

# Effective Sizing and Content Definition of Work Packages

Tzvi Raz, Tel Aviv University, Graduate School of Business Administration, Tel Aviv 69978 Israel

Shlomo Globerson, Tel Aviv University, Graduate School of Business Administration, Tel Aviv 69978 Israel

## ■ Abstract

The definition of a project's scope requires comprehensive specification of its work breakdown structure. An essential element of this is appropriate division of the project into manageable work packages. We present the main considerations relevant to determining the size and contents of work packages. We also provide two supporting tools: a checklist for examining the adequacy of the breakdown and a form for capturing the required information.

*Keywords:* work packages; work breakdown structure; deliverables

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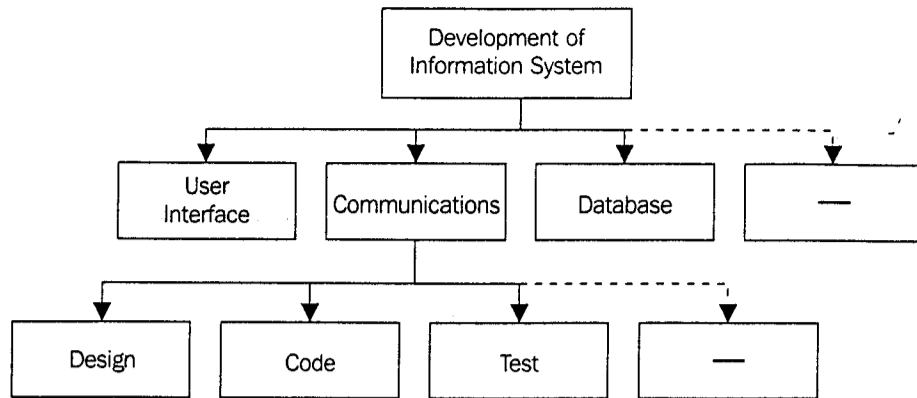
Successful project management depends, to a significant extent, on the manager's ability to effectively specify the work contents of the project in terms of its activities and deliverables. One of the principal tools for planning and controlling the work contents of a project is the work breakdown structure (WBS). According to *A Guide to the Project Management Body of Knowledge (PMBOK™ Guide)* (Project Management Institute Standards Committee, 1996), "the WBS is a deliverable-oriented grouping of project elements which organizes and defines the total scope of the project. Each descending level represents an increasingly detailed definition of a project component. Project components may be products or services." Similar definitions are found in other official sources, such as U.S. MIL-STD-881A (1975) and the U.S. Department of Energy's Performance Measurement Guidelines (1977).

In effect, the WBS is a hierarchical representation of the work contents, whereby the project is divided into progressively smaller elements. The elements at the bottom of the hierarchy are called work packages (WPs). The PERT Coordinating Group (1962) defined a WP as "the work required to complete a specific job or process, such as a report, a design, a documentation requirement or portion thereof, a piece of hardware, or a service." According to the *PMBOK™ Guide* (Project Management Institute Standards Committee, 1996), "a work package is a deliverable at the lowest level of the WBS." Thus, the work contents of the project can be viewed as the set of WPs obtained by applying the WBS.

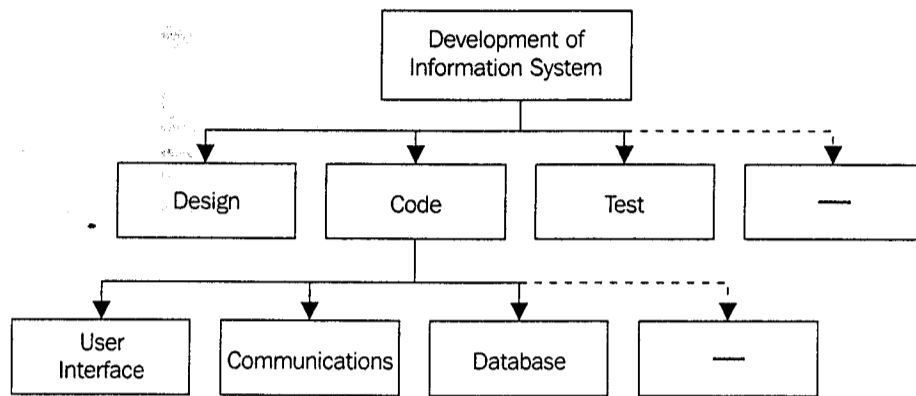
Since the set of WPs plays a central role in representing the scope of the project, it is important to define them in a manner that will facilitate the planning, execution, and control of the individual activities and of the project as a whole. Informal interaction with many project managers brought us to the conclusion that the issue is not treated properly, and no commonly accepted methodologies for WBS definition are available. This lack of formal methodology is expected to have a stronger impact in the future, as projects become more complex. In this paper, we contribute to closing the methodology gap by presenting, discussing, and illustrating the main factors to consider when sizing and defining WPs. We conclude with a checklist and a generic form for WP planning.

## Work Packages and the WBS

The WBS provides a common language for describing the work contents of the project. This common language, expressed through the WP definitions and the hierarchical coding of the WBS, enables all project stakeholders—customers, suppliers, and other participants—to communicate effectively throughout the whole life of the project. Appropriate development, maintenance, and use of the WBS contributes significantly to the probability of successful completion of a project. For example, Hall (1993) reports on the successful completion of a large-scale project in the range of \$225 million, and claims that a major contributor to its success was appropriate use of the WBS.



a. First level decomposition based on product component; second level decomposition based on life-cycle stage.



b. First level decomposition based on life-cycle stage; second level decomposition based on product component.

**Figure 1.** Two Alternative WBSs for a Sample Project

Two main issues need to be addressed in the development of a WBS: structure and level of detail. Structure reflects the criteria applied in the hierarchical decomposition of each work element into its parts. As shown by Globerson (1994), a variety of different WBS structures may be generated for any given project, each being suited to different specific conditions.

The structure of the WBS is manifested by the nature of the levels within the WBS hierarchy. Normally, the top level of the WBS represents the entire project. Lower levels represent decomposition according to a number of criteria, such as product components, organization functions, or life-cycle stages. Different WBSs are obtained by applying the criteria in a different order. For example, Figure 1 shows parts of two possible work breakdown structures for an information system development project. In Figure 1a, the project was first broken down according to the components of the system (user interface, communications routines, database, etc.), and then according to the stages of the development life cycle (design, code, test, etc.). In Figure 1b, the same decomposition criteria were

applied in the reverse order. Decomposition of the work contents of the same project according to two or more criteria will normally lead to the same set of work packages, regardless of the order in which they were applied. When fully developed, both the WBS in Figure 1a and in Figure 1b will include work packages for the design of the communication routines, the design of the database, and so forth, as well as work packages for coding the communications routines, testing them, and so forth.

Different WBSs convey different views of the project work contents, reflecting the structure of the organization that performs the project, the managerial style of the project manager, and other relevant considerations. The relationship between WBS configuration and different organizational considerations is further explored by Globerson (1994). Sometimes more than one WBS may be required. Luby, Peel, and Swahl (1995) reported on a case that required two WBSs, one product-based and the other process-based. Raz (1997) discussed how the information contents of multiple WBSs can be measured and combined.

We assume that the project planning team can determine the appropriate decomposition criteria and the order in which they should be applied to generate the WBS; the rest of this paper focuses on the question of how much decomposition is required.

Since each WP requires a certain amount of planning, reporting, and control, decomposition of the project into smaller and more numerous WPs increases the workload on the project manager and on the project team. Some organizations have general guidelines for the recommended size of WPs—see, for instance, Kiewel (1998). Guidelines are typically expressed in terms of effort (e.g., person-hours, person-days, dollar value) or in terms of elapsed time (e.g., days, weeks). Guidelines like these do not usually take into account the specific content of the WPs. The following sections of the paper present several key characteristics of the work contents that should be considered in the decision whether further decomposition of the WBS is warranted.

### Cost and Schedule Estimation

The planning phase of a project involves estimating the time and resources required to carry out its work contents. Estimates based on smaller work packages are, in general, more accurate. There are two reasons for this. First, dividing the work into smaller, homogeneous "chunks" helps focus on the activities involved, providing a better information basis for the estimation. As an example, consider the activity "design of the user interface." It is easier to estimate its duration and cost if its various components are considered separately, such as menu design, design of input screens, design of output screens, design of installation screens, design of online help formats, etc. These work components are easier to comprehend when considered separately; this leads to more reliable estimates. In addition, the components may require different estimating expertise, and may be routed to the appropriate expert. In this way, the quality of the estimates is increased.

The second factor in favor of estimation based on smaller work packages is related to the statistical nature of estimation errors. Cost and duration estimates for the various branches of the WBS and for the project as a whole are obtained by summing the estimates for the individual work packages. Due to the uncertainty inherent in the estimation process, each estimate at the work package level has a random error, which, assuming that there is no systematic bias, may equally be positive or negative. When the estimates are summed, some of the errors cancel out, with the result that the sum of the estimates has a relative smaller error than each original estimate. The statistical base of this assertion is explained next.

Assume that our ability to estimate any single cost amount is limited by 15% accuracy. This means that if the actual cost of a work package is  $C$ , then our estimate will be anywhere in the range between  $0.85C$  and  $1.15C$ .

If we can assume that the distribution of the estimation errors is close to normal, then the range of the estimates ( $1.15C - 0.85C = 0.30C$ ) corresponds to six standard deviations of the error distribution, and the standard deviation  $\sigma$  will be equal to  $(0.30C)/6 = 0.05C$ . Let's say that instead of estimating the cost of the work package as a single unit, we divided it into two smaller work packages, A and B, with actual costs  $C_A$  and  $C_B$  (of course,  $C_A + C_B = C$ ). Since our cost estimation accuracy is still  $\pm 15\%$ , the estimate for  $C_A$  will fall in the range between  $0.85C_A$  and  $1.15C_A$ , and the corresponding standard deviation  $\sigma_A$  will be  $0.05C_A$ . Similarly, the estimate for  $C_B$  will be in the range between  $0.85C_B$  and  $1.15C_B$  and the standard deviation  $\sigma_B$  will be  $0.05C_B$ .

Now, if the estimates for A and B were made independently, then the standard deviation of the sum can be calculated according to the following relationship, which appears in all elementary statistics texts: the standard deviation of the sum of two independent random variables is equal to the square root of the sum of the

### ■ About the Authors

**Tzvi Raz** holds a B.Sc., M.A.Sc. and Ph.D. in industrial and management engineering. He is



on the faculty of the Management of Technology Program of the Leon Recanati Graduate School of Business Administration at Tel Aviv University. Previously, he managed a technology insertion program at an IBM software development laboratory, and was on the industrial engineering faculties of Ben Gurion University, the University of Iowa, and the University of Arizona. Dr. Raz serves on the editorial boards of the *Project Management Journal* and the *International Journal of Industrial Engineering* and has been certified as a Project Management Professional by the Project Management Institute.

**Shlomo Globerson**, Ph.D., PMP, is a researcher, educator, and consultant in the fields of project management and operations management. A professor at the Graduate School of Business Administration, Tel Aviv University, he is extensively involved in developing new courses and workshops for MBA students, project managers, and top executives. He is also the academic director of MANPAT—MANagement of Projects & Technology. Professor Globerson has published over 70 refereed articles and six books. His book, *Project Management: Engineering, Technology and Implementation* (co-authored) received the 1995 Book-of-the-Year Award of the Institute of Industrial Engineers. His consulting experience includes involvement in numerous professional activities related to operations management and project management.



squares of the individual standard deviations. In our case,  $\sigma_{\text{sum}} = \sqrt{(0.05C_A)^2 + (0.05C_B)^2} = 0.05\sqrt{C_A^2 + C_B^2}$ .

Since the expression under the square root is less than  $(C_A + C_B)^2$ , the square root is less than  $C_A + C_B$ , which is equal to  $C$ , and  $\sigma_{A+B}$  is smaller than the original  $\sigma$ , which is  $0.05C$ . The precise decrease in standard deviation depends on the relative magnitudes of  $C_A$  and  $C_B$ . When both are equal, the standard deviation of the sum of the two estimates is smaller than the standard deviation of a single estimation by a factor of  $\sqrt{2}$ .

In general, increasing the number of work packages used to estimate the cost (or duration) and making them as equal in size as possible contributes to increasing the accuracy of the estimate of the total cost. This is true when the estimation errors are mutually independent or weakly correlated. If that is not the case, or if there is some systematic bias in the estimation procedure—for instance, every estimate is inflated by a certain amount to protect against risks—then additional decomposition of work packages may actually have a negative effect on the accuracy of the cost estimate.

In practice, there seems to be a limit to the precision of the estimates, beyond which estimation errors remain constant or even increase slowly. Thus, from the estimation perspective, division into smaller WPs should be carried out up to the point where it no longer improves the estimation accuracy.

### Responsibility Assignment

For appropriate management of a project, the project manager should ensure that each WP can be assigned to a single person or organizational unit, and that this unit has the ability to deal with all the aspects of that WP. The person or unit responsible for the execution of a WP is often called the "work package owner." If a significant portion of a WP is outside the domain of the organizational unit to which it was assigned, then the WP must be redefined and probably subdivided along responsibility lines. As an example, consider the WP "product assembly," which includes the manufacture of jigs and fixtures, which are produced by the tooling department, and the assembly work itself, which is carried out by the assembly department. In this case, there should be two separate WPs, "assembly preparations" and "assembly work," each assigned to the appropriate department and each having a single person responsible for its execution. The two WPs could appear under the same branch in the WBS, with one person responsible for overseeing the entire assembly process.

### Progress Control

Progress control is exercised by comparing actual performance with planned performance, and initiating corrective action. This requires measuring the amount of work

actually completed. As Globerson and Shtub (1995) argued, it is easier to monitor the completion of WPs than it is to estimate the completed portion of WPs still in progress. Therefore, the greater the number of WPs defined in the project, the greater the precision in measuring performance, and the tighter the control that can be applied. However, if the number of WPs is too large and the WPs are too small, then a disproportionate amount of time and effort is spent measuring and reporting progress, resulting in an increase in nonproductive administrative work. Here again, there is a natural limit on the ability to measure performance. The implication is that work should be divided into smaller packages as long as the benefits resulting from more accurate measurement of progress outweigh the additional administrative costs. In this context, some companies use guidelines such as "a work package should last not more than three reporting periods and no less than one." That is, if a progress report is generated every week, then the duration of a WP should be between one and three weeks.

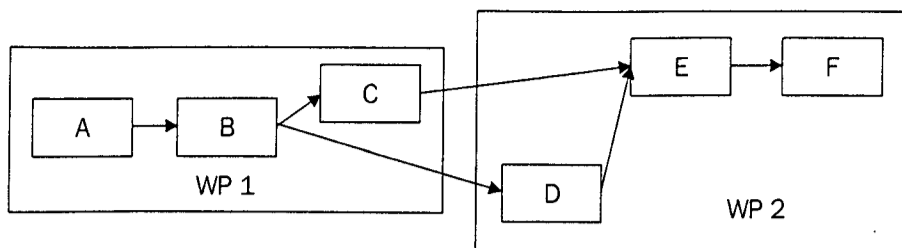
### Network Construction

Work packages are, by definition, the smallest manageable work elements of the project. However, each WP may consist of a number of activities, all of which should fall under the responsibility of the party responsible for the WP. If the dependencies among WP activities cross work package boundaries, then the construction of the project network becomes more complex and the accuracy of the WBS may be impaired. This situation is illustrated in Figure 2a. We see two WPs, each consisting of three internal activities. The arrows among the activities represent dependencies derived from technological or administrative constraints. While constructing the project network, we must define the relationship between WP 1 and WP 2. If we make WP 1 a predecessor to WP 2, we lose the fact that activity D can be carried out in parallel to activity C. Allowing some overlap between the two WPs by means of negative delay may help, but this requires precise knowledge of the completion of activity B. A better solution is to repackage the activities so as to reduce the coupling between the two WPs. This solution is shown in Figure 2b, with activity D assigned to WP 1. In this way, we can construct the network accurately and simply with a finish-to-start relationship between WP 1 and WP 2.

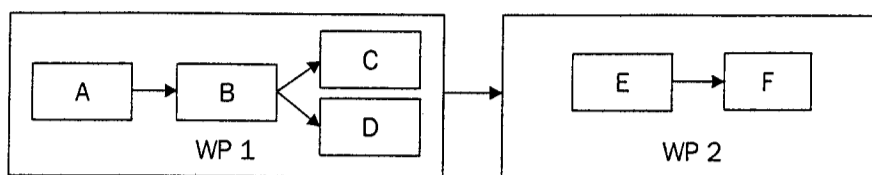
In general, activities that are highly interdependent should be assigned to the same WP, in order to reduce the coupling among work packages and to make it easier to construct the network and to calculate the schedule.

### Internal Cohesion

There is not much point in assigning independent activities to the same WP. The extent to which the work activities that constitute a given WP are related to each other is



a. Coupling between activities in different work packages.



b. Repackaged activities resulting in reduced coupling.

**Figure 2.** Effect of Work Package Contents on Network Construction

### Should the Work Package be Decomposed Further?

The greater the number of positive answers to the following questions, the stronger the justification for breaking down the work package.

- Is there a need to improve the accuracy of the cost and duration estimates?
- Is more than one individual responsible for the work contents?
- Does the work content include more than one type of activity?
- Is there a need to know precisely the timing of activities internal to the work package?
- Is there a need to cost-out activities internal to the work package?
- Are there any dependencies between the internal activities and other work packages?
- Are there any significant time breaks in the execution of the internal activities?
- Do resources requirements within the work package change over time?
- Do the prerequisites differ among the internal activities?
- Are there any acceptance criteria applicable before the completion of the entire work package?
- Are there any intermediate deliverables that can be used to generate a positive cash flow?
- Are there any specific risks that require focused attention?

**Figure 3.** Work Package Decomposition Checklist

called the internal cohesion of the WP. Some relevant dimensions of cohesion are organizational responsibility, which was discussed earlier, resources required, execution time frame, starting conditions, and completion criteria.

If the activities assigned to a given WP do not share most of the cohesion dimensions, then it may be best to break down the WP into smaller WPs, until each WP includes either a single well-defined activity or a small number of tightly interrelated activities. For instance, consider the product testing activity. If it consists of tests at the component, module, and system level, each

carried out at different stages in the project, possibly requiring different facilities and involving different personnel, then we should define a separate WP for each level of testing. In this way, each type of test can be budgeted and scheduled separately, allowing finer planning and control resolution.

### Cash Flow

Contractors are typically paid according to the progress of the project, as measured by the WPs completed and

## Work Package Definition Form

**Identification:**

Project Name \_\_\_\_\_ Project Code \_\_\_\_\_ Project Manager \_\_\_\_\_  
 WP Name \_\_\_\_\_ WP Code \_\_\_\_\_ WP Owner \_\_\_\_\_  
 Deliverables \_\_\_\_\_  
 Revision No. \_\_\_\_\_ Date \_\_\_\_\_ Previous Revision \_\_\_\_\_

**Resource Requirements:**

Human Resources	Quantity	Other Resources	Quantity	Cost
Hardware Engineer	_____	Subcontractor	_____	_____
Software Engineer	_____	Equipment	_____	_____
Editor	_____	Materials	_____	_____
Programmer	_____	Facilities	_____	_____
Other	_____	Other	_____	_____

**Total Budget for the Work Package:** \_\_\_\_\_

**Dependencies:**

Required Inputs \_\_\_\_\_  
 Required Coordination \_\_\_\_\_  
 Completion Criteria \_\_\_\_\_  
 Immediate Successors \_\_\_\_\_  
 Risks \_\_\_\_\_

**Schedule:**

Duration (days/weeks) \_\_\_\_\_  
 Early Start \_\_\_\_\_ Late Start \_\_\_\_\_ Scheduled Start \_\_\_\_\_  
 Early Finish \_\_\_\_\_ Late Finish \_\_\_\_\_ Scheduled Finish \_\_\_\_\_

**Progress Control:**

Criteria for Performance Measurement \_\_\_\_\_  
 Internal Milestones/Expected Date \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

**Approvals:**

Responsible Party	Name _____	Signature _____	Date _____
WP Customer	Name _____	Signature _____	Date _____
Project Manager	Name _____	Signature _____	Date _____

**Figure 4.** Work Package Definition Form

delivered to the customer. This means that the cost of the WP is borne by the contractor until it is completed. Under this condition, the duration of the WP has a great impact on the project's cash flow, and therefore on its profitability. Smaller WPs result in more frequent deliveries to the customer and in earlier payments, reducing finance charges to the contractor and increasing them for the customer. It is advantageous to the contractor to define the WPs so that as soon as value to the customer is created, it can be delivered and payment can be made. For example, consider a project that entails the development of training materials. Rather than having this activity be a single WP, it could be divided into a number of

WPs—end-user training, system operator training, maintenance training, installation training, etc. If each training module results in payment upon delivery, then the contractor's cash flow will improve, while the customer will enjoy earlier the benefits of a trained workforce.

**Risk Management**

The specific way that a project is decomposed into WPs may affect the manner in which risks are identified and mitigated. For instance, consider a project that involves erecting a new high-rise apartment building in a well-established neighborhood. In order to proceed with the project,

several permits and approvals from different authorities and stakeholders are required. This is typically a high-risk activity, with the sources of risk varying depending on the type of permit or approval. Thus, it may be helpful to define a separate WP for each permit or approval, and to assign it to a person with the appropriate expertise (attorney, public relations, environmental engineer). In this manner, risks are isolated and treated individually, allowing more effective focusing of risk management attention.

### Work Package Decomposition Checklist

The considerations discussed so far can be summarized in a checklist that provides guidance regarding the need to further decompose the work contents of the project. Consider a given WP. If the answers to most of the items in the checklist in Figure 3 are positive, then further decomposition of the WP should be considered.

### Work Package Definition Form

Poor performance at the WP level means poor performance on the project level. Therefore, the success of the project depends on the ability of the project manager to properly define, plan, and control each WP. A powerful tool for this purpose is the WP definition form, which describes the relevant attributes of the WP. By capturing key information, the WP definition form not only facilitates the planning process but also promotes communication and agreement among the various parties involved. It could also be used as the basis for a contract, either formal or informal, between the project manager as the customer and the party responsible for the WP execution as its supplier. Figure 4 presents a sample generic form. The sample form is a composite of various form styles that we have encountered, and can be readily adapted to the needs of any particular project.

### Concluding Remarks

The appropriate definition of the WBS in general, and of the WPs in particular, is a crucial factor for the successful completion of a project. In this paper, we discussed some key considerations involved in determining the size and contents of WPs. We have also provided two supporting tools: a checklist for examining the adequacy of the breakdown, and a form for capturing the required information. The principles and tools presented here are applicable, with appropriate modifications, to virtually any type of project.

In spite of the great importance of WP definition, very little research has been done on the subject. In order to develop a well-grounded methodology for developing a WBS and defining WPs, further research is required. The research should explore the practice used in WP definitions of projects that were completed successfully, and identify the characteristics that contributed to their success.

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