Work Breakdown Structure (WBS)

Work Breakdown Structure (WBS) is a basic project document that describes all the work that must be done to complete the project and forms the basis for costing, scheduling, and work responsibility.

A work breakdown structure (WBS) is prepared to determine the exact nature of the tasks required to complete the project.

It is a (usually hierarchical) way of viewing the activities in the action plan.

Often, the WBS consists of a simple list of all project activities with major activities broken down into subactivities, and these broken down still further. Schedules may also be shown, and resources, budget account numbers, and other specific aspects of the project may be displayed.

The WBS may also picture a project subdivided into hierarchical units of tasks, subtasks, work packages etc.

Most current project management software like Microsoft's Project will generate a WBS on command.

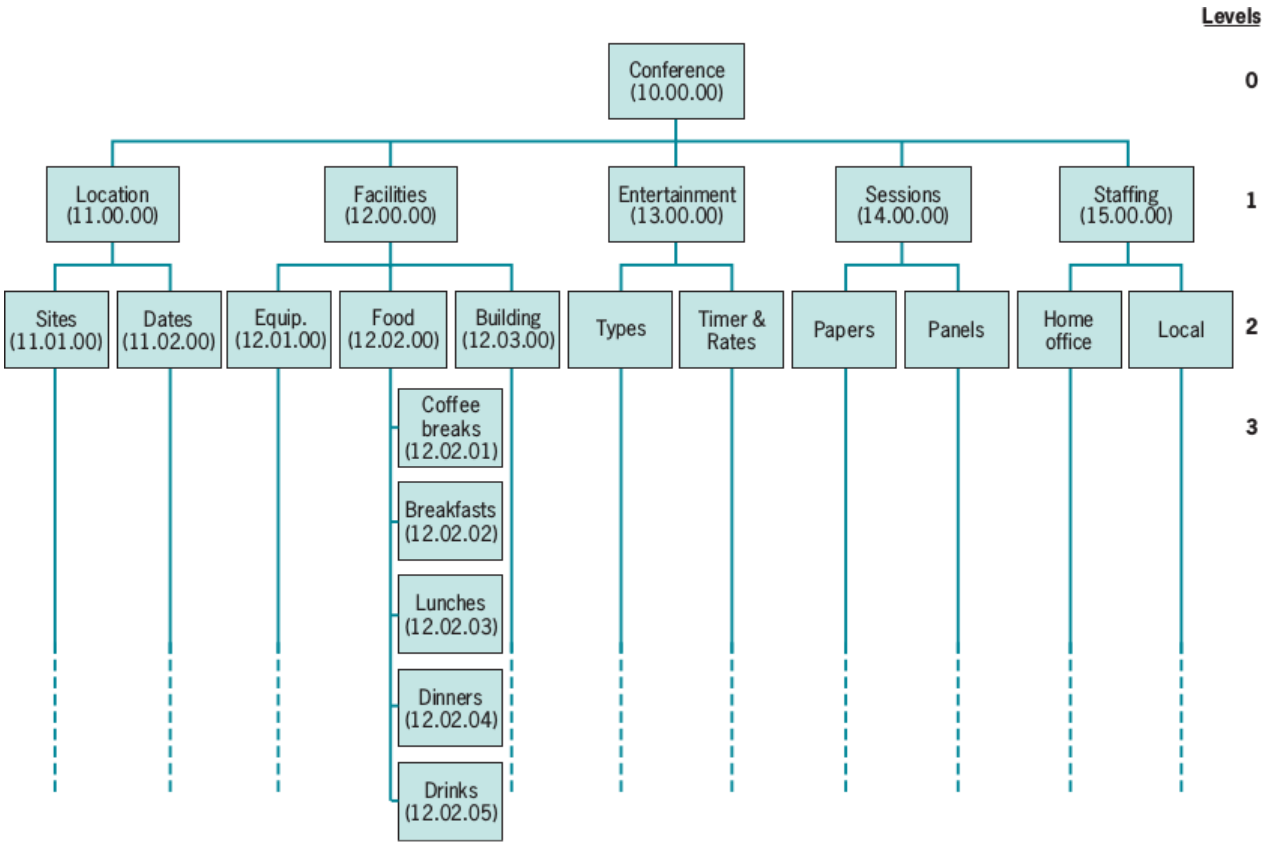


Figure 6-6 Work breakdown structure (account numbers shown).

Figure 6-6 is shows a WBS for a conference.

Figure 6-6 shows the organizational elements associated with specific categories of tasks. The Food group in the Facilities staff has responsibility for meals and drinks, including coffee breaks and water pitchers in the conference rooms. Five different food functions are shown, each presumably broken down into more detailed tasks. In this case, the account numbers for each task are shown so that proper charges can be assigned for each piece of work done on the project.

The WBS is an important document and can be tailored for use in a number of different ways :
1) It may illustrate how each piece of the project contributes to the whole in terms of performance, responsibility, budget, and schedule.
2) It may, if the PM wishes, list the vendors or subcontractors associated with specific tasks.
3) It may be used to document that all parties have signed off on their various commitments to the project.
4) It may note detailed specifications for any work package, establish account numbers, specify hardware/software to be used, and identify resource needs.
5) It may serve as the basis for making cost estimates or estimates of task duration.

Its uses are limited only by the needs of the project and the imagination of the PM. No one version of the WBS will suit all needs, so the WBS is not a document, but any given WBS is simply one of many possible documents.

Linear Responsibility Chart

WBS / Responsibility		Project Office				Field Oper.	
Subproject	Task	Project Manager	Contract Admin.	Project Eng.	Industrial Eng.	Field Manager	
Determine need	A1	○		●	▲		
	A2	■	○	▲	●		
Solicit quotations	B1	○	■	▲		●	
Write approp. request.	C1	■	▲	○	●		
	C2		●	○	▲		
	C3	●	■	▲		■	
" " "	" " "						

Legend:
▲ Responsible
● Support
■ Notification
○ Approval

Figure 6-7 Linear responsibility chart.

A linear responsibility chart (sometimes called a responsibility matrix) is used to show who is responsible for what.

This chart also shows critical interfaces between units that may require special managerial coordination.

With it, the PM can keep track of who must approve what and who must report to whom.

Such a chart is illustrated in Figure 6-7.

If the project is not too complex, the responsibility chart can be simplified (see Figure 6-

8).

	Vice-president	General manager	Project manager	Manager engineering	Manager software	Manager manufacturing	Manager marketing	Subprogram manager manufacturing	Subprogram manager software	Subprogram manager hardware	Subprogram manager services
Establish project plan	6	2	1	3	3	3	3	4	4	4	4
Define WBS		5	1	3	3	3	3	3	3	3	3
Establish hardware specs		2	3	1	4	4	4				
Establish software specs		2	3	4	1		4				
Establish interface specs		2	3	1	4	4	4				
Establish manufacturing specs		2	3	4	4	1	4				
Define documentation		2	1	4	4	4	4				
Establish market plan	5	3	5	4	4	4	1				
Prepare labor estimate			3	1	1	1		4	4	4	4
Prepare equipment cost estimate		3	1	1	1			4	4	4	4
Prepare material costs			3	1	1	1		4	4	4	4
Make program assignments			3	1	1	1		4	4	4	4
Establish time schedules		5	3	1	1	1	3	4	4	4	4

1 Actual responsibility
2 General supervision
3 Must be consulted
4 May be consulted
5 Must be notified
6 Final approval

Figure 6-8 Simplified linear responsibility chart.

Figure 6-9 shows one page of a verbal responsibility chart developed by a firm to reorganize its distribution system.

		Responsible Individuals	
Activities	***Initiate Action***	***Work with***	***Clear Action with***
Distribution System and Its Administration			
1. Recommend distribution system to be used.	Mktg Officers	ILI & IHI LOB MCs M-A Cttee VP&Agcy Dir	Sr VP Mktg
	Mktg Officers	Group LOB MC M-A Cttee VP & Agcy Dir	Sr VP Mktg
	Mktg Officers	IA LOB MC M-A Cttee VP&Agcy Dir	Sr VP Mktg
Compensation			
2. Determine provisions of sales-compensation programs (e.g., commissions, subsidies, fringes).	Compensation Task Force	Mktg, S&S & Eqty Prod Offrs	President
	Compensation Task Force	Mktg, S&S & Eqty Prod Offrs	
	Compensation Task Force	Mktg, S&S & Eqty Prod Offrs	President
3. Ensure cost-effectiveness testing of sales compensation programs.	Compensation Task Force	Mktg, S&S & Eqty Prod Offrs	President
Territory			
4. Establish territorial strategy for our primary distribution system.	VP&Agcy Dir	Dir MP&R M-A Cttee	Sr VP Mktg
5. Determine territories for agency locations and establish priorities for starting new agencies.	VP&Agcy Dir	Dir MP&R M-A Cttee	Sr VP Mktg
6. Determine agencies in which advanced sales personnel are to operate.	Dir Ret Plnng Sls Dir Adv Sls	VP S & S	Sr VP Mktg

Legend: IA, ILI, IHI: Product lines
LOB: Line of business
MC: Management committee
M-A Cttee: Marketing administration committee
S&S: Sales and service
MP&R: Marketing planning and research

Figure 6-9 Verbal responsibility chart.

In this case, the chart takes the form of a 30-page document covering 116 major activities.

PERT and CPM

The most common approach to project scheduling is the use of network techniques such as PERT and CPM.

Program Evaluation and Review Technique (PERT)

The Program Evaluation and Review Technique (PERT) was developed by the U.S. Navy in cooperation with Booz Allen Hamilton and the Lockheed Corporation for the Polaris missile/submarine project.

In application, PERT has primarily been used for R&D projects, the type of projects for which it was developed, though its use is more common on the "development" side of R&D than it is on the "research" side.

The use of PERT has decreased sharply in recent years because a large majority of project management software generates Critical Path Method (CPM) networks.

Originally, PERT was strictly oriented to the time element of projects and used probabilistic activity time estimates to aid in determining the probability that a project could be completed by some given date.

A PERT chart is a project management tool that provides a graphical representation of a project's timeline.

The Program Evaluation Review Technique (PERT) breaks down the individual tasks of a project for analysis.

PERT charts are considered preferable to Gantt charts because they identify task dependencies, but they're often more difficult to interpret

PERT has defined four types of time required to accomplish an activity:

Optimistic time: The minimum possible time

Pessimistic time: The maximum possible time

Most likely time: The best estimate of the time

Expected time: The average time ,the task would require if the task were repeated on a number of occasions over an extended period of time

Critical Path Method (CPM)

The Critical Path Method was developed by DuPont Inc.

CPM was designed for construction projects and has been generally embraced by the construction industry.

A large majority of project management software generates CPM networks.

CPM used deterministic activity time estimates and was designed to control both the time and cost aspects of a project, in particular, time/cost trade-offs.

In CPM, activities can be "crashed" (expedited) at extra cost to speed up the completion time.

Critical path is the sequential activities from start to the end of a project.
Although many projects have only one critical path, some projects may have more than one critical paths depending on the flow logic used in the project.
Critical path method is based on mathematical calculations and it is used for scheduling project activities.
In the critical path method, the critical activities of a program or a project are identified.
These are the activities that have a direct impact on the completion date of the project.

Key Steps in Critical Path Method :

Step 1: Activity specification
Step 2: Activity sequence establishment
Step 3: Network diagram
Step 4: Estimates for each activity
Step 5: Identification of the critical path

- Earliest start time (ES) - The earliest time an activity can start once the previous dependent activities are over.
- Earliest finish time (EF) - ES + activity duration.
- Latest finish time (LF) - The latest time an activity can finish without delaying the project.
- Latest start time (LS) - LF - activity duration.

The float time for an activity is the time between the earliest (ES) and the latest (LS) start time or between the earliest (EF) and latest (LF) finish times.
Step 6: Critical path diagram to show project progresses

Project Critical Path

Both techniques PERT and CPM identified a project critical path with activities that could not be delayed, and also indicated activities with slack (or float) that could be somewhat delayed without lengthening the project completion time.

For almost half a century, PERT and CPM networks have been used in project management.

However, in 2005, the Project Management Institute (PMI) renamed PERT as ADM (Arrow Diagram Method) and CPM as PDM (Precedence Diagram Method).

In PERT (ADM) network where the activities are shown as arrows on the network, we will call it an AOA (activity on arrow) network, and if we refer to a CPM (PDM) network where the activities are shown as nodes, we will call it an AON (activity on node) network.

Gantt Chart

One of the oldest but still one of the most useful methods of presenting project schedule information is the Gantt chart, developed around 1917 by Henry L. Gantt, a pioneer in the field of scientific management.

The Gantt chart was invented as a scheduling aid.

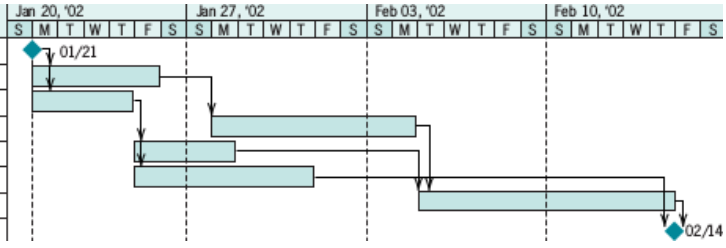
Occasionally, planners attempt to plan by using Gantt charts, a network device commonly used to display project schedules.

In essence, the project's activities are shown on a horizontal bar chart with the horizontal bar lengths proportional to the activity durations.

The Gantt chart shows planned and actual progress for a number of tasks displayed as bars against a horizontal time scale.

The activity bars are connected to predecessor and successor activities with arrows.

ID	Task Name	Duration	Start	Finish	Predecessors
1	Start	0 days	01/21/2002	01/21/2002	
2	a	5 days	01/21/2002	01/25/2002	1
3	b	4 days	01/21/2002	01/24/2002	1
4	c	6 days	01/28/2002	02/04/2002	2
5	d	2 days	01/25/2002	01/28/2002	3
6	e	5 days	01/25/2002	01/31/2002	3
7	f	8 days	02/05/2002	02/14/2002	4,5
8	Finish	0 days	02/14/2002	02/14/2002	6,7



It is a particularly effective and easy-to-read method of indicating the actual current status for each of a set of tasks compared to the planned progress for each item of the set.

As a result, the Gantt chart can be helpful in expediting, sequencing, and reallocating resources among tasks, as well as in the valuable but mundane job of keeping track of how things are going.

In addition, the charts usually contain a number of special symbols to designate or highlight items of special concern to the situation being charted.

Advantages :

There are several advantages to the use of Gantt charts :

1) First, even though they may contain a great deal of information, they are easily understood.

2) While they do require frequent updating (as does any scheduling/control device), they are easy to maintain as long as task requirements are not changed or major alterations of the schedule are not made.

3) Gantt charts provide a picture of the current state of a project.

4) Another significant feature of Gantt charts is that they are as easy to construct as a network.

Disadvantages :

If a project is complex with a large set of activities, it may be very difficult to follow multiple activity paths through the project.

Project Management Information Systems (PMIS)

The systems, activities, and data that allow information flow in a project, frequently computerized but not always.

Computerized Project Management Information Systems (PMIS)

Real projects are often extremely large, with hundreds of tasks and thousands of work units.

Diagramming, scheduling, and tracking all these tasks is clearly a job for the computer, and computerized PMISs were one of the earlier business applications for computers.

Initially, the focus was on simple scheduling packages, but this quickly extended to include costs, earned values, variances, management reports, and so on.

The earlier packages ran on large, expensive mainframe computers; thus, only the larger firms had access to them. Still, the use of these packages for managing projects on a day-to-day basis was not particularly successful. This was because of the inability of project managers to update plans in real time, mainframe computers typically being run in a batch rather than online mode.

With the development and proliferation of desktop (and laptop) computers, and servers, and the corresponding availability of a wide variety of project management software, project managers now use at least one PMIS.

These server or desktop computer-based PMISs are considerably more sophisticated than earlier

systems and use the computer's graphics, color, and other features more extensively.

Many systems can handle almost any size project, being limited only by the memory available in the computer. Many will handle multiple projects and link them together to detect resource over allocation. For example, Microsoft Project can consolidate more than 1,000 projects.

The PMIS trend has been to integrate the project management software with spreadsheets, databases, word processors, communication, graphics, and the other capabilities of Windows based software packages.

In general, there are six areas of PMIS internal capabilities, separate from the ability to migrate data and communicate externally, that should be considered. These are project planning, resource management, risk management, tracking/monitoring, report generation, and decision aiding.

The potential purchaser of a PMIS should consider the intended use of the package, the background and needs of all the potential users, and the organizational setting where the package is to be employed, including the needs and orientation of those who will be receiving the reports and graphics.

A general **PMIS selection process** is as follows :
1) Establish a comprehensive set of selection criteria, considering capabilities in project planning, resource management, tracking/monitoring, report generation, earned value/variance analysis, risk management.

2) Set priorities for the criteria, separating "must have" items from "nice to have" items and "not needed" items.

3) Conduct a preliminary evaluation of the software packages relative to the criteria using vendor supplied data, product reviews, and software surveys.

4) Limit the candidate packages to three and obtain demos of each, evaluating the vendors at the same time in terms of interest, software maintenance, and support.

5) Evaluate each package with a standard project typical of your current and projected future needs. Make note of any weaknesses or strengths that are particularly relevant to your situation.

6) Negotiate on price, particularly if you are making a volume purchase or contemplating a site license. Include descriptions of vendor support, training, and product maintenance in the contract.

PMIS Disadvantages

Finally, it is worth noting that these systems can very easily be misused or inappropriately applied as can any tools. The most common error of this type is managing the PMIS rather than the project itself. This and other such errors are :

1) Computer paralysis

Excessive computer involvement with computer activity replacing project management; loss of touch with the project and its realities.

2) PMIS verification

PMIS reports may mask real project problems, be massaged to look good, or simply verify that real problems exist, yet are not acted upon.

3) Information overload

Too many reports, too detailed, or the distribution of reports, charts, tables, data, and general information from the PMIS to too many people overwhelms managers and effectively hides problems.

4) Project isolation

The PMIS reports replace useful and frequent communication between the project manager and top management, or even between the PM and the project team.

5) Computer dependence

PM or top management wait for the computer reports/results to react to problems rather than being proactive and avoiding problems in the first place.

6) PMIS misdirection

Due to the unequal coverage of the PMIS, certain project subareas are over managed and other areas receive inadequate attention; symptoms of problems are monitored and managed (budget overruns, schedule slippages), rather than the problems themselves.

We have also found that problems can result when someone other than the Project Manager attempts to update projects without involving the Project Manager in the changes.