Developing the Schedule and Cost Plan

Farid Ahmadi

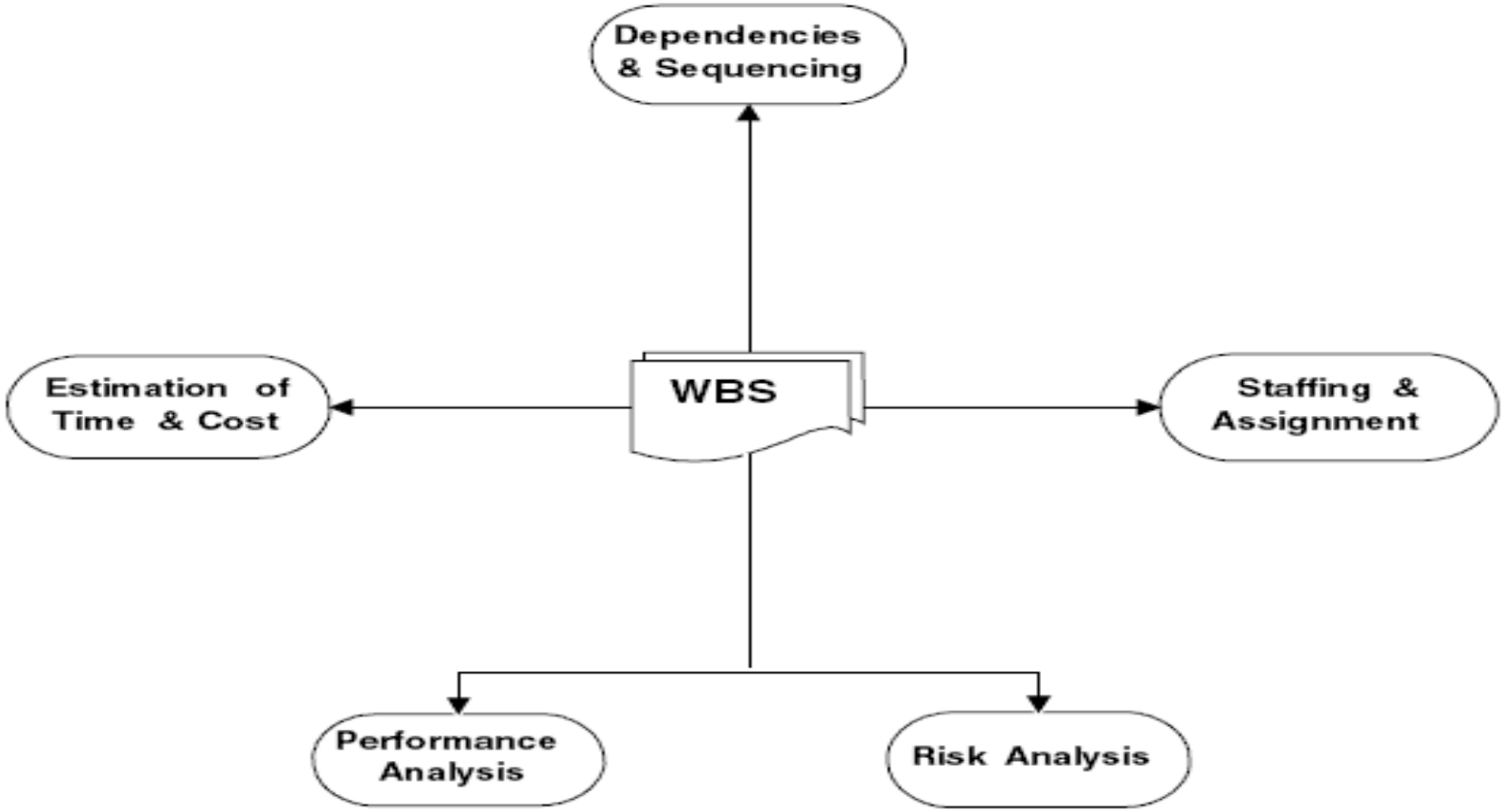
WBS

- After the requirements have been determined, documented, and approved, a detail analysis and breakdown of that project's scope are created.
- The PMI definition of a WBS is "A *deliverable oriented grouping of project* elements that *organizes and defines the total work scope of the project"*
- For most projects, the WBS is typically arranged in a multilevel hierarchical manner, a so-called tree structure. The first level (Level zero, or top level) typically corresponds to the project phases. Each level of the WBS is a further breakdown of the previous level.
- Note also that, although the WBS specifies the work to be done, it does not specify the order in which the work is to be done, nor does the WBS numbering indicate the order in which work items are to be done.

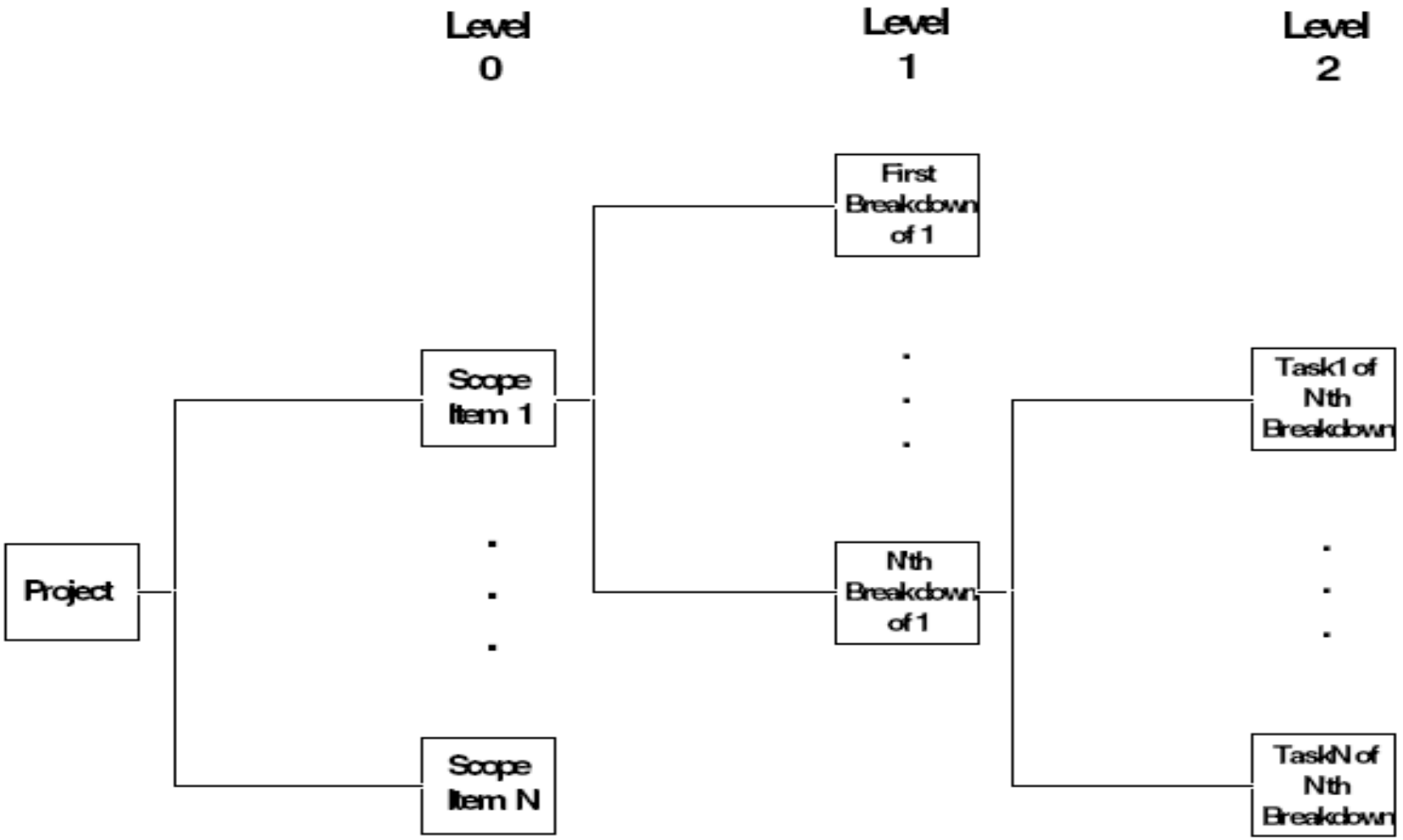
WBS

- The WBS numbering also does not indicate assignment of work to responsible organizational components, assignment of work to any resources, or the cost of any work item. The lowest level (when viewed as a vertical tree) defines the actual tasks, often called
- work packets are also called activity WBS codes, as opposed to the WBS codes at the higher levels, which are called “control” codes. A control code has one or more lower level subsidiary code, each of which is either another control code or an activity code. Each activity code is associated with one and only one control code.

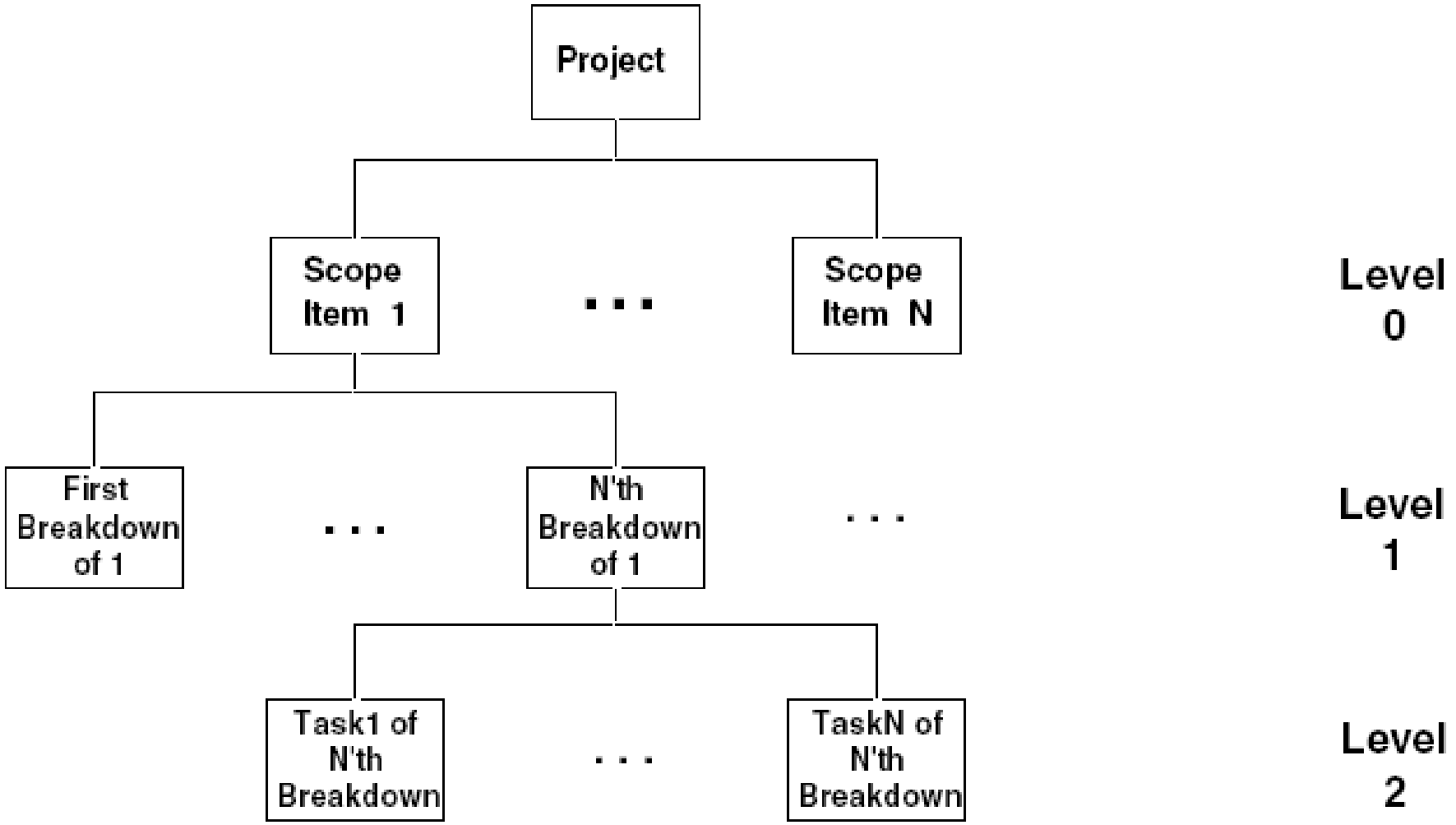
WBS uses



Horizontal WBS



Vertical WBS



Methods of breaking down

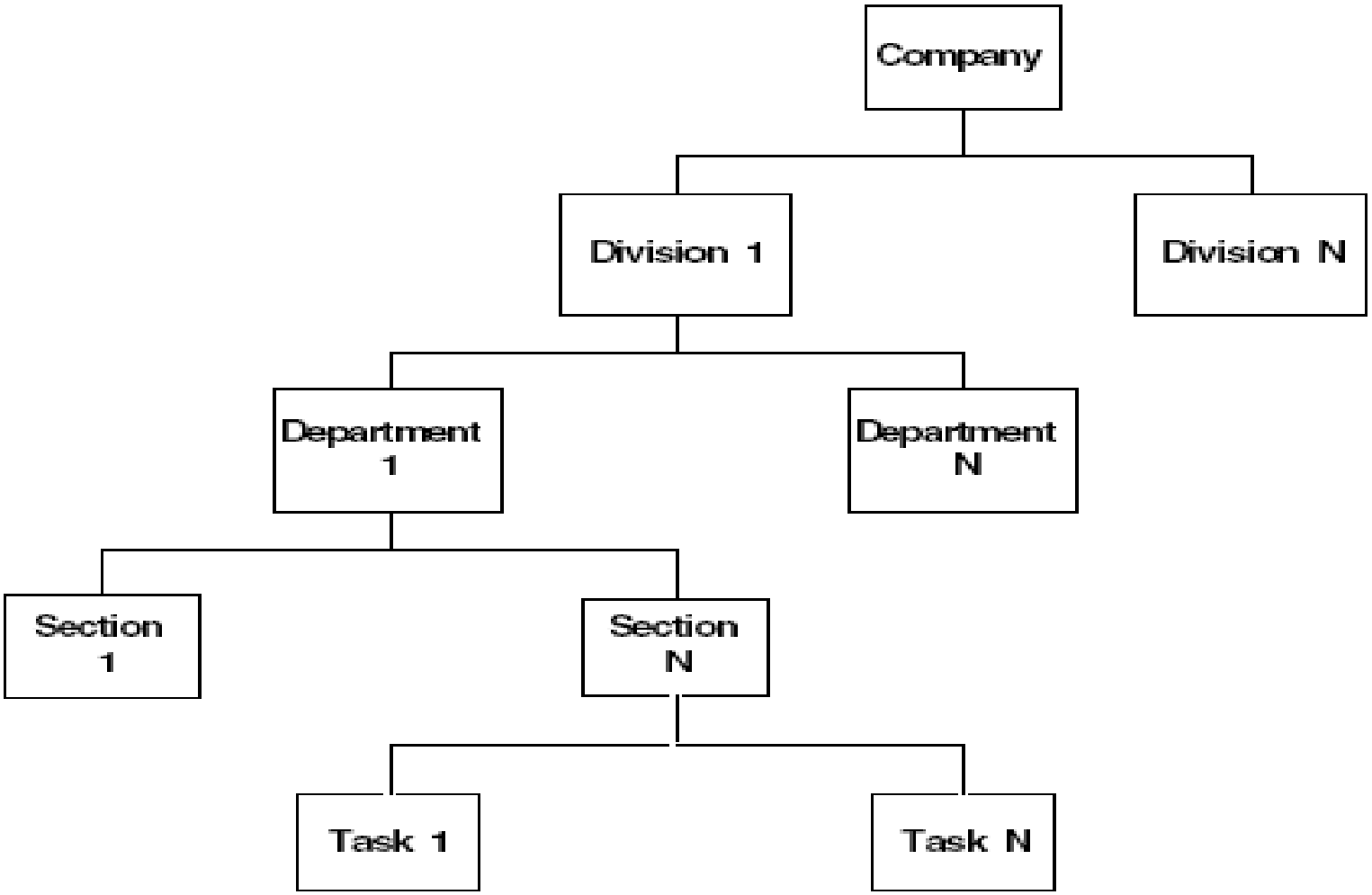
- There are several common methods of logically breaking down the scope of a project.

- These methods not only logically divide the overall work, but also are relate to the way costs are accumulated for the project in an organization.

Organizational WBS

- The organizational method divides the scope based upon the organization doing the work (performing organization), responsible for the work (responsible organization), or benefiting from the work (benefiting organization, usually the customer).

Organizational WBS

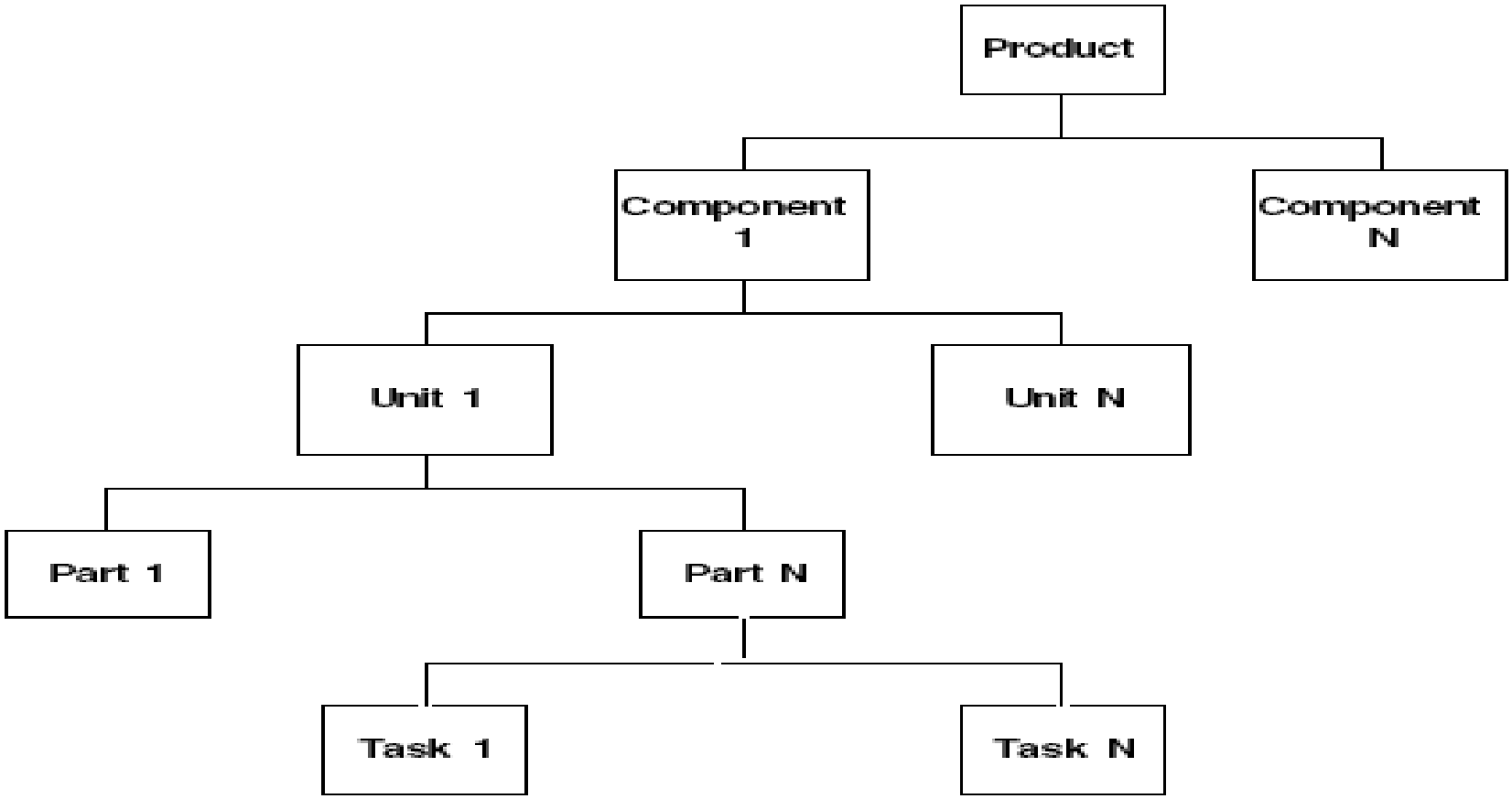


product method

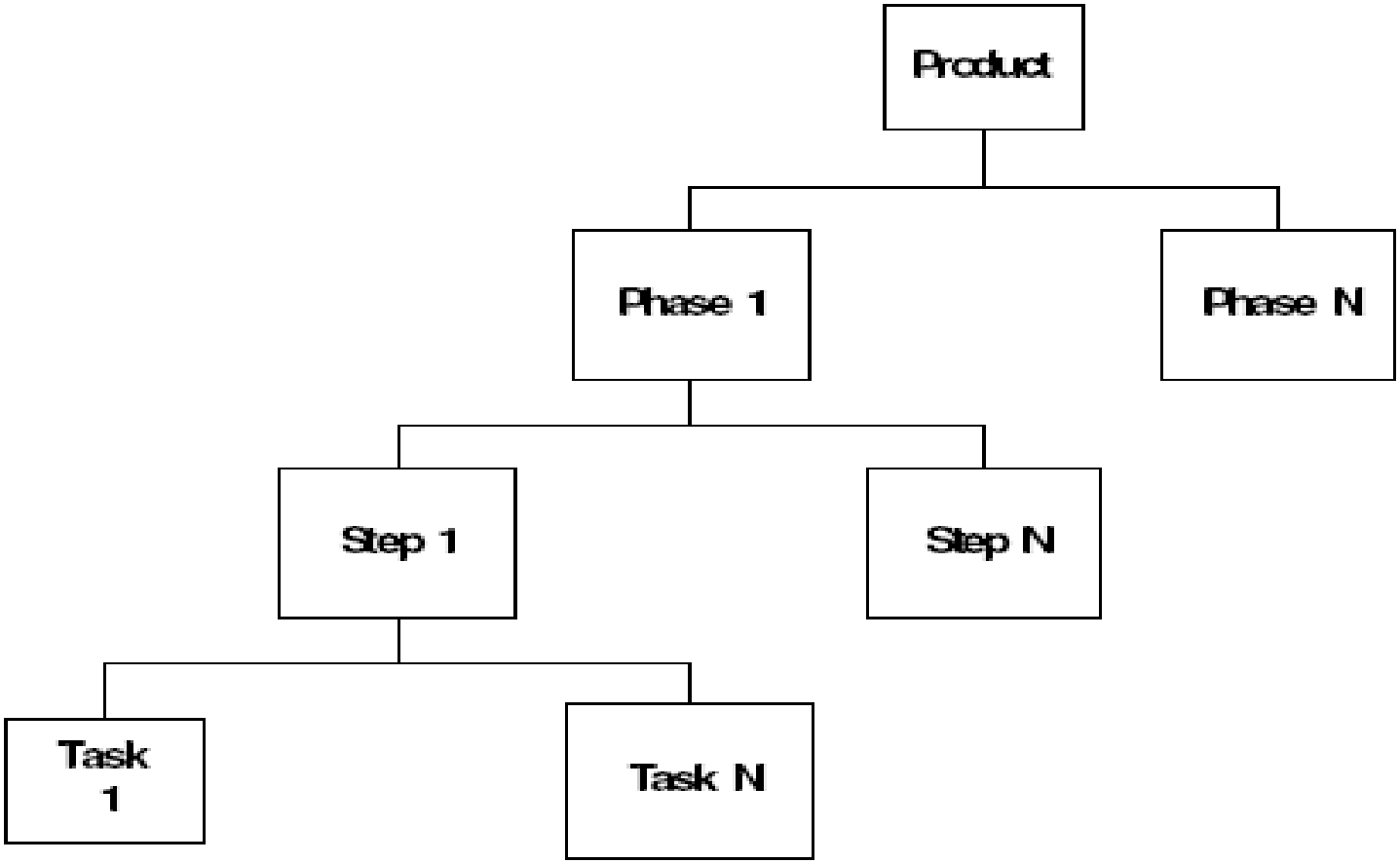
- The product method organizes the scope based upon the logical or physical parts of a product, which is the subject of the project.

- The functional (or task-based) WBS is based upon the work being done to carry out the scope of the project.

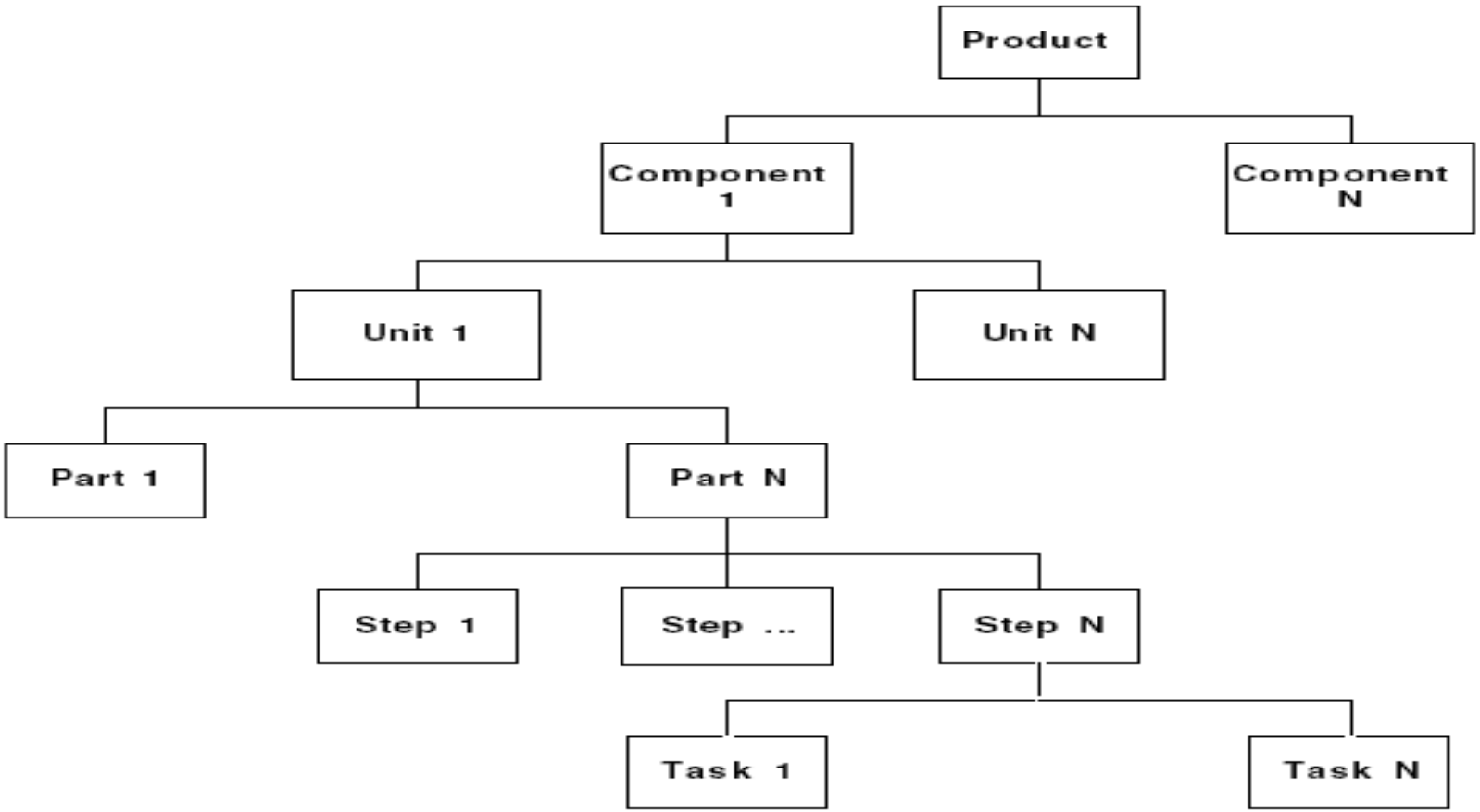
product method



Functional WBS



hybrid method



OBS & PBS

- To account for the multiple dimensions of organization, product, cost category, and resources, other coding systems may be used for a project in addition to the WBS. These are used for both pure and hybrid types of WBS structures.
- *OBS: The organizational breakdown structure is used to show organizational units* of a performing or responsible organization.
- *PBS: The part breakdown structure shows the physical breakdown of parts. A PBS* may be the "top" of a hybrid WBS, which has a task-based, lower level WBS.

other methods

- *RBS: The resource breakdown structure is used to identify resources that are to* be used on a project such as individuals (or labor categories).
- CBS: The *contractor breakdown structure identifies outside (outside of the* company or responsible organization) responsibilities for work or other services and may be used in a similar manner to the OBS (or the OBS may accommodate internal and external organizations).
- EOC: The element of cost structure identifies the type of cost incurred or to be incurred such as labor, lease, travel, space allocations and other charges to a project.
- GL: The *general ledger code is an accounting code to which charges are applied* in the company's financial system.

RAM

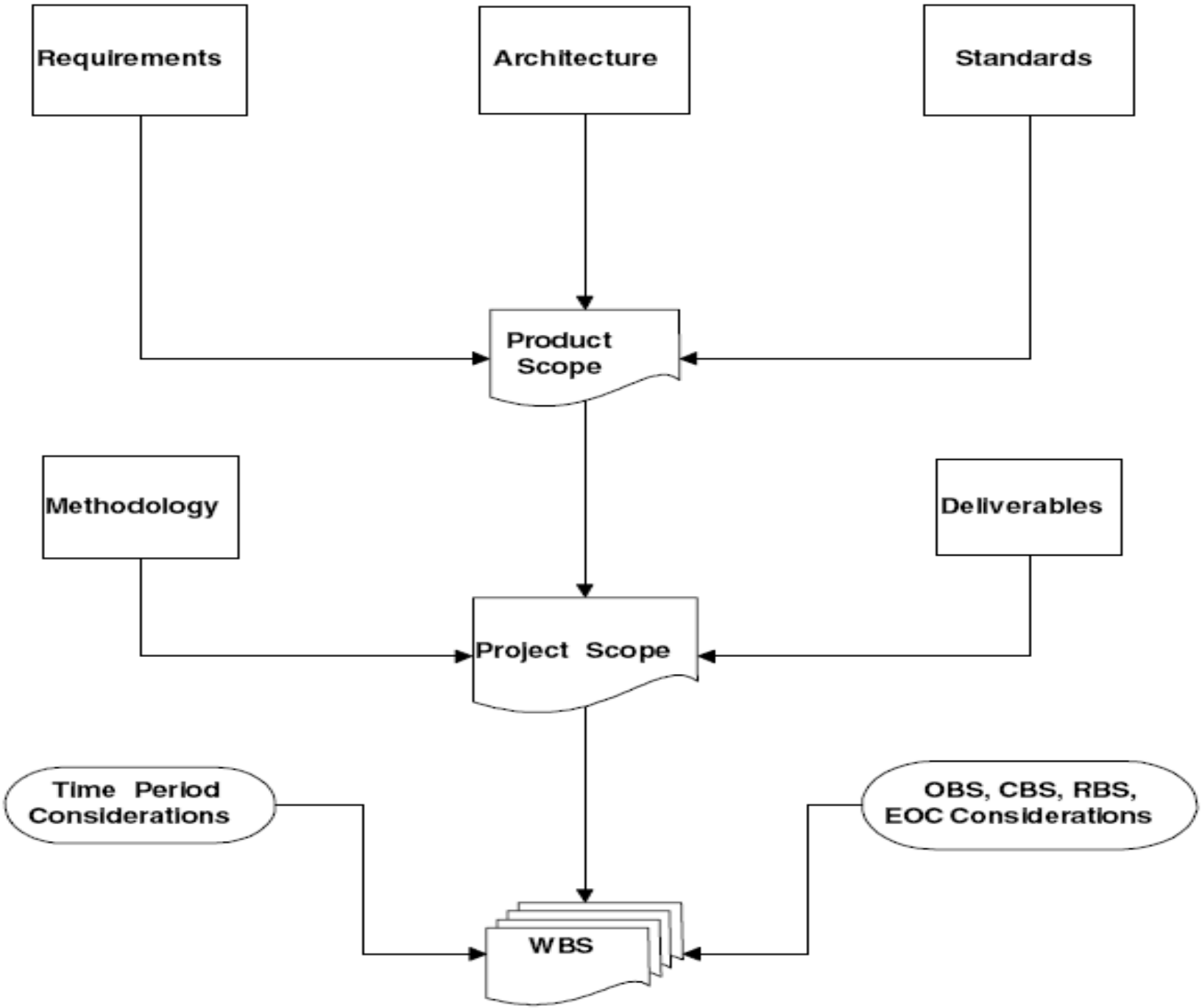
- In some organizations (i.e., the U.S. government) it is common to develop an organizational assignment matrix, which maps the WBS (down to the lowest level, excluding the work packets/activities) to the OBS. This may be called a responsibility assignment matrix (RAM), but that term is also commonly used for a mapping between the WBS and the RBS.

Organizational Assignment Matrix

			OBS					
				1.1			2.0	
WBS			1.1	1.2	1.3	2.1	2.2	2.3
1.0								
	1.1							
		1.1.1	X					
		1.1.2			X			
		1.2.3					X	
	1.2							
		1.2.1		X				
		1.2.2		X				
		1.2.3				X		
	1.3							
		1.3.1						X
		1.3.2						X
		1.3.3	X					
2.0								
	2.1							
		…						

best approach for IT projects

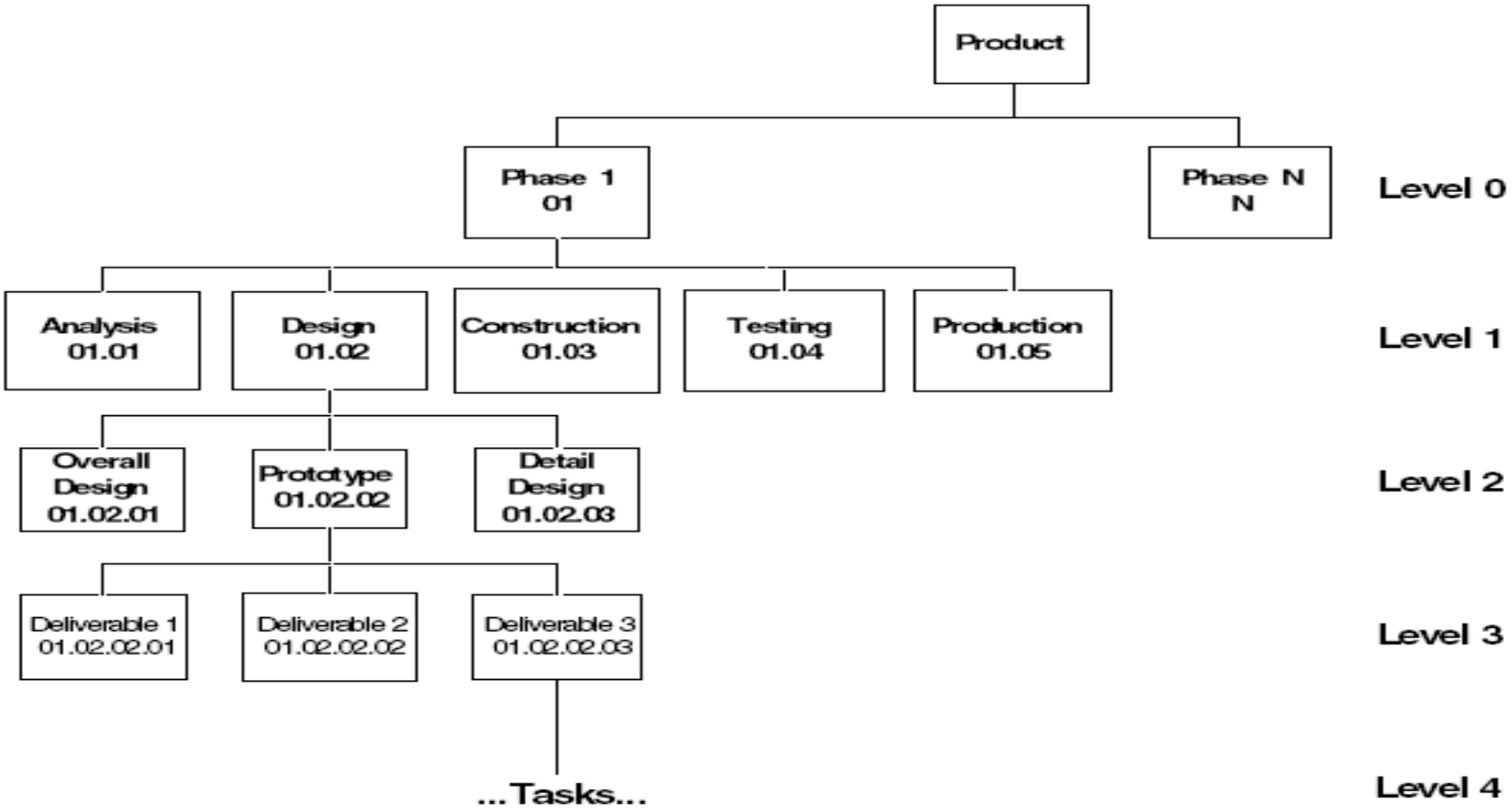
- The best approach for IT projects is to base the WBS tasks on the company's adopted methodology for software development, software acquisition, and/or software integration. Thus, an IT WBS is best developed from the project scope using adopted methodology with consideration for how the work will be allocated to organizational components and further broken down into manageable pieces.



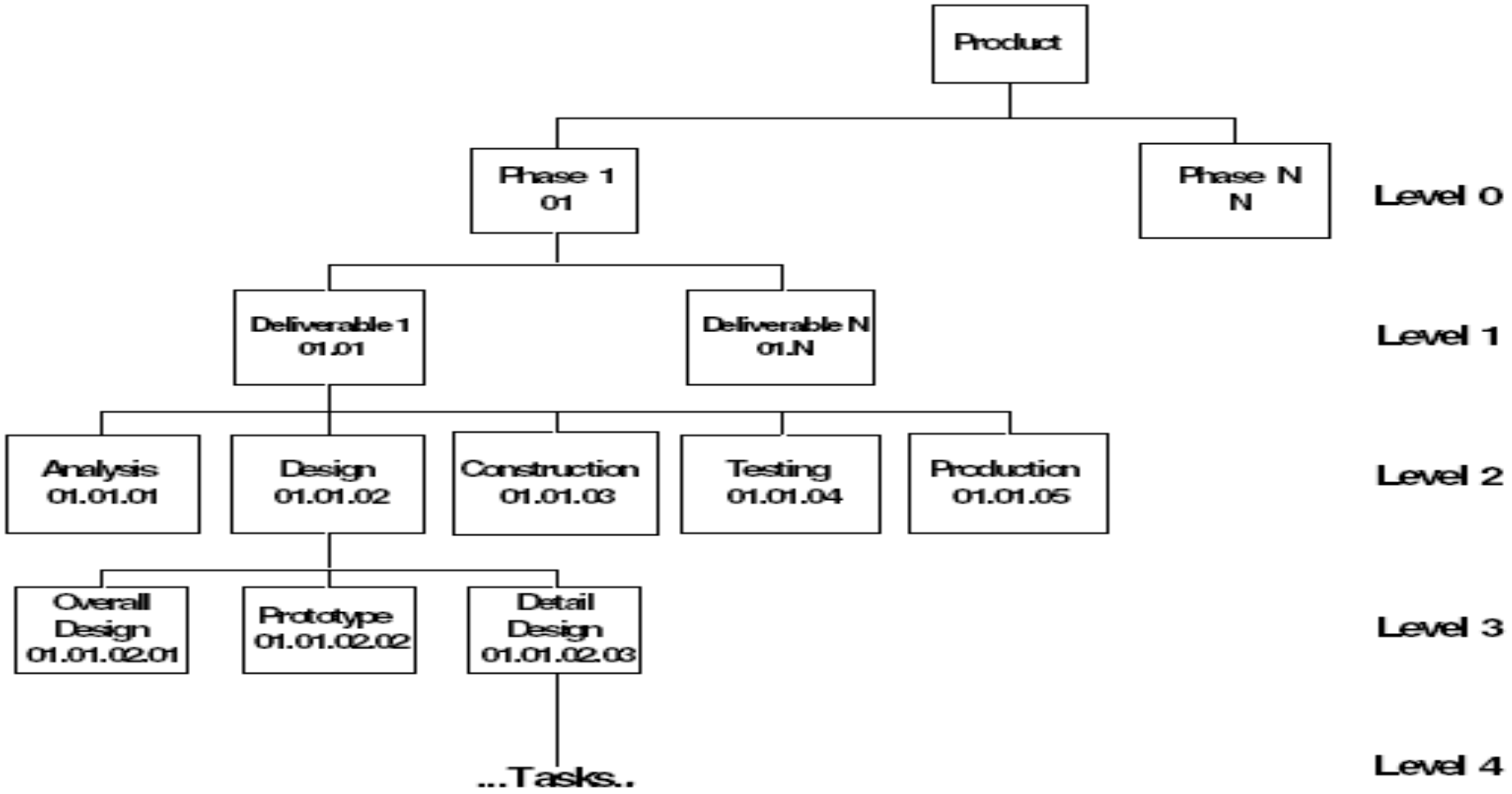
Hybrid WBS

- In using a methodology and task-based structure, it is common to use a PBS to create a hybrid WBS. The PBS for IT projects usually corresponds to software and/or hardware deliverables. There are two ways to structure such a hybrid WBS.

Methodology WBS

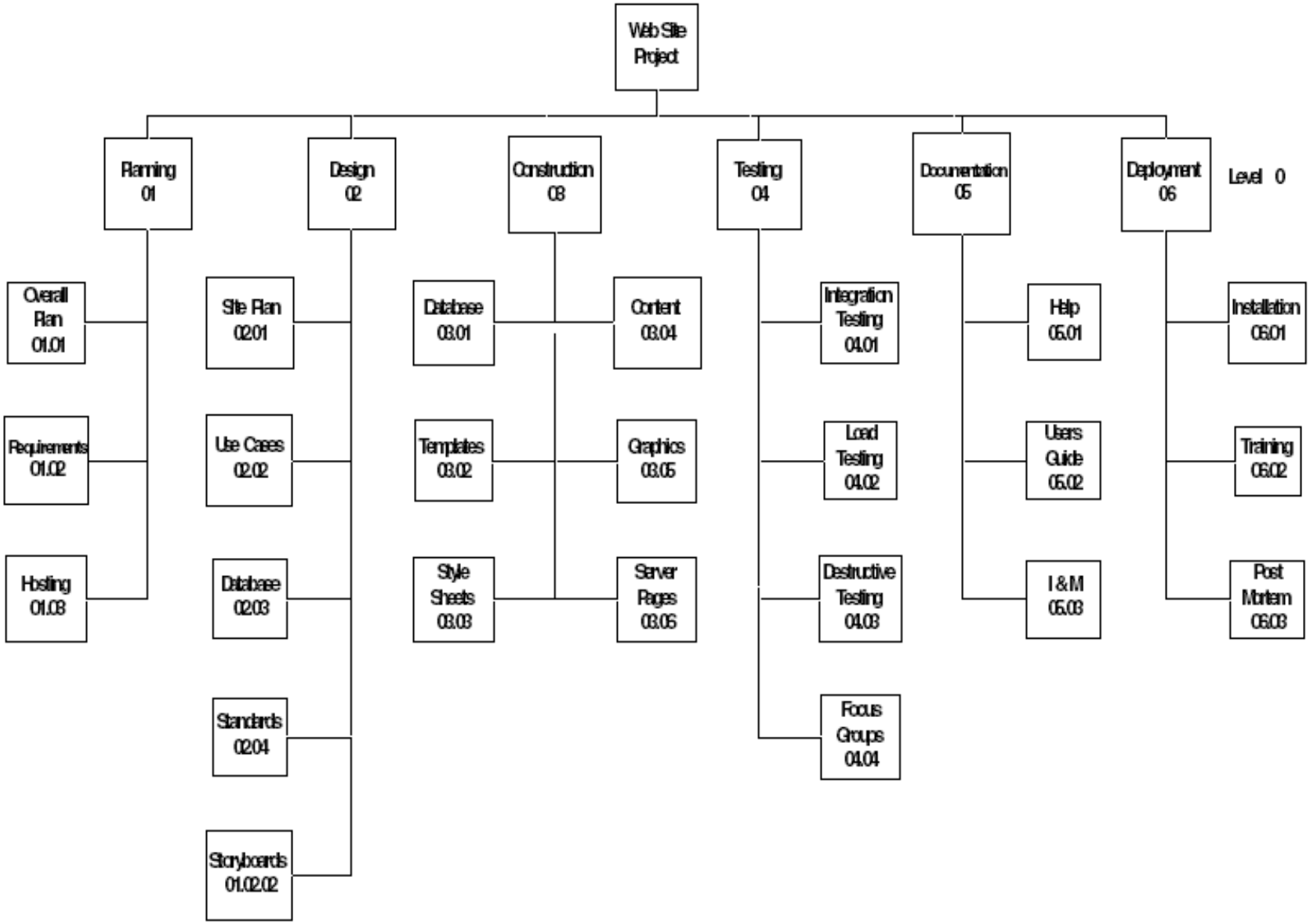


Deliverable WBS



WBS Dictionary

- to the formulation of the WBS itself, a WBS dictionary is often created by the project team and is typically used to control what work is done and when. It puts a clear boundary around each work packet:
  - *Work Packet ID Info: Code, name, element of cost*
  - *Assignments: Performing organization, resource assigned to, customer contact*
  - *Time Information: Start, length, end*
  - *Dependencies (dependent WBS codes)*
  - *Detail Description (both product/service and work)*
  - *Acceptance: Quality criteria, testing required, approval by*



Software packages for PM

- Software packages used in project management are discussed in Chapter XV, but a typical form to add a WBS code to a project appears in Figure. from the Web-based FiveAndDime system.

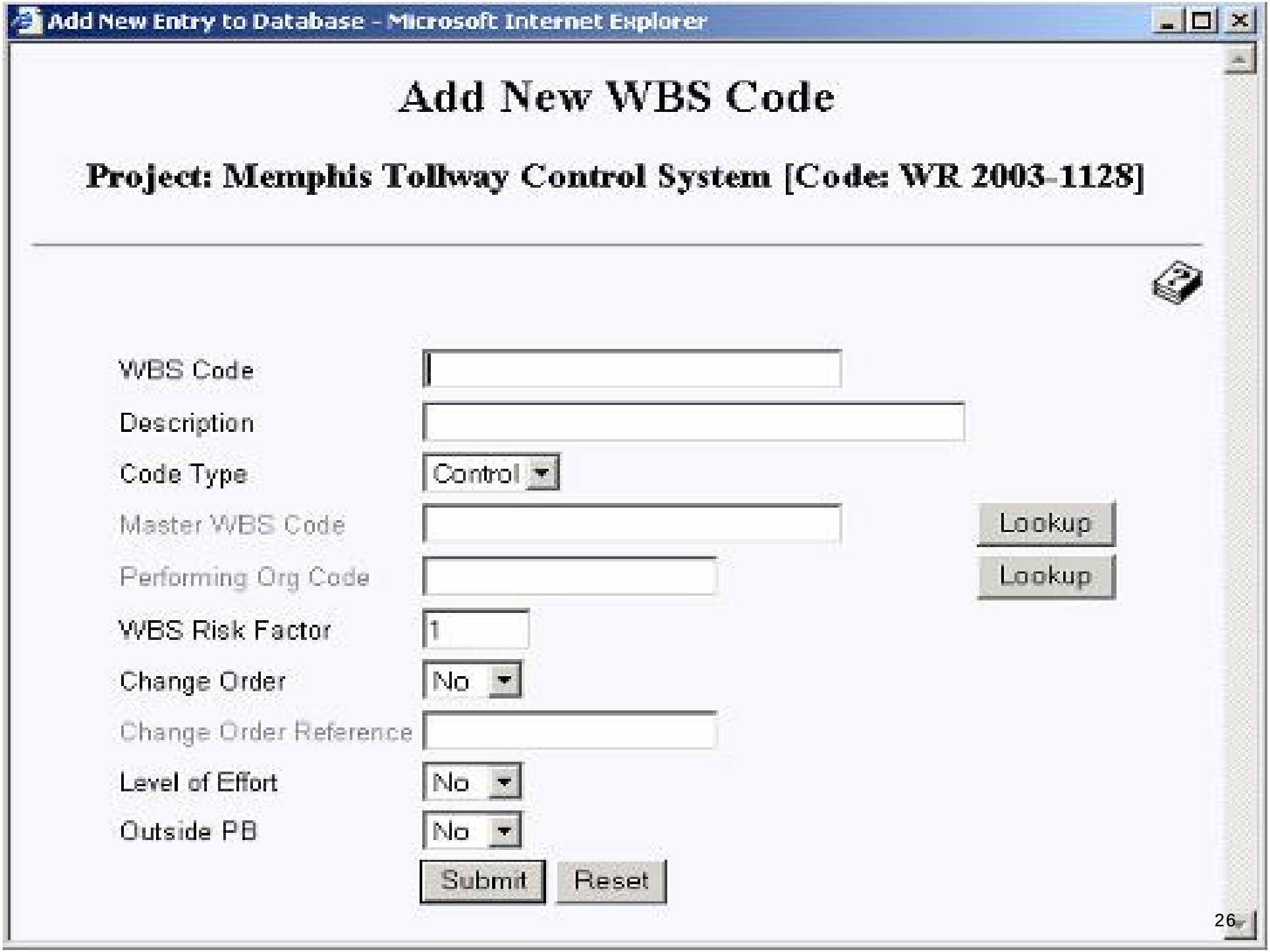
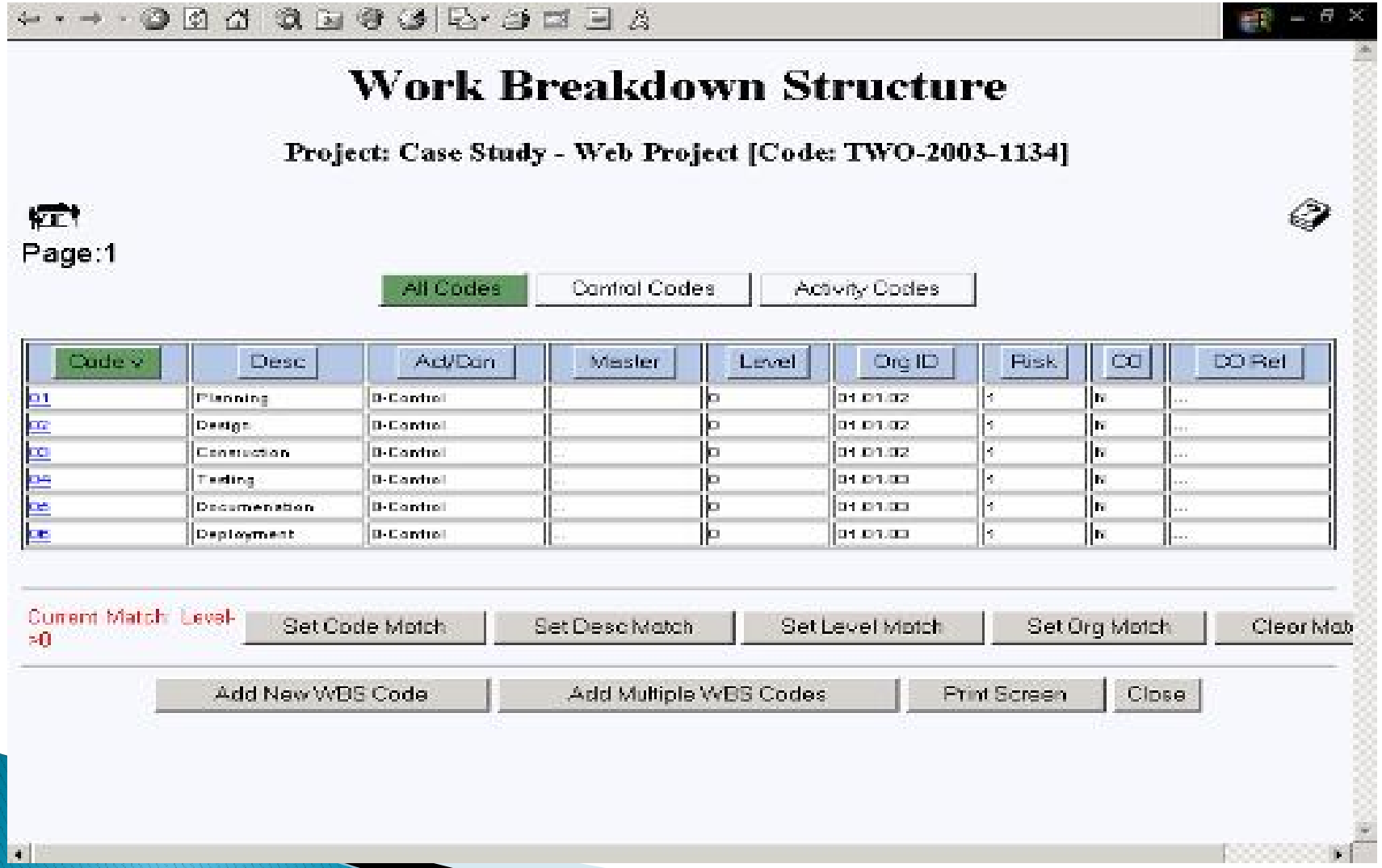


Table of Level 0 WBS codes



Work Breakdown Structure

Project: Case Study - Web Project [Code: TWO-2003-1134]

Page:1

All Codes | Control Codes | Activity Codes

Code	Desc	Add/Con	Master	Level	Org ID	Risk	CD	DD Rel
01	Planning	0-Control		0	01.01.02	1	N	...
02	Design	0-Control		0	01.01.02	1	N	...
03	Construction	0-Control		0	01.01.02	1	N	...
04	Testing	0-Control		0	01.01.03	1	N	...
05	Documentation	0-Control		0	01.01.03	1	N	...
06	Deployment	0-Control		0	01.01.03	1	N	...

Current Match Level: >0 | Set Code Match | Set Desc Match | Set Level Match | Set Org Match | Clear Mat

Add New WBS Code | Add Multiple WBS Codes | Print Screen | Close

Work Breakdown Structure

Project: Case Study - Web Project [Code: TWO-2003-1134]

Page:1

All Codes | Control Codes | Activity Codes

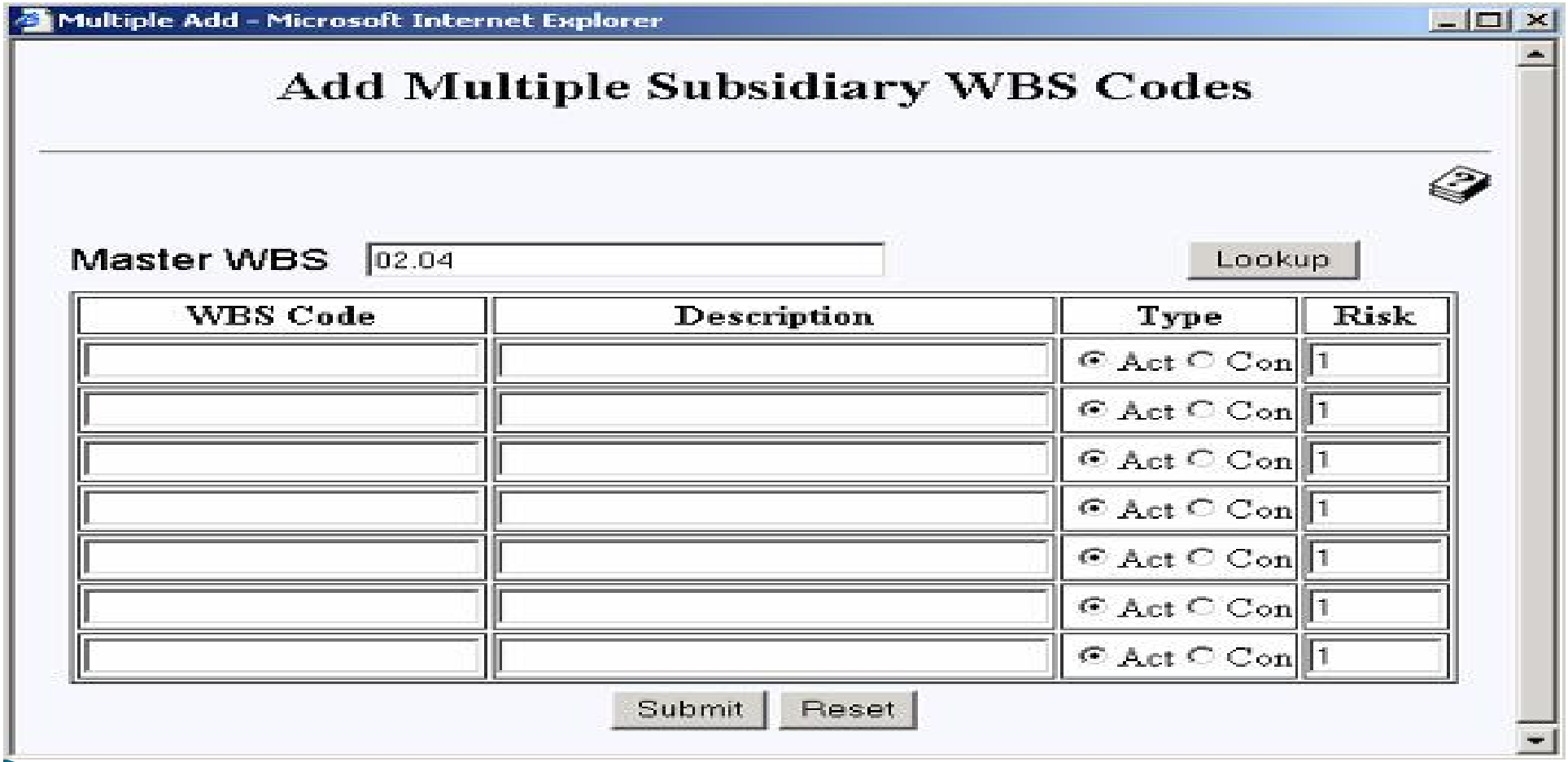
Code	Desc	Act/Con	Master	Level	Org ID	Risk	CO	CO Rel
02.04	Standards	0-Control	02	1	01.01.02	1	N	
02.04.01	Documentation Standards	1-Activity	02.04	2	01.01.02	1	N	
02.04.02	User Interface Standards	1-Activity	02.04	2	01.01.02	1	N	
02.04.03	Navigation/Linking Standards	1-Activity	02.04	2	01.01.02	1	N	
02.04.04	Accessability Standards	1-Activity	02.04	2	01.01.02	1	N	
02.04.05	Security Standards	1-Activity	02.04	2	01.01.02	1	N	
02.04.06	Client Coding Standards	1-Activity	02.04	2	01.01.02	1	N	
02.04.07	Server Coding Standards	1-Activity	02.04	2	01.01.02	1	N	
02.04.08	Testing/Approval Standards	1-Activity	02.04	2	01.01.02	1	N	
02.04.09	Installation/Operation Standards	1-Activity	02.04	2	01.01.02	1	N	

Current Match: Code->02.04

Set Code Match | Set Desc Match | Set Level Match | Set Org Match | Clear Mat

Add New WBS Code | Add Multiple WBS Codes | Print Screen | Close

Form to add subsidiary WBS codes



Task Estimation

- After a WBS is formed, the next step is to estimate the amount of time it will take to perform each of the tasks at the lowest level of the WBS (work packets).
- Task estimation is still a problem area for IT projects.
- The amount of time needed to complete a work packet should be a function of the type of resource and number of resources assigned.
- in IT, the productivity rate varies widely between individuals, even in the same grade. As a contrasting example, in the construction area, most bricklayers have a similar productivity rate in terms of bricks per hour.

Generic Resources

Code	Description	Burdened Rate
P1	Programmer 1	30
P2	Programmer 2	35
P3	Programmer 3	40
PA1	Programmer Analyst 1	45
PA2	Programmer Analyst 1	50
PA3	Programmer Analyst 1	55
SA1	Systems Architech 1	60
SA2	Systems Architech 2	65
SA3	Systems Architech 3	70
DB1	Database Analsys 1	50
DB2	Database Analsys 2	55
DB3	Database Analsys 3	60
TW1	Technical Writer 1	30
TW2	Technical Writer 2	40
SEC1	Security Specialist 1	40
SEC2	Security Specialist 2	50
TEST1	Test Specialist 1	30
TEST2	Test Specialist 2	40
PM1	Project Manager 1	60
PM2	Project Manager 2	70
PM3	Project Manager 3	80

IT projects task estimation

- For IT projects, most packets involve only labor and the amount of work is usually estimated by using historical data, benchmarks, and/or some specific parametric tech-Unique such as lines of code, function point analysis, or number and type of requirements involved.

IT projects task estimation

- One or more benchmarks of task level work may be available from previous, similar projects, or actual benchmarks may be used. Often, prototyping and benchmarking efforts can be combined. These benchmarks may be used in a linear manner to estimate time for the tasks at hand. For example, we may know that a Web screen form with four fields took 2 hours to build and test, and that another Web form with eight fields took 3 hours to build and test. A linear relationship (two equations in two unknowns) would then predict the time to build and unit test such Web forms would be 1 hour plus the number of fields divided by 2. If there are many such Web forms to build, a “learning curve” relationship could be added, which is usually in a form as:

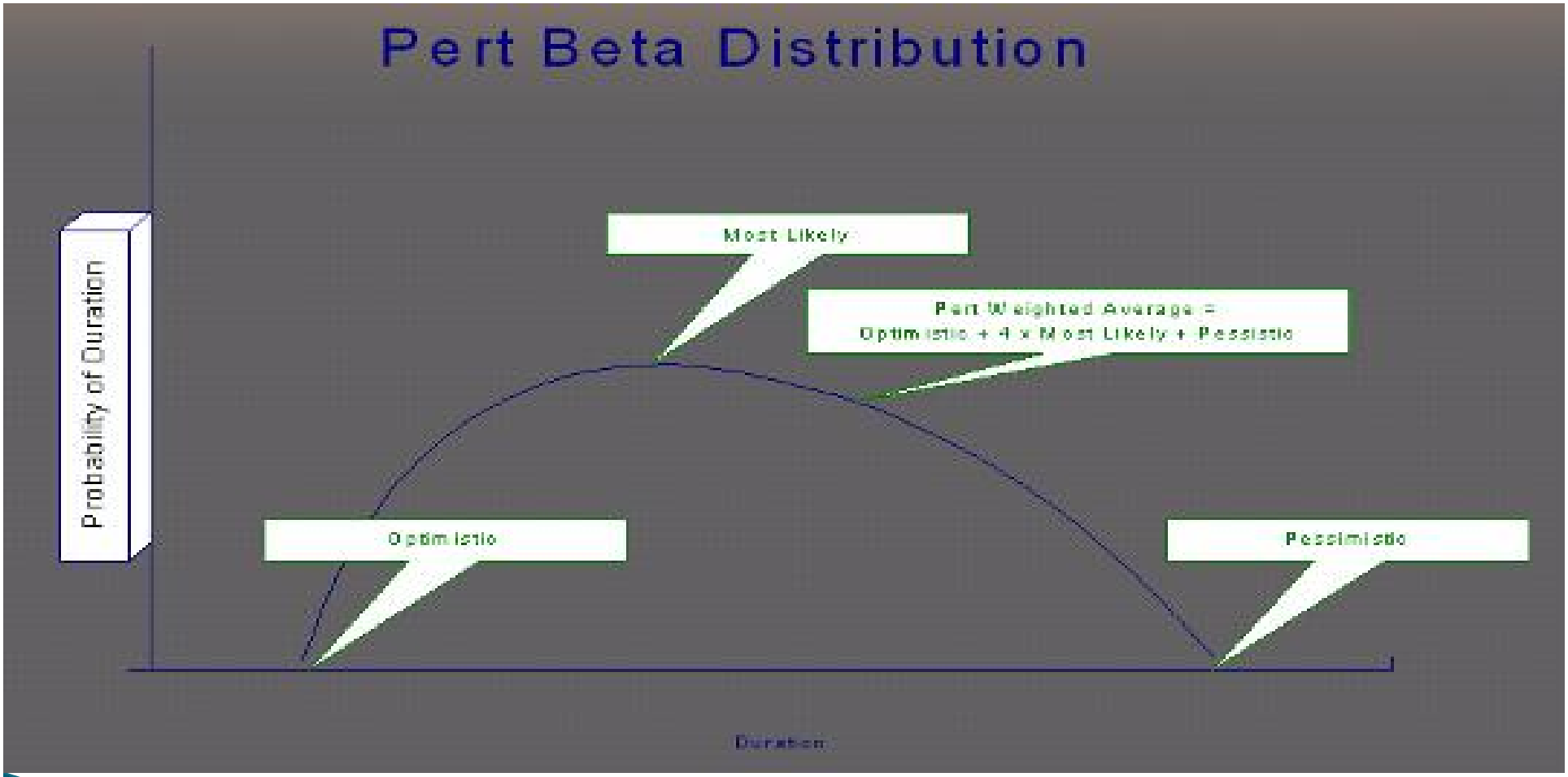
- $T(i) = T(1)*(a + (1-a)i-b),$

  where $T(i)$ *is the time to build the i’th form,* $T(1)$ *is the time to build the first form,* b *is the* learning rate which is less than 1 (typically in the range of .01 to .1), and a *is the* incompressibility factor also less than 1 (typically about .5).
- Actual values of *a and b can* be calculated by how long it would take a programmer to build the first such form and how long it takes him to build a second and third such form. These values are then substituted in the formula (which is made linear via log functions) to determine the learning factor and the compressibility factor.

Task Sequencing and the Critical Path

- Once a WBS is established and the effort involved in each work packet is determined, the next step is to sequence the tasks in the order they need to be performed. Task sequencing typically uses a network diagram, sometimes called a logic diagram, that shows how the project tasks (work packets) will flow in time from beginning to end of project.
- However, for the determination of a critical path, we must know how long it will take to do each task as well as the order in which the tasks can be done. How long it takes to do each task depends not only on the amount of effort of a task (typically measured in person hours) but also on how many people will be assigned to a task.

Beta distribution



Network diagram

- A network diagram is constructed by taking the tasks and putting them in the order they will be done, taking into account any dependencies. This process is called activity sequencing.
- Note that this process need not be done at the lowest level of the WBS, although it is typically done at that level to maximize the parallelism (the number of task that can be worked on simultaneously).
- To maximize parallelism, and thus minimize overall development calendar time, it is more common to have the implementation and unit testing of one software module only dependent upon completion of the design for that one module (in reality one module's design may involve a number of design tasks such as its user interface, involved database tables, etc.).
- Eventually, all the software modules come together for integration testing, which would be dependent upon completion of the implementation and unit testing of every module.

Network diagram

- The two general ways to do draw these network diagrams are activity-on-arrow and activity-on-node. The original critical path method (CPM) developed by Dupont and Remington Rand in 1957 used the activity-on-arrow method and used one time estimate only per task (as opposed to several estimates as in the PERT method).

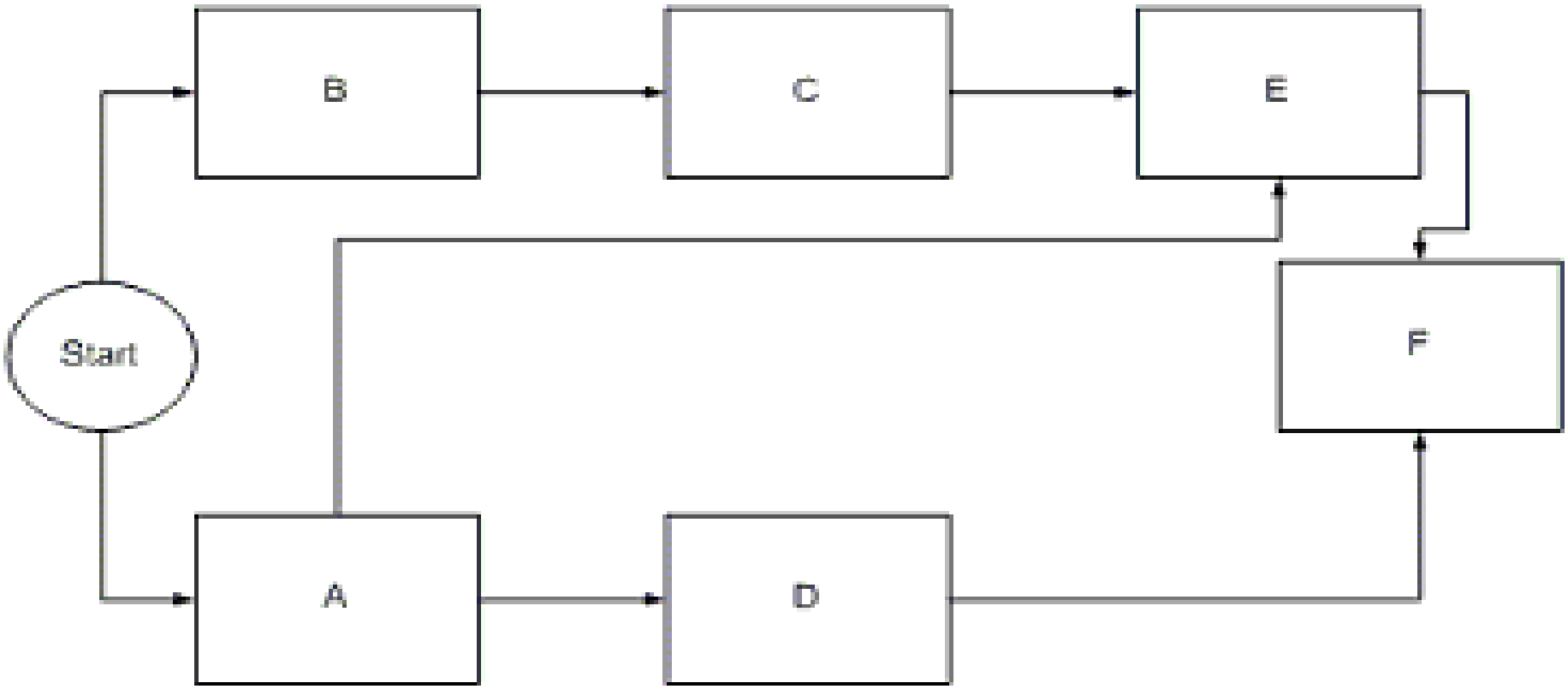
- The more common method today is to show the activity on a node and the precedence diagramming method (PDM) is based on this representation. In the PDM method, nodes or boxes represent tasks, and arrows between the nodes show task dependencies. This is illustrated in Figure.

types of dependencies

There are four types of dependencies that may apply between two tasks:

1. *Finish-to-start: A task must finish before another one can start.*
2. *Finish-to-finish: A task must finish before another can finish.*
3. *Start-to-start: A task must start before another one can start.*
4. *Start-to-finish: A task must start before another one can finish.*

PDM method



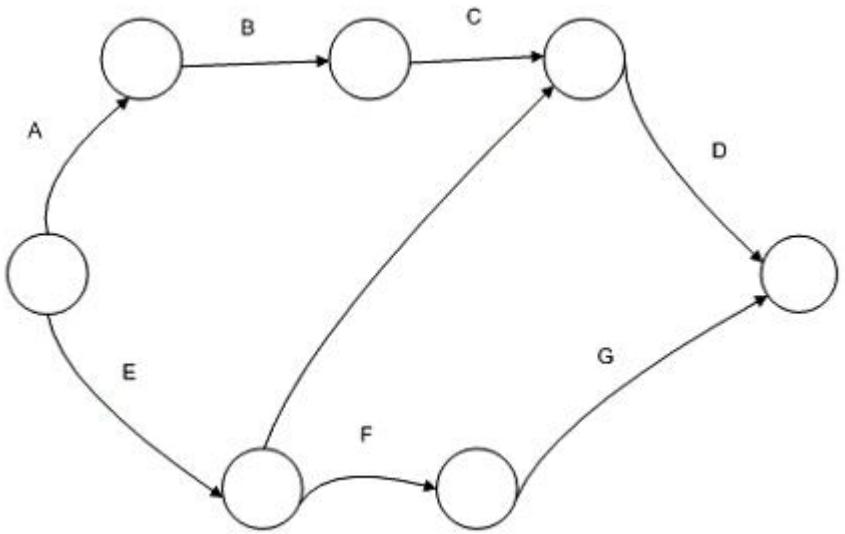
PDM method

- In the illustration, task E is dependent on tasks A and C. All, except the finish-to-start, are not commonly used and can be simulated by setting an earliest start date for a task, if necessary. There are no dummy activities in this method, and this method is easier to visualize than the activity-on-arrow method. Most modern project management software packages use this method.

AOA

- In the activity-on-arrow (AOA) method, arrows are used to represent tasks, and ovals are used to relate tasks. Generally, only finish-to-start relationships can be used. This method was the one originally used with PERT. Dummy activities may be needed to show dependencies between tasks (often shown with a dotted line). This method does have a visual advantage in that the length of arrow can optionally be used for duration of task.
- Figure illustrates this, and in that figure task D is dependent on E and C, and a dummy activity (no task identification letter) is used to show the dependence of D on E.

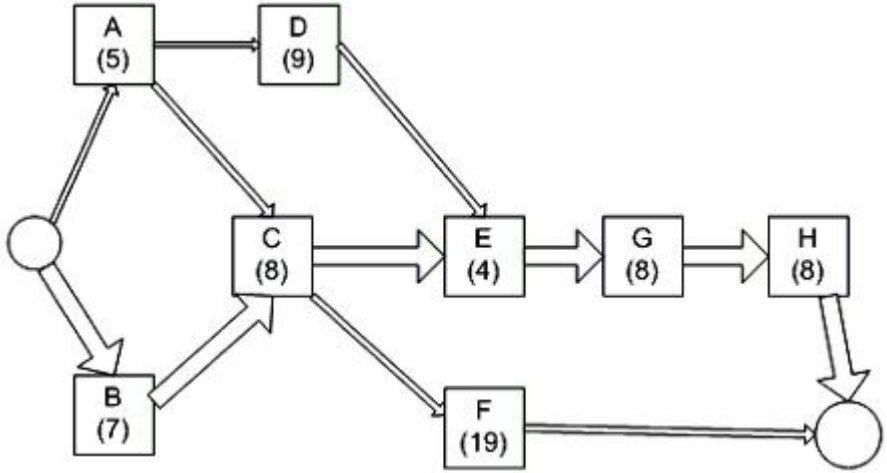
AOA method



critical path

- The critical path determines the earliest completion date for the project. It may change during a project, if task estimates are revised. There can be more than one critical path, and this is not desirable because it increases overall risk. Critical paths are calculated by most project management scheduling software systems and are done using dynamic or linear programming techniques

PDM network diagram



Scheduling

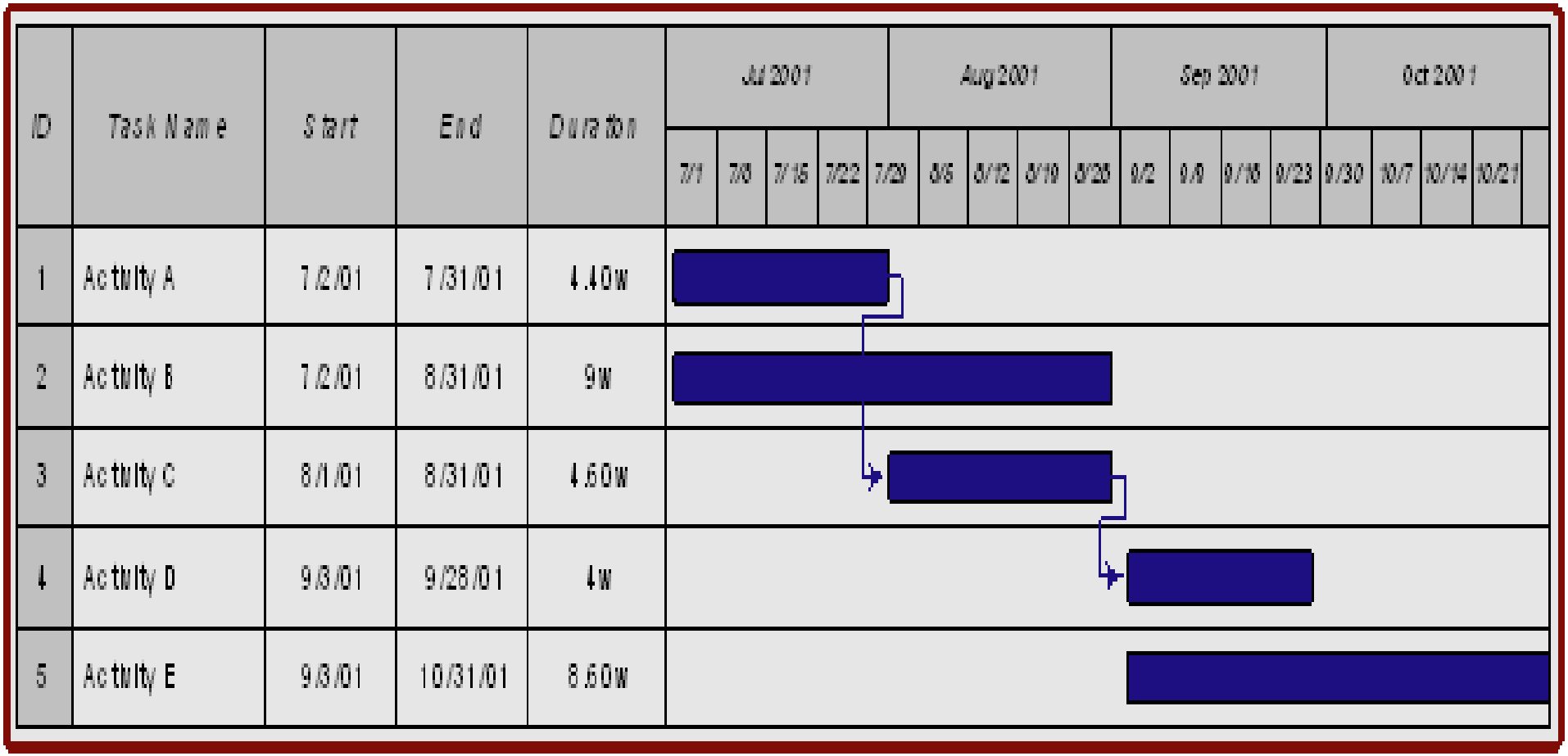
- The difference between a network diagram and a schedule is that a schedule is *calendar based and takes into* account the length of work weeks and holidays.

  - WBS defines “what”
  - Network Diagram defines “how”
  - Schedule defines “when”
  - RAM defines “who”

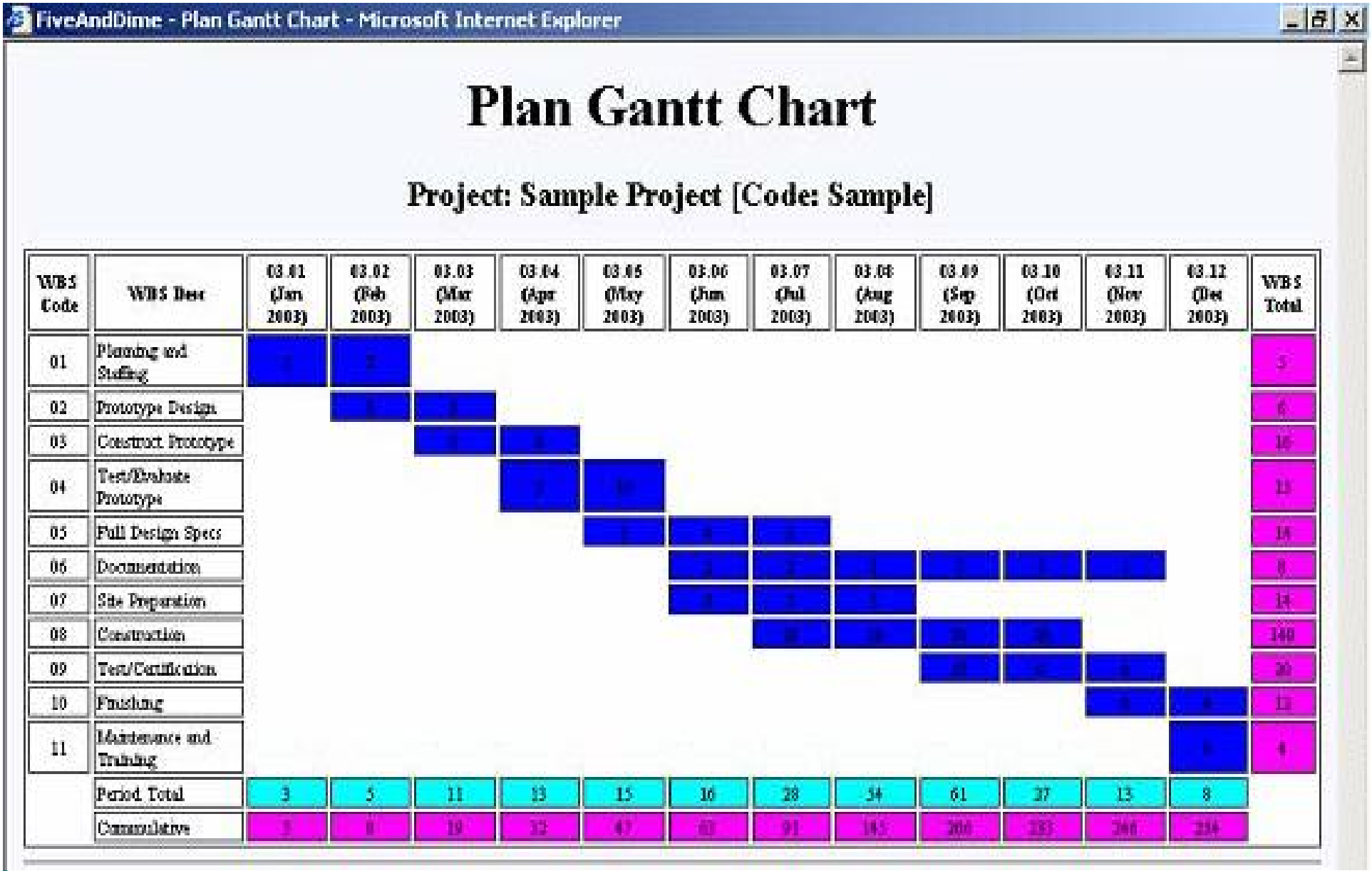
Gantt chart

- The typical graphical representation of a schedule, however, is the Gantt chart, which is the most commonly used graphic in project management.

Gantt chart



ID	Task Name	Start	End	Duration
1	Activity A	7/2/01	7/31/01	4.40w
2	Activity B	7/2/01	8/31/01	9w
3	Activity C	8/1/01	8/31/01	4.50w
4	Activity D	9/3/01	9/28/01	4w
5	Activity E	9/3/01	10/31/01	8.50w



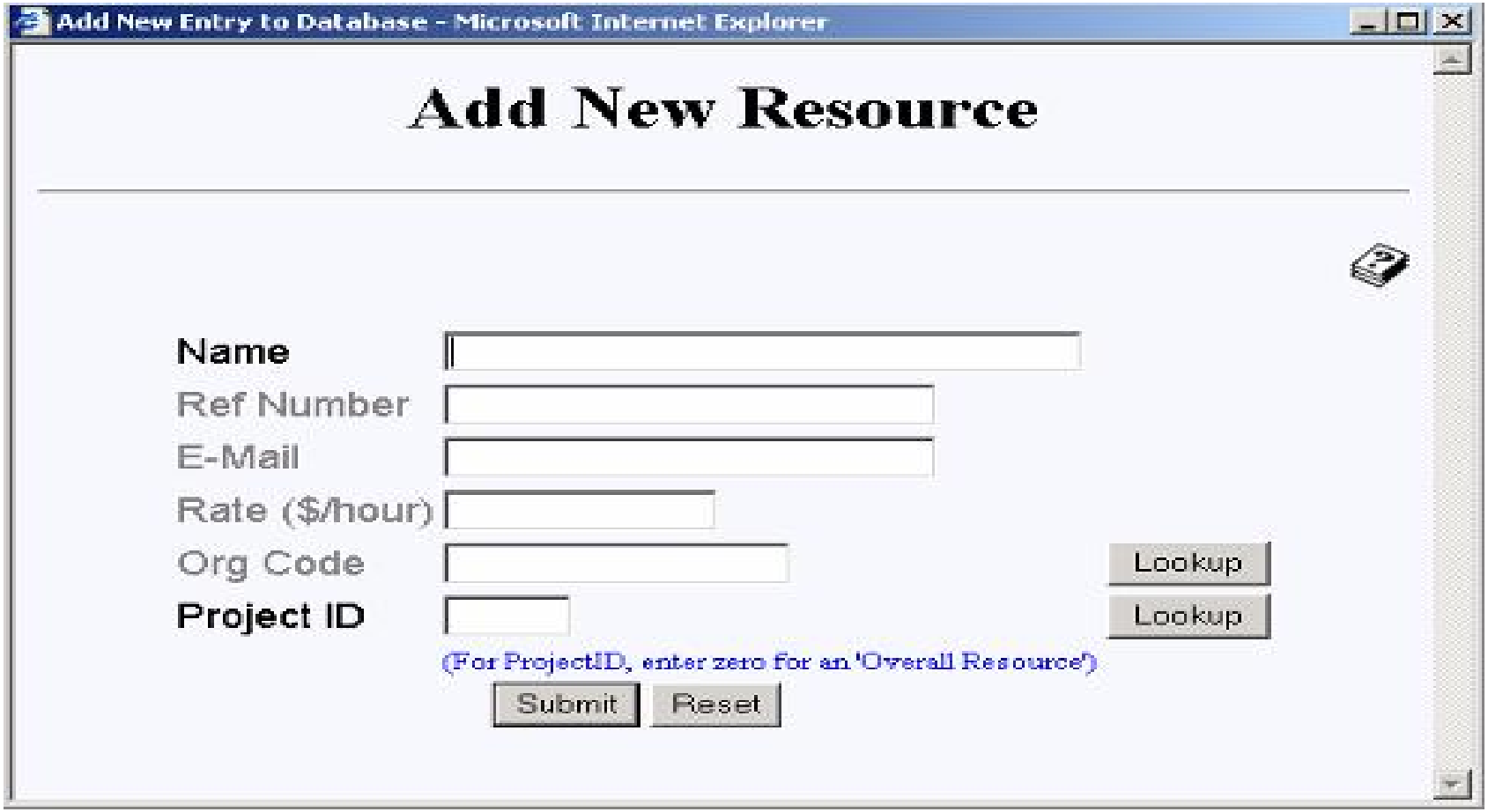
Scheduling

- According to Young (2003), seven things to do before one can create a realistic schedule are:
  1. Nail down the scope and requirements
  2. Prototype the biggest technical risks
  3. Create a model for the user interface
  4. Pay attention to industry-standard estimates for similar projects
  5. Let each person create an estimated task schedule for his own work
  6. Accept only observable, measurable status reports
  7. Subdivide all the tasks until each task takes 1 or 2 weeks to complete

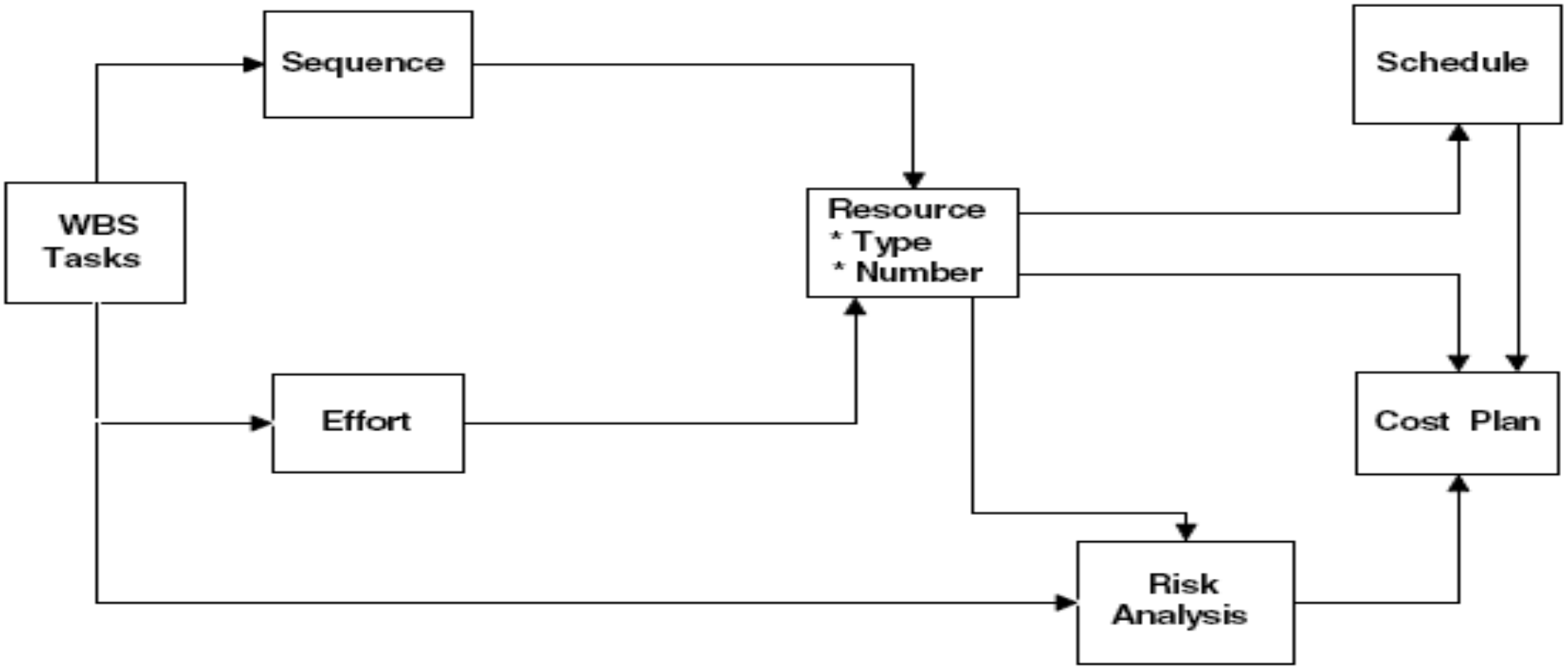
Scheduling

- The project may be reestimated (repriced) at that time if there is a significant difference in the rates for the actual resources versus the planned rates for those resources; for contracted projects, this depends on the terms of the contract.
- A responsibility assignment matrix (RAM) may be developed, which is similar to the organizational assignment matrix previously shown but shows the actual resources (mapping between WBS and RBS) as well as the organization; some organizations may maintain a single RAM for all projects.

FiveAndDime



Developing the Cost Plan

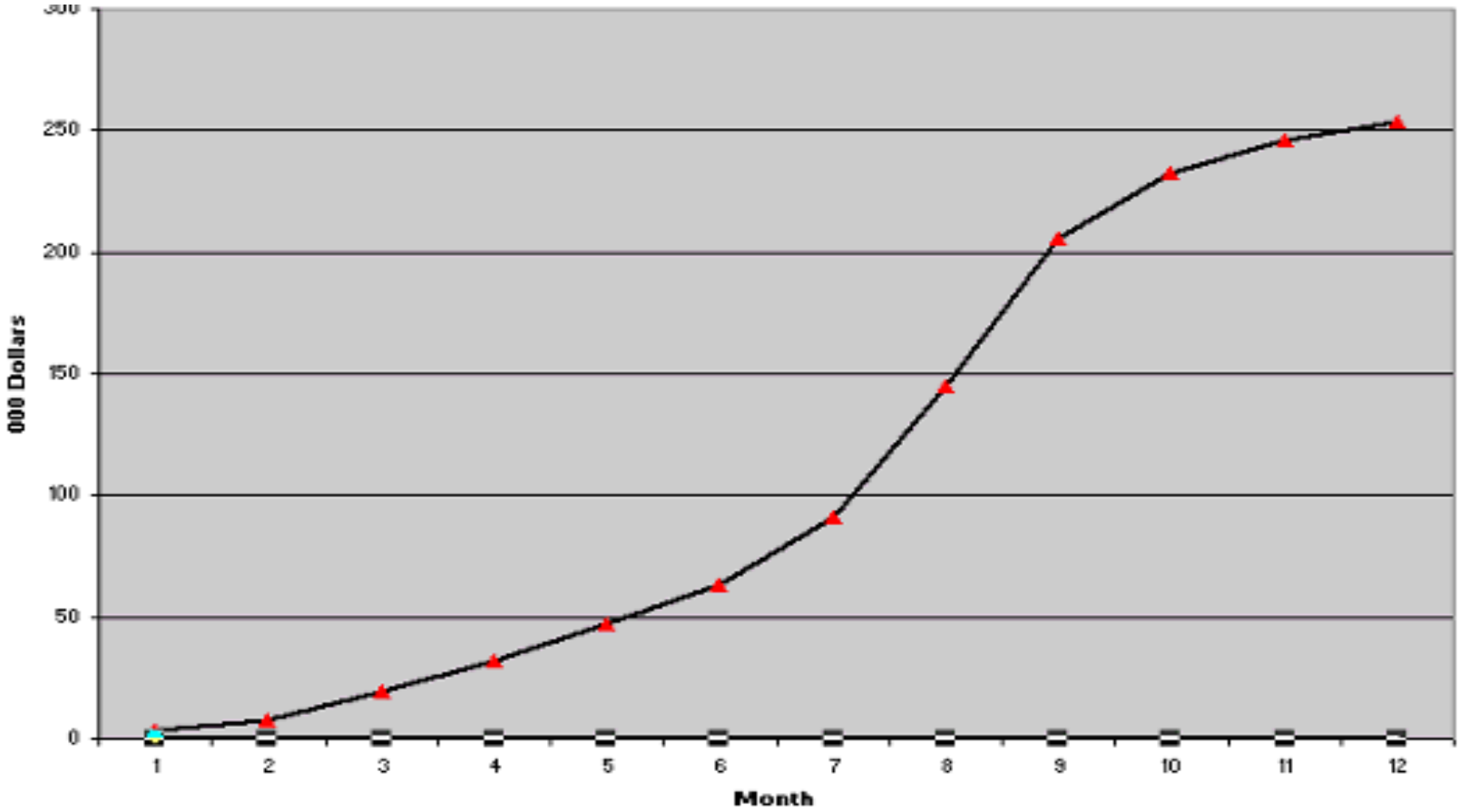


Cost plan in spreadsheet

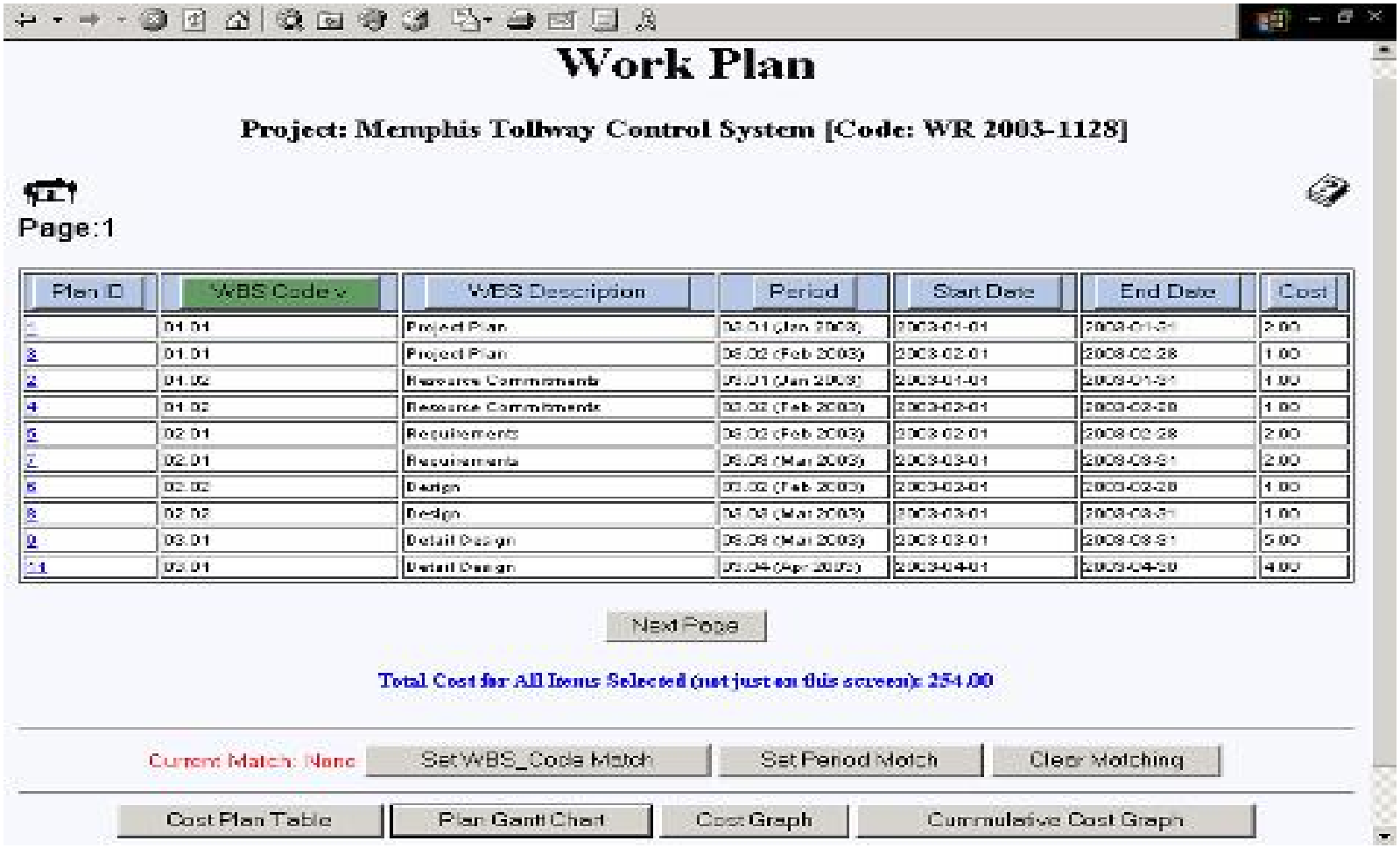
Project Cost Plan

WBS (Level 0)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Planning & Staffing	3	2											5
Prototype Design		3	3										6
Construct Prototype			8	8									16
Test/Evaluate Prototype				5	10								15
Full Design Specs					5	6	3						14
Documentation						2	2	1	1	1	1		8
Site Preparation						8	3	3					14
Construction							20	50	50	20			140
Test/Certification									10	6	4		20
Finishing											8	4	12
Maintenance Training												4	4
Monthly Plan	3	5	11	13	15	16	28	54	61	27	13	8	254
Cumulative	3	8	19	32	47	63	91	145	206	233	246	254	

Cost plan graph



Cost plan table



Work Plan

Project: Memphis Tollway Control System [Code: WR 2003-1128]

Page:1

Plan ID	WBS Code	WBS Description	Period	Start Date	End Date	Cost
1	01.01	Project Plan	01.01 (Jan 2003)	2003-01-01	2003-01-31	2.00
3	01.01	Project Plan	01.02 (Feb 2003)	2003-02-01	2003-02-28	1.00
2	01.02	Resource Commitments	01.01 (Jan 2003)	2003-01-01	2003-01-31	1.00
4	01.02	Resource Commitments	01.02 (Feb 2003)	2003-02-01	2003-02-28	1.00
5	02.01	Requirements	01.02 (Feb 2003)	2003-02-01	2003-02-28	2.00
7	02.01	Requirements	01.03 (Mar 2003)	2003-03-01	2003-03-31	2.00
6	02.02	Design	01.02 (Feb 2003)	2003-02-01	2003-02-28	1.00
8	02.02	Design	01.03 (Mar 2003)	2003-03-01	2003-03-31	1.00
9	03.01	Detail Design	01.03 (Mar 2003)	2003-03-01	2003-03-31	5.00
11	03.01	Detail Design	01.04 (Apr 2003)	2003-04-01	2003-04-30	4.00

Next Page

Total Cost for All Items Selected (not just on this screen): 254.00

Current Match: None | Set WBS_Code Match | Set Period Match | Clear Matching

Cost Plan Table | Plan Gantt Chart | Cost Graph | Cumulative Cost Graph