



Estimating project times and costs

Lecture 10

Chapter 9

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PMG101

Foundations of Project Management

Learning Outcomes

- Factors Influencing the Quality of Estimates.
- Estimating Guidelines for Times, Costs, and Resources.
- Top-Down versus Bottom-Up Estimating.
- Methods for Estimating Project Times and Costs .



Why Estimating Time and Cost Is Important?

- Estimates are needed to support good decisions.
- Estimates are needed to schedule work.
- Estimates are needed to determine how long the project should take and its cost.
- Estimates are needed to determine whether the project is worth doing.
- Estimates are needed to develop cash flow needs.
- Estimates are needed to determine how well the project is progressing.
- Estimates are needed to develop time-phased budgets and establish the project baseline.

Understand estimating project times and costs are the foundation for project planning and control

- **Estimating** is the process of forecasting or approximating the time and cost of completing project deliverables.

Estimating processes are frequently classified as:

- **Top-down**: Top-down estimates are usually done by senior management. Management will often derive estimates from analogy, group consensus, or mathematical relationships.
- **Bottom-up**: Bottom-up estimates are typically performed by the people who are doing the work. Their estimates are based on estimates of elements found in the work breakdown structure.

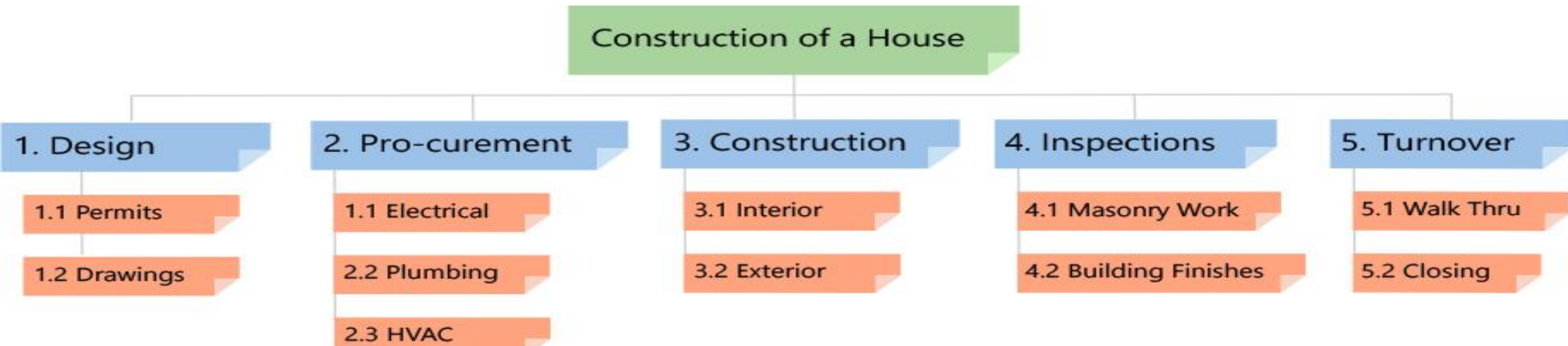
Understand estimating project times and costs are the foundation for project planning and control

All project stakeholders prefer accurate cost and time estimates, but they also understand the inherent uncertainty in all projects. Inaccurate estimates lead to false expectations and consumer dissatisfaction. Accuracy is improved with greater effort but is it worth the time and cost?—estimating costs money! Project estimating becomes a trade-off, balancing the benefits of better accuracy against the costs for securing increased accuracy

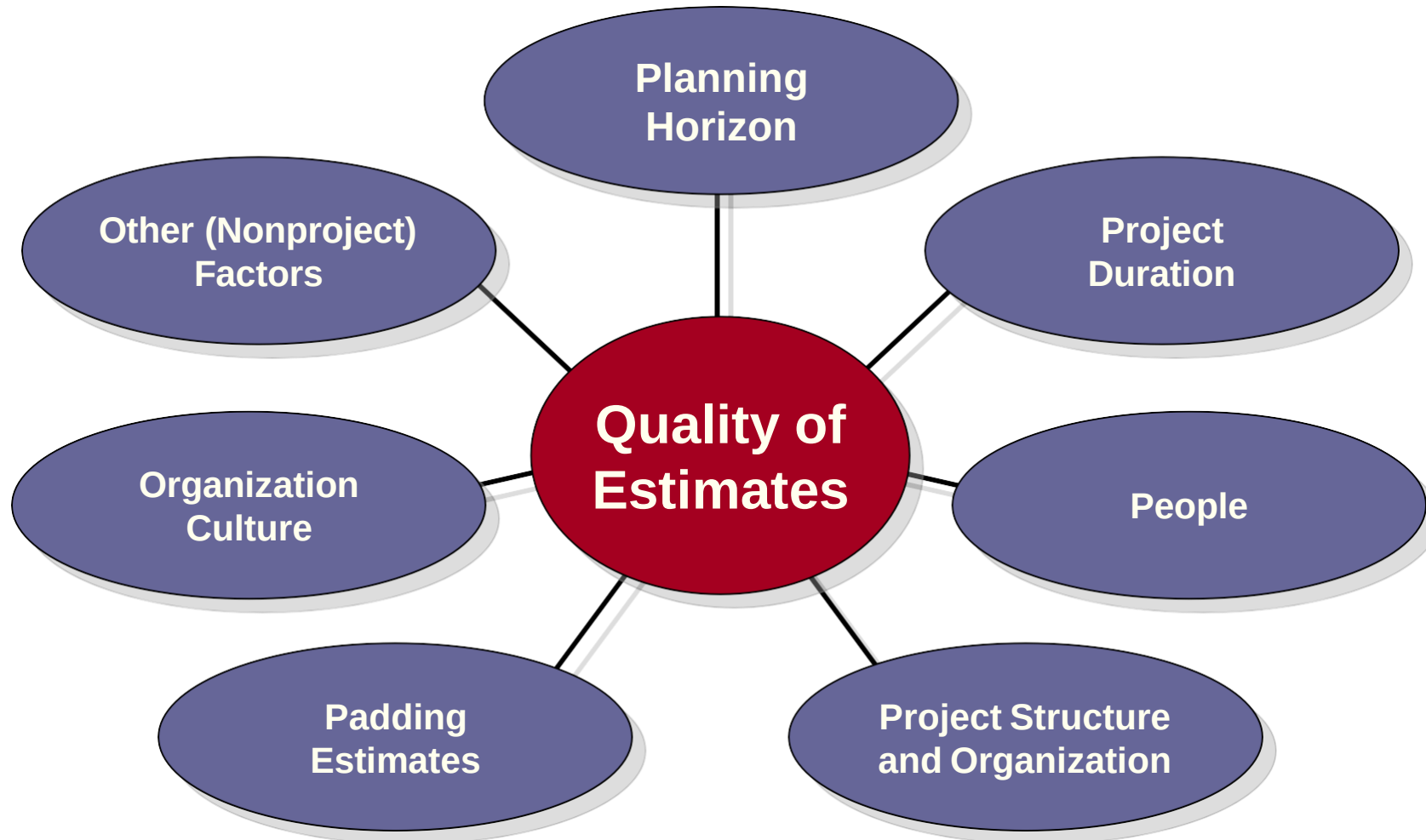
Cost, time, and budget estimates are the lifeline for control; they serve as the standard for comparison of actual and plan throughout the life of the project. **Project status reports** depend on reliable estimates as the major input for measuring variances and taking corrective action. Ideally, the project manager, and in most cases the project owner, would prefer to have a database of detailed schedule and cost estimates for every work package in the project. Regrettably, such detailed data gathering is not always possible or practical and other methods are used to develop project estimates.

What Is a Work Package in Project Management?

A work package is a group of related tasks within a project. Because they look like projects themselves, they are often thought of as sub-projects within a larger project. Work packages are the smallest unit of work that a project can be broken down into when creating your Work Breakdown Structure (WBS). Tasks are typically grouped into work packages based on geographical area, engineering discipline, technology, or the time needed to accomplish them.



Factors Influencing the Quality of Estimates



Factors Influencing the Quality of Estimates

A typical statement in the field is the desire to “have a 95 percent probability of meeting time and cost estimates.” Experience is a good starting point for developing time and cost estimates. But experience estimates must almost always be refined by other considerations to reach the 95 percent probability level. Factors related to the uniqueness of the project will have a strong influence on the accuracy of estimates. Project, people, and external factors all need to be considered to improve quality of estimates for project times and costs.

1. Planning Horizon

The quality of the estimate depends on the planning horizon; estimates of current events are close to 100 percent accurate but are reduced for more distant events.

For example, cost estimates for a party you are organizing this weekend should be much more accurate than the estimates for a party that will take place in six months. The accuracy of time and cost estimates should improve as you move from the conceptual phase to the point where individual work packages are defined. Long-duration projects increase the uncertainty in estimates.

Factors Influencing the Quality of Estimates

2. Project Duration

Time to implement new technology has a habit of expanding in an increasing, nonlinear fashion. Sometimes poorly written scope specifications for new technology result in errors in estimating times and costs

3. People

The people factor can influence the quality of time and cost estimates. For example, accuracy of estimates depends on the skills of the people making the estimates. How familiar are they with the task they are estimating?

4. Project Structure and Organization

Which project structure is chosen to manage the project will influence time and cost estimates. One of the major advantages of a dedicated project team is the speed gained from concentrated focus and localized project decisions. This speed comes at an additional cost of tying up personnel full time. Conversely, projects operating in a matrix environment may reduce costs by more efficiently sharing personnel across projects but may take longer to complete since attention is divided and coordination demands are higher.

Factors Influencing the Quality of Estimates

5. Padding Estimates

In some cases, people are inclined to pad estimates. For example, if you are asked how long it takes you to drive to the airport, you might give an average time of 30 minutes, assuming a 50/50 chance of getting there in 30 minutes. If you are asked the fastest you could possibly get there, you might reduce the driving time to 20 minutes. Finally, if you are asked how long the drive would take if you absolutely had to be there to meet with the president, it is likely you would increase the estimate to say 50 minutes to ensure not being late.

In work situations where you are asked for time and cost estimates, most of us are inclined to add a little padding to increase the probability and reduce the risk of being late. If everyone at all levels of the project adds a little padding to reduce risk, the project duration and cost are seriously overstated. This phenomenon causes some managers or owners to call for a 10–15 percent cut in time and/or cost for the project. Of course, the next time the game is played, the person estimating cost and/or time will pad the estimate to 20 percent or more. Clearly such games defeat chances for realistic estimates, which is what is needed to be competitive

Factors Influencing the Quality of Estimates

6. Organization Culture

Organization culture can significantly influence project estimates. In some organizations padding estimates is tolerated and even privately encouraged. Other organizations place a premium on accuracy and strongly discourage estimating gamesmanship. Organizations vary in the importance they attach to estimates. The prevailing belief in some organizations is that detailed estimating takes too much time and is not worth the effort or that it's impossible to predict the future. Other organizations subscribe to the belief that accurate estimates are the bedrock of effective project management. Organization culture shapes every dimension of project management; estimating is not immune to this influence.

7. Other Factors

Finally, non project factors can impact time and cost estimates. For example, equipment down-time can alter time estimates. National holidays, vacations, and legal limits can influence project estimates. Project priority can influence resource assignment and impact time and cost.

Estimating Guidelines for Times, Costs, and Resources

Managers recognize time, cost, and resource estimates must be accurate if project planning, scheduling, and controlling are to be effective. However, there is substantial evidence suggesting poor estimates are a major contributor to projects that have failed. Therefore, every effort should be made to see that initial estimates are as accurate as possible since the choice of no estimates leaves a great deal to luck and is not palatable to serious project managers. Even though a project has never been done before, *a manager can follow seven guidelines to develop useful work package estimates.*

1. Responsibility.

At the work package level, estimates should be made by the person(s) most familiar with the task. Draw on their expertise! Except for super technical tasks, those responsible for getting the job done on schedule and within budget are usually first-line supervisors or technicians who are experienced and familiar with the type of work involved. These people will not have some preconceived, imposed duration for a deliverable in mind. They will give an estimate based on experience and best judgment. If those involved are not consulted, it will be difficult to hold them responsible for failure to achieve the estimated time. Finally, drawing on the expertise of team members who will be responsible helps to build communication channels early.

2. Use several people to estimate.

It is well known that a cost or time estimate usually has a better chance of being reasonable and realistic when several people with relevant experience and/or knowledge of the task are used (sometimes called “crowdsourcing” *التعهيد الجماعي*). True, people bring different biases based on their experience. But discussion of the individual differences in their estimate leads to consensus and tends to eliminate extreme estimate errors.

3. Normal conditions.

When task time, cost, and resource estimates are determined, they are based on certain assumptions. Estimates should be based on normal conditions, efficient methods, and a normal level of resources. Normal conditions are sometimes difficult to discern, but it is necessary to have a consensus in the organization as to what normal conditions mean in this project. If the normal workday is eight hours, the time estimate should be based on an eight-hour day. Similarly, if the normal workday is two shifts, the time estimate should be based on a two-shift workday. Any time estimate should reflect efficient methods for the resources normally available. The time estimate should represent the normal level of resources—people or equipment. For example, if three programmers are available for coding or two road graders are available for road construction, time and cost estimates should be based on these normal levels of resources unless it is anticipated the project will change what is currently viewed as “normal.”

4. Time units.

Specific time units to use should be selected early in the development phase of the project network. All task time estimates need consistent time units. Estimates of time must consider whether normal time is represented by calendar days, workdays, workweeks, person days, single shift, hours, minutes, etc. In practice the use of workdays is the dominant choice for expressing task duration. However, in projects such as a heart transplant operation, minutes probably would be more appropriate as a time unit. One such project that used minutes as the time unit was the movement of patients from an old hospital to an elegant new one across town. Since there were several life-endangering moves, minutes were used to ensure patient safety so proper emergency life-support systems would be available if needed. The point is, network analysis requires a standard unit of time. When computer programs allow more than one option, some notation should be made of any variance from the standard unit of time. If the standard unit of time is a five-day workweek and the estimated activity duration is in calendar days, it must be converted to the normal workweek.

5.Independence.

Estimators should treat each task as independent of other tasks that might be integrated by the WBS. Use of first-line managers usually results in considering tasks independently; this is good. Top managers are prone to aggregate many tasks into one time estimate and then deductively make the individual task time estimates add to the total. If tasks are in a chain and performed by the same group or department, it is best not to ask for all the time estimates in the sequence at once to avoid the tendency for a planner or a supervisor to look at the whole path and try to adjust individual task times in the sequence to meet an arbitrary imposed schedule or some rough “guesstimate” of the total time for the whole path or segment of the project. This tendency does not reflect the uncertainties of individual activities and generally results in optimistic task time estimates. In summary, each task time estimate should be considered independently of other activities

6. Contingencies.

Work package estimates should not include allowances for contingencies. The estimate should assume normal or average conditions even though every work package will not materialize as planned. For this reason, top management needs to create an extra fund for contingencies that can be used to cover unforeseen events.

7. Adding risk assessment

Adding risk assessment to the estimate helps to avoid surprises to stakeholders. It is obvious some tasks carry more time and cost risks than others. For example, a new technology usually carries more time and cost risks than a proven process. Simply identifying the degree of risk lets stakeholders consider alternative methods and alter process decisions. A simple breakdown by optimistic, most likely, and pessimistic for task time could provide valuable information regarding time and cost.

Top-Down versus Bottom-Up Estimating

Since estimating efforts cost money, the time and detail devoted to estimating are important decisions. Yet, when estimating is considered, you as a project manager may hear statements such as these:

Rough order of magnitude is good enough. Spending time on detailed estimating wastes money.

Time is everything; our survival depends on getting there first! Time and cost accuracy is not an issue.

The project is internal. We don't need to worry about cost.

The project is so small, we don't need to bother with estimates. Just do it.

Top-Down versus Bottom-Up Estimating

However, there are sound reasons for using top-down or bottom-up estimates. Table 5.1 depicts conditions that suggest when one approach is preferred over another. Top-down estimates usually are derived from someone who uses experience and/ or information to determine the project duration and total cost. However, these estimates are sometimes made by top managers who have very little knowledge of the component activities used to complete the project. For example, a mayor of a major city making a speech noted that a new law building would be constructed at a cost of \$23 million and would be ready for occupancy in two and one-half years. Although the mayor probably asked for an estimate from someone, the estimate could have come from a luncheon meeting with a local contractor who wrote an estimate (guesstimate) on a napkin. This is an extreme example, but in a relative sense this scenario is frequently played out in practice. The question actually is, do these estimates represent low cost, efficient methods? Seldom. The fact that the estimate came from the top can influence people responsible to “do what it takes to make the estimate.”

Top-Down versus Bottom-Up Estimating

Condition	Top-Down Estimates	Bottom-Up Estimates
Strategic decision making	X	
Cost and time important		X
High uncertainty	X	
Internal, small project	X	
Fixed-price contract		X
Customer wants details		X
Unstable scope	X	

Top-Down versus Bottom-Up Estimating

If possible and practical, you want to push the estimating process down to the work package level for bottom-up estimates that establish low-cost, efficient methods. This process can take place after the project has been defined in detail. Good sense suggests project estimates should come from the people most knowledgeable about the estimate needed. The use of several people with relevant experience with the task can improve the time and cost estimate. The bottom-up approach at the work package level can serve as a check on cost elements in the WBS by rolling up the work packages and associated cost accounts to major deliverables. Similarly, resource requirements can be checked. Later, the time, resource, and cost estimates from the work packages can be consolidated into time-phased networks, resource schedules, and budgets that are used for control.

Top-Down versus Bottom-Up Estimating

The bottom-up approach also provides the customer with an opportunity to compare the low-cost, efficient method approach with any imposed restrictions. For example, if the project completion duration is imposed at two years and your bottom-up analysis tells you the project will take two and one-half years, the client can now consider the trade-off of the low-cost method versus compressing the project to two years—or in rare cases canceling the project.

Similar trade-offs can be compared for different levels of resources or increases in technical performance. The assumption is any movement away from the low-cost, efficient method will increase costs—e.g., overtime. The preferred approach in defining the project is to make rough top-down estimates, develop the WBS/OBS, make bottom-up estimates, develop schedules and budgets, and reconcile differences between top-down and bottom-up estimates. Hopefully, these steps will be done *before* final negotiation with either an internal or external customer. In conclusion, the ideal approach is for the project manager to allow enough time for both the top-down and bottom-up estimates to be worked out so a complete plan based on reliable estimates can be offered to the customer. In this way false expectations are minimized for all stakeholders and negotiation is reduced.

Methods for Estimating Project Times and Costs

Top-Down Approaches for Estimating Project Times and Costs

At the strategic level top-down estimating methods are used to evaluate the project proposal. Sometimes much of the information needed to derive accurate time and cost estimates is not available in the initial phase of the project—for example, design is not finalized. In these situations top-down estimates are used until the tasks in the WBS are clearly defined.

1. Consensus Methods

This method simply uses the pooled experience of senior and/or middle managers to estimate the total project duration and cost. This typically involves a meeting where experts discuss, argue, and ultimately reach a decision as to their best guess estimate. Firms seeking greater rigor will use the Delphi Method to make these macro estimates.

The Delphi method is a **process** used to arrive at a group opinion or decision by surveying a panel of experts. Experts respond to several rounds of questionnaires, and the responses are aggregated and shared with the group after each round.

1. Consensus Methods

It is important to recognize that these first top-down estimates are only a rough cut and typically occur in the “conceptual” stage of the project. The top-down estimates are helpful in initial development of a complete plan. However, such estimates are sometimes significantly off the mark because little detailed information is gathered. At this level individual work items are not identified. Or, in a few cases, the top-down estimates are not realistic because top management “wants the project.” Nevertheless, the initial top-down estimates are helpful in determining whether the project warrants more formal planning, which would include more detailed estimates. Be careful that macro estimates made by senior managers are not dictated to lower level managers who might feel compelled to accept the estimates even if they believe resources are inadequate.

2. Ratio Methods

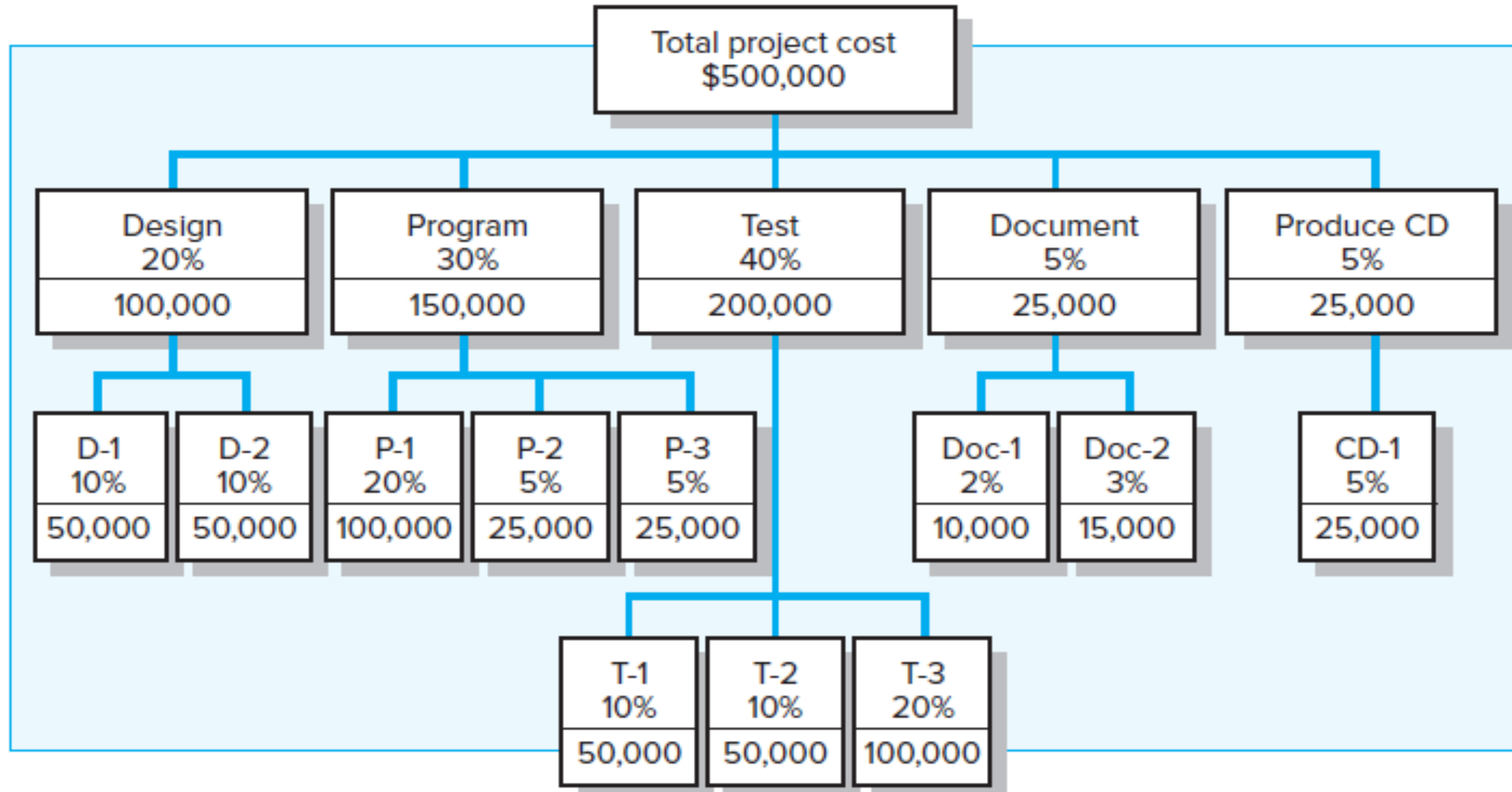
Top-down methods (sometimes called parametric) usually use ratios to estimate project times or costs. Top-down approaches are often used in the concept or “need” phase of a project to get an initial duration and cost estimate for the project. For example, contractors frequently use number of square feet to estimate the cost and time to build a house; that is, a house of 2,700 square feet might cost \$160 per square foot (2,700 feet $\times$ \$160 per foot equals \$432,000). Likewise, knowing the square feet and dollars per square foot, experience suggests it should take approximately 100 days to complete. Two other common examples of top-down cost estimates are the cost for a new plant estimated by capacity size, or a software product estimated by features and complexity.

3. Apportion Methods طريقة التقسيم

This method is an extension to the ratio method. Apportionment is used when projects closely follow past projects in features and costs. Given good historical data, estimates can be made quickly with little effort and reasonable accuracy. This method is very common in projects that are relatively standard but have some small variation or customization.

Anyone who has borrowed money from a bank to build a house has been exposed to this process. Given an estimated total cost for the house, banks and the FHA (Federal Housing Authority) authorize pay to the contractor by completion of specific segments of the house. For example, foundation might represent 3 percent of the total loan, framing 25 percent, electric, plumbing and heating 15 percent, etc. Payments are made as these items are completed. An analogous process is used by some companies that apportion costs to deliverables in the WBS—given average cost percentages from past projects. Figure 5.1 presents an example similar to one found in practice. Assuming the total project cost is estimated, using a top-down estimate, to be \$500,000, the costs are apportioned as a percentage of the total cost. For example, the costs apportioned to the “Document” deliverable are 5 percent of the total, or \$25,000. The sub deliverables “Doc-1 and Doc-2” are allocated 2 and 3 percent of the total—\$10,000 and \$15,000, respectively.

FIGURE 5.1 Apportion Method of Allocating Project Costs Using the Work Breakdown Structure



4. Learning curves

Some projects require that the same task, group of tasks, or product be repeated several times. Managers know intuitively that the time to perform a task improves with repetition. This phenomenon is especially true of tasks that are labor intensive. In these circumstances the pattern of improvement phenomenon can be used to predict the reduction in time to perform the task. From empirical evidence across all industries, the pattern of this improvement has been quantified in the learning curve (also known as improvement curve, experience curve, and industrial progress curve), which is described by the following relationship:

Each time the output quantity doubles, the unit labor hours are reduced at a constant rate. In practice the improvement ratio may vary from 60 percent, representing very large improvement, to 100 percent, representing no improvement at all.

The main disadvantage of top-down approaches to estimating is simply that the time and cost for a specific task are not considered. Grouping many tasks into a common basket encourages errors of omission and the use of imposed times and costs. Micro estimating methods are usually more accurate than macro methods.

Bottom-Up Approaches for Estimating Project Times and Costs

1. Template Methods

If the project is similar to past projects, the costs from past projects can be used as a starting point for the new project. Differences in the new project can be noted and past times and costs adjusted to reflect these differences. For example, a ship repair drydock firm has a set of standard repair projects (i.e., templates for over-haul , قوالب للإصلاح الشامل , electrical, mechanical) that are used as starting points for estimating the cost and duration of any new project. Differences from the appropriate standardized project are noted (for times, costs, and resources) and changes are made. This approach enables the firm to develop a potential schedule, estimate costs, and develop a budget in a very short time span. Development of such templates in a database can quickly reduce estimate errors.

2. Parametric Procedures Applied to Specific Tasks

Just as parametric techniques such as cost per square foot can be the source of top-down estimates, the same technique can be applied to specific tasks. For example, as part of an MS Office conversion project, 36 different computer workstations needed to be converted. Based on past conversion projects, the project manager determined that on average one person could convert three workstations per day. Therefore the task of converting the 36 workstations would take three technicians four days $[(36/3)/3]$. Similarly, to estimate the wallpapering allowance on a house remodel, the contractor figured a cost of \$5 per square yard of wallpaper and \$2 per yard to install it, for a total cost of \$7. By measuring the length and height of all the walls she was able to calculate the total area in square yards and multiply it by \$7.

3. Range Estimating تقدير المدي

When do you use range estimating? Range estimating works best when work packages have significant uncertainty associated with the time or cost to complete. If the work package is routine and carries little uncertainty, using a person most familiar with the work package is usually the best approach. They know from experience or know where to find the information to estimate work package durations and costs. However, when work packages have significant uncertainty associated with the time or cost to complete, it is a prudent policy to require three time estimates—low, average, and high (borrowed off of PERT methodology that uses probability distributions). The low to high give a range within which the average estimate will fall. Determining the low and high estimates for the activity is influenced by factors such as complexity, technology, newness, familiarity.

How do you get the estimates? Since range estimating works best for work packages that have significant uncertainty, having a group determine the low, average, and high cost or duration gives best results. Group estimating tends to refine extremes by bringing more evaluative judgments to the estimate and potential risks. The judgment of others in a group helps to moderate extreme perceived risks associated with a time or cost estimate. Involving others in making activity estimates gains buy in and credibility to the estimate.

3. Range Estimating تقدير المدي

Figure 5.2 presents an abridged estimating template using three time estimates for work packages developed by a cross functional group(s) of project stakeholders. The group estimates show the low, average, and high for each work package. The Risk Level column is the group's independent assessment of the degree of confidence that the actual time will be very close to the estimate. In a sense this number represents the group's evaluation of many factors (e.g., complexity, technology) that might impact the average time estimate. In our example, the group feels work packages 104, 108, 110, 111, and 114 have a high chance that the average time may vary from expected. Likewise, the group's confidence feels the risk of work packages 102, 105 and 112 not materializing as expected is low.

How do you use the estimate? Group range estimating gives the project manager and owner an opportunity to assess the confidence associated with project times (and/or costs). The approach helps to reduce surprises as the project progresses. The range estimating method also provides a basis for assessing risk, managing resources, and determining the project contingency fund. Range estimating is popular in software and new product projects where up-front requirements are fuzzy and not well known. Group range estimating is often used with phase estimating, which is discussed next.

Range Estimating Template

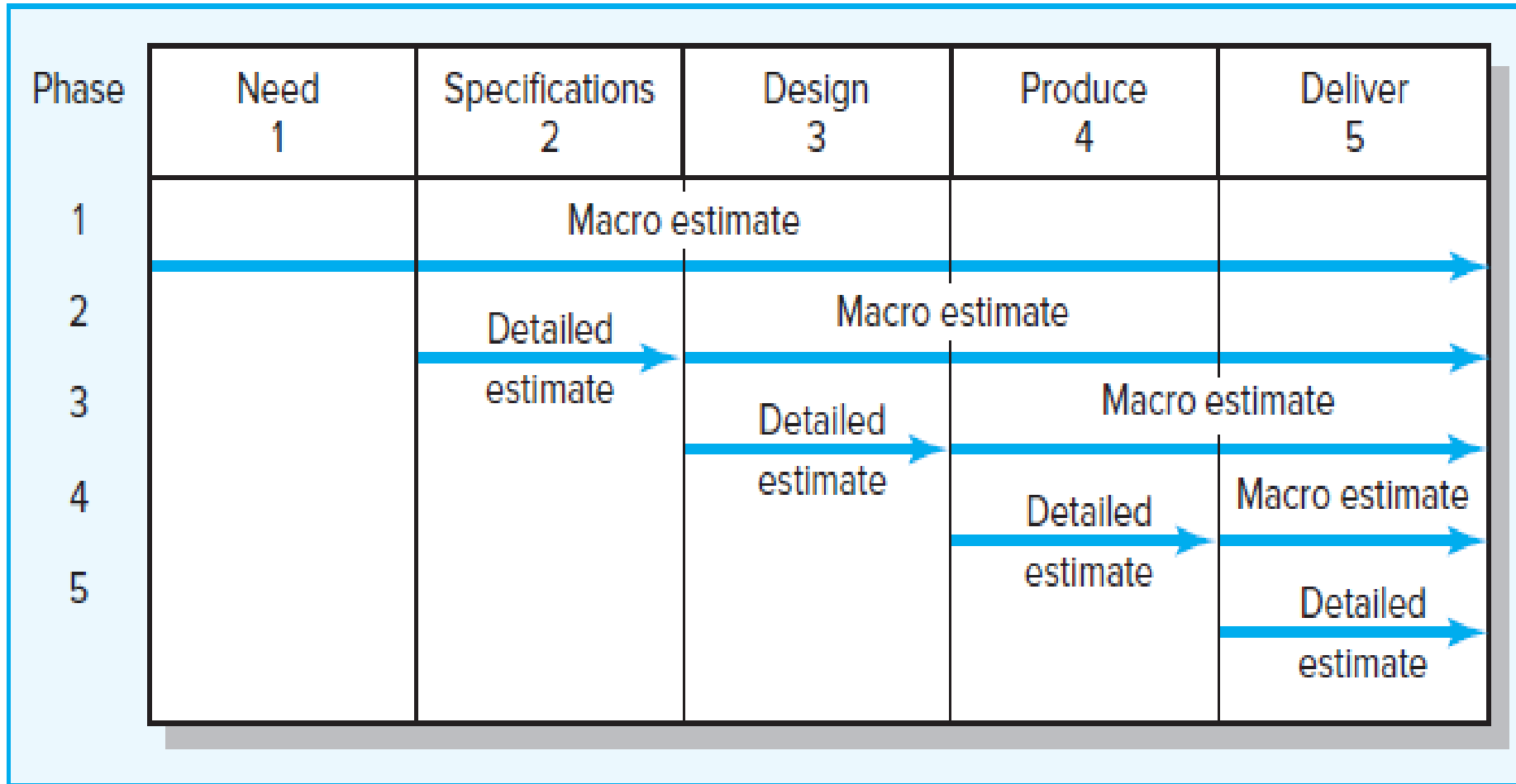
	A	B	C	D	E	F	G	H
1	Project number: 18				Project Manager: Dawn O'Connor			
2	Project description: New Organic Wine Launch				Date: 2/17/2xxx			
3	Organic Wine Launch Project							
4	Range Estimates							
5								
6	WBS	Description	Low	Average	High	Range	Risk	
7	ID		Estimate	Estimate	Estimate		Level	
8			Days	Days	Days	Days		
9								
10	102	Approval	1	1	3	2	low	
11	103	Design packaging	4	7	12	8	medium	
12	104	ID potential customers	14	21	35	21	high	
13	105	Design bottle logo	5	7	10	5	low	
14	106	Contract kiosk space	8	10	15	7	medium	
15	107	Construct kiosk	4	4	8	4	medium	
16	108	Design fair brochure	6	7	12	6	high	
17	109	Trade journal advertising	10	12	15	5	medium	
18	110	Production test	10	14	20	10	high	
19	111	Produce to inventory	5	5	10	5	high	
20	112	Business card scanner hookup	1	2	3	2	low	
21	113	Video hook up	2	2	4	2	medium	
22	114	Event rehearsal	2	2	5	3	high	

4. A Hybrid: Phase Estimating

This approach begins with a top-down estimate for the project and then refines estimates for phases of the project as it is implemented. Some projects by their nature cannot be rigorously defined because of the uncertainty of design or the final product. Although rare, such projects do exist. These projects are often found in aerospace projects, IT projects, new technology projects, and construction projects where design is incomplete. In these projects, phase or life-cycle estimating is frequently used.

Phase estimating is used when an unusual amount of uncertainty surrounds a project and it is impractical to estimate times and costs for the entire project. Phase estimating uses a two-estimate system over the life of the project. A detailed estimate is developed for the immediate phase and a macro estimate is made for the remaining phases of the project. Figure 5.3 depicts the phases of a project and the progression of estimates over its life.

Phase Estimating over Project Life Cycle



4. A Hybrid: Phase Estimating

For example, when the project need is determined, a macro estimate of the project cost and duration is made so analysis and decisions can be made. Simultaneously a detailed estimate is made for deriving project specifications and a macro estimate for the remainder of the project. As the project progresses and specifications are solidified, a detailed estimate for design is made and a macro estimate for the remainder of the project is computed. Clearly, as the project progresses through its life cycle and more information is available, the reliability of the estimates should be improving.

Phase estimating is preferred by those working on projects where the final product is not known and the uncertainty is very large—for example, the integration of wireless phones and computers. The commitment to cost and schedule is only necessary over the next phase of the project and commitment to unrealistic future schedules and costs based on poor information is avoided. This progressive macro/micro method provides a stronger basis for using schedule and cost estimates to manage progress during the next phase.

Unfortunately, your owner or project sponsor—internal or external—will want an accurate estimate of schedule and cost the moment the decision is made to implement the project. Additionally, the owner/ sponser who is paying for the project often perceives phase estimating as a blank check because costs and schedules are not firm over most of the project life cycle. Even though the reasons for phase estimating are sound and legitimate, most customers have to be sold on its legitimacy. A major advantage for the customer is the opportunity to change features, re-evaluate, or even cancel the project in each new phase. In conclusion, phase estimating is very useful in projects that possess huge uncertainties concerning the final nature (shape, size, features) of the project. See Figure 5.4 for a summary of the differences between top-down and bottom-up estimates.

Obtaining accurate estimates is a challenge. Committed organizations accept the challenge of coming up with meaningful estimates and invest heavily in developing their capacity to do so. Accurate estimates reduce uncertainty and support a discipline for effectively managing projects.

summary of the differences between top-down and bottom-up estimates.

Top-Down Estimates	Bottom-Up Estimates
Intended Use Feasibility/conceptual phase Rough time/cost estimate Fund requirements Resource capacity planning	Intended Use Budgeting Scheduling Resource requirements Fund timing
Preparation Cost 1/10 to 3/10 of a percent of total project cost	Preparation Cost 3/10 of a percent to 1.0 percent of total project cost
Accuracy Minus 20%, to plus 60%	Accuracy Minus 10%, to plus 30%
Method Consensus Ratio Apportion Function point Learning curves	Method Template Parametric WBS packages Range estimates

Apportionment

Bottom-up estimates

Delphi Method

Learning curves

Padding estimates

Phase estimating

Range estimating

Ratio methods

Template method

Top-down estimates





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