5

Work breakdown structures (WBS)

Before any meaningful programme can be produced, it is essential that careful thought is given to the number and size of networks required. Not only is it desirable to limit the size of network, but each 'block' of networks should be considered in relation to the following aspects:

1 The geographical location of the various portions or blocks of the project;
2 The size and complexity of each block;
3 The systems in each block;
4 The process or work being carried out in the block when the plant is complete;
5 The engineering disciplines required during the design and construction stage;
6 The erection procedures;
7 The stages at which individual blocks or systems have to be completed, i.e. the construction programme;
8 The site organization envisaged;
9 Any design or procurement priorities.

For convenience, a block can be defined as a *geographical process area within a project*, which can be easily identified, usually because it serves a specific function. The importance of choosing the correct blocks, i.e. drawing the demarcation lines in the most advantageous way, cannot be overemphasized. This decision has an effect not only on the number and size of planning networks but also on the organization of the design teams and, in the case of large projects, on the organizational structure of the site management set-up.

Because of its importance, a guide is given below which indicates the type of block distribution which may be sensibly selected for various projects. The list is obviously limited, but it should not be too difficult to abstract some firm guidelines to suit the project under consideration.

1 Pharmaceutical factory

Block A Administration block (offices and laboratories)
Block B Incoming goods area, raw material store
Block C Manufacturing area 1 (pills)
Block D Manufacturing area 2 (capsules)
Block E Manufacturing area 3 (creams)
Block F Boiler house and water treatment
Block G Air-conditioning plant room and electrical distribution control room
Block H Finished goods store and dispatch

For planning purposes, general site services such as roads, sewers, fencing and guard houses can be incorporated into Block A or, if extensive, can form a block of their own.

2 New housing estate

Block A Low-rise housing area – North
Block B Low-rise housing area – East
Block C Low-rise housing area – South
Block D Low-rise housing area – West
Block E High-rise – Block 1
Block F High-rise – Block 2
Block G Shopping precinct
Block H Electricity substation

Obviously, the number of housing areas or high-rise blocks can vary with the size of the development. Roads and sewers and statutory services are part of their respective housing blocks unless they are constructed earlier as a separate contract, in which case they would form their own block or blocks.

3 Portland cement factory

Block A Quarry crushing plant and conveyor
Block B Clay pit and transport of clay
Block C Raw meal mill and silos
Block D Nodulizer plant and precipitators
Block E Preheater and rotary kiln
Block F Cooler and dust extraction
Block G Fuel storage and pulverization
Block H Clinker storage and grinding
Block I Cement storage and bagging
Block J, Administration, offices, maintenance workshops, lorry park

Here again, the road and sewage system could form a block on its own incorporating the lorry park.

4 Oil terminal

Block A Crude reception and storage
Block B Stabilization and desalting
Block C Stabilized crude storage
Block D NGL separation plant
Block E NGL storage
Block F Boiler and water treatment
Block G Effluent and ballast treatment
Block H Jetty loading
Block J Administration block and laboratory
Block K Jetty 1
Block L Jetty 2
Block M Control room 1
Block N Control room 2
Block P Control room 3

Here roads, sewers and underground services are divided into the various operational blocks.

5 Multistorey block of offices

Block A Basement and piling work
Block B Ground floor
Block C Plant room and boilers

Block D Office floors 1–4
Block E Office floors 5–8
Block F Lift well and service shafts
Block G Roof and penthouse
Block H Substation
Block J Computer room
Block K External painting, access road and underground services

Clearly, in the construction of a multistorey building, whether for offices or flats, the method of construction has a great bearing on the programme. There is obviously quite a different sequence required for a block with a central core – especially if sliding formwork is used – than with a more conventional design using reinforced concrete or structural steel columns and beams. The degree of precasting will also have a great influence on the split of the network.

6 Colliery surface reconstruction

Block A Headgear and airlocks
Block B Winding house and winder
Block C Mine car layout and heapstead building
Block D Fan house and duct
Block E Picking belt and screen building
Block F Wagon loading and bunkering
Block G Electricity substation, switch room and lamp room
Block H Administration area and amenities
Block J Baths and canteen (welfare block)

Roads, sewers and underground services could be part of Block J or be a separate block.

7 Bitumen refinery

Block A Crude line and tankage
Block B Process unit
Block C Effluent treatment and oil/water separator
Block D Finished product tankage
Block E Road loading facility, transport garage and lorry park
Block F Rail loading facility and sidings
Block G Boiler house and water treatment
Block H Fired heater area

Block J Administration building, laboratory and workshop
Block K Substation
Block L Control room

Depending on size, the process unit may have to be subdivided into more blocks but it may be possible to combine K and L. Again, roads and sewers may be separate or part of each block.

8 Typical manufacturing unit

Block A Incoming goods ramps and store
Block B Batching unit
Block C Production area 1
Block D Production area 2
Block E Production area 3
Block F Finishing area
Block G Packing area
Block H Finished goods store and dispatch
Block J Boiler room and water treatment
Block K Electrical switch room
Block L Administration block and canteen

Additional blocks will, of course, be added where complexity or geographical location dictates this.

It must be emphasized that these typical block breakdowns can, at best, be a rough guide, but they do indicate the splits which are possible. When establishing the boundaries of a block, the main points given on page 25 must be considered.

The interrelationship and interdependence between blocks during the construction stage is, in most cases, remarkably small. The physical connections are usually only a number of pipes, conveyors, cables, underground services and roads. None of these offer any serious interface problems and should not, therefore, be permitted to unduly influence the choice of blocks. Construction restraints must, of course, be taken into account but they too must not be allowed to affect the basic block breakdown.

This very important point is only too frequently misunderstood. On a refinery site, for example, a delay in the process unit has hardly any effect on the effuent treatment plant except, of course, right at the end of the job.

In a similar way, the interrelationship at the design stage is often overemphasized. Design networks are usually confined to work in the various engineering departments and need not include such activities as planning and financial approvals or acceptance of codes and standards. These should preferably be obtained in advance by project management. Once the main flowsheets, plot plans and piping and instrument diagrams have been drafted (i.e. they need not even have been completed), design work can proceed in each block with a considerable degree of independence. For example, the tank farm may be designed quite independently of the process unit or the NGL plant, etc., and the boiler house has little effect on the administration building or the jetties and loading station.

In the case of a single building being divided into blocks, the roof can be designed and detailed independently of the other floors or the basement, provided, of course, that the interface operations such as columns, walls, stairwell, lift shaft and service ducts have been located and more or less finalized. In short, therefore, the choice of blocks is made as early as possible, taking into account all or most of the factors mentioned before, particular attention being given to design and construction requirements.

This split into blocks or work areas is, of course, taking place in practice in any design office or site, whether the programme is geared to it or not. One is, in effect, only formalizing an already well-proven and established procedure. Depending on size, most work areas in the design office are serviced by squads or teams, even if they only consist of one person in each discipline who looks after that particular area. The fact that on a small project the person may look after more than one area does not change the principle; it merely means that the team is half an operator instead of one.

On-site, the natural breakdown into work areas is even more obvious. Most disciplines on a site are broken down into gangs, with a ganger or foreman in charge, and, depending again on size and complexity, one or more gangs are allocated to a particular area or block. On very large sites, a number of blocks are usually combined into a complete administrative centre with its own team of supervisors, inspectors, planners, subcontract administrators and site engineers, headed by an area manager.

No difficulty should, therefore, be experienced in obtaining the cooperation of an experienced site manager when the type, size and number of blocks are proposed. Indeed, this early discussion serves as an excellent opportunity to involve the site team in the whole planning process, the details of which are added later. By that time, the site team is at least aware of the principles and a potential communication gap, so frequently a problem with construction people, has been bridged.

Generic work breakdown structure

While such a breakdown into blocks is suitable for an engineering contract, a similar system can be used for any other type of project. By breaking the project down into discrete components or tasks, we create what is known as a work breakdown structure or WBS.

The choice of tasks incorporated in the WBS is best made by the project team drawing on their combined experience or engaging in a brainstorming session.

Once the main tasks have been decided upon, they can in turn can be broken down into subtasks, which should be coded to fit in with the project cost coding system. This will greatly assist in identifying the whole string of relationships from overall operational areas down to individual tasks. For this reason the WBS is the logical starting point for subsequent planning networks. Another advantage is that a cost allocation can be given to each task in the WBS and, if required, a risk factor can be added. This will assist in building up the total project cost and creates a risk register for a subsequent, more rigorous risk assessment.

The object of all this is to be able to control the project by allocating resources (human, material and financial) and giving time constraints to each task. It is always easier to control a series of small entities which make up a whole, than trying to control the whole enterprize as one operation. What history has proven to be successful for armies, which are divided into divisions, regiments, battalions, companies and platoons, or corporations which have area organizations, manufacturing units and sales territories, is also true for projects, whether they are large or small, sophisticated or straightforward.

The tasks will clearly vary enormously with the type of project in both size and content, but by representing their relationship diagramatically, a clear graphical picture can be created. This, when distributed to other members of the project team, becomes a very useful tool for disseminating information as well as a reporting medium to all stakeholders. As the main tasks are in effect the major project milestones, the WBS is an ideal instrument for reporting progress upwards to senior management and for this reason it is essential that the status of each task is regularly updated.

Table 5.1

Project risks			
Organization	**Environment**	**Technical**	**Financial**
Management	Legislation	Technology	Financing
Resources	Political	Contracts	Exchange rates
Planning	Pressure groups	Design	Escalation
Labour	Local customs	Manufacture	Financial stability of
Health and safety	Weather	Construction	(a) project
Claims	Emissions	Commissioning	(b) client
Policy	Security	Testing	(c) suppliers

As the WBS is produced in the very early stages of a project, it will probably not reflect all the tasks which will eventually be required. Indeed the very act of draughting the WBS often throws up the missing items or work units, which can then be formed into more convenient tasks. As these tasks are decomposed further, they may be given new names such as unit or work package It is then relatively easy for management to allocate task owners to each task or group of tasks, who have the responsibility for delivering this task to the normal project criteria of cost, time and quality/performance.

Although the WBS may have been built up by the project team, based on their collective experience or by brainstorming, there is always the risk that a stage or task has been forgotten. An early review then opens up an excellent opportunity to refine the WBS and carry out a risk identification for each task, which can be the beginning of a risk register. At a later date a more rigorous risk analysis can then be carried out. The WBS does in effect give everyone a better understanding of the risk assessment procedure.

Indeed a further type of breakdown structure is the Risk Breakdown Structure. Here the main risks are allocated to the WBS or PBS in either financial or risk rating terms, giving a good overview of the project risks.

In another type of Risk Breakdown Structure the main areas of risk are shown in the first level of the Risk Breakdown Structure and the possible risk headings are listed below. See Table 5.1.

The abbreviation WBS is a generic term for a hierarchy of stages of a project. However, some methodologies like PRINCE call such a hierarchical diagram a Product Breakdown Structure (PBS). The difference is basically what part of speech is being used to describe the stages. If the words used are *nouns*, it is

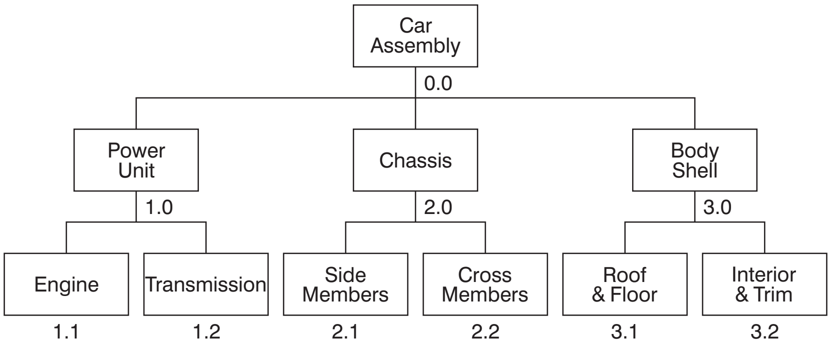

Figure 5.1 PBS

strictly speaking a Product Breakdown Structure (PBS), because we are dealing with products or things. If on the other hand we are describing the work which has to be performed on the nouns and use *verbs*, we call it a Work Breakdown Structure (WBS). Frequently, a diagram starts as a PBS for the first three or four levels and then becomes a WBS as more detail is being introduced.

Despite this unfortunate lack of uniformity of nomenclature in the project management fraternity, the principles of subdividing the project into manageable components are the same.

It must be pointed out, however, that the work breakdown structure is *not* a programme, although it looks like a precedence diagram. The interrelationships shown by the link lines do not necessarily imply a time dependence or indeed any sequential operation.

Figure 5.1, which is a Product Breakdown Structure, shows the process as: Car assembly, Power unit, Chassis, Body shell etc. Giving numbers to the tasks, enables a logical costing system to be built up as shown in Figure 5.3.

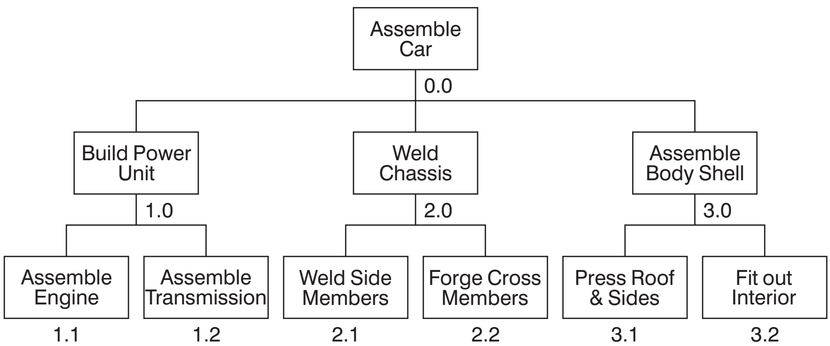

Figure 5.2 WBS

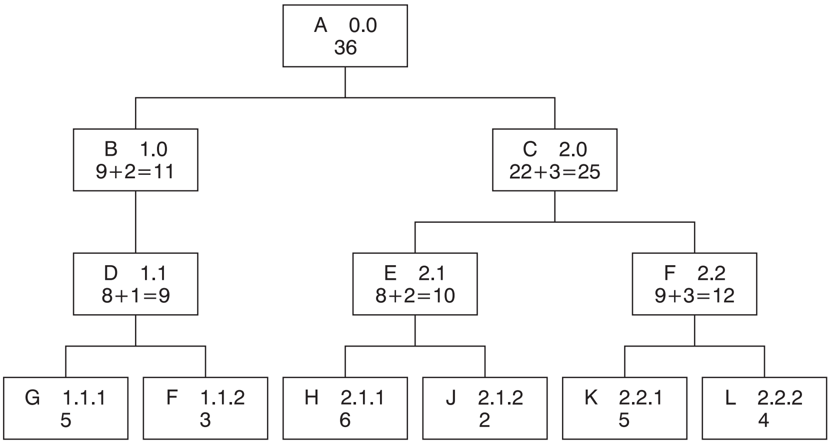

Figure 5.3

The corresponding Work Breakdown Structure shown in Figure 5.2 uses verbs and the descriptions of the packages or tasks then become: *Assemble* car, *build* power unit, *weld* chassis, *press* body shell etc.

It can be seen that a WBS is a powerful tool which can show clearly and graphically who is responsible for a task, how much it should cost and how it relates to the other tasks in the project. It was stated earlier that the WBS is not a programme, but once it has been accepted as a correct representation of the project tasks, it will become a good base for drawing up the network diagram. The interrelationships of the tasks will have to be shown more accurately and the only additional items of information to be added are the durations.

The degree to which the WBS needs to be broken down before a planning network can be drawn, will have to be decided by the project manager, but there is no reason why a whole family of networks cannot be produced to reflect each level of the WBS.

Once the WBS (or PBS) has been drawn, a bottom-up cost estimate can be produced starting at the lowest branch of the family tree. In this method, each work package is costed and arranged in such a way that the total cost of the packages on any branch must add up to the cost of the package of the parent package on the branch above. If the parent package has a cost value of its own, this must clearly be added before the next stage of the process. This is shown in Figure 5.3, which not only explains the bottom-up estimating process, but also shows how the packages can be coded to produce a project cost coding system that can be carried through to network analysis and earned value analysis.

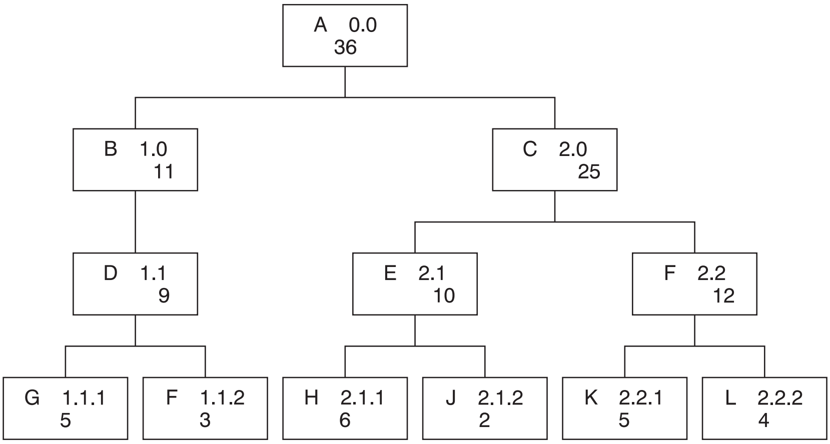

Figure 5.4 Top-down cost allocation

An alternative to the *bottom-up* cost allocation is the *top-down* cost allocation. In this method, the cost of the total project (or subproject) has been determined and is allocated to the top package of the WBS (or PBS) diagram. The work packages below are then forced to accept the appropriate costs so that the total cost of each branch cannot exceed the total cost of the package above. Such a top-down approach is shown in Figure 5.4

In practice both methods may have to be used. For example, the estimator of a project may use the bottom-up method on a WBS or PBS diagram to calculate the cost. When this is given to the project manager, he/she may break this total down into the different departments of an organization and allocate a proportion to each, making sure that the sum total does not exceed the estimated cost. Once names have been added to the work packages of a WBS or PBS it becomes an Organization Breakdown Structure or OBS.

It did not take long for this similarity to be appreciated, so that another name for such an organization diagram became 'Organization Breakdown'. This is the family tree of the organization in the same way that the WBS is in effect the family tree of the project. It is in fact more akin to a family tree or organization chart (organogram).

Figure 5.5 shows a typical OBS for a manufacturing project such as the assembly of a prototype motor car. It can be seen that the OBS is not identical in layout to the WBS, as one manager or task owner can be responsible for more than one task.

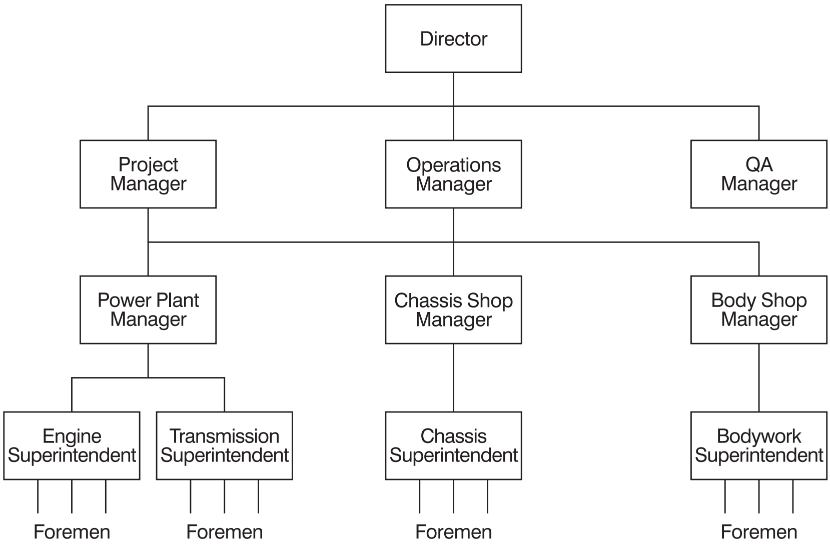

Figure 5.5 OBS

The OBS shown is typical of a matrix-type project organization where the operations manager is in charge of the actual operating departments for 'pay and rations', but each departmental head (or his designated project leader) also has a reporting line to the project manager. If required, the OBS can be expanded into a responsibility matrix to show the responsibility and authority of each member of the organization or project team.

	Director	Project Manager	Operations Manager	QA Manager	Power Plant Manager	Chassis Shop Manager	Body Shop Manager	Engine Superintendent	Transmission Superintendent	Chassis Superintendent	Bodywork Superintendent
Car Assembly	A	B	A	B							
Power Unit	A	B	A	B	C						
Chassis	A	B	A	B		C					
Body Shell	A	B	A	B			C				
Engine		B	A	B	C			C			
Transmission		B	A	B	C				C		
Side Members		B	A	B		C				C	
Cross Members		B	A	B		C				C	
Roof & Floor		B	A	B			C				C
Interior & Trim		B	A	B			C				C

Figure 5.6

The quality assurance (QA) manager reports directly to the director to ensure independence from the operating and projects departments. He will, however, assist all operating departments with producing the quality plans and give ongoing advice on QA requirements and procedures as well as pointing out any shortcomings he may discover.

Responsibility matrix

By combining the WBS with the OBS it is possible to create a Responsibility Matrix. Using the car assembly example given in Figures 5.1 and 5.5, the matrix is drawn by writing the WBS work areas vertically and the OBS personnel horizontally as shown in Figure 5.6.

By placing a suitable designatory letter into the intersecting boxes, the level of responsibility for any work area can be recorded on the matrix.

A = Receiving monthly reports
B = Receiving weekly reports
C = Daily supervision