimizing resource utilization.

6.4.3 Estimate Activity Resources: Outputs

- 6.4.3.1 Activity Resource Requirements
  - Identify the **types** and **quantities** of **resources** required for each activity in a work package.
  - The resource requirements documentation for each activity can include the basis of estimate for each resource, as well as the assumptions that were made in determining which types of resources are applied, their availability, and what quantities are used.

6.4.3 Estimate Activity Resources: Outputs

- 6.4.3.2 Resource Breakdown Structure
  - The resource breakdown structure is a hierarchical representation of resources by category and type.
  - Examples of resource categories include:
    - Labor, material, equipment, and supplies.
  - Resource types may include:
    - The skill level, grade level, or other information as appropriate to the project.
  - The resource breakdown structure is useful for organizing and reporting project schedule data with resource utilization information.

6.4.3 Estimate Activity Resources: Outputs

- 6.4.3.3 Project Documents Updates
  - Project documents that may be updated include, but are not limited to:
    - Activity list.
    - Activity attributes.
    - Resource calendars.

6.5 Estimate Activity Durations (PG: Planning)

- The process of **estimating the number of work periods** needed to complete individual activities with estimated resources.

  - The key benefit of this process is:
    - Provides the amount of time each activity will take to complete.

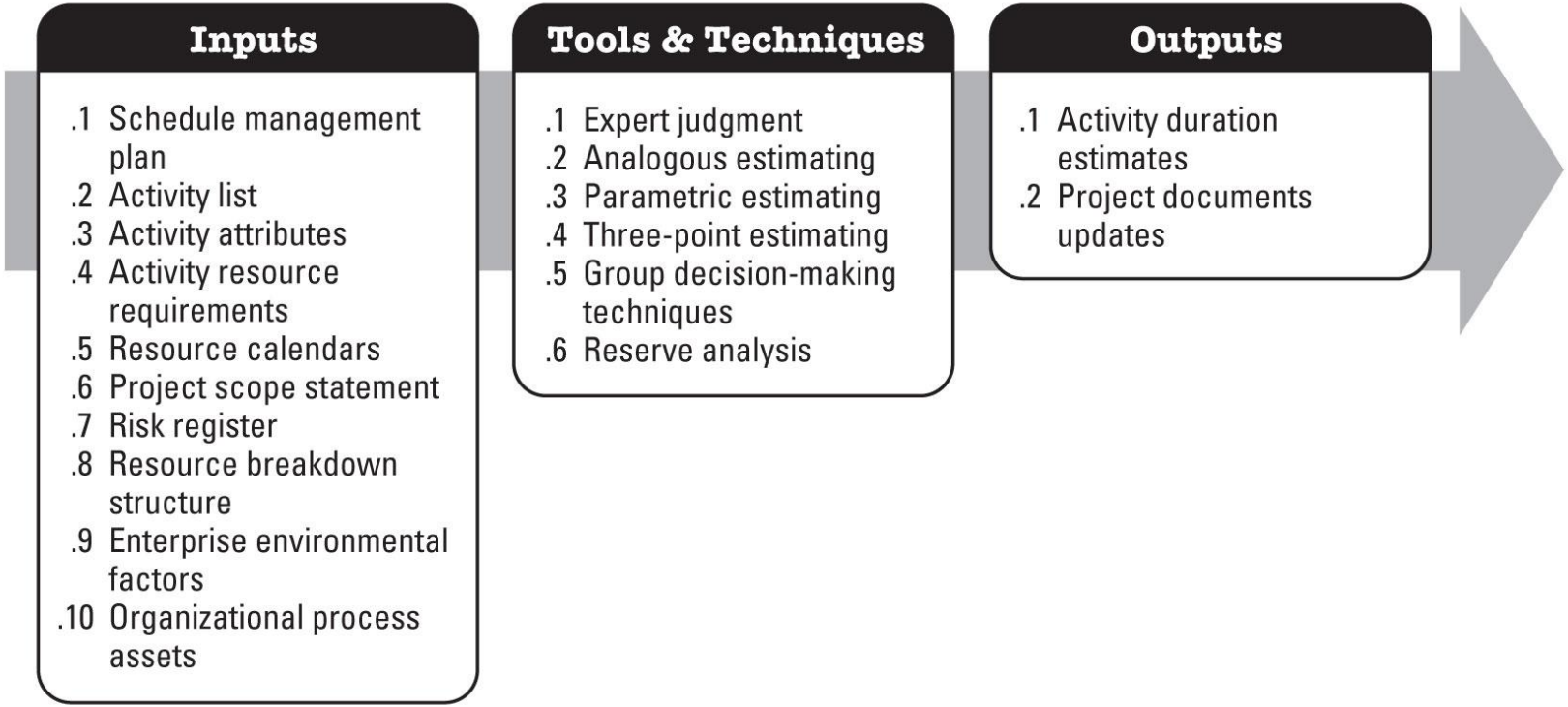


Figure 6-14. Estimate Activity Durations: Inputs, Tools & Techniques, and Outputs

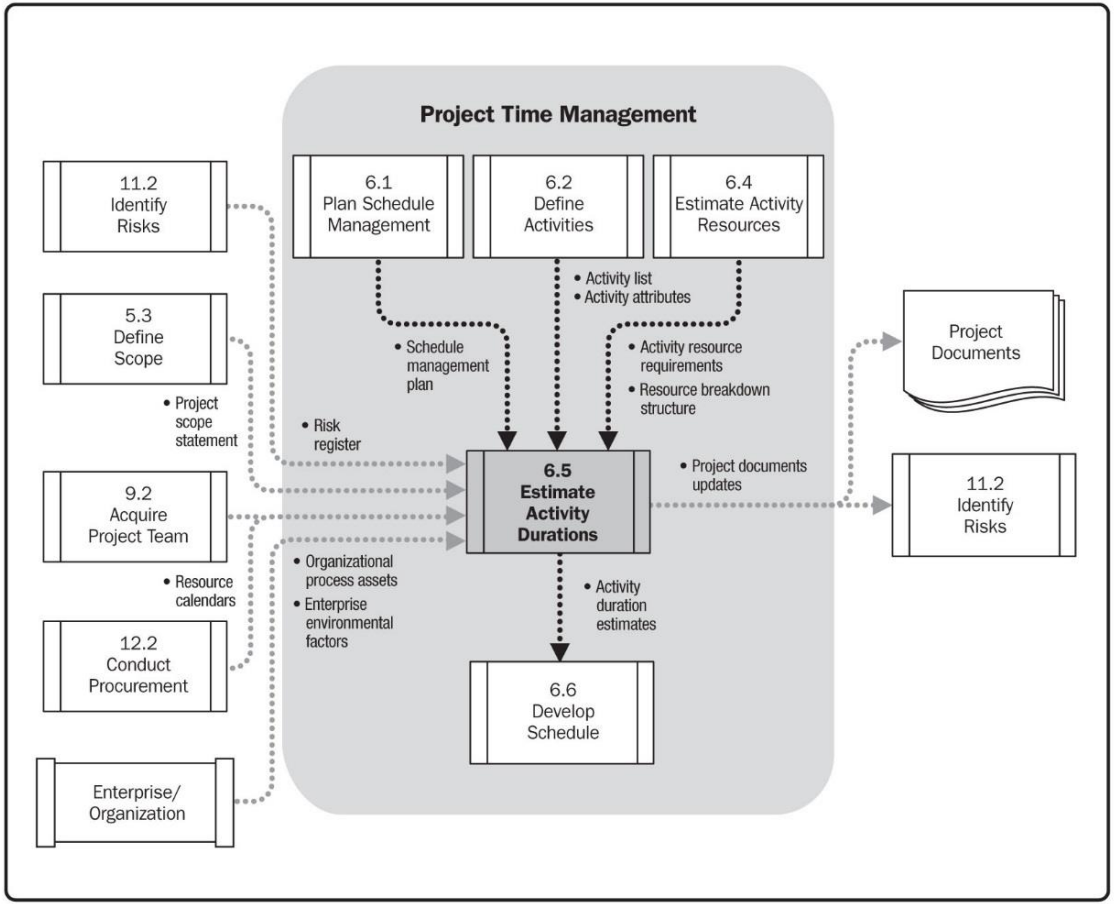


Figure 6-15. Estimate Activity Durations Data Flow Diagram

6.5.1 Estimate Activity Durations: Inputs

- 6.5.1.1 Schedule Management Plan (Out: 6.1)
  - The schedule management plan defines the method used and the level of accuracy along with other criteria required to estimate activity durations including the project update cycle.

- 6.5.1.2 Activity List (Out: 6.2)
  - The activity list identifies the activities that will need duration estimates.

6.5.1 Estimate Activity Durations: Inputs

- 6.5.1.3 Activity Attributes (Out: 6.2)
  - The activity attributes provide the primary data input for use in estimating durations required for each activity in the activity list.

- 6.5.1.4 Activity Resource Requirements (Out: 6.4)
  - The estimated activity resource requirements will have an effect on the duration of the activity, since the level to which the resources assigned to the activity meet the requirements will significantly influence the duration of most activities.

6.5.1 Estimate Activity Durations: Inputs

- 6.5.1.5 Resource Calendars (Out: 6.4)
  - The resource calendars influence the duration of schedule activities due to the availability of specific resources, type of resources, and resources with specific attributes.

6.5.1 Estimate Activity Durations: Inputs

- 6.5.1.6 Project Scope Statement (Out: 5.3)
  - The assumptions and constraints from the project scope statement are considered when estimating the activity durations.
  - Examples of assumptions include:
    - Existing conditions.
    - Availability of information.
    - Length of the reporting periods.
  - Examples of constraints include:
    - Available skilled resources, and
    - Contract terms and requirements.

6.5.1 Estimate Activity Durations: Inputs

- 6.5.1.7 Risk Register (Out: 11.2)
  - The risk register provides the list of risks, along with the results of risk analysis and risk response planning.
  - Updates to the risk register are included with project document updates described in Section 11.5.3.2.

- 6.5.1.8 Resource Breakdown Structure (Out: 6.4)
  - The resource breakdown structure provides a hierarchical structure of the identified resources by resource category and resource type.

6.5.1 Estimate Activity Durations: Inputs

- 6.5.1.9 Enterprise Environmental Factors (Out: 2.1.5)
  - The enterprise environmental factors that can influence the Estimate Activity Durations process include, but are not limited to:
    - Duration estimating databases and other reference data.
    - Productivity metrics.
    - Published commercial information.
    - Location of team members.

6.5.1 Estimate Activity Durations: Inputs

- 6.5.1.10 Organizational Process Assets (Out: 2.1.4)
  - The organizational process assets that can influence the Estimate Activity Durations process include, but are not limited to:
    - Historical duration information.
    - Project calendars.
    - Scheduling methodology.
    - Lessons learned.

6.5.2 Estimate Activity Durations: Tools and Techniques

- 6.5.2.1 Expert Judgment
  - Expert judgment, guided by historical information, can provide duration estimate information or recommended maximum activity durations from prior similar projects.
  - Expert judgment can also be used to determine whether to combine methods of estimating and how to reconcile differences between them.

6.5.2 Estimate Activity Durations: Tools and Techniques

- 6.5.2.2 Analogous Estimating
  - A technique for estimating the duration or cost of an activity or a project using **historical data from a similar activity or project**.
    - Uses parameters from a previous, similar project, Less costly and less time consuming than other techniques, but it is also less accurate.
    - Applied to a total project or to segments of a project and may be used in conjunction with other estimating methods.
    - Analogous estimating is most reliable when the previous activities are similar in fact and not just in appearance, and the project team members preparing the estimates have the needed expertise.

6.5.2 Estimate Activity Durations: Tools and Techniques

- 6.5.2.3 Parametric Estimating
  - An estimating technique in which an algorithm is used to calculate cost or duration based on **historical data** and **project parameters**.
    - It uses a statistical relationship between historical data and other variables to calculate an estimate for activity parameters.
    - It can be quantitatively determined by multiplying the quantity of work to be performed by labor hours per unit of work.
    - This technique can produce higher levels of accuracy depending upon the sophistication and underlying data built into the model.
    - It can be applied to a total project or to segments of a project, in conjunction with other estimating methods.

6.5.2 Estimate Activity Durations: Tools and Techniques

- 6.5.2.4 Three-Point Estimating
  - The accuracy of single-point activity duration estimates may be improved by considering estimation uncertainty and risk.
    - This concept originated with the program evaluation and review technique (PERT).
    - PERT uses three estimates to define an approximate range for an activity's duration:
      - Most likely (tM)
      - Optimistic (tO)
      - Pessimistic (tP)
  - PERT: Program evaluation and review technique

6.5.2 Estimate Activity Durations: Tools and Techniques

- 6.5.2.4 Three-Point Estimating
  - Depending on the assumed distribution of values within the range of the three estimates the expected duration, tE, can be calculated using a formula.
  - Two commonly used formulas are triangular and beta distributions. The formulas are:
    - Triangular Distribution
      - tE = (tO + tM + tP) / 3
    - Beta Distribution (from the traditional PERT technique)
      - tE = (tO + 4tM + tP) / 6

6.5.2 Estimate Activity Durations: Tools and Techniques

- 6.5.2.5 Group Decision-Making Techniques
  - Team-based approaches, such as brainstorming, the Delphi or nominal group techniques, are useful for engaging team members to improve estimate accuracy and commitment to the emerging estimates.

6.5.2 Estimate Activity Durations: Tools and Techniques

- 6.5.2.6 Reserve Analysis
  - Duration estimates may include **contingency reserves**, sometimes referred to as **time reserves** or **buffers**, into the project schedule to account for schedule uncertainty.
  - Contingency reserves are the estimated duration within the schedule baseline, which is allocated for identified risks that are accepted and for which contingent or mitigation responses are developed.
  - Contingency reserves are associated with the "**known-unknowns**" which may be estimated to account for this unknown amount of rework.

6.5.3 Estimate Activity Durations: Outputs

- 6.5.3.1 Activity Duration Estimates
  - A quantitative assessments of the likely number of time periods that are required to complete an activity.
  - Duration estimates do not include any lags
  - May include some indication of the range of possible results. example:
    - 2 weeks ± 2 days, which indicates that the activity will take at least eight days and not more than twelve (assuming a five-day workweek); and
    - 15 % probability of exceeding three weeks, which indicates a high probability—85 %—that the activity will take three weeks or less.

6.5.3 Estimate Activity Durations: Outputs

- 6.5.3.2 Project Documents Updates
  - Project documents that may be updated include, but are not limited to:
    - Activity attributes.
    - Assumptions made in developing the activity duration estimate, such as skill levels and availability, as well as a basis of estimates for durations.

6.6 Develop Schedule (PG: Planning)

- The process of **analyzing activity sequences, durations, resource requirements,** and **schedule constraints** to create the project schedule model.
  - The key benefit of this process is:
    - That by entering schedule activities, durations, resources, resource availabilities, and logical relationships into the scheduling tool, it generates a schedule model with planned dates for completing project activities.

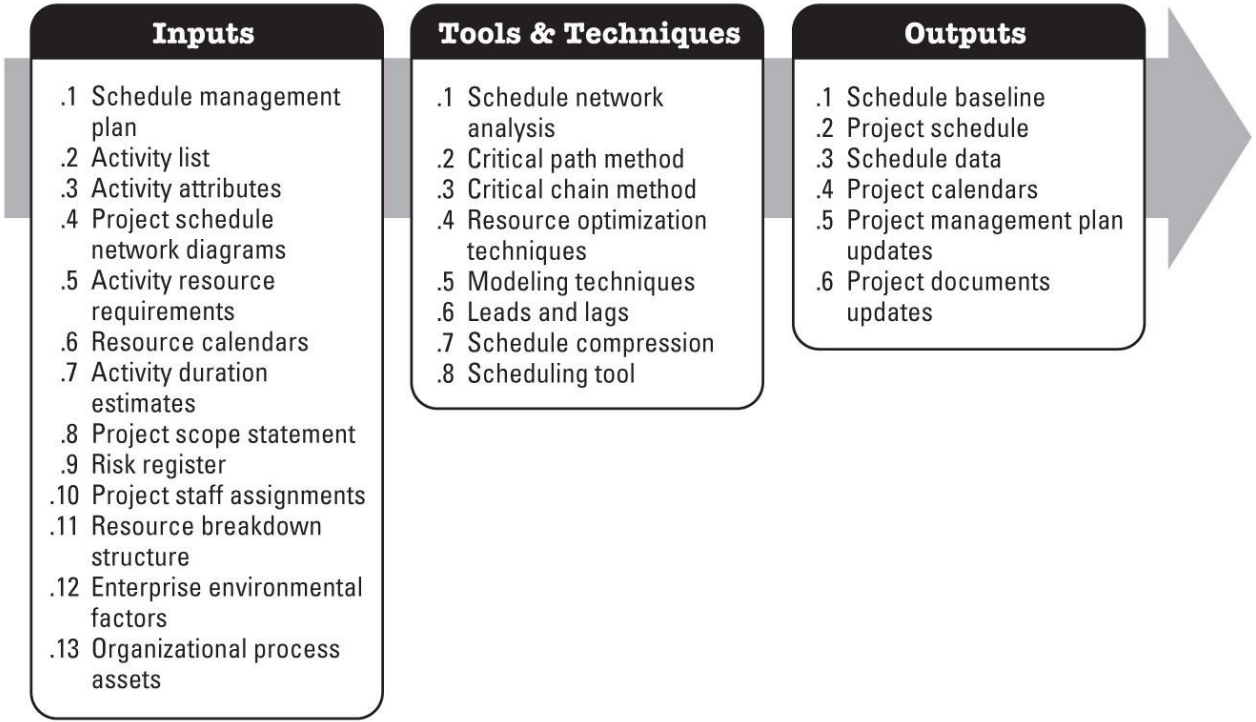


Figure 6-16 Develop Schedule: Inputs, Tools & Techniques, and Outputs

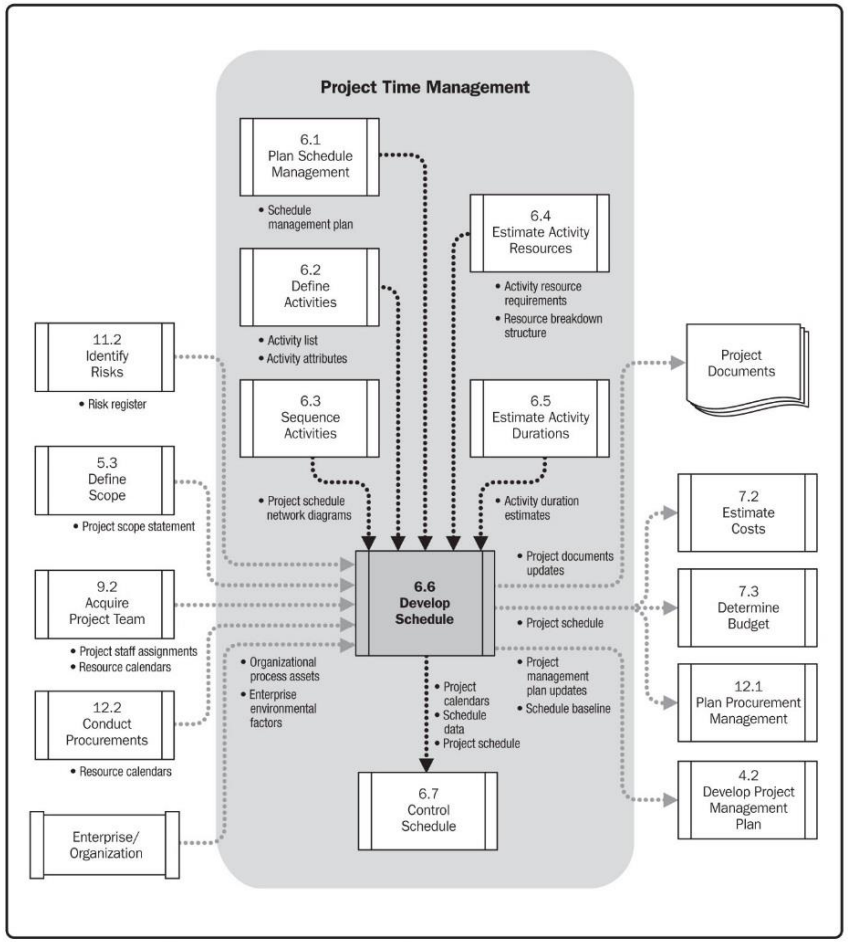


Figure 6-17. Develop Schedule Data Flow Diagram

6.6.1 Develop Schedule: Inputs

- 6.6.1.1 Schedule Management Plan (Out: 6.1)
  - The schedule management plan identifies the scheduling method and tool used to create the schedule, and how the schedule is to be calculated.

- 6.6.1.2 Activity List (Out: 6.2)
  - The activity list identifies the activities that will be included in the schedule model.

6.6.1 Develop Schedule: Inputs

- 6.6.1.3 Activity Attributes (Out: 6.2)
  - The activity attributes provide the details used to build the schedule model.

- 6.6.1.4 Project Schedule Network Diagrams (Out: 6.3)
  - The project schedule network diagrams contain the logical relationships of predecessors and successors that will be used to calculate the schedule.

6.6.1 Develop Schedule: Inputs

- 6.6.1.5 Activity Resource Requirements (Out: 6.4)
  - The activity resource requirements identify the types and quantities of resources required for each activity used to create the schedule model.

- 6.6.1.6 Resource Calendars (Out: 9.2 and 12.2)
  - The resource calendars contain information on the availability of resources during the project.

6.6.1 Develop Schedule: Inputs

- 6.6.1.7 Activity Duration Estimates (Out: 6.5)
  - The activity duration estimates contain the quantitative assessments of the likely number of work periods that will be required to complete an activity that will be used to calculate the schedule.

- 6.6.1.8 Project Scope Statement (Out: 5.3)
  - The project scope statement contains assumptions and constraints that can impact the development of the project schedule.

6.6.1 Develop Schedule: Inputs

- 6.6.1.9 Risk Register (Out: 11.2)
  - The risk register provides the details of all identified risks and their characteristics that affect the schedule model.

- 6.6.1.10 Project Staff Assignments (Out: 9.2)
  - The project staff assignments specify which resources are assigned to each activity.

6.6.1 Develop Schedule: Inputs

- 6.6.1.11 Resource Breakdown Structure (Out: 6.4)
  - The resource breakdown structure provides the details by which resource analysis and organizational reporting can be done.

- 6.6.1.12 Enterprise Environmental Factors (Out: 2.1.5)
  - The enterprise environmental factors include:
    - Standards.
    - Communication channels.
    - Scheduling tool to be used in developing the schedule model.

6.6.1 Develop Schedule: Inputs

- 6.6.1.13 Organizational Process Assets (Out: 2.1.4)
  - The organizational process assets that can influence the Develop Schedule process include, but are not limited to: scheduling methodology and project calendar(s)

6.6.2 Develop Schedule: Tools and Techniques

- 6.6.2.1 Schedule Network Analysis
  - A technique that generates the project schedule model.
  - It employs various analytical techniques, such as:
    - critical path method
    - critical chain method
    - what-if analysis
    - resource optimization techniques
  - Calculate the early and late start and finish dates for the uncompleted portions of project activities.

6.6.2 Develop Schedule: Tools and Techniques

- 6.6.2.2 Critical Path Method
  - A method used to estimate the minimum project duration and determine the amount of scheduling flexibility on the logical network paths within the schedule model.

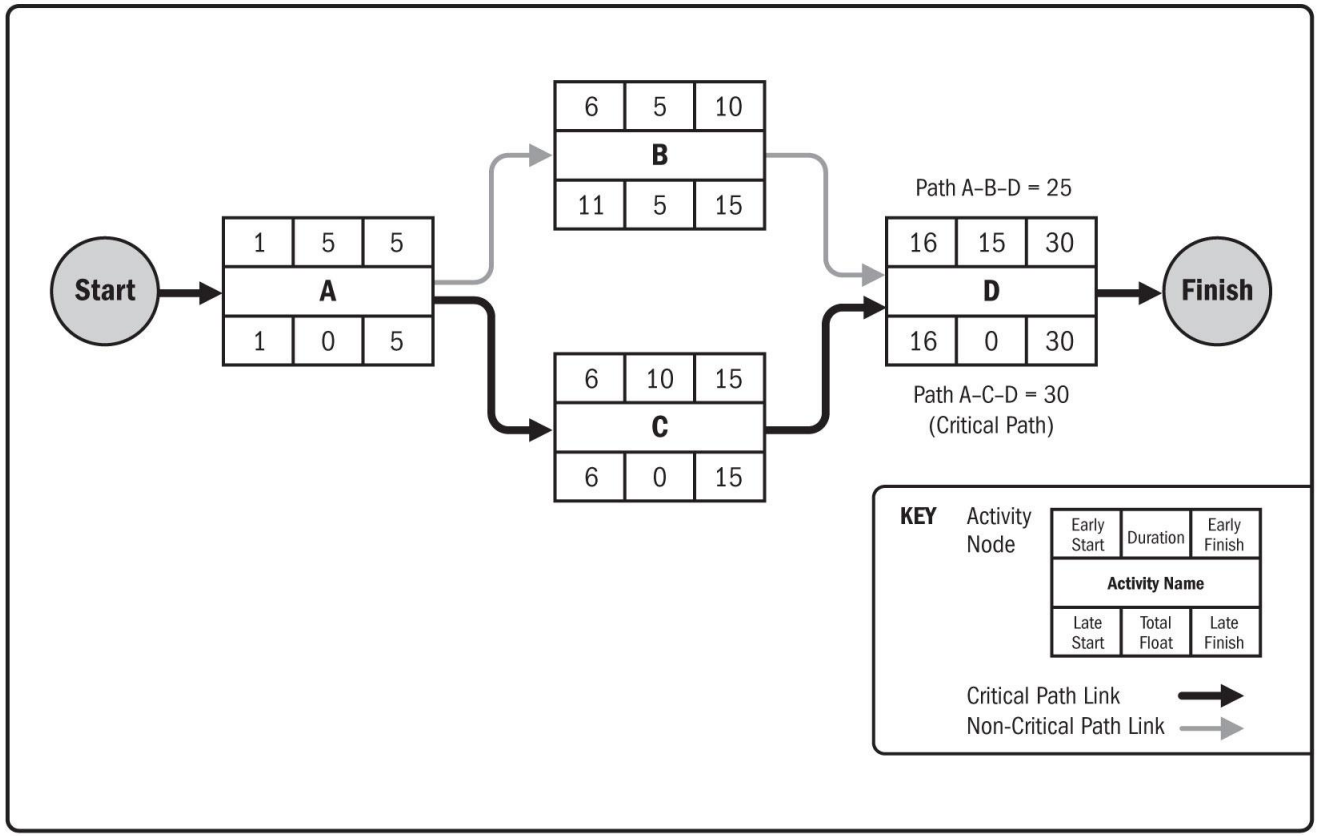


Figure 6-18. Example of Critical Path Method

6.6.2 Develop Schedule: Tools and Techniques

- 6.6.2.3 Critical Chain Method
  - The critical chain method (CCM) is a schedule method that allows the project team to place buffers on any project schedule path to account for limited resources and project uncertainties.

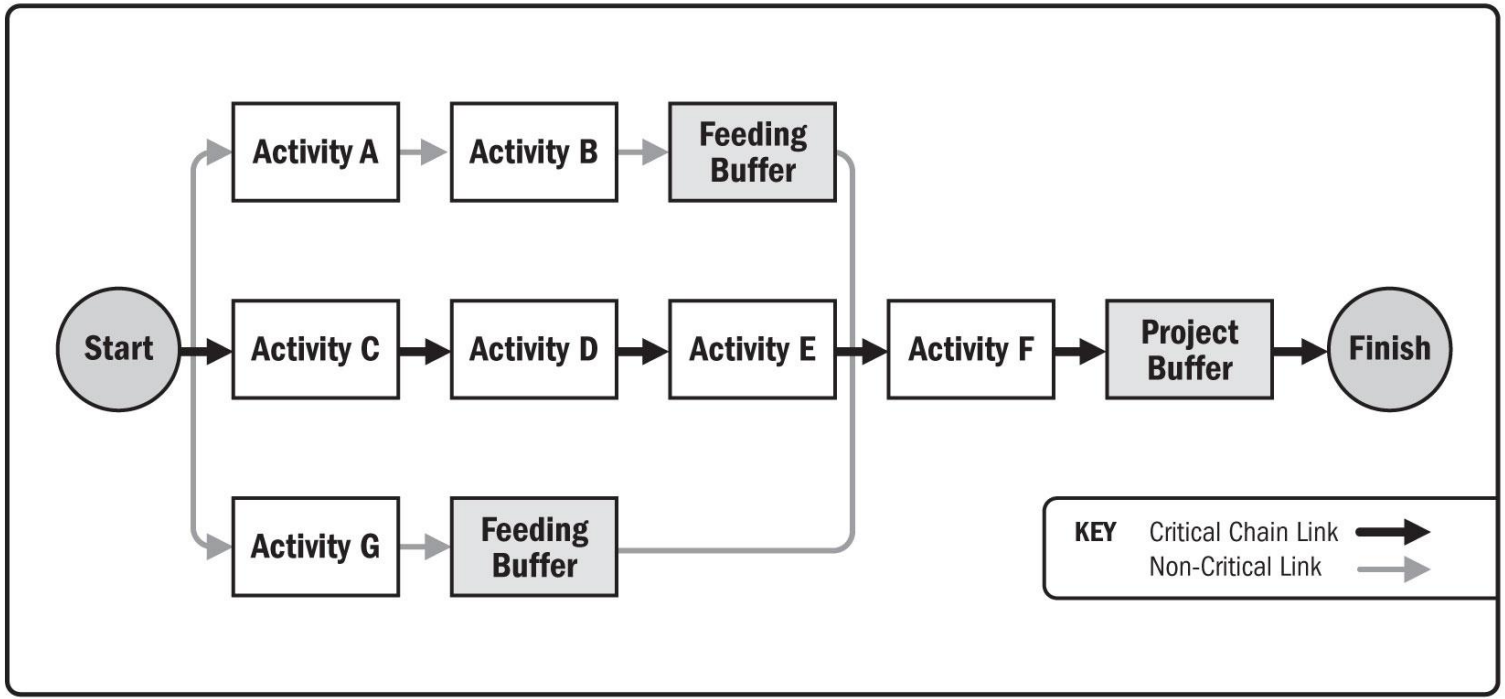


Figure 6-19. Example of Critical Chain Method

6.6.2 Develop Schedule: Tools and Techniques

- 6.6.2.4 Resource Optimization Techniques
  - Examples of resource optimization techniques that can be used to adjust the schedule model due to demand and supply of resources include:
    - Resource leveling
      - A technique in which start and finish dates are adjusted based on resource constraints
      - A way to fix resource overallocation
    - Resource Smoothing
      - A technique that adjusts the activities of a schedule model

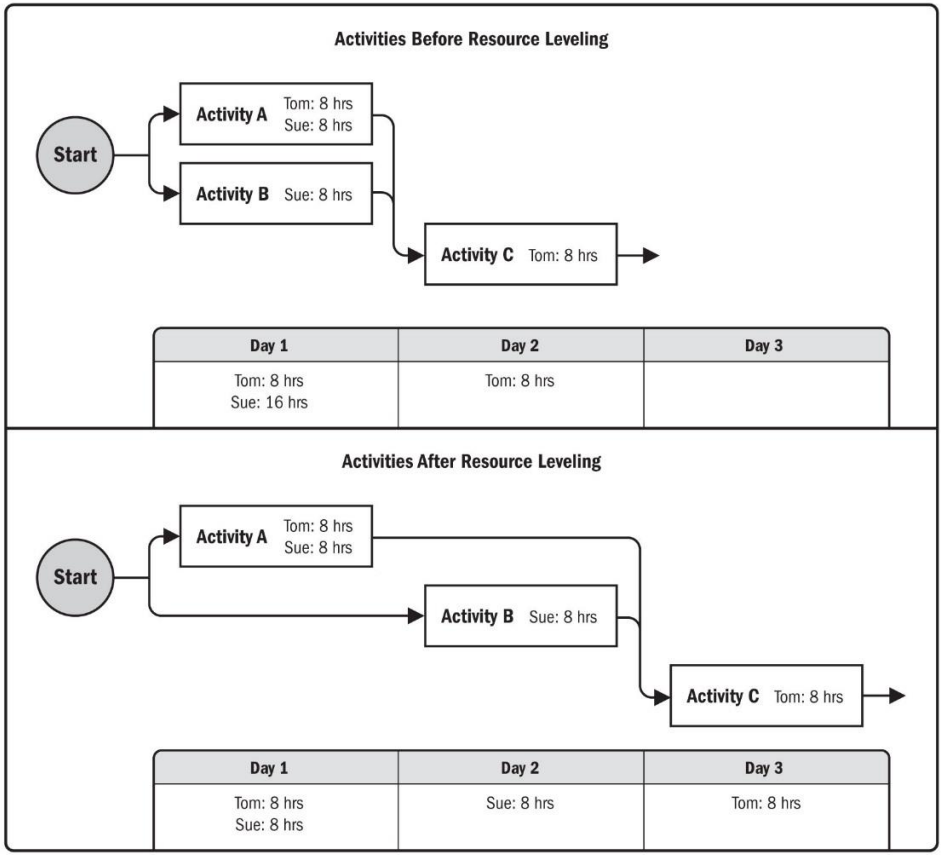


Figure 6-20. Resource Leveling

6.6.2 Develop Schedule: Tools and Techniques

- 6.6.2.5 Modeling Techniques
  - Examples of modeling techniques include:
    - What-If Scenario Analysis
      - Evaluating scenarios in order to predict their effect positively or negatively on project objectives.
    - Simulation
      - Calculating multiple project durations with different sets of activity assumptions usually using probability distributions constructed from the three-point estimates to account for uncertainty.

6.6.2 Develop Schedule: Tools and Techniques

6.6.2.5 Modeling Techniques

- What-If Scenario Analysis
  - The process of evaluating scenarios in order to predict their effect positively or negatively on project objectives.
  - The outcome of the what-if scenario analysis can be used to assess the feasibility of the project schedule under adverse conditions and in preparing contingency and response plans to overcome or mitigate the impact of unexpected situations.

6.6.2 Develop Schedule: Tools and Techniques

6.6.2.5 Modeling Techniques

- Simulation
  - Calculating multiple project durations with different sets of activity assumptions usually using probability distributions constructed from the three-point estimates to account for uncertainty.
  - The most common simulation technique is Monte Carlo analysis in which a distribution of possible activity durations is defined for each activity and used to calculate a distribution of possible outcomes for the total project.

6.6.2 Develop Schedule: Tools and Techniques

- 6.6.2.6 Leads and Lags
  - **Leads** and **lags** are refinements applied during network analysis to develop a viable schedule by adjusting the start time of the successor activities.
  - **Leads** are used in limited circumstances to advance a successor activity with respect to the predecessor activity
  - **Lags** are used in limited circumstances where processes require a set period of time to elapse between the predecessors and successors without work or resource impact.

6.6.2 Develop Schedule: Tools and Techniques

- 6.6.2.7 Schedule Compression
  - Schedule compression techniques are used to shorten the schedule duration without reducing the project scope, in order to meet schedule constraints, imposed dates, or other schedule objectives. Schedule compression techniques include:
    - Crashing:
      - A technique used to shorten the schedule duration by adding resources
    - Fast tracking:
      - Activities or phases normally done in sequence are performed in parallel.

6.6.2 Develop Schedule: Tools and Techniques

- 6.6.2.8 Scheduling Tool
  - Automated scheduling tools contain the schedule model and expedite the scheduling process by generating start and finish dates based on the inputs of activities, network diagrams, resources and activity durations using schedule network analysis.
  - A scheduling tool can be used in conjunction with other project management software applications as well as manual methods.

6.6.3 Develop Schedule: Outputs

- 6.6.3.1 Schedule Baseline
  - **The approved version** of a schedule model that can be changed only through formal **change control procedures** and is used as a basis for comparison to actual results.
  - Accepted & approved by the appropriate stakeholders.
  - During M&C, the approved baseline dates are compared to the actual start and finish dates to determine whether variances have occurred.

6.6.3 Develop Schedule: Outputs

- 6.6.3.2 Project Schedule
  - An output of a schedule model that presents linked activities with planned dates, durations, milestones, and resources.
  - It can be presented in tabular form using one or more of the following formats:
    - Bar charts
    - Milestone charts
    - Project schedule network diagrams

6.6.3 Develop Schedule: Outputs

- 6.6.3.3 Schedule Data
  - The collection of information for describing and controlling the schedule.
  - Includes at least the schedule milestones, schedule activities, activity attributes, and documentation of all identified assumptions & constraints.
  - The amount of additional data varies by application area. Information frequently supplied as supporting detail includes:
    - Resource requirements by time period
    - Alternative schedules.
    - Scheduling of contingency reserves.

6.6.3 Develop Schedule: Outputs

- 6.6.3.4 Project Calendars
  - A project calendar identifies working days and shifts that are available for scheduled activities.
  - It distinguishes time periods in days or parts of days that are available to complete scheduled activities from time periods that are not available.
  - A schedule model may require more than one project calendar to allow for different work periods for some activities to calculate the project schedule.

6.6.3 Develop Schedule: Outputs

- 6.6.3.5 Project Management Plan Updates
  - Elements of the project management plan that may be updated include:
    - Schedule baseline (Section 6.6.3.1),
    - Schedule management plan (Section 6.1.3.1).

6.6.3 Develop Schedule: Outputs

- 6.6.3.6 Project Documents Updates
  - Project documents that may be updated include:
    - Activity resource requirements
    - Activity attributes
    - Risk register

6.7 Control Schedule (PG: M&C)

- The process of **monitoring the status of project activities** to update project progress and manage changes to the schedule baseline to achieve the plan.
  - It provides the means to recognize deviation from the plan and take corrective and preventive actions and thus minimize risk.
  - Control Schedule is concerned with:
    - Determining the current status of the project schedule
    - Influencing the factors that create schedule changes
    - Determining if the project schedule has changed
    - Managing the actual changes as they occur.

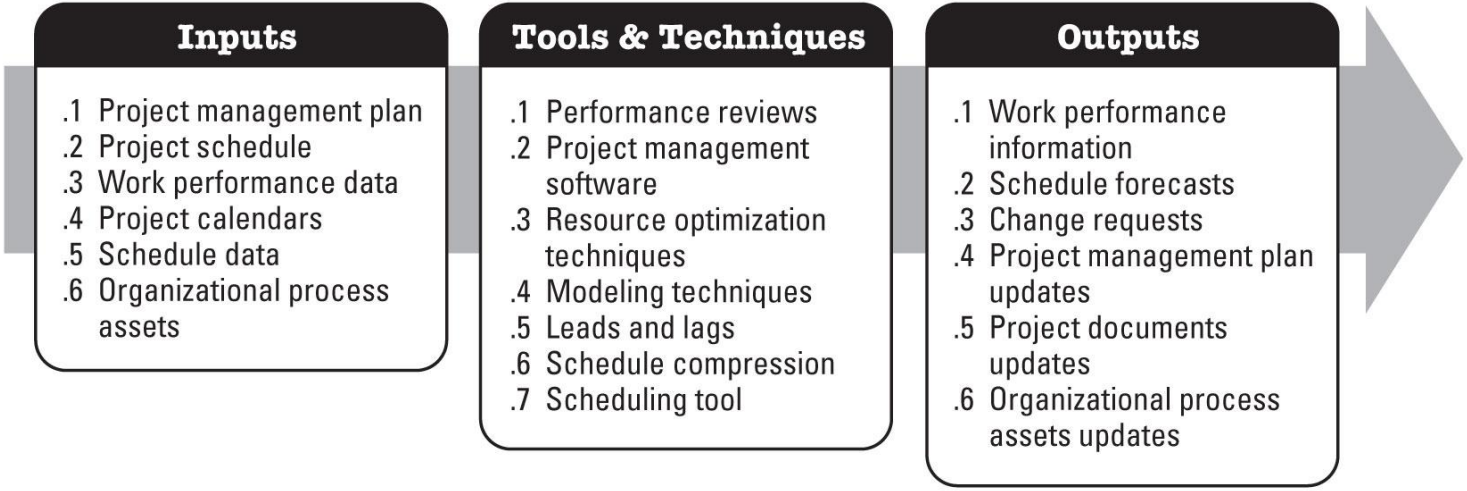


Figure 6-22. Control Schedule: Inputs, Tools & Techniques, and Outputs

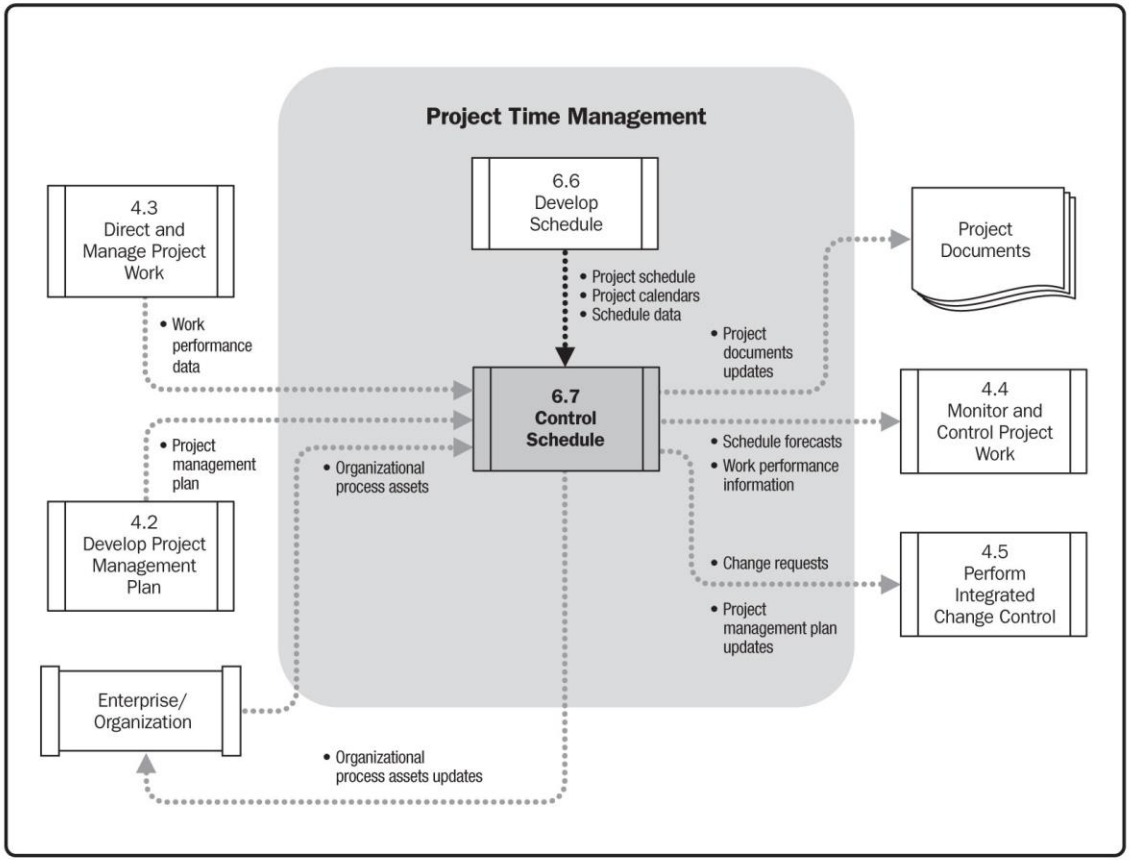


Figure 6-23. Control Schedule Data Flow Diagram

6.7.1 Control Schedule: Inputs

- 6.7.1.1 Project Management Plan (Out: 4.2)
  - Contains the schedule management plan and the schedule baseline.
  - The schedule management plan describes how the schedule will be managed and controlled.
  - The schedule baseline is used as a reference to compare with actual results to determine if a change, corrective action, or preventive action is necessary.

6.7.1 Control Schedule: Inputs

- 6.7.1.2 Project Schedule (Out: 6.6)
  - Project schedule refers to the most recent version with notations to indicate updates, completed activities, and started activities as of the indicated data date.

- 6.7.1.3 Work Performance Data (Out: 4.3)
  - Work performance data refers to information about project progress such as which activities have started, their progress and which activities have finished.

6.7.1 Control Schedule: Inputs

- 6.7.1.4 Project Calendars (Out: 6.6)
  - A schedule model may require more than one project calendar to allow for different work periods for some activities to calculate the schedule forecasts.

- 6.7.1.5 Schedule Data (Out: 6.6)
  - Schedule data will be reviewed and updated in the Control Schedule process.

6.7.1 Control Schedule: Inputs

- 6.7.1.6 Organizational Process Assets (Out: 2.1.4)
  - The organizational process assets that influence the Control Schedule process include:
    - Existing formal and informal schedule control-related policies, procedures, and guidelines.
    - Schedule control tools.
    - Monitoring and reporting methods to be used.

6.7.2 Control Schedule: Tools and Techniques

- 6.7.2.1 Performance Reviews
  - Performance reviews measure, compare, and analyze schedule performance such as:
    - actual start
    - finish dates
    - percent complete
    - remaining duration for work in progress.

6.7.2 Control Schedule: Tools and Techniques

- 6.7.2.2 Project Management Software
  - Project management software for scheduling provides the ability to track planned dates versus actual dates, to report variances to and progress made against the schedule baseline, and to forecast the effects of changes to the project schedule model.

- 6.7.2.3 Resource Optimization Techniques
  - Resource optimization techniques involve the scheduling of activities and the resources required by those activities while taking into consideration both the resource availability and the project time.

6.7.2 Control Schedule: Tools and Techniques

- 6.7.2.4 Modeling Techniques
  - Modeling techniques are used to review various scenarios guided by risk monitoring to bring the schedule model into alignment with the project management plan and approved baseline.

- 6.7.2.5 Leads and Lags
  - Adjusting leads and lags is applied during network analysis to find ways to bring project activities that are behind into alignment with the plan.

6.7.2 Control Schedule: Tools and Techniques

- 6.7.2.6 Schedule Compression
  - Schedule compression techniques are used to find ways to bring project activities that are behind into alignment with the plan by fast tracking or crashing schedule for the remaining work.

- 6.7.2.7 Scheduling Tool
  - Schedule data is updated and compiled into the schedule model to reflect actual progress of the project and remaining work to be completed.

6.7.3 Control Schedule: Outputs

- 6.7.3.1 Work Performance Information
  - The calculated **SV** and **SPI** time performance indicators for WBS components, in particular the work packages and control accounts are documented and communicated to stakeholders.

6.7.3 Control Schedule: Outputs

- 6.7.3.2 Schedule Forecasts
  - Schedule forecasts are **estimates** or **predictions** of conditions and events in the project's future based on information and knowledge available at the time of the forecast.
  - Forecasts are updated and reissued based on work performance information provided as the project is executed.
  - The information is based on the project's past performance and expected future performance, and includes earned value performance indicators that could impact the project in the future.

6.7.3 Control Schedule: Outputs

- 6.7.3.3 Change Requests
  - Change requests are processed for review and disposition through the Perform Integrated Change Control process (Section 4.5).
  - **Preventive actions** may include recommended changes to eliminate or reduce the probability of negative schedule variances.

6.7.3 Control Schedule: Outputs

- 6.7.3.4 Project Management Plan Updates
  - Elements of the project management plan that may be updated include, but are not limited to:
    - Schedule baseline
    - Schedule management plan
    - Cost baseline

6.7.3 Control Schedule: Outputs

- 6.7.3.5 Project Documents Updates
  - Project documents that may be updated include:
    - Schedule Data
    - Project Schedule
    - Risk Register

6.7.3 Control Schedule: Outputs

- 6.7.3.6 Organizational Process Assets Updates
  - Organizational process assets that may be updated include:
    - Causes of variances
    - Corrective action chosen and the reasons
    - Other types of lessons learned from project schedule control.

Questions

- An activity has an optimistic estimate of 10 days, pessimistic estimate of 16 days, and most likely estimate of 13 days. What is the PERT estimate for the task?
  - A. 13 days
  - B. 10 days
  - C. 16 days
  - D. Cannot be determined with available information

In a normal distribution, the PERT duration (also called mean)
= {Pessimistic + (4 x Most Likely) + Optimistic}/6
= {16 + (4 x 13) + 10}/6
= 13

- **If the optimistic estimate for an activity is 12 days, and the pessimistic estimate is 18 days, what is the standard deviation of this activity?**

A. 1

B. 1.3

C. 6

D. 3

Explanation The beta standard deviation is computed by (P - 0)/6. Therefore, the answer is (18 12)/6 = 6/6 = 1.

- **Lag means**

A. the amount of time an activity can be delayed without delaying the project finish date.

B. the amount of time an activity can be delayed without delaying the early start date of its successor.

C. waiting time.

D. the product of a forward and backward pass.

Answer C

Explanation Total float and free float are the time an activity can be delayed without impacting the entire project or the next activity. A forward or backward pass refers to a network analysis technique, not waiting time. Waiting time is the correct definition of lag.

- **Which of the following is the BEST project management tool to use to determine the longest time the project will take?**

A. Work breakdown structure

B. Network diagram

C. Bar chart

D. Project charter

Answer B

Explanation The bar chart may show an end date, but it is not used to determine dates. The project charter also may include a required end date, but not a logical determination of how long the project will take. The network diagram takes the activities from the activity list and adds dependencies. The dependencies allow us to look at the various paths through the diagram to determine the longest duration (critical) path. The network diagram is the best answer.

- You are taking over a project during the planning stage. You have managed to identify five tasks to be completed during the project. Please refer to the table given below:
- What is the length of the critical path in months?

A. 12

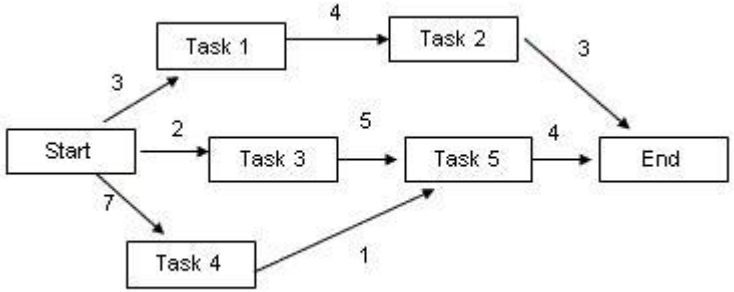
B. 10

C. 11

D. 14

Task	Preceding Activity	Estimate in Months
Start	-	0
1	Start	3
2	1	4
3	Start	2
5	3	5
4	Start	7
5	4	1
End	2	3
End	5	4

- The tasks are shown as a network diagram below.
- The lengths of different paths are:
  - Start⟶ 1⟶ 2⟶ End: 10 Months
  - Start⟶ 3⟶ 5⟶ End: 11 Months
  - Start⟶ 4⟶ 5⟶ End: 12 Months



- Since the longest path is Start⟶ 4⟶ 5⟶ End;
- This is the critical path. Length of the critical path is 12 months.

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