

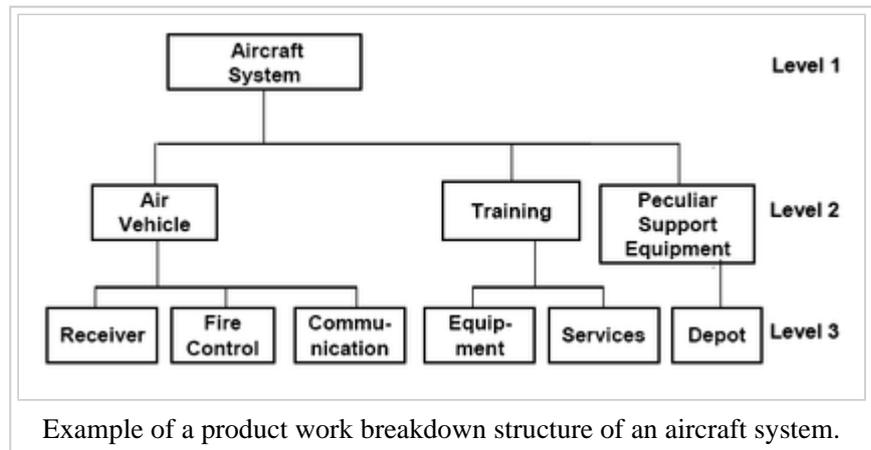
# Work breakdown structure

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A **work breakdown structure (WBS)** in project management and systems engineering, is a tool used to define and group a project's discrete work elements (or tasks) in a way that helps organize and define the total work scope of the project<sup>[1]</sup>.

A work breakdown structure element may be a product, data, a service, or any

combination. A WBS also provides the necessary framework for detailed cost estimating and control along with providing guidance for schedule development and control. Additionally the WBS is a dynamic tool and can be revised and updated as needed by the project manager.<sup>[1]</sup>



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## Overview

The Work Breakdown Structure is a tree structure, which shows a subdivision of effort required to achieve an objective; for example a program, project, and contract. In a project or contract, the WBS is developed by starting with<sup>[2]</sup> :

- the end objective and
- successively subdividing it into manageable components
- in terms of size, duration, and

responsibility (e.g., systems, subsystems, components, tasks, subtasks, and work packages)

- which include all steps necessary to achieve the objective.

Example of Work breakdown structure applied in a NASA reporting structure.<sup>[2]</sup>

The Work Breakdown Structure provides a common framework for the natural development of the overall planning and control of a contract and is the basis for dividing work into definable increments from which the statement of work can be developed and technical, schedule, cost, and labor hour reporting can be established.<sup>[2]</sup>

A work breakdown structure permits summing of subordinate costs for tasks, materials, etc., into their successively higher level "parent" tasks, materials, etc. For each element of the work breakdown structure, a description of the task to be performed is generated.<sup>[3]</sup> This technique (sometimes called a System Breakdown Structure<sup>[4]</sup>) is used to define and organize the total scope of a project.

The WBS is organized around the primary products of the project (or planned outcomes) instead of the work needed to produce the products (planned actions). Since the planned outcomes are the desired ends of the project, they form a relatively stable set of categories in which the costs of the planned actions needed to achieve them can be collected. A well-designed WBS makes it easy to assign each project activity to one and only one terminal element of the WBS. In addition to its function in cost accounting, the WBS also helps map requirements from one level of system specification to another, for example a requirements cross reference matrix mapping functional requirements to high level or low level design documents.

## History

The concept of the Work Breakdown Structure developed with the Program Evaluation and Review Technique (PERT) in the United States Department of Defense (DoD). PERT was introduced by the U.S. Navy in 1957 to support the development of its Polaris missile program. [1] While the term "work breakdown structure" was not used, this first implementation of PERT did organize the tasks into product-oriented categories.<sup>[5]</sup>

By June 1962, DoD, NASA and the aerospace industry published a document for the PERT/COST system which described the WBS approach.<sup>[6]</sup> This guide was endorsed by the Secretary of Defense for adoption by all services.<sup>[7]</sup> In 1968, the DoD issued "Work Breakdown Structures for Defense Materiel Items" (MIL-STD-881), a military standard requiring the use of work breakdown structures across the DoD.<sup>[8]</sup> This standard established top-level templates for common defense materiel items along with associated descriptions (WBS dictionary) for their elements.

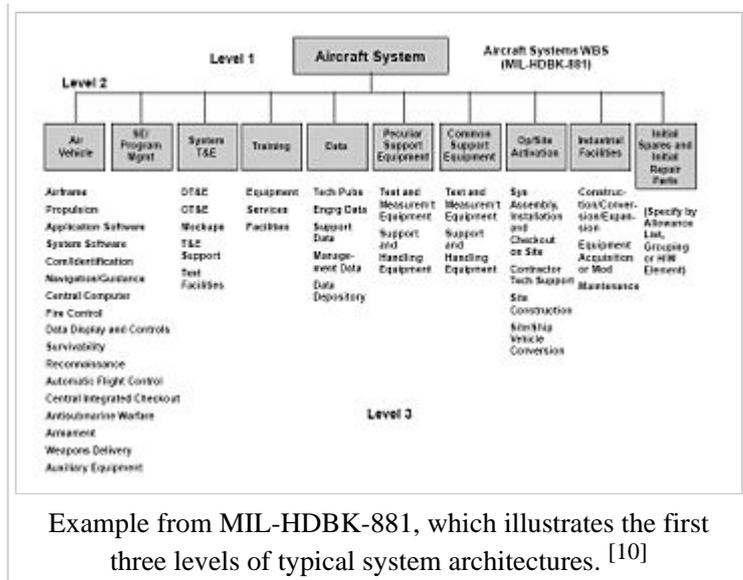
The document has been revised several times, most recently in 2005. The current version of this document can be found in "Work Breakdown Structures for Defense Materiel Items" (MIL-HDBK-881A).<sup>[9]</sup> It includes instructions for preparing work breakdown structures, templates for the top three levels of typical systems, and a set of "common elements" that are applicable to all major systems and subsystems.

Defense Material Item categories from MIL-HDBK-881A:

- Aircraft Systems
- Electronic/Automated Software Systems
- Missile Systems

- Ordnance Systems
- Sea Systems
- Space Systems
- Surface Vehicle Systems
- Unmanned Air Vehicle Systems
- Common Elements

The common elements identified in MIL-HDBK-881A, Appendix I are: Integration, assembly, test, and checkout; Systems engineering; Program management; Training; Data; System test and evaluation; Peculiar support equipment; Common support equipment; Operational and site activation; Industrial facilities; and Initial spares and repair parts



In 1987, the Project Management Institute (PMI) documented the expansion of these techniques across non-defense organizations. The Project Management Body of Knowledge (PMBOK) Guide provides an overview of the WBS concept, while the "Practice Standard for Work Breakdown Structures" is comparable to the DoD handbook, but is intended for more general application. [11]

## WBS design principles

### The 100% rule

One of the most important Work Breakdown Structure design principles is called the 100% Rule [12]. It has been defined as follows:

***The 100% Rule**...states that the WBS includes 100% of the work defined by the project scope and captures all deliverables – internal, external, interim – in terms of the work to be completed, including project management. The 100% rule is one of the most important principles guiding the development, decomposition and evaluation of the WBS. The rule applies at all levels within the hierarchy: the sum of the work at the “child” level must equal 100% of the work represented by the “parent” and the WBS should not include any work that falls outside the actual scope of the project, that is, it cannot include more than 100% of the work... It is important to remember that the 100% rule also applies to the activity level. The work represented by the activities in each work package must add up to 100% of the work necessary to complete the work package. [13]*

### Mutually exclusive elements

Mutually exclusive: In addition to the 100% Rule, it is important that there is no overlap in scope definition between two elements of a Work Breakdown Structure. This ambiguity could result in duplicated work or miscommunications about responsibility and authority. Likewise, such overlap is likely to cause confusion regarding project cost accounting. If the WBS element names are ambiguous, a WBS dictionary can help clarify the distinctions between WBS elements. The WBS Dictionary describes each component of the WBS with milestones, deliverables, activities, scope, and sometimes dates, resources, costs, quality.

### Planned outcomes, not planned actions

If the Work Breakdown Structure designer attempts to capture any action-oriented details in the WBS, he/she will likely include either too many actions or too few actions. Too many actions will exceed 100% of the parent's scope and too few will fall short of 100% of the parent's scope. The best way to adhere to the 100% Rule is to define WBS elements in terms of outcomes or results. This also ensures that the WBS is not overly prescriptive of methods, allowing for greater ingenuity and creative thinking on the part of the project participants. For new product development projects, the most common technique to ensure an outcome-oriented WBS is to use a product breakdown structure. Feature-driven software projects may use a similar technique which is to employ a feature breakdown structure. When a project provides professional services, a common technique is to capture all planned deliverables to create a deliverable-oriented WBS. Work breakdown structures that subdivide work by project phases (e.g. Preliminary Design Phase, Critical Design Phase) must ensure that phases are clearly separated by a deliverable also used in defining Entry and Exit Criteria (e.g. an approved Preliminary Design Review document, or an approved Critical Design Review document).

## Level of detail

A question to be answered in determining the duration of activities necessary to produce a deliverable defined by the WBS is when to stop dividing work into smaller elements. There are several heuristics or "rules of thumb" used when determining the appropriate duration of an activity or group of activities necessary to produce a specific deliverable defined by the WBS.

- The first is the "80 hour rule" which means that no single activity or group of activities to produce a single deliverable should be more than 80 hours of effort.
- The second rule of thumb is that no activity or series of activities should be longer than a single reporting period. Thus if the project team is reporting progress monthly, then no single activity or series of activities should be longer than one month long.
- The last heuristic is the "if it makes sense" rule. Applying this rule of thumb, one can apply "common sense" when creating the duration of a single activity or group of activities necessary to produce a deliverable defined by the WBS.

A work package at the activity level is a task that:

- can be realistically and confidently estimated;
- makes no sense practically to break down any further;
- can be completed in accordance with one of the heuristics defined above;
- produces a deliverable which is measurable; and
- forms a unique package of work which can be outsourced or contracted out.

## WBS coding scheme

It is common for Work Breakdown Structure elements to be numbered sequentially to reveal the hierarchical structure. For example **1.3.2 Rear Wheel** identifies this item as a Level 3 WBS element, since there are three numbers separated by a decimal point. A coding scheme also helps WBS elements to be recognized in any written context.<sup>[14]</sup>

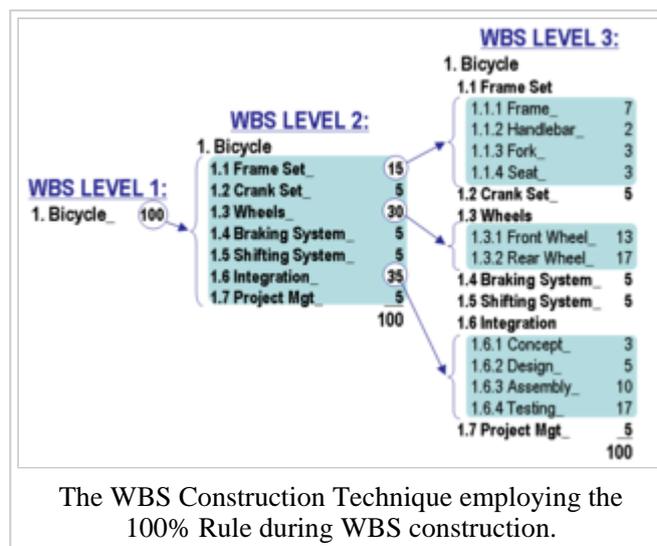
## Terminal element

A terminal element is the lowest element (activity or deliverable) in a work breakdown structure; it is not further subdivided. Terminal elements are the items that are estimated in terms of resource requirements, budget and duration; linked by dependencies; and scheduled. A terminal element is sometimes called a work package, although the two terms are not synonymous.

## Example

The figure (on the right) shows a Work Breakdown Structure construction technique that demonstrates the 100% Rule and the "progressive elaboration" technique. At WBS Level 1 it shows 100 units of work as the total scope of a project to design and build a custom bicycle. At WBS Level 2, the 100 units are divided into seven elements. The number of units allocated to each element of work can be based on effort or cost; it is not an estimate of task duration.

The three largest elements of WBS Level 2 are further subdivided at Level 3. The two largest elements at Level 3 each represent only 17% of the total scope of the project. These larger elements could be further subdivided using the *progressive elaboration* technique described above.



WBS design can be supported by software (e.g. a spreadsheet) to allow automatic rolling up of point values. Estimates of effort or cost can be developed through discussions among project team members. This collaborative technique builds greater insight into scope definitions, underlying assumptions, and consensus regarding the level of granularity required to manage the project.

## Pitfalls and misconceptions

- A Work Breakdown Structure is not an exhaustive list of work. It is instead a comprehensive classification of project scope.
- A WBS is neither a project plan, a schedule, nor a chronological listing. It is considered poor practice to construct a project schedule (e.g. using project management software) before designing a proper WBS. This would be similar to scheduling the activities of home construction before completing the house design. Without concentrating on planned outcomes, it is very difficult to follow the 100% Rule at all levels of the WBS hierarchy.
- A WBS is not an organizational hierarchy. Some practitioners make the mistake of creating a WBS that shadows the organizational chart. While it is common for responsibility to be assigned to organizational elements, a WBS that shadows the organizational structure is not descriptive of the project scope and is not outcome-oriented. See also: responsibility assignment (RACI) matrix (also called a *Staffing Matrix*).
- WBS updates, other than progressive elaboration of details, require formal change control. This is another reason why a WBS should be outcome-oriented and not be prescriptive of methods. Methods can, and do, change frequently, but changes in planned outcomes require a higher degree of formality. If outcomes and actions are blended, change control may be too rigid for actions and too informal for outcomes.
- A WBS is not a logic model. Nor is it a strategy map.

## See also

- List of project management topics
- Project planning
- Product breakdown structure

- Project management software
- Structure chart

## References

- <sup>^</sup> <sup>*a*</sup> <sup>*b*</sup> Booz, Allen & Hamilton Earned Value Management Tutorial Module 2: Work Breakdown Structure, Office of Project Assessment, doe.gov. Accessed 01. Dec 2008.
- <sup>^</sup> <sup>*a*</sup> <sup>*b*</sup> <sup>*c*</sup> NASA (2001). NASA NPR 9501.2D. May 23, 2001.
- <sup>^</sup> Electronic Industries Alliance Standard *Systems Engineering Capability Model* EIA-731.1
- <sup>^</sup> Institute of Electrical and Electronics Engineers *Standard for Application and Management of the Systems Engineering Process* IEEE Std 1220-2005
- <sup>^</sup> Haugan, Gregory T., *Effective Work Breakdown Structures*, pp7-8
- <sup>^</sup> DOD and NASA Guide, PERT/COST System Design, June 1962
- <sup>^</sup> Hamilton, R. L., "Study of Methods for Evaluation of the PERT/Cost Management System", MITRE Corporation, June 1964 <http://handle.dtic.mil/100.2/AD603425>
- <sup>^</sup> MIL-STD-881, 1 November 1968
- <sup>^</sup> MIL-HDBK-881A, [http://assist.daps.dla.mil/quicksearch/basic\\_profile.cfm?ident\\_number=202687](http://assist.daps.dla.mil/quicksearch/basic_profile.cfm?ident_number=202687)
- <sup>^</sup> *Systems Engineering Fundamentals*. Defense Acquisition University Press, 2001
- <sup>^</sup> Haugan, Gregory T., *The Work Breakdown Structure in Government Contracting*, Management Concepts, 2003 ISBN 978-1567261202
- <sup>^</sup> *Effective Work Breakdown Structures* By Gregory T. Haugan, Published by Management Concepts, 2001, ISBN 1567261353, p.17
- <sup>^</sup> *Practice Standard for Work Breakdown Structures (Second Edition)*, published by the Project Management Institute, ISBN 1933890134, page 8
- <sup>^</sup> Several examples of standardized WBS structures for Construction are:
  - CSI's Masterformat- [http://www.csinet.org/s\\_csi/sec.asp?TRACKID=&CID=1377&DID=11339](http://www.csinet.org/s_csi/sec.asp?TRACKID=&CID=1377&DID=11339)
  - CSI's Unifomat- [http://www.csinet.org/s\\_csi/docs/15700/15694.pdf](http://www.csinet.org/s_csi/docs/15700/15694.pdf)
  - NORSOK Z-014 Offshore Petroleum WBS Example- <http://www.standard.no/imaker.exe?id=1521>

## Further reading

- Carl L. Pritchard. *Nuts and Bolts Series 1: How to Build a Work Breakdown Structure*. ISBN 1-890367-12-5
- Project Management Institute. *Project Management Institute Practice Standard for Work Breakdown Structures, Second Edition (2006)*. ISBN 1-933890-13-4 (Note: The Second Edition is an extensive re-write of the Practice Standard.)
- Gregory T. Haugan. *Effective Work Breakdown Structures (The Project Management Essential Library Series)*. ISBN 1-56726-135-3
- Dennis P. Miller, PMP, "Building Your Project Work Breakdown Structure -- Visualizing Your Objectives, Deliverables, Activities and Schedule". ISBN 1-42006969-1 (Note: This new book is essentially a facilitator's guide for planning a project based on the WBS.)

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