Concepts in Engineering Design

Design Objectives

Design objectives – Client requirements, user needs or product purpose

The types of question that are useful in expanding and clarifying objectives are the simple ones of why?, how? and what?

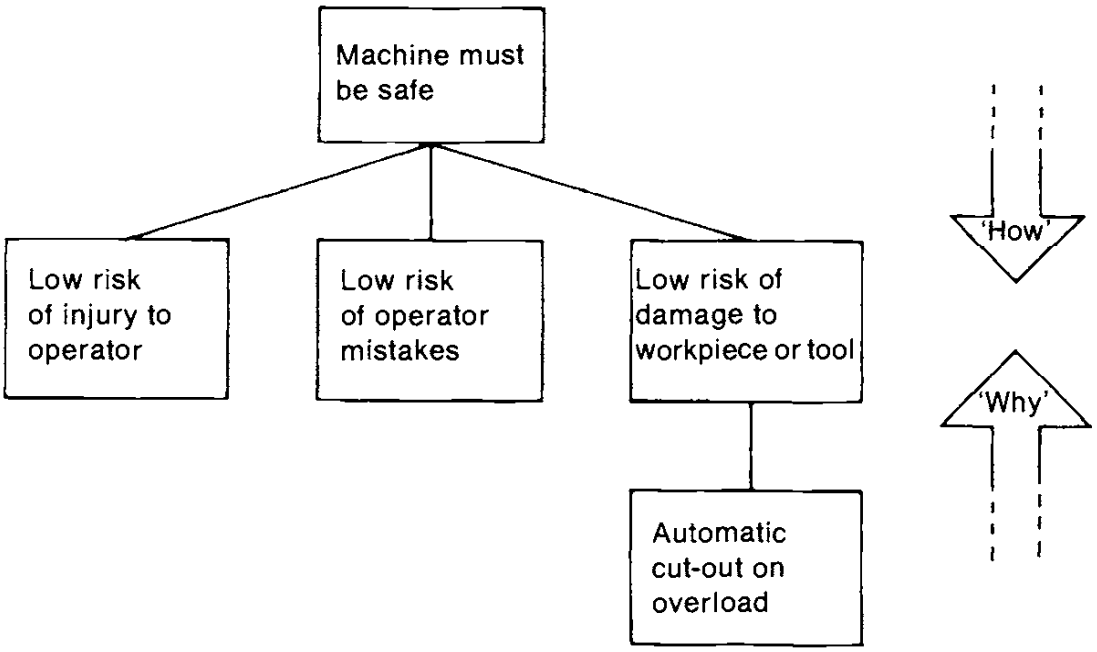
Why do you want to achieve this objective?

How can we achieve it? And

What implicit objectives underline the stated ones? or What is the problem really about?

Order the list of objectives into sets of higher level and lower level objectives.

Diagramatic tree of objectives, showing hierarchical relationships and interconnections



Working down the tree a link indicates how a higher level objective might be achieved; working up a tree a link indicates why a lower level objective is included.

The aim of the objectives tree method is to clarify design objectives and sub-objectives, and the relationships between them. The procedure is as follows.

1. Prepare a list of design objectives. These are taken from the design brief, from questions to the client, and from discussion in the design team.

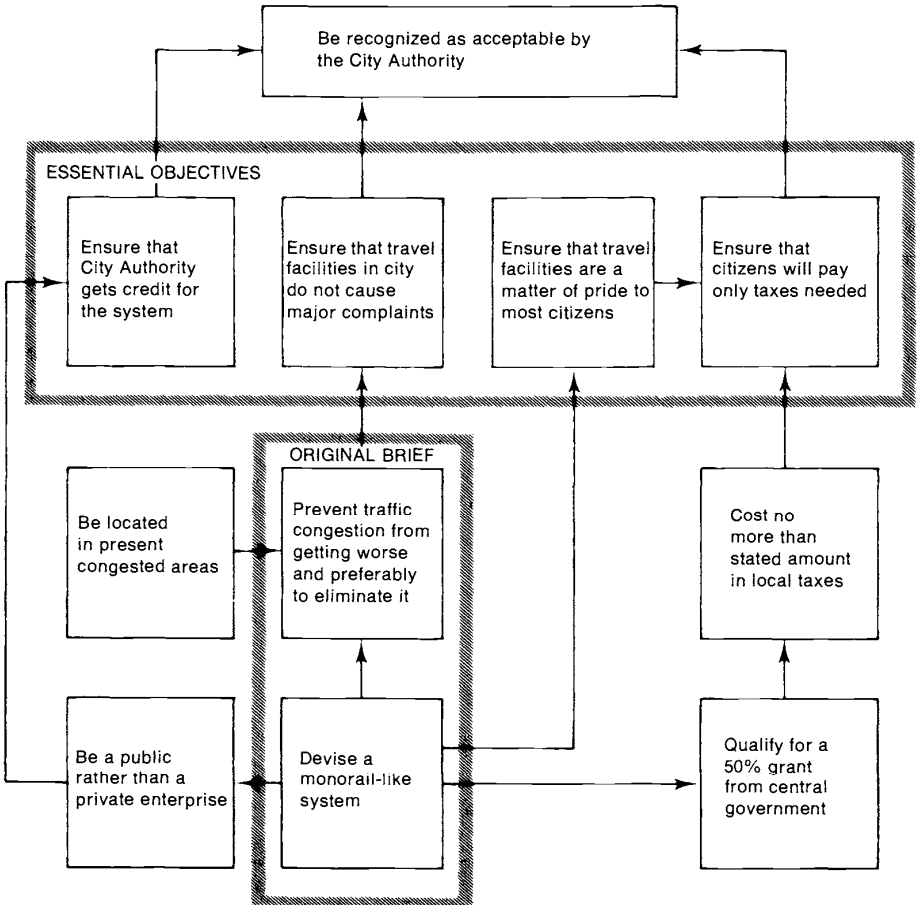
2. Order the list into sets of higher-level and lower-level objectives. The expanded list of objectives and sub-objectives is grouped roughly into hierarchical levels.

3. Draw a diagrammatic tree of objectives, showing hierarchical relationships and interconnections. The branches (or roots) in the tree represent relationships which suggest means of achieving objectives.

City transportation system

This is an example of expanding and clarifying design objectives from an initially vague brief. A city planning authority asked a transport design team for proposals for 'a modern system, such as a monorail, which would prevent traffic congestion in the city from getting any worse and preferably remove it altogether.'

The only clear objective in this statement is 'To prevent traffic congestion ... from getting any worse ...' What are the implicit objectives behind the desire for 'a modern system, such as a monorail'? Traffic congestion might be held constant or reduced by other means.



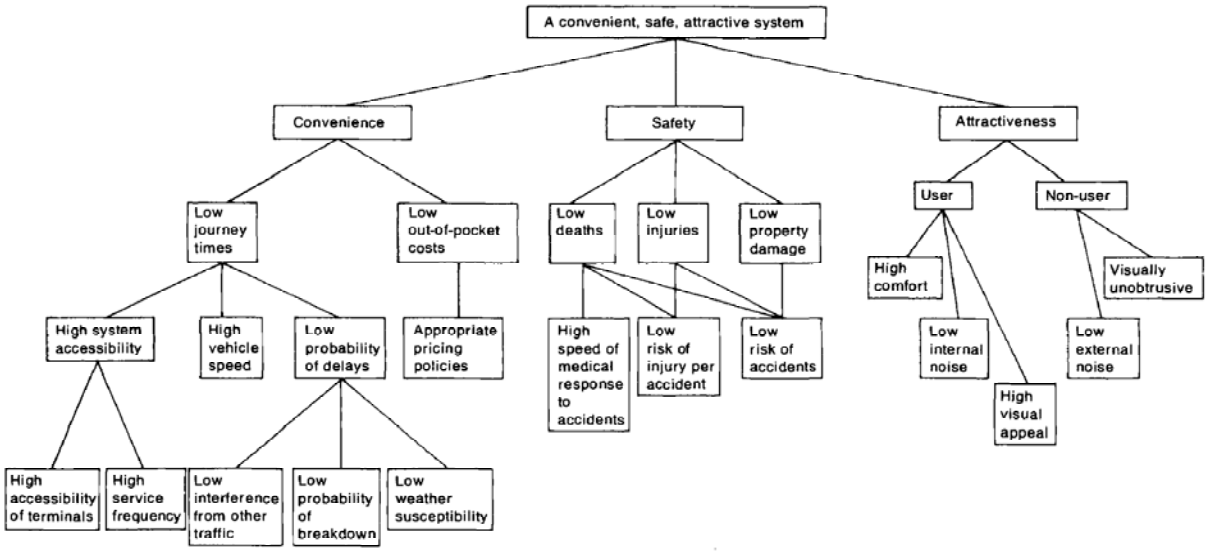
Regional transportation system

Another example from transport design is shown here, for a larger regional system. The designers started from the clients' vague definition of 'a convenient, safe, attractive system', and expanded each objective in turn. For example convenience was defined in terms of low journey times and low out-of-pocket costs for users. The latter objective can be met by appropriate pricing policies; low journey times can be met by a variety of sub-objectives, as shown on the left-hand side of the objectives tree in Figure 24.

Two aspects of attractiveness were defined: user and non-user aspects. The user aspects were subdivided into comfort, visual appeal and internal noise, whereas the non-user aspects were external noise and visual obtrusiveness.

The safety objective was defined to include deaths, injuries and property damage. The sub-objectives to these show how sub-objectives can contribute to more than one higher-level objective. A low risk of accidents can contribute to all three higher-level objectives. If accidents do occur, a low risk of injury per accident can contribute to keeping down both injuries and deaths.

Regional transportation system

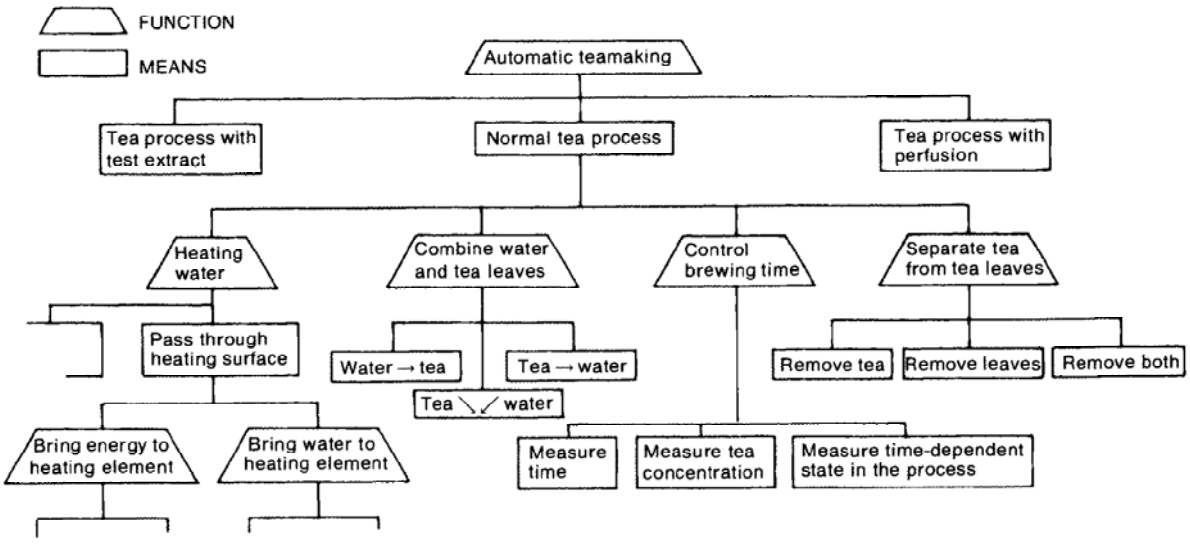


Automatic tea maker

The objectives tree method can also be used in designing a relatively simple device such as an automatic teamaker. In this example, a distinction is made between functions and means. Each function is an objective, which may be achieved by a number of different means or sub-objectives. Thus the function 'combine water and tea leaves' could be achieved by adding the water to the tea, adding the tea to the water, or bringing them both together into one receptacle (Figure 26).

This is a variation on the objectives tree as described earlier and demonstrated in the other examples, and might more accurately be called a functions tree. However, the same principles apply of breaking-down objectives into sub-objectives, or functions into means, and ordering them into a hierarchical tree. This application of the tree structure approach helps to ensure that all the possible means of achieving a function (or objective) are considered by the designer (Tjalve, 1979).

Automatic tea maker



Car door

This is another example of a function tree. In considering the requirements for a car door, the designers set out a tree of functions (Figure 27). The tree starts from high-level functional requirements (on the left of the figure), and works through to lower-level detailed functions that can actually be implemented in terms of engineering design decisions (Pugh, 1991).