

Stop Promising Miracles¹

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Most software professionals must provide estimates for their work, but few of us are skillful estimators. Many of us haven't been trained in estimation techniques. We're too optimistic, with short memories that mask the painful overruns from previous projects. We don't incorporate contingency buffers to accommodate unexpected events or risks that materialize. And we often overlook necessary aspects of an activity, so that when we eventually confront those tasks, we either perform them—thereby exceeding our estimates—or skip them, perhaps compromising quality in the process.

There are several ways to become a better estimator. The most basic approach is to record effort, duration or size estimates as well as your estimating processes and assumptions, and then record the actual results from each estimated activity. Comparing actual outcomes to the estimates helps generate more accurate estimates in the future. Estimating procedures and templates that itemize tasks help avoid the common problem of overlooking necessary work.

Another approach builds on the principle that multiple heads are better than one. Developed at the Rand Corporation in 1948, the Delphi estimation method asks a small team of experts to anonymously generate individual estimates from a problem description and reach consensus on a final set of estimates through iteration. In the early 1970s, Barry Boehm and his Rand colleagues modified this method into Wideband Delphi, which included more estimation team interaction; see Boehm's *Software Engineering Economics* (Prentice Hall, 1981). Mary Sakry and Neil Potter of The Process Group, a Dallas, Texas-based consulting company, later created a repeatable procedure for performing Wideband Delphi estimation on software projects.

Using the Wideband Delphi method provides several advantages over obtaining an estimate from a single individual. First, it helps build a complete task list or work breakdown structure for major activities, because each participant will think of tasks. The consensus approach helps eliminate bias in estimates produced by self-proclaimed experts, inexperienced estimators or influential individuals who have hidden agendas or divergent objectives. People are generally more committed to estimates they help produce than to those generated by others. No participant in an estimation activity knows the "right" answer, and creating multiple estimates acknowledges this uncertainty. Finally, users of the Delphi approach recognize the value of iteration on any complex activity.

Wideband Delphi

Wideband Delphi can be used to estimate virtually anything—the number of labor months needed to implement a specific subsystem, the lines of code or number of classes in an entire product, or the gallons of paint needed to redecorate Bill Gates' house. I used Wideband Delphi

¹ This paper was originally published in *Software Development*, February 2000. It is reprinted (with modifications) with permission from *Software Development* magazine.

once with a process improvement group to estimate the effort it would take a particular organization to achieve level two of the Capability Maturity Model.

The Delphi method helps you develop a detailed work breakdown structure, which provides the foundation for bottom-up effort and schedule or size estimation. The starting point for a Delphi session could be a specification of the problem being estimated or an initial high-level task list or project schedule. The outputs are a detailed project task list; a list of associated quality, process-related and overhead tasks; estimation assumptions; and a set of task and overall project estimates, one from each participant.

Figure 1 illustrates the process flow for a Wideband Delphi session. The problem being estimated is defined and the participants selected during planning. The kickoff meeting gets all estimators focused on the problem. Each participant then individually prepares his or her initial task lists and estimates. They bring these items to the estimation meeting, during which several estimating cycles lead to a more comprehensive task list and a revised set of estimates. The moderator or project manager then consolidates the assorted estimation information offline, and the team reviews the estimation results. When some predetermined exit criteria are satisfied, the session is completed. The resulting range of estimates is likely to be a more realistic predictor of the future than any single estimate. Let's look at each of these process steps in turn.

Planning

A Wideband Delphi session begins with defining and scoping the problem. Large problems are broken down into manageable portions that can be estimated more accurately, perhaps by different teams. The person who initiated the estimation activity assembles a problem specification that will give the participants enough information to produce credible, informed estimates.

The estimation participants include a moderator, who plans and coordinates the activity, the project manager and two to four other estimators. The moderator should be informed enough to participate as an estimator, but acts as an impartial facilitator who won't skew the results with his or her own biases or insights. The participants are selected because they understand the problem or project and associated estimation issues.

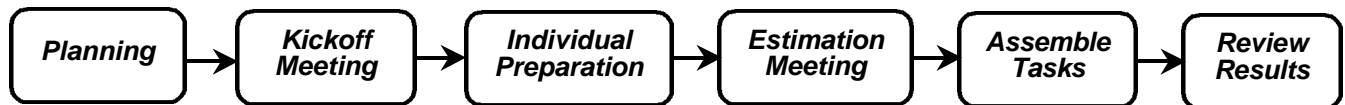


Figure 1. Wideband Delphi process flow.

The Kickoff

An initial kickoff meeting of up to an hour gets all participants up to speed on the estimation problem. The moderator explains Wideband Delphi to team members who are unfamiliar with it and supplies the other estimators with the problem specification and any assumptions or project constraints. The moderator strives to give the estimators enough information to do a good job without unduly influencing their estimates.

The team reviews the estimation objectives and discusses the problem and any estimation issues. The participants agree on the estimation units they will use, such as weeks, labor hours, dollars or lines of code. If the moderator concludes that all team members are sufficiently knowledgeable to contribute to the estimation activity, the group is ready to roll. Otherwise, the participants may need to be briefed more fully on the problem they're estimating, or possibly replaced by others who can generate more accurate estimates.

To determine whether you're ready to proceed with the Wideband Delphi session, check your entry criteria—that is, the prerequisites that must be satisfied for you to proceed with subsequent process steps. Before you dive into the estimation exercise, ensure that the following conditions are satisfied:

- Appropriate team members have been selected.
- The kickoff meeting has been held.
- The participants have agreed on the estimation goal and units.
- The project manager can participate in the session.
- The estimators have the information they need to participate effectively.

Individual Preparation

Let's assume that you wish to estimate the total amount of work effort (typically expressed in labor hours) needed to complete a certain project. The estimation process begins with each participant independently developing an initial list of the tasks that will have to be completed to reach the stated project goal, using a form like that shown in Figure 2. Each participant then estimates the effort each task will consume. Break each activity down into tasks that are small enough to estimate accurately. I don't feel comfortable estimating individual tasks larger than about 20 labor hours. State the tasks clearly, because someone will have to merge all of the participant task lists into a single composite list. Total the estimates you produce for each project task, in the agreed-upon units, to generate your initial overall estimate.

Your estimate should have no relationship to the answer you think the project manager or other stakeholders want to hear. There's a good chance the estimate will fall outside the acceptable project bounds of schedule, effort or cost, a situation that demands negotiation and might lead to scope reduction, schedule extension or resource adjustments. But don't let outside pressure sway your best projection of how the project will play out.

In addition to identifying the project tasks, separately record any tasks for related or supporting activities. In my first Wideband Delphi session, every participant forgot to list tasks dealing with quality control and assurance, configuration management and process-related activities on the first cycle. We caught this quickly and added them in for the next iteration. Be sure to include rework tasks following testing or inspection activities. Reworking to correct defects is a fact of life, so you should plan for it. If you're estimating a schedule, also think of any overhead activities that aren't specific to the project that you might have to build into your planning. These include meetings, vacation, training, other project assignments and myriad other things that suck time out of your day.

Since radically different assumptions can lead to wide estimate variations, record any assumptions you made while preparing your estimates. For example, if you assumed that you will purchase a specific component library or reuse one from a previous project, write that down. Another estimator might assume that the project will develop that library, which will lead to a mismatch between your two overall estimates.

Task	Estimate #1	Change #1	Change #2	Change #3	Final
Change	--				--
Total					

Figure 2. Sample Delphi estimation form.

Keep the following estimation guidelines in mind:

- Assume one person (you) will perform all tasks.
- Assume all tasks will be performed sequentially; don't worry about sequencing and predecessor tasks at this time.
- Assume that you can devote uninterrupted effort to each task (this may seem absurdly optimistic, but it simplifies the estimation process).
- In units of calendar time, list any known waiting times you expect to encounter between tasks. This will help you translate effort estimates into schedule estimates later on.

Estimation Meeting

The moderator begins the estimation meeting by collecting the participants' individual estimates and creating a chart such as Figure 3. Each participant's total project estimate is shown as an X on the "Round 1" line. Each estimator can see where his or her initial value fits along the spectrum. The initial estimates probably will cover a frighteningly large range. Just imagine the different conclusions you might have collected had you asked just one of the participants for his or her estimate and used that to plan the project.

The moderator does not identify who created each estimate; this anonymity is an important aspect of the Delphi technique. Anonymity prevents an outspoken colleague from

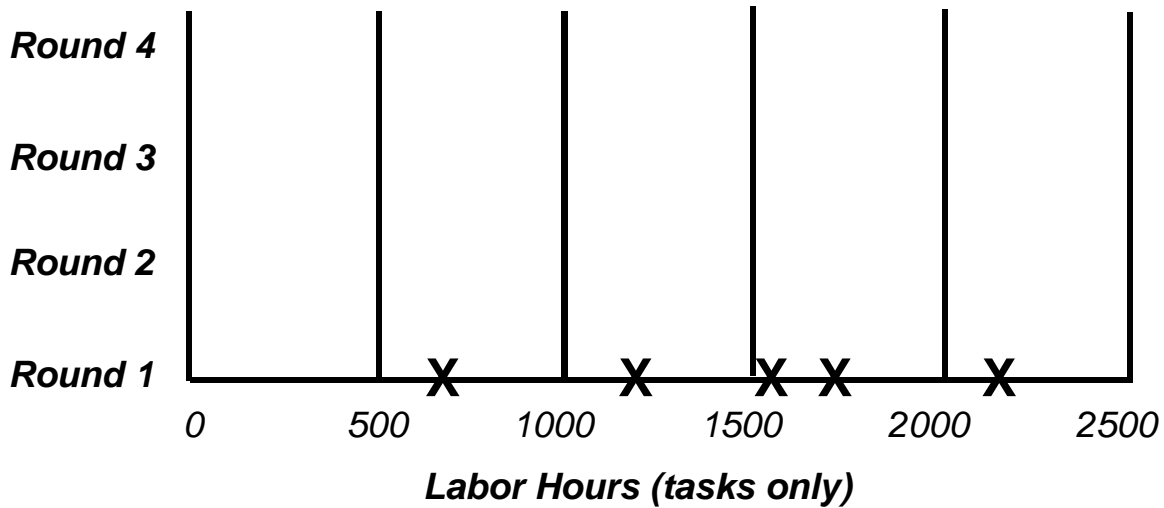


Figure 3. Initial estimation chart from a Wideband Delphi session.

intimidating the other participants into seeing things his or her way. It also means team members are less likely to defer to the most respected participant’s judgment when their own analyses lead to different conclusions.

Each estimator reads his or her initial task list, identifying any assumptions made and raising any questions or issues, without revealing which estimate was theirs. Each participant will have listed different tasks that need to be performed. Combining these individual task lists leads to a more complete list than any single estimator is likely to produce. This approach will work for up to several dozen individual tasks. If you have more tasks than that, they might be too detailed. You may want to break the problem into several subproblems and estimate them individually.

During this initial discussion, the team members also talk about their assumptions, estimation issues and questions they have about the problem. As a result, the team will begin to converge on a shared set of assumptions and a common task list. Retain this final task list to use as a starting point the next time you must estimate a similar project.

After this initial discussion, all participants modify their estimates concurrently (and silently) in the meeting room. They might revise their task lists based on the information shared during the discussion, and they’ll adjust individual task estimates based on their new understanding of the task scope or changed assumptions. All estimators can add new tasks to their forms and note any changes they wish to make to their initial task estimates. The net change for all tasks equals the change in that participant’s overall project estimate.

The moderator collects the revised overall estimates and plots them on the same chart, on the Round 2 line. I’ve done this on a whiteboard for easy visibility. As Figure 4 illustrates, the second round might lead to a narrower distribution of estimates centered around a higher mean than the mean of the Round 1 values. Additional rounds should further narrow the distribution. The cycle of revising the task list, discussing issues and assumptions and preparing new estimates continues until:

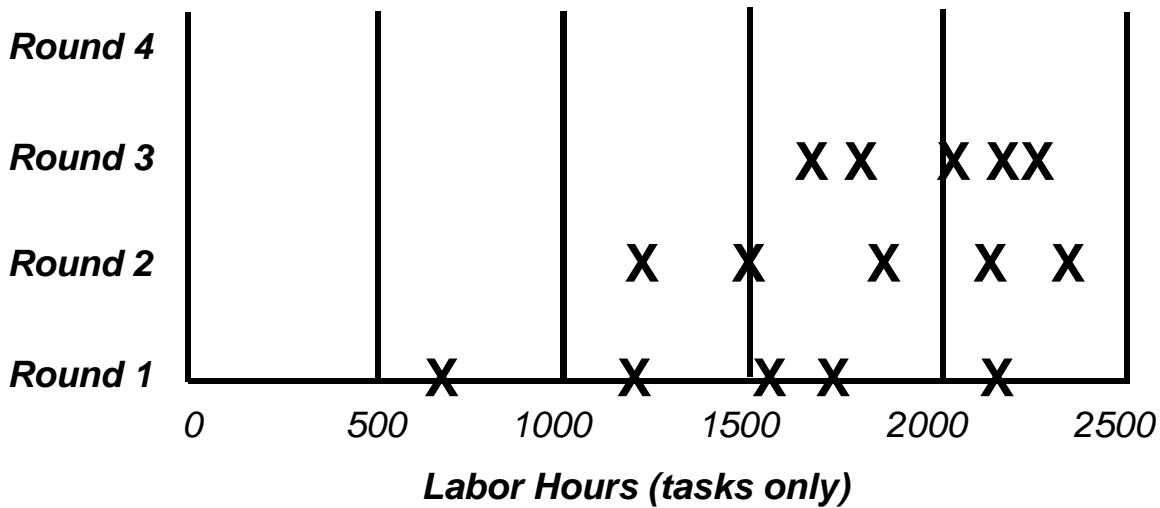


Figure 4. Estimation chart showing three rounds from a Wideband Delphi session.

- you have completed four rounds;
- the estimates have converged to an acceptably narrow range (defined in advance);
- the allotted estimation meeting time (typically two hours) is over; or
- all participants are unwilling to alter their latest estimates.

The moderator keeps the group on track, time-boxing discussions to 15 or 20 minutes to avoid endless rambling. The moderator should follow effective meeting facilitation practices, such as starting and ending on time, encouraging all participants to contribute and maintaining an impartial and non-judgmental environment. While preserving the anonymity of individual estimates is important for the first couple of rounds, the team members might agree at some point to put all their cards on the table and reach closure through an open discussion. This gives them a chance to discuss tasks for which their estimates vary substantially. Otherwise, though, the moderator should not identify the individual who produced each final estimate until the session is completed.

Assembling Tasks

The work isn't done when the estimation meeting concludes. Either the moderator or the project manager assembles the project tasks and their individual estimates into a single master task list. This person also merges the individual lists of assumptions, quality- and process-related activities, overhead tasks and wait times.

The merging process involves removing duplicate tasks and reaching some reasonable resolution of different estimates for individual tasks. "Reasonable" doesn't mean replacing the team's estimates with values the project manager prefers. Large estimate differences for apparently similar tasks might indicate that estimators interpreted that task in different ways. For example, two people might both have a task called "implement a class." However, one estimator might have included unit testing and code review in the task, while the other meant just the coding effort. All estimators should define their tasks clearly to minimize confusion during this merging step. The merging step should retain the estimate range for each task, but if one estimator's task

estimate was wildly different from that of the other estimators, understand it and then perhaps discard or modify it.

Review Results

In the final step, the estimation team reviews the summarized results and reaches agreement on the final outcome. The project manager provides the other estimators with the overall task list, individual estimates, cumulative estimates, assumption list, and any other information. Bring the team back together for a 30- to 60-minute review meeting to bring closure to the estimation activity. This meeting also provides an opportunity for the team to contemplate this execution of the Wideband Delphi process and suggest ways it can be improved for future applications.

The participants should make sure the final task list is as complete as possible. They might have thought of additional tasks since the estimation meeting, which could be added to the task list now. Check to see whether tasks that had wildly different individual estimates have been merged in a sensible way. The ultimate objective is to produce an estimate range that allows the project manager and other key stakeholders to proceed with project planning and execution at an acceptable confidence level.

Completing the Estimation

The estimation process is completed when specified exit criteria are satisfied. Exit criteria help you determine when a process execution is done, so you can declare victory and move on with your life. Typical Wideband Delphi exit criteria are that:

- The overall task list has been assembled
- You have a summarized list of estimating assumptions
- The estimators have reached consensus on how their individual estimates were synthesized into a single set with an acceptable range.

Now you must decide what to do with the data. You could simply average the final estimates to come up with a single point estimate, which is what the person who requested the estimate probably wants to hear. However, a simple average is likely to be too low, and there's merit in retaining the estimate range. Estimates are predictions of the future, and the range reflects the inherent uncertainty of gazing into the crystal ball. You might present three numbers: the average of the estimates as the planned case, the minimum value as the best case and the maximum as the worst case. Or you could present the average value as the nominal expected outcome, plus the maximum-minus-the-average value, and minus the average-minus-the-minimum value.

Each estimate has a certain probability of coming true, so a set of estimates forms a probability distribution. In Chapter 6 of *A Discipline for Software Engineering* (Addison-Wesley, 1995), Watts Humphrey describes a mathematically precise way to combine multiple estimates and their uncertainties to generate an overall estimate with upper and lower prediction intervals. Another sophisticated approach is to perform a Monte Carlo simulation to generate a probability distribution of possible estimate outcomes based on the final estimate values.

While the results of a Delphi session might not be what the movers and shakers want to hear, they can decide whether they want to plan their project at a 10 percent confidence level, a 90 percent confidence level or somewhere in-between. Be sure to compare the actual project results to your estimates to improve your future estimating accuracy.

Wideband Delphi Evaluated

No estimation method is perfect; if it were, it would be called prediction, not estimation. However, the Wideband Delphi technique incorporates some solid estimating principles. The team approach acknowledges the value of combining multiple expert perspectives. The range of estimates produced reflects the variability intrinsic to the estimation process. Although it takes time and requires a panel of experienced estimators, Wideband Delphi removes some of the politics from estimation and filters out extreme initial values. This approach illustrates my philosophy of the correct answer to any request for an estimate: “Let me get back to you on that.”