



Estimating (EST)

Required PA Information

Intent

Estimate the size, effort, duration, and cost of the work and resources needed to develop, acquire, or deliver the solution.

Value

Estimation provides a basis for making commitments, planning, and reducing uncertainty, which allows for early corrective actions and increases the likelihood of meeting objectives.

Additional Required PA Information

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Explanatory PA Information

Practice Summary

Level 1

EST 1.1 Develop high-level estimates to perform the work.

Level 2

EST 2.1 Develop, keep updated, and use the scope of what is being estimated.

EST 2.2 Develop and keep updated estimates for the size of the solution.

EST 2.3 Based on size estimates, develop and record effort, duration, and cost estimates and their rationale for the solution.

Level 3

EST 3.1 Develop and keep updated a recorded estimation method.

EST 3.2 Use the organizational measurement repository and process assets for estimating work.

Additional PA Explanatory Information

Estimation provides the basis for making commitments. An estimate takes into consideration the scope, size, and complexity of the work. Base the estimate on the available information. Record any uncertainty as a risk.

Uncertainty or risk in a commitment can be handled by:

- Providing an initial commitment with an understanding that the initial commitment may be changed if the scope changes
- Defining milestones to refine an initial commitment range to produce a final commitment after more investigation

- Committing to the known parts of the project, and committing to the remainder of the work after further investigation and definition

Historical data describing the relationship between measured size and resources such as effort, cost, and schedule should be used when planning future work. A good understanding of historical data is critical to successful estimating. Use historical data when planning future work and to calibrate estimation formulas and models. Record qualitative information such as context, methods, tools and techniques used, and lessons learned from past projects.

Estimate and track several aspects of the work to realize value. For example, based on the table below, how complete is the work?

Table EST-1: Example Tracking Information

Aspect	Percent Completed
Size	10%
Effort	60%
Duration	50%
Cost	75%

This question cannot be answered if only effort is tracked. In order to get a complete picture of the status, the other aspects of the project need to be estimated and tracked. If all of these aspects are not estimated and tracked, it could lead to an incomplete or misleading understanding of the work status. The numbers in the table indicate a potential problem and should trigger an investigation to determine the real status of the project. There are other aspects of the work, such as complexity, that may affect the answer. For example, the size may only be 10% complete because the project front loaded the highly complex components. Understanding the aspects and their relationships will provide a more comprehensive estimate. The rationale of the estimate should be based on historical data, rather than on the experience and knowledge of the estimator.

Related Practice Areas

Refer to the Requirements Development and Management practice area for additional information on requirements for understanding the work prior to estimation.

Refer to the Risk and Opportunity Management practice area for additional information on the identification of risk.

Refer to the Managing Performance and Measurement practice area for additional information on historical data and performance models.

Context Specific

Agile with Scrum Guidance

Context Tag:	Agile with Scrum
Context:	Practices used by projects to adopt agile with Scrum when developing estimates.

In general, agile teams using Scrum estimate during the backlog grooming and sprint planning steps:

- Estimates for backlog items are typically a rough order of magnitude.

- Some agile teams using Scrum develop a comprehensive estimate during release planning for a set of stories or epics.
- Estimates for each sprint are typically more refined, allowing the team to understand their commitments.

The typical agile estimation steps develop the following information:

- **Size:** During backlog review, assign backlog items, such as requirements and user stories, a relative size using story points (see **Table EST-3**). In addition to story points, agile with Scrum teams may use such techniques as planning poker or t-shirt size (small, medium, large, or extra-large) to estimate size. Often requirements are converted into user stories before estimation is performed. Complex needs or requirements may be transformed into an epic, which is typically a large user story that can span more than one sprint. If the epic spans more than one sprint, it is typically broken into smaller user stories. The transformation of user stories into story points takes into account the size and complexity of the solution.
- **Tasks and Effort:** During sprint planning, agile teams using Scrum and the product owner collaborate to select user stories off the backlog based on the priority of the product owner and estimate them using relative sizing techniques such as planning poker, t-shirt sizing, or the Team Estimation Game. Using the team's known velocity as a guide, prioritized stories are accepted by all stakeholders into the sprint. Some agile teams estimate the task effort in hours for each story based on historical data or other effort estimation technique.
 - Determine how many user stories can be committed to the sprint when team velocity is known (story points completed per sprint).
 - Estimate effort at the task level and use the total to determine the amount of work that can fit into a sprint based on available capacity.
 - Use known velocity numbers to make a first estimate of what can be committed to in a sprint, and then use task breakdown and effort data to refine and validate the decision.
- **Task Assumptions:** Assumptions are discussed and confirmed during sprint planning events and often reviewed during the retrospective to improve estimates. Assumptions should be recorded, clarified, and communicated during these events (see examples in Table EST-3).

Figure EST-1 shows where estimation is typically performed in an agile project. **Table EST-2** and **Table EST-3** show example estimation data and the model practices used to generate this information.

Figure EST-1: Estimating in an Agile Cycle



Table EST-2: Backlog with Estimates

Backlog Item	Size (Story points)
Requirement 1	40
Requirement 2	30
User Story 1	20
...	...
Practice(s)	1.1

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Table EST-3: Requirement/Task Estimation & Model Practices

Backlog Item & Tasks	Size (Story Points)	Effort (Hours)	Task Assumptions (Rationale)
Requirement 1	40		
Task 1		34	Familiar with coding language
Task 2		40	Existing database is clean (no errors)
...		100	Familiar with coding language
Requirement 2	20		
Task 1		8	Task has been done before - easy
User Story 1	30	60	Medium complexity
Practices: 2.1	1.1 2.2	1.1 2.3	2.4

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Level 1

EST 1.1

Required Practice Information

Practice Statement

Develop high-level estimates to perform the work.

Value

A high-level estimate addresses work size, cost, and schedule uncertainties to avoid pursuing work that may result in schedule or budget overruns.

Additional Required Information

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Explanatory Practice Information

Additional Explanatory Information

The high-level estimate is typically:

- A rough draft, top-down estimate (also called a rough order of magnitude estimate)
- Based on identified or recorded assumptions and uncertainty
- Developed quickly
- Based on previous knowledge and experience

Example Activities

Example Activities	Further Explanation
Review needs and assumptions and determine high-level estimates with stakeholders.	

Example Work Products

Example Work Products	Further Explanation
Rough order of magnitude estimate	Includes: <ul style="list-style-type: none"> • An estimate of the size, complexity, cost, effort, or duration of the solution • Assumptions • Unit of measure

Level 2

EST 2.1

Required Practice Information

Practice Statement

Develop, keep updated, and use the scope of what is being estimated.

Value

Ensures the entire solution is addressed which increases the likelihood of meeting objectives and avoiding rework.

Additional Required Information

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Explanatory Practice Information

Additional Explanatory Information

The scope:

- Includes the work effort
- Defines the solution to be developed, delivered, or acquired
- Results in the information needed to estimate the size, effort, cost, and duration
- Addresses any resources that must be acquired or will be consumed during the project
- Establishes the work constraints (e.g., what is included and what is not included)

Use an initial set of requirements and work objectives to form the basis for establishing the scope. Defining and using the scope can help uncover missing or misunderstood requirements, identify risks, and develop more detailed estimates. Inaccurate estimation is often the result of not understanding the scope of the work. Update the scope as the project progresses to address changes.

Example Activities

Example Activities	Further Explanation
Review requirements and objectives with stakeholders to determine scope.	

Example Work Products

Example Work Products	Further Explanation
List of tasks and activities or Work Breakdown Structure (WBS)	To more accurately estimate costs, include identified resources for tasks and durations.
List of needed resources	Includes not just staff, but also other resources needed to accomplish the work (e.g., facilities, acquired solutions, tools).
Work flow diagram	Visualizes how tasks will flow between resources and what conditions allow the sequence to move forward.

Related Practice Areas

Refer to the *Requirements Development and Management* practices for more information about requirements.

EST 2.2

Required Practice Information

Practice Statement

Develop and keep updated estimates for the size of the solution.

Value

Well-defined estimates allow work tracking and timely corrective actions to deliver the solution on time and within budget.

Additional Required Information

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Explanatory Practice Information

Additional Explanatory Information

Size is the primary input to many estimation models. Estimation is not a one-time activity that is only performed before or at the start of the project. It is a recurring activity where the estimate is adjusted as new information becomes available throughout the lifecycle of a solution, operations and maintenance, or for services produced and delivered.

Estimating size provides a consistent basis for estimating effort, duration, and cost. A relative level of difficulty or complexity may be associated with size estimates and is used in the transformation to effort, duration, cost, and quality. For example:

- For services, size could be the type or number of service requests, number of calls received in an hour, or the number of customers desiring a service delivery, etc.
- For software development, size could be the number of objects, the number of components, the number of features, standard or customized function points, the number of requirements, or the number of lines of code, etc.
- For hardware development, size could be the number of connections or connection points, the number of welds, the number of boards, the number of components, or the number of hardware and software integration points, etc.
- For supplier management, size could be the number of requirements, the number of features, the number of items to be acquired, or the number and types of bidders, etc.

Example Activities

Example Activities	Further Explanation
Use applicable methods to estimate the size and complexity of solutions and tasks.	Methods for determining size include: <ul style="list-style-type: none"> • Analogy • Delphi • 3-point estimation

Example Activities	Further Explanation
	<ul style="list-style-type: none"> • Parametric estimation <p>The project estimation methods and their use may change over time as the understanding of the relationship of solution characteristics to size improves.</p> <p>Complexity is typically used in the transformation from size to effort, duration, and cost. Complexity may also include qualitative aspects of the solution, such as new vs. legacy.</p>

Example Work Products

Example Work Products	Further Explanation
Size estimate	<p>Typically includes:</p> <ul style="list-style-type: none"> • Size • Unit of measure • Rationale or basis for estimate, including assumptions and constraints • Complexity – could be a multiplier of size, or a modifier (such as Hard, Medium, Easy), to take into account the potential difficulty of implementing the solution

EST 2.3

Required Practice Information

Practice Statement

Based on size estimates, develop and record effort, duration, and cost estimates and their rationale for the solution.

Value

Enables a better basis for commitments and improves accuracy of the estimates, leading to better decision making.

Additional Required Information

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Explanatory Practice Information

Additional Explanatory Information

This practice transforms the size estimate into estimates of effort, duration, and cost. Use estimation models, historical data, expert judgment, or a combination of all three. Understanding the size of the solution provides a more accurate basis for determining the effort, duration, and cost for the solution. During the course of the work, compare the rationale to actual conditions to identify missing or unnecessary aspects in the original estimate. Identifying missing or unnecessary aspects supports re-planning the current work or estimating future work.

Managers and leads typically perform top down estimation. Bottom up estimation is typically performed by team members.

Develop and calibrate estimation models using available historical data. To maintain confidence, update estimation models as additional data becomes available.

Sometimes, historical data is not available, such as when efforts are unprecedented. Unprecedented efforts are riskier and require more research to develop a basis of estimate. Record rationale for what made the work unique to aid understanding of any assumptions made in the initial planning phases.

Example Activities

Example Activities	Further Explanation
<p>Collect and use historical data to develop, calibrate, or recalibrate models or methods to transform size and complexity into effort, duration, and cost estimates.</p>	<p>To ensure a high level of confidence in the estimate, use multiple models or methods as needed, for example, based on the most important set of tasks and activities.</p> <p>Historical data should include:</p> <ul style="list-style-type: none"> • Size, cost, effort, and schedule (duration) data from previous completed projects. • Appropriate scaling data to account for differing sizes and complexity. • In addition, information on factors that influenced the performance and other contextual information will help determine if past data can be included, excluded, or adjusted. <p>Historical data can also be used with analogies (e.g., if a current project is 10% smaller than a similar historical project, use the historical project's results reduced by 10%). There may be instances where historical data is not available or does not apply. In the absence of historical data (for example, no prior history of work similar to current work) external sources like industry data may be used.</p> <p>Models can also be based on other characteristics such as service level, connectivity, complexity, availability, reusability, and structure. Other examples of characteristics include:</p> <ul style="list-style-type: none"> • Critical competencies and roles needed to perform the work • Needed knowledge, skills, experience, and training • Selected lifecycle model and processes • Travel • Team productivity • Geographic dispersal of work group members • Proximity of customers, end users, and suppliers • Amount of risk • How agreeable or difficult the customer is • Direct labor rates and overhead • Penalties for warranty work • Regulatory requirements or environment • Level of security required for tasks, work products, hardware, software, personnel, and work environment
<p>Describe and record the rationale for the estimates of effort, duration, and cost for the solution.</p>	<p>Recording the rationale provides the context for using historical data for estimating future work.</p>

Example Activities	Further Explanation
Include estimates of supporting infrastructure needs.	<p>The supporting infrastructure includes resources needed to support the project but are not necessarily included in the project itself. Consider the infrastructure resources needed for the work, including:</p> <ul style="list-style-type: none"> • Contracts • Facilities • Tools • Consumables • Licenses • Travel

Example Work Products

Example Work Products	Further Explanation
Effort estimate	<p>Typically includes:</p> <ul style="list-style-type: none"> • Effort • Unit of measure (typically hours or days) • Productivity • Context for the effort estimate
Duration estimate	<p>Typically includes:</p> <ul style="list-style-type: none"> • Duration • Unit of measure (typically hours or days) • Rationale for the duration estimate
Cost estimate	<p>Typically includes:</p> <ul style="list-style-type: none"> • Cost • Unit of measure (e.g., local currency, contract currency) • Rationale for the cost estimate
Estimating rationale	<p>Typically includes:</p> <ul style="list-style-type: none"> • Description of what is being estimated • Scope • Assumptions and constraints • Comparisons to similar work • Team experience with the technology and domain • Risks • Use of historical data • Tools, techniques, or methods used: <ul style="list-style-type: none"> ○ Off the shelf tools ○ Internally developed tools ○ Formulas and calculations ○ Models

Level 3

EST 3.1

Required Practice Information

Practice Statement

Develop and keep updated a recorded estimation method.

Value

Maximizes consistency and efficiency for developing accurate estimates and increases the likelihood of meeting objectives.

Additional Required Information

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Explanatory Practice Information

Additional Explanatory Information

A defined estimation method is a standard approach using established processes and the best available valid data to estimate the current or future size, effort, cost, and duration of a project based on what is known. Valid estimating data is applicable to the context of the work being estimated. Organizations may have more than one estimation method.

Methods using historical data provide a data driven approach to estimation. Calibrate methods based on actual results vs. historical data and recalibrate methods when conditions, assumptions, processes, or performance change. Use an analysis of estimation accuracy to improve the method.

Some standard methods are described in the following table:

Table EST-4: Example Estimation Methods

Method	Brief Description
Delphi method	Estimates are developed by a group of subject matter experts where each independently gives their estimates and assumptions to the designated facilitator. The team discusses the differences and re-estimates. This is repeated until the estimates converge. The facilitator then records the final estimate.
Comparative or analogous estimation	Estimates are based directly on past results for similar projects. The estimate is then adjusted for differences in size, complexity, or other factors to reflect current knowledge.
Parametric estimation	Parametric estimates are based on historical data and project parameters and typically use a tool. Note that there are various forms of estimation tools, including: <ul style="list-style-type: none"> • Mathematical • Scenario-based • Simulation • Calibrating the estimation tool as it is used can provide additional estimation accuracy.

Method	Brief Description
3-point estimation	Each estimator (note that there may be only one estimator) provides high, low, and most-likely estimates. The facilitator combines them and calculates the resulting value by using the formula: $(high + (4 * most\ likely) + low) / 6.$

Example Activities

Example Activities	Further Explanation
Determine the acceptable estimation methods.	Estimation methods are most accurate when based on historical data and validated before use. The estimation methods should be used consistently for similar activities, projects, domains, etc. Involve subject matter experts in developing and approving the method. The estimation tools can be built or acquired, but should be calibrated with organizational data.
Calibrate and adjust method based on actual results.	One approach to calibrate is to refresh the data periodically or recalibrate data after the most recent use. For example, compare the actuals from the most recent calendar quarter of data to an estimate of that same quarter using the average of the previous three calendar quarters. Based on differences, adjust the method.
Validate method.	The method should be validated by subject matter experts who have used and understand when to apply the method.

Example Work Products

Example Work Products	Further Explanation
Recorded estimation methods	The process, tools, and data used for the selected estimation methods.

EST 3.2

Required Practice Information

Practice Statement

Use the organizational measurement repository and process assets for estimating work.

Value

Increases estimation precision, accuracy, and consistency enabling better decision making, a higher likelihood of meeting objectives, and reduced risk.

Additional Required Information

This section left blank for future content.

Explanatory Practice Information

Additional Explanatory Information

Using organizational assets as a basis for estimating leverages the data and experience from previous projects to improve the reliability of estimates for similar work. Select the most appropriate estimation method and use it to produce the estimates.

When using organizational assets consider:

- Historical and validated data from this work or similar work and its context
- Similarities and differences between the current work and work from which historical data will be used
- Rationale used to select the historical data
- Type of work
- Tailoring performed
- Geographic-specific information
- Domain and technology

Examples of data contained in the organization's measurement repository that could be used in estimation may include:

- Size
- Effort
- Cost
- Duration
- Personnel
- Experience
- Response time
- Capacity
- Performance
- Quality
- Context specific information

Example Activities

Example Activities	Further Explanation
Use organizational assets and measures for estimation.	Include selection criteria and rationale for the chosen estimation technique.
Use estimation methods.	
Contribute results and measures to the organization in order to improve the estimation methods and update organizational assets.	Include actual results, contextual information, and identified improvements.
Analyze organizational data.	Analyze data to better understand:

Example Activities	Further Explanation
	<ul style="list-style-type: none"> • Variability • Data quality • Mean, median, mode

Example Work Products

Example Work Products	Further Explanation
Work estimates	Include historical data, context, and approved use from the organization.
Updated organizational process assets	<p>Updated organizational process assets may include:</p> <ul style="list-style-type: none"> • Templates • Best practice examples • Approved methods for use • Guidelines <p>Updates to the organizational measurement repository may include:</p> <ul style="list-style-type: none"> • Historical estimation data (e.g., actual effort expended, number of function points) • Rationale for the estimate (e.g., team skill levels, amount of code reused) • Contextual information (e.g., domain, type of work, customer) • Updated estimation results