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## Glossary of

# Terms used in operational research

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# Contents

# Foreword

This British Standard has been prepared under the direction of Technical Committee MS/2. It was decided that the time was opportune to produce a glossary of Operational Research (OR) terms in view of the wide application of OR techniques in industry, commerce and the public services. This standard complements several related BSI glossaries dealing with management and scientific disciplines.

The term Operational Research (OR) was first used to describe the application of scientific methods to military operations and is known as operations research or management science in North America. In the late 1940s, many civilian OR groups were set up in industries such as steel, coal and oil, where the mathematical approach was applied to operations in areas such as purchasing, stock control and production scheduling. Operational Research then spread rapidly into all areas of manufacturing and service industry, the financial sector and government departments. A number of academic OR departments were founded and OR is now taught both as a subject in itself and as part of more broadly based studies such as business, accountancy, computing and engineering.

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**Summary of pages**

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 38, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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# Introduction

## Concepts of Operational Research

The management science of Operational Research (OR) is entirely practical in intention and its objective is to propose solutions for complex problems arising in the direction and management of large systems of people, machines, materials and money in industry, business, government and community services. The distinctive OR approach is to develop a scientific model of the system under review, incorporating measurements of factors such as chance and risk, with which to predict the outcomes of alternative decisions, strategies or controls. OR should therefore enable management to determine its policy and actions scientifically. The purpose of this standard is to promote the use of standardized terminology for Operational Research as an aid to effective communications, particularly in business studies and where OR techniques have come into more general use.

There is a continuing debate within Operational Research circles as to what OR actually is, because the words "operational" and "research" can both be misleading. "Operational" suggests that OR ought to be concerned with ongoing operations, the tactical as opposed to the strategic; whereas "research" paradoxically suggests almost the opposite, namely that OR should be concerned with possible future operations which cannot be put into effect until certain necessary analysis, involving models, experimentation and pilot studies has been satisfactorily completed. In order to avoid these semantic difficulties, some organizations, while making use of the OR approach and techniques, have replaced the term Operational Research with other phrases such as Management Science, Management Services, Systems Analysis, or Information Science. In many occupations and professions, one or two particular techniques may be very important, while the rest remain unused.

As originally conceived, an Operational Research team was composed of experts drawn from various fields such as general management, finance, marketing, logistics, manufacturing and quality assurance. Cross-fertilization of ideas and pooling of expertise was encouraged, so that complex and apparently intractable problems might be solved. Many of the early OR successes resulted from the application of relatively simple techniques such as linear regression and experimental design in situations where these techniques had not previously been applied. In due course OR became a subject in its own right and the OR expert emerged.

The OR approach could be described first in terms of the scientific method where hypotheses are formulated and tested and second by the standard approach to problem solving using the following process:

— define the problem and formulate it in such a way that a quantitative approach is possible;

— develop an appropriate model;

— collect relevant data;

— validate the model by checking that it produces the same answer using the same data found in the real world;

— evaluate the options by running hypothetical, forecast or what-if data through the model and interpreting results;

— select the preferred option;

— prepare appropriate documentation and/or computer programs;

— implement.

A central concept within OR is that of a model, by which the OR practitioner reaches a deeper understanding of the problem area. The purpose of the model is to generate practical solutions with regard to difficulties of implementation. As one of the pioneers of OR expressed it, the third-best solution that can be produced tomorrow may be more useful than the second-best in a month, or the best solution that could take years or may be too difficult to put into operation. In OR terms, a model may be a set of equations, a computer program, occasionally an analogue device, or indeed any operating description, preferably quantitative, of the dynamics of the situation. Where this cannot be represented mathematically, it may be simulated. The relationships modelled may be on a one-to-one basis, where each element in the real world corresponds to an element in the model. More usually the relationships are on a one-to-many basis, for example, where one number may represent all the invoices passed in a month. Model is to OR as metaphor is to language.

The complexity of an OR problem frequently arises from the fact that there is no evident structure in it and no obvious method of solution. Various internal and external pressures, such as industrial relations and legal or contractual constraints, may be involved and may require modifications to an otherwise good solution. There may be no solution (in the mathematical sense of the word) to an ill-defined problem, but enlightenment may be gained by a structured approach. The first task of OR is therefore to explore the problem situation itself to determine its structure. The factors that affect the problem and are affected by it, should then be defined and assessed quantitatively if possible. The aim should be to clarify the precise nature of the problem and make it evident to all the parties involved.

When all parties involved in the problem situation agree that it is adequately formulated, then the operational researcher can employ the methods and techniques of OR. These are merely the tools that the operational researcher uses on the way to solving problems and implementing their solution; some of these tools are surprisingly powerful. Although the bulk of this standard is devoted to terms used in these techniques, it is essential to understand that OR is far more than a collection of techniques.

The role of OR is not finished when proposals for resolving the original problem are accepted; an important aspect is implementation, which almost invariably raises difficulties of its own, for example the need to adjust administrative procedures, to change attitudes, skills and established practices.

**Arrangement**

Sections **1** to **9** of this British Standard cover particular topics of Operational Research and within these sections a wide range of terms is defined as follows:

section **1** defines the fundamental and generic terms used in Operational Research;

section **2** defines terms used in mathematical programming;

section **3** defines terms used in queuing theory;

section **4** defines terms used in simulation;

section **5** defines terms used in gaming;

section **6** defines terms used in forecasting;

section **7** defines terms used in graph theory;

section **8** defines terms used in decision theory; and

section **9** defines terms used in soft operational research.

In some cases, where two or more terms have the same meaning and one of them is preferred, the preferred term is printed in bold type (as are all single terms) and the others are printed in ordinary type. Italic type denotes a term that is defined elsewhere in this glossary.

Other British Standard glossaries such as BS 3138, BS ISO 3534, BS 3811, BS 4335, BS EN ISO 8402 and BS 5191 include some OR terms that are relevant to their respective disciplines. It is envisaged that in due course a new standard BS 6079 *Guide to project management* will be published which will also contain OR terms that are relevant.

# Section 1. Fundamental terms

| No. | Term | Definition |
|---|---|---|

## 1.1 Terms and definitions

| | | |
|---|---|---|
| 11001 | **bottom-up** | An approach that starts at the level of greatest detail or lowest hierarchical level and proceeds up towards the level of least detail or highest hierarchical level. |
| 11002 | **decision variable** | A quantity that varies, or a vector of such quantities, that is under the control of the decision maker. |
| 11003 | **heuristics** | A systematic procedure involving informal trial and error solutions.<br>NOTE The solution is narrowed down by using experience, rather than only theoretical knowledge, to reject obviously impractical routes. |
| 11004 | **model** | A representation of reality that reproduces the essential features or elements of the *system* or *entity* being studied. |
| 11005 | **Operational Research (OR)** | The application of the methods of science to complex problems arising in the management of large systems of people, machines, materials and money in industry, business, government and community services.<br>NOTE 1 The distinctive approach is to develop a *model* of the *system*, incorporating measures of factors such as chance and *risk*, with which to predict and compare the outcomes of alternative decisions, strategies or controls. The purpose is to help management determine its policy and actions scientifically.<br>NOTE 2 The practical application of OR makes use of certain specific disciplinary methods such as probability, statistics, *mathematical programming* and queuing theory. |
| 11006 | **optimizing** | 1) Obtaining the best possible mathematical solution to a given set of equations.<br>2) Obtaining the best possible solution within the constraints of a problem where the situation cannot be completely described by mathematical equations. |
| 11007 | **parameter** | A value circumscribing a problem, that is constant within a process, but may be changed for subsequent processes. |
| 11008 | **satisficing** | Achieving an acceptable solution that is not necessarily the best achievable solution. |
| 11009 | **sensitivity analysis (general)** | Investigation of the behaviour of the solution as a result of variations of the *parameters*. |
| 11010 | **steady state (general)** | The state of the *system* when its variables have converged to values independent of time.<br>NOTE See also 45005. |
| 11011 | **system** | A coherent and logical arrangement of principles, people, data, material, components, equipment and/or procedures. |
| 11012 | **top-down** | An approach that starts at the level of least detail or highest hierarchical level and proceeds downwards to the level of greatest detail or lowest hierarchical level. |
| 11013 | **validation** | The process of checking by comparing a *model* with the real world. |
| 11014 | **verification** | The process of checking how consistent a *model* is in itself. |

# Section 2. Mathematical programming

| No. | Term | Definition |
|---|---|---|

## 2.1 Programming methodology

21001 **convex programming** Optimization of a *convex function* over the *region* where it is convex.

NOTE 1 *Linear programming* and *quadratic programming* are special cases of *convex programming*.

NOTE 2 The problems P1, P2 below are *convex programming* problems:

P1 min $f(x)$, subject to

$x \in R$, $R = \{x \mid g_i(x) \leq 0, i = 1,2,....,m\}$

P2 max $h(x)$, subject to $x \in R$

where

$f(x)$ is a *convex function*;

$h(x)$ is a *concave function*;

$g_i(x)$, $i = 1, 2,...,m$ are *convex functions* whereby $R$ is a convex set.

21002 **integer programming** Linear programming with the added restriction that all the variables are constrained to be integers.

NOTE The general mathematical formulation of the *integer programming* problem is the set of matrix relationships as follows:

min (or) max $f(x) = c^T x$

subject to

$Ax \leq b$

and

$x \geq 0$

and

$x$ integer for all $x_j$; $j = 1,2,....,m$

21003 **linear programming** The general problem of *optimizing* a linear function of several variables subject to a number of *constraints* that are linear in these variables and a subset of which restrict the variables to be non-negative.

NOTE The general mathematical formulation of the *linear programming* problem is the set of matrix relationships as follows:

min (or) max $f(x) = c^T x$

subject to

$Ax \leq b$

and

$x \geq 0$.

21004 **mathematical programming** The general problem of *optimizing* a function of several variables subject to a number of *constraints*.

21005 **mixed (integer) programming** *Linear programming* with the added restriction that some variables are constrained to be integers.

NOTE The general mathematical formulation of the *mixed programming* problem is the set of matrix relationships as follows:

min (or) max $f(x) = c^T x$

subject to

$Ax \leq b$

and

$x_j \geq 0; j = 1,2,...,n$

and

$x_j$ integer for $j = 1,2,...,k$

and

$k < n$

| No. | Term | Definition |
|---|---|---|
| 21006 | **non-linear programming** | An inclusive term covering all types of constrained optimization problems except those problems where the *objective function* and the *constraints* are all linear.<br>NOTE 1 Special types of *non-linear programming* for which theories have been developed are *convex programming, concave programming* and *quadratic programming*.<br>NOTE 2 The general mathematical formulation of the *non-linear programming* problem is the set of matrix relationships as follows:<br>max (or) min $f(x)$<br>subject to<br>$g_i(x) \leq b$<br>and<br>$x \geq 0$<br>and<br>where $f(x)$ and $g(x)$ are non-linear functions of $x$. |
| 21007 | **quadratic programming** | Maximization/minimization, subject to linear *constraints*, of an *objective function* that is a *concave/convex* quadratic function.<br>NOTE The general mathematical formulation of the quadratic programming problem for, say, the minimization case is the set of matrix relationships as follows:<br>$\min f(x) = p^T x - \frac{1}{2} x^T Q x$<br>subject to<br>$Ax \leq b$<br>and<br>$x \geq 0$<br>where<br>$p$ is an n-vector of coefficients;<br>$Q$ is an $n \times n$ matrix of quadratic form. |
| 21008 | **separable programming** | A method of formulating certain suitable *non-linear programming* problems such that each non-linear function appearing may be expressed as the sum of separate linear or non-linear functions of single variables.<br>$g(x_1,x_2,....,x_n) = g_1(x_1) + g_2(x_2) + ...g_n(x_n)$.<br>The simplex algorithm is appropriately modified for the solution of such problems. |
| 21009 | **stochastic programming** | A generalization of *linear programming* where any of the coefficients may be probabilistic. |

| No. | Term | Definition |
|---|---|---|
| **2.2 Specific programming terminology** | | |
| 22001 | **constraint** | An equation or inequality relating the variables in an optimization problem. |
| 22002 | **feasible solution** | A solution satisfying the *constraints* of a *mathematical programming* problem. |
| 22003 | **infeasible solution** | A solution to a *mathematical programming* problem where *constraints*, specifically the non-negativity *constraints* of the problem, have not all been satisfied. |
| 22004 | **iteration** | A single *cycle* of operations in the algorithm used to solve the problem. |
| 22005 | **objective function** | The combination of the variables of a *mathematical programming* problem whose value is to be maximized or minimized subject to the *constraints* of the problem. |
| 22006 | **optimal solution**<br>optimum solution | A *set* of values of the variables in a *mathematical programming* problem that optimizes the *objective function* and satisfies the problem *constraints*. |
| 22007 | **redundant constraint** | A *constraint* in a *mathematical programming* problem that for any *feasible solution* will never be binding because one or more *constraints* in the problem are equally or more restrictive. |
| 22008 | **sensitivity analysis (in LP)**<br>post-optimal analysis<br>ranging analysis | Investigation of the behaviour of the *optimal solution* as a result of variations in coefficient in the *objective function* or *constraint* values of a problem. |
| **2.3 Programming terms with wider application** | | |
| 23001 | **branch and bound method** | A method of solving an optimization problem in which the space of *feasible solutions* is repeatedly partitioned into smaller and smaller subsets (branching) and the lower bound (for minimum problems) is calculated (bounding). After each partitioning those subsets with bounds exceeding a known *feasible solution* are excluded from further partitioning. |
| 23002 | **cutting plane method** | A method of problem solving in which the initial problem is relaxed by removing a restriction. If this does not fathom the original problem the relaxation is then tightened by adding a new *constraint*. |
| 23003 | **fathomed problem** | A problem that either has no *feasible solution*, or no solution with an *objective function* better than some predetermined value, or its optimum solution is revealed by analysis. |
| 23004 | **relaxation, principle of** | The principle that when a problem is relaxed to another problem, every *feasible solution* to the original problem should be a *feasible solution* to the relaxed problem.<br>NOTE This leads to the following results.<br>a) If there is no *feasible solution* of the relaxed problem, then there is no *feasible solution* to the original problem.<br>b) The optimum value of the relaxed problem is at least as good as that of the original problem.<br>c) If an *optimal solution* of the relaxed problem is a *feasible solution* of the original problem, it is an *optimal solution* of the original problem. |
| 23005 | **separation, principle of** | The principle that a problem is separated into sub-problems (descendants) if every *feasible solution* to the problem is a *feasible solution* of one and only one of the descendants and if every *feasible solution* of every descendant is a *feasible solution* of the problem. |
| 23006 | **stationary policy** | A policy that always prescribes the same action whenever the *system* is in a given *state*. |

| No. | Term | Definition |
|---|---|---|

## 2.4 Linear, integer and mixed programming terminology

COMMENT. Applications in several apparently unconnected problem areas often have very similar mathematical structures and therefore almost identical methods of solution. It is customary to name all such problems after the first published one. For example, the *travelling salesman problem* is encountered in many managerial and scientific guises all of which share the same approach to the solution.

Many *linear programming* (LP) problems having special structures can be solved with algorithms that are more efficient than those needed for general LP problems. These problems also tend to be known by their first published application that might be quite irrelevant to another application. Examples of specially named problems are terms 24027 and 24028 and also network flow problem, *assignment problem*, routing problem, machine shop problem, cutting problem, knapsack problem.

| | | |
|---|---|---|
| 24001 | **artificial variable** | An auxiliary variable introduced into an equality *constraint* at the start of the *simplex method* of *linear programming*, to provide an identity basis required to initiate the procedure. |
| 24002 | **assignment problem** | A special case of the *transportation problem* where in the solution the variables $x_{ij}$ are allowed to take only the values 0 and 1.<br>NOTE 1 The problem is usually interpreted as one of assigning $n$ persons to $n$ jobs in an optimal manner.<br>NOTE 2 The problem can be stated as an LP problem or as a *transportation problem* but can be solved via a special algorithm. |
| 24003 | **basic feasible solution** | A basic solution that satisfies the *constraints* of a *linear programming* problem, including the non-negativity *constraints*. |
| 24004 | **basic solution** | A solution to a *linear programming* problem where the number of variables with non-zero values is, at most, equal to the number of *constraints* in the problem. |
| 24005 | **basic variable** | A variable not initially set to zero in a basic solution.<br>NOTE A basic variable corresponds to one of the column vectors in the *basis*. |
| 24006 | **basis** | In linear programming an $m \times m$ non-singular matrix consisting of $m$ columns of the problem matrix.<br>NOTE The requirement that the *basis* is non-singular means that the chosen column vectors have to be linearly independent. |
| 24007 | **binary variable**<br>**zero-one variable**<br>**go-no go alternative**<br>**logical variable** | A variable that takes one of two possible values, zero or one. |
| 24008 | **complementary slackness** | The duality property that states that when, in the *optimal solution* of the primal, a *slack variable* has a positive value (i.e. its associated *constraint* is not binding) then the dual variable corresponding to this primal *constraint* is zero in the *optimal solution* of the dual and vice versa. |
| 24009 | **cycling** | In the *linear programming* solution procedure, the repetitive occurrence of a sequence of *basic feasible solutions* during which the value of the *objective function* does not improve. |
| 24010 | **decomposition (in LP)** | A method for subdividing a large *linear programming* problem into smaller, more manageable linear programs, solving the smaller programs in the standard way and then combining these solutions to solve the original problem.<br>NOTE Linear programs that qualify in particular for *decomposition* are those whose variables can be separated into classes *X, Y, Z,...* and the *constraints* into classes $C_0$, $C_1$, $C_2$,... such that the *constraints* in class $C_0$ can involve all the variables, *constraints* in class $C_1$ involve only the variables in *X*, the *constraints* in class $C_2$ only involve the variables in *Y*, the *constraints* in class $C_3$ involve only the variables in *Z* and so on. The subsets of *constraints* each involving only part of the variables are called sub-programs while the subset of *constraints* in $C_0$ is called the master program. |

| No. | Term | Definition |
|---|---|---|
| 24011 | **degenerate basic solution** | A *basic solution* where one or more of the basic variables assume a zero value. |
| 24012 | **dual feasible solution** | A solution of the dual of a *linear programming* problem that satisfies all the *constraints* in the *dual problem*.<br>NOTE In general, unless the optimum has been reached, the primal solution corresponding to a *dual feasible solution* is infeasible and vice versa. |
| 24013 | **duality** | The set of mathematical properties that links the solution of a *primal problem* with that of its corresponding *dual problem*, for example the fact that the optimum values of both *objective functions* are equal. |
| 24014 | **dual problem** | An alternative formulation of a *linear programming* problem that is obtained by transposing the matrix (such that column vectors in the primal become row vectors in the dual and vice versa) and where the cost coefficients of the primal *objective function* become *constraint* values and vice versa, and *shadow costs* and *reduced costs* in the primal become the values of the variables in the dual and vice versa. Maximization of the primal corresponds with minimization of the dual and vice versa.<br>NOTE 1 Conventionally a *constraint* is expressed as a polynomial of the variables concerned and related to a numerical value on the right-hand side (of the equality or inequality sign).<br>NOTE 2 The concept is to convert a maximization problem into a dual minimization problem when the latter is easier to solve.<br>NOTE 3 *Primal/dual problems* are also encountered in *graph* theory. |
| 24015 | **ellipsoid method** | An alternative procedure to the *simplex method*. |
| 24016 | **free variable** | A variable not constrained to integer values only. |
| 24017 | **integer variable** | A variable that assumes whole number values only. |
| 24018 | **lattice point** | A point (set of values) satisfying the integer *constraint* (in integer and mixed programs). |
| 24019 | **parametric programming** | A method for investigating the effect on an optimal *linear programming* solution of a sequence of proportionate changes in the elements of a single row or column of the matrix. Most commonly the method is applied to either the *objective function* row or the *constraint* column. |
| 24020 | **primal problem** | A programming problem stated in terms of the original variables and *constraints*. |
| 24021 | **projective method** | An alternative procedure to the *simplex method*. |
| 24022 | **reduced cost (of a non-basic variable)** | The amount by which, for a non-basic variable, the *objective function* would change if this variable were to be given unit value.<br>NOTE 1 *Reduced costs* can be regarded as the *shadow prices* on the non-negativity *constraints* of the respective variables.<br>NOTE 2 The *reduced costs* of basic variables are zero. |
| 24023 | **revised simplex method** | A variant of the *simplex method*, where the number of calculations necessary to move from one *iteration* to the next in the simplex procedure is kept as small as possible. Only those calculations are carried out that are needed for the next decision to be made in the problem procedure.<br>NOTE The method is especially suitable for problems where the number of variables is much larger than the number of equations. |
| 24024 | **shadow price**<br>**dual price**<br>**marginal cost**<br>**marginal price**<br>**marginal value**<br>**shadow cost** | The amount by which the *objective function* would change on a particular *constraint* in a *linear programming* problem if the right-hand side value of that *constraint* was increased by one unit. |

| No. | Term | Definition |
|---|---|---|
| | | NOTE 1 For a non-binding *constraint* (i.e. the associated *slack variable* has a positive value) the *shadow price* is zero.<br>NOTE 2 The *shadow prices* are obtained as the values of the *basic variables* in the solution of the *dual problem*. |
| 24025 | **simplex method** | An algorithm allowing a systematic search for an *optimal solution* to an LP problem (if one exists), from among the basic *feasible solutions*.<br>NOTE The *ellipsoid* and *projective methods* are alternatives to the *simplex method*. |
| 24026 | **slack variable** | An auxiliary variable introduced to convert an inequality *constraint* to an equation. |
| 24027 | **transportation problem** | Descriptive term for optimization problems of the type:<br>minimize $\Sigma_i \Sigma_j c_{ij} x_{ij}$ ($i = 1,\ldots m, j = 1,\ldots n$)<br>subject to:<br>$\Sigma_j x_{ij} \geq p_i$ ($i = 1,\ldots m$)<br>$\Sigma_i xij \leq qi$ ($j = 1,\ldots n$)<br>and<br>$x_{ij} \geq 0$ ($i = 1,\ldots m, j = 1,\ldots n$<br>NOTE 1 The *transportation problem* is a special case of the *linear programming* problem. Its particular structure allows a method of solution that is more efficient computationally than the simplex algorithm.<br>NOTE 2 In its original form the *transportation problem* was concerned with transporting homogeneous goods from a number of sources to a number of destinations as cheaply as possible, hence the name. |
| 24028 | **transshipment problem** | 1) A *transportation problem* with a cost matrix containing zero entries.<br>2) A *transportation problem* with capacity restrictions. |
| 24029 | **travelling salesman problem** | Descriptive term for the problem of finding the shortest route, visiting all points of a given set of points. |

| No. | Term | Definition |
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## 2.5 Non-linear programming

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|---|---|---|
| 25001 | **concave function** | A function such that, for example in two dimensions, a straight line that joins any two points lies wholly within or on the boundary of that function. See Figure 1. |
| 25002 | **convex function** | A function such that, for example in two dimensions, a straight line that joins any two points may not lie wholly within the boundary of that function. See Figure 1. |

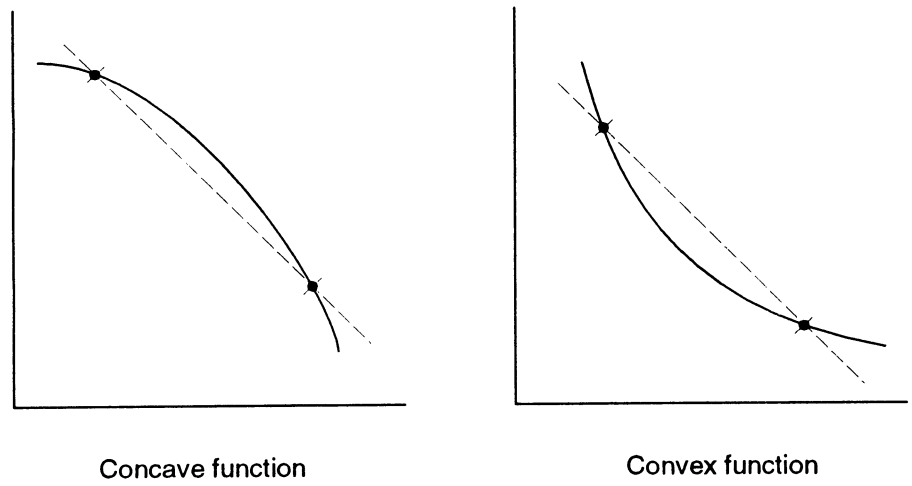


**Figure 1 — Concave and convex functions**

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|---|---|---|
| 25003 | **local optimum maximum or minimum** | The *maximum* or *minimum* solution relating to a self-contained *region* or subset of the whole solution space.<br><br>NOTE The *optimal solution* relates to the *maximum* or *minimum* values extracted from the complete set of considered solutions. |
| 25004 | **piecewise linear approximation** | The representation of a non-linear function approximation by a set of contiguous line segments. |

## 2.6 Dynamic programming

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|---|---|---|
| 26001 | **dynamic programming** | A programming method for dealing with *multi-stage problems*. |
| 26002 | **multi-stage problem** | A problem situation that consists of a series of sequential stages or phases, such that the output or result at any stage depends only on the decisions taken at the previous stage. |
| 26003 | **optimality, principle of** | Principle whereby an optimal policy has the property that, whatever the initial state and the initial decision, the remaining decisions need to form an optimal policy with regard to the state resulting from the first decision. |

| No. | Term | Definition |
|---|---|---|

## 2.7 Theory of games

COMMENT. The theory of *games* deals with *games* involving two or more players in which the numerical outcomes for each player, for every combination of permissible *moves*, are numerically predetermined. The theory of *games* is distinct from the term "*gaming*", which is defined in 51002.

The mathematical analysis of *games*, in which the players optimize the results of their own moves, is part of *linear programming*.

| | | |
|---|---|---|
| 27001 | **game** | 1) A *model* of a dynamic situation involving two or more decision makers.<br>2) A collection of *rules* that determine what the players may do, who eventually wins and what is won, dependent on the *moves* that are chosen by the players.<br>NOTE In *mathematical programming* the term "*game*" is not synonymous with *gaming*, see also 51002 *gaming*. |
| 27002 | **mixed strategy** | A policy that prescribes one of several *moves*, each with fixed probability, whenever the same situation arises. |
| 27003 | **move** | A constituent part of a *game*.<br>NOTE A series of moves constitutes a *play*, see also 27007 *play*. |
| 27004 | **n-person game** | A *game* between two or more players. |
| 27005 | **non-zero sum game** | A *game* for two or more players where the sum of losses of losing players and the sum of gains of winning players is not equal. |
| 27006 | **pay-off table (in theory of games)**<br>pay-off matrix | The tabulation of the outcomes of all possible combinations of *moves* by the players. |
| 27007 | **play** | 1) A single run-through of a *game*.<br>2) A replication of a *game* under a single set of *starting conditions*. |
| 27008 | **pure strategy** | A policy that prescribes the same move whenever the same situation arises. |
| 27009 | **saddle point**<br>(min.-max.) | In a two person *game*, a pair of *moves* such that the smallest outcome for one player is the largest outcome for the other player. See Figure 2. |

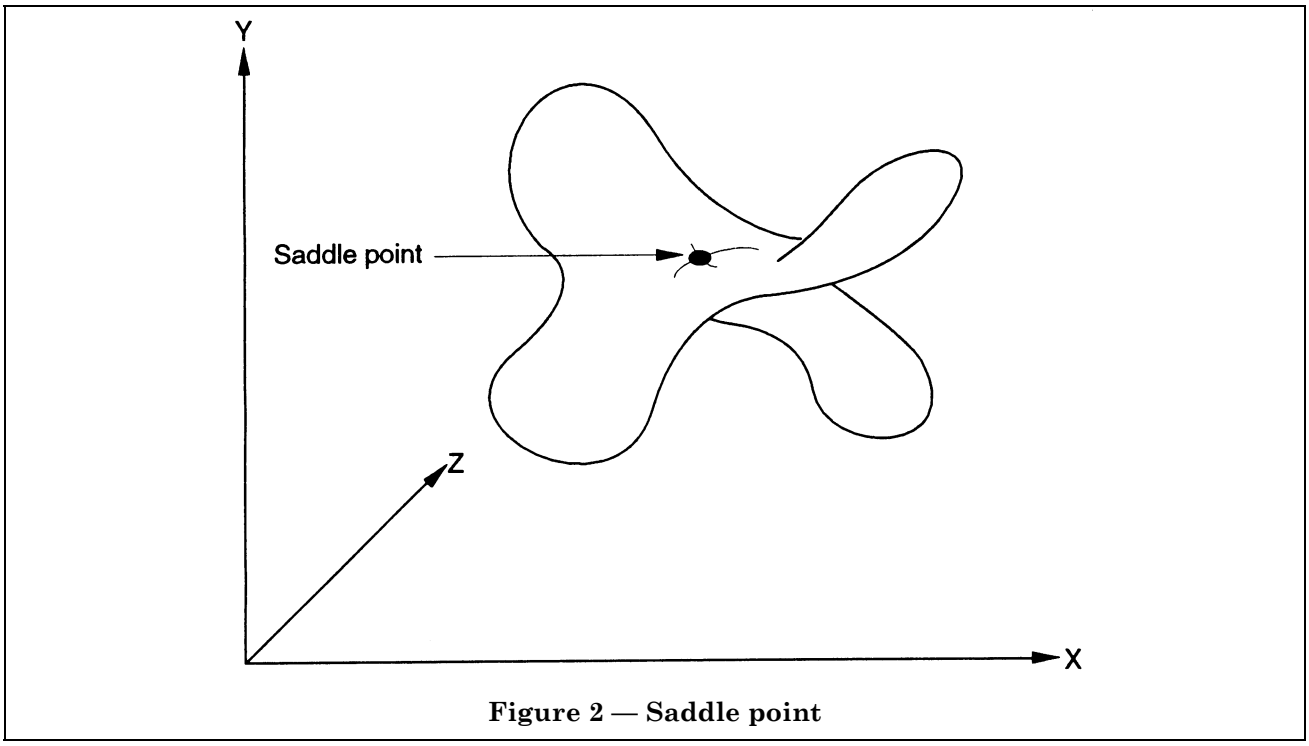


**Figure 2 — Saddle point**

| | | |
|---|---|---|
| 27010 | **strategy** | The selection of options for one of the players in each possible situation. |
| 27011 | **two-person game** | A *game* between two players. |
| 27012 | **zero-sum game** | A *game* for two or more players where the sum of the losses equals the sum of the gains. |

| No. | Term | Definition |
|---|---|---|

## 2.8 Multi-criteria decision making

COMMENT. If there are two or more existing clients providing criteria for decision and one or more decision makers and if there is more than one option or criterion to optimize, it can be proved mathematically that if the clients' responses to the criteria differ, there is no solution that optimizes for all parties.

| | | |
|---|---|---|
| 28001 | **aggregation of preferences** | The summation or combination of numerical values representing qualitative preferences for the various aspects of an outcome. |
| 28002 | **dominant strategy** | An approach that produces a better outcome than all others irrespective of all choices made by other parties. |
| 28003 | **goal programming** | An extension of *mathematical programming*, especially *linear programming*, in which solutions are judged according to a penalty function, that is associated with the sum of the distances of each criterion from its specified objective. |
| 28004 | **multi-criteria decision making** | Making a choice when there exists more than one option and at least one individual concerned has more than one criterion on which to evaluate a choice. |
| 28005 | **ordering of preferences** | Arranging preferences according to their value, having regard to sequential preferences, *transitivity* and completeness. |
| 28006 | **strong preference (for a solution)** | A solution that is preferred under all circumstances. |
| 28007 | **weak preference** | A solution preferred under at least one circumstance and indifferent under all others. |
| 28008 | **weighting** | Assigning a numerical value to each function or criterion, producing a ranked sequence.<br>NOTE The sum of the weighted values is taken as a measure of the overall preference for various outcomes. |
| 28009 | **weighting function** | A function, that may be continuous or discrete, for transforming the values assigned to each function or criterion. |

# Section 3. Queuing theory

| No. | Term | Definition |
|---|---|---|
| **3.1 General terms** | | |
| 31001 | **arrival rate** | The number of customers arriving at the *system* per unit time (usually denoted by $\lambda$). |
| 31002 | **waiting time**<br>queuing time | The time from the instant of a customer entering the *system* to the instant that the service begins. |
| 31003 | **service rate** | The number of customers that can be served per unit time at the service point (usually denoted by $\mu$). |
| 31004 | **sojourn time** | The total time a customer is in the *system*. |
| 31005 | **traffic intensity**<br>utilization factor<br>utilization intensity | The ratio of the *arrival rate* to the *service rate* (usually denoted by $\rho$, where $\rho = \lambda/\mu$). |
| **3.2 Arrival patterns** | | |
| 32001 | **arrival instant** | The time at which a specific customer arrives. |
| 32002 | **batched arrivals** | An arrival pattern such that each arrival event corresponds to the arrival of a batch of customers. |
| 32003 | **finite input source** | An input population of customers that is finite. |
| 32004 | **inter-arrival time** | The interval between successive arrivals of customers. |
| **3.3 Queues and queue disciplines** | | |
| 33001 | **balking** | Leaving one *queue* for another. |
| 33002 | **blocked customer** | A customer arriving during a *busy period*. |
| 33003 | **cyclic queues** | A set of *queues* in sequence serving $N$ units using ordered service, where a unit leaving the last phase of service waits for service in the *queue* of the first phase and so on, going through the *queue* and service of the phases in sequence. |
| 33004 | **first come, first served**<br>First In First Out (FIFO) | A discipline where customers are chosen for service in the order that they arrive. |
| 33005 | **gating** | A *system* in which an arriving customer who finds the server idle causes a gate to close. When this customer's service is complete, the gate opens and admits into a waiting room all those customers who arrive during this service time and then closes. When all customers in the waiting room have been served, the gate opens and admits into the waiting room all those customers who arrived during the collective service times of the preceding group of customers, after which it closes. The process continues in this manner. When the gate opens and finds no waiting customers, it remains open until the next arrival. |
| 33006 | **head of queue** | The customer who expects to be served next. |
| 33007 | **jockeying** | Continually moving from one *queue* to another. |
| 33008 | **last come, first served**<br>Last In First Out (LIFO) | A discipline where the next customer to be served is the one who arrived last. |
| 33009 | **lost customers** | Customers who leave the *system* without service. (See also 33015 *reneging*.) |
| 33010 | **queue discipline** | The rules determining which customer in a *queue* is to be served. |
| 33011 | **queue length** | The number of customers being served and waiting in the *queue*. |
| 33012 | **queue size** | The number of customers in the *queue* awaiting service. |
| 33013 | **random priority service** | An arbitrary priority assigned to the customer, set at the *arrival instant*. |

| No. | Term | Definition |
|---|---|---|
| 33014 | **random service** | A service where the server chooses the next customer to be served at random out of the waiting customers. (See also 33013 *random priority service*.) |
| 33015 | **reneging** | A customer leaving the *queue* without being served. (See also 33009 *lost customers*.) |
| 33016 | **virtual waiting time** at instant $t$ | The time a customer would wait if joining the *queue* at *instant t*. |

## 3.4 Service mechanisms

| | | |
|---|---|---|
| 34001 | **busy period** | Period when a server is occupied. |
| 34002 | **delayed interruption** non-break-in interruption postponed interruption | An interruption that occurs and is not attended to until the server finishes the service at hand. |
| 34003 | **delayed service** bulk service delay | A serving discipline for bulk *queues* where the server starts to serve the next batch only if the service capacity of this batch can be fully used.<br>NOTE *Delayed service* occurs if the server becomes idle and is ready for serving the next batch, but the number of available customers in the system is less than the service capacity for this batch. The server then waits until a sufficient number of new customers has arrived to fill this batch. |
| 34004 | **do-nothing policy** | A policy requiring that unoccupied servers are not diverted to ancillary work. |
| 34005 | **idle period** (of a server) | A period when the server is unoccupied and available. |
| 34006 | **interruption time** | The interval during which a lower priority customer has to wait. (See also 34011 *pre-emptive interruption* and 34002 *delayed interruption*.) |
| 34007 | **limited availability** | A feature of service channels that are not available for all services or for all customers (as opposed to full availability). |
| 34008 | **N-policy** | The policy where the server remains idle, although available, until there are $N$ customers to be served. |
| 34009 | **non-pre-emptive priority queues** | A queuing system where the service of a customer is allowed to finish although customers of higher priority have arrived during the service. (See also 34002 *delayed interruption* and 34011 *pre-emptive interruption*.) |
| 34010 | **occupation time** (of a server) | The interval required to complete (*at instant t*), the serving of all the customers in the *queue* at time $t$. |
| 34011 | **pre-emptive interruption break-in interruption** | An interruption that occurs when the server stops the service and attends a higher priority activity or customer. |
| 34012 | **pre-emptive priority** | The *degree* of priority such that when a customer of higher priority arrives during the service of a low priority customer, the low priority customer returns to the head of the *queue* of customers of the priority group and service commences on the higher priority arrival. |
| 34013 | **priority queues** | A queuing system where arriving customers are ranked according to priority of service. |
| 34014 | **server utilization** | The proportion of the available time during which the server is busy. |
| 34015 | **service time** holding time | The time taken to serve a customer. |

| No. | Term | Definition |
|---|---|---|
| 34016 | **T-policy** | A policy where the server is "turned off" at the end of a *busy period* (when there are no customers present) and "turned on" (i.e. made to look) after an interval of length $t$. If there are no customers present when the server looks, the server is turned off and looks again after another interval of length $t$. The procedure is repeated until the server finds a customer waiting. The server is then left on until the end of a *busy period*. |

## 3.5 Probability distributions and processes

COMMENT. Queuing situations are characterized by several *parameters*, three of which tend to be most important. A symbolic form $A/S/n$ has become established, and the meaning of these symbols is as follows.

$A$ is the arrival pattern, namely the distribution of the inter-arrival times.

$S$ is the service time distribution.

$n$ is the number of servers.

*A and S* can take the values *G* (or *GI*), *M, D* or *E*.

In the definitions in this section the *parameter* "r" stands for "$\lambda$" in the case of the inter-arrival distribution and "$\mu$" in the case of the service time distribution.

| | | |
|---|---|---|
| 35001 | **deterministic distribution**<br>Symbol: $D$ | A probability distribution defined by "$D$".<br>$F(x) = 0,\ x < r$<br>$= 1,\ x \geq r$<br>NOTE This is a useful approximation for variates that have very little variation. |
| 35002 | **Erlang distribution**<br>Symbol: $E_k$ | A probability distribution defined by<br>$f(x) = \frac{r(rx)^{k-1}}{(k-1)!}e^{-rx}\ x \geq 0$<br>$= 0 \qquad x < 0$<br>NOTE Mean = $k/r$; variance = $k/r^2$. |
| 35003 | **gamma distribution** | The *Erlang distribution* when $k$ is not an integer; the factorial function being replaced by the corresponding gamma function. |
| 35004 | **general distribution**<br>Symbol: $G$ | A distribution where no assumption is made about the form of the distribution functions. |
| 35005 | **negative exponential distribution**<br>Symbol: $M$ | A probability distribution defined by<br>$f(x) = re^{-rx}\ x \geq 0$<br>$= 0 \qquad x < 0$<br>NOTE Mean = $1/r$; variance = $1/r^2$.<br>The *inter-arrival time* distribution = when customers arrive independently of one another; the service time distribution = when the beginning and finish of the service are independent of one another. |
| 35006 | **Poisson process** | The process where the *inter-arrival times* are mutually independent random variables. |

# Section 4. Simulation

| No. | Term | Definition |
|---|---|---|
| **4.1 Basic terms** | | |
| 41001 | **continuous time simulation** | The construction and use of a *model* in which time is used as a continuous variable.<br>NOTE 1 The *model* is built around simultaneous differential equations that can use analogue or digital techniques of other areas, for example *games*, to obtain results.<br>NOTE 2 The *model* can contain random elements as well as analogue reading or display units, for example flight simulators. |
| 41002 | **Monte Carlo method** | The solution of a static problem by a process using *pseudo random numbers*.<br>NOTE This term is often loosely used to describe general simulation techniques and its use as such is deprecated. |
| 41003 | **pseudo random number** | A number from a sequence of numbers generated by a process that starts from a *seed* and that can replicate the sequence.<br>NOTE *Pseudo random numbers* behave, within defined limits, as if they were truly random. |
| 41004 | **seed** | An arbitrary number selected for starting the *pseudo random number* process.<br>NOTE The *parameters* following the selection of the *seed* will normally be a function of a generating process. |
| 41005 | **simulation** | The construction and use of a *model* that represents essential features of the behaviour of some *system* (usually through time).<br>NOTE 1 The purpose of *simulation* is to experiment with the value of the *parameters* of the *model* to study the behaviour of the *system* under various conditions of its operation.<br>NOTE 2 All *parameters*, including time, may be scaled in the use of the *model*. |
| 41006 | **what-if simulation** | The use of a deterministic model in which one or more *parameters* or conditions are changed for a single pass through the process. The effect or consequences of such decisions on the output of the *model*, or on the *states of nature*, are determined.<br>NOTE Normally *what-if simulation* uses *gaming* techniques. |
| **4.2 Time** | | |
| 42001 | **continuous time** | A view of time in the *simulation* in which it is treated as a continuous variable. |
| 42002 | **discrete time** | A view of time in the *simulation* in which it is regarded as taking discrete steps over the total simulated duration. |
| **4.3 Time handling** | | |
| 43001 | **activity based technique** | An approach where the *simulation clock* is advanced to the next earliest ending of an activity from amongst those in progress. |
| 43002 | **next event technique** | The approach where the *simulation clock* is advanced to the next expected *event*. |
| 43003 | **simulation clock** | A device by which the passage of time is controlled in the *model*.<br>NOTE It may run slower or faster than real time. |
| 43004 | **time slicing** | An approach where simulated time is moved forward in equal time increments. |

| No. | Term | Definition |
|---|---|---|

## 4.4 Variability

| | | |
|---|---|---|
| 44001 | **deterministic behaviour** | Behaviour that is entirely predictable when defined circumstances occur. |
| 44002 | **stochastic behaviour** | Behaviour that varies according to *probabilistic rules* and thus cannot be exactly predicted. |

## 4.5 Objects within a simulation model

| | | |
|---|---|---|
| 45001 | **attribute** | A property or characteristic that may be assigned to an *entity*. |
| 45002 | **class** | A collection of *entities* with similar properties. |
| 45003 | **entity** | An individual object studied in the simulation *model*. |
| 45004 | **set**<br>queue | A temporary ordered grouping of all those items in a *class* that are inactive waiting for a particular service. |
| 45005 | **steady state, of a simulation model** | A condition in a *model* such that the averages of the *parameters* of interest remain constant within a defined period.<br>NOTE This use is not as tightly constrained as the general use of *steady state*. |

## 4.6 Action within a simulation model

| | | |
|---|---|---|
| 46001 | **active state** | The state of taking part in an activity. |
| 46002 | **activity, of a simulation model** | An operation or process requiring two or more *entities* to cooperate in the time-consuming execution of a task. |
| 46003 | **activity cycle diagram** | A simple flow diagram in which the progress of each *class* follows a *path* made up of alternate *active* and *passive states*.<br>NOTE The *active states* are normally represented by rectangles and the *passive states* by circles. The interaction of these processes defines the behaviour of the *entities* in the *system*. |
| 46004 | **event** | An instant of time when a state change occurs to one or more *entities*. |
| 46005 | **event routine** | A statement of all possible logical consequences of the occurrence of a specified *system event*. |
| 46006 | **passive state** | A state in which the *entity* is inactive. |

| No. | Term | Definition |
|---|---|---|

## 4.7 Model representations

| | | |
|---|---|---|
| 47001 | **activity based model** | A *simulation model* where the behaviour of all *entities* is described as an alternation of *sets* and *activities*. |
| 47002 | **analogue model** | A *physical model* where a similar concept of the real world *entity* is represented by a different physical means.<br>NOTE For example an electrical circuit may be used to model a mechanism. |
| 47003 | **event based model** | A *simulation model* where the behaviour of all *entities* is described by a group of *event routines*. |
| 47004 | **homomorphic model** | A *model* where one element represents one element of the real world. |
| 47005 | **iconic model** | A pictorial *model* where the scale has been changed. |
| 47006 | **isomorphic model** | A *model* where one element represents many elements in the real world.<br>NOTE For example an average invoice may be used to represent a million real invoices. |
| 47007 | **mathematical model** | A representation of the real world *entity* or situation, expressed in terms of mathematical, statistical and/or logical functions. |
| 47008 | **physical model** | A *model* constructed from material that represents real world entities or concepts that may be abstract. |
| 47009 | **rate model** | A representation in which the rate of change of the *parameters* over a period, rather than discrete changes, is of interest. |

# Section 5. Gaming

| No. | Term | Definition |
|---|---|---|

COMMENT. The *simulation* of conflict situations such as competitions, bargaining and negotiations, is known as *gaming*. In general such situations are not amenable to analysis using techniques from the theory of games.

NOTE See also terminology in section **9**.

## 5.1 Basic terms

| | | |
|---|---|---|
| 51001 | **coordinator** | The communication link between player and the *system* analysing the game. |
| 51002 | **gaming** | The *simulation* of a competitive or combative situation, where opposing players decide what course(s) of action to follow based on their knowledge about their position, resources and intentions and their (usually incomplete) information about their opponents. |
| 51003 | **post-game analysis** | The use of data generated during a game or series of games to derive conclusions about the problem to which play is directed. |
| 51004 | **scenario** | A description of the present or a future situation in terms of participants and their available options. |
| 51005 | **side analysis** | An evaluation of game events conducted separately from the main flow of the game. |

## 5.2 Gaming concepts

| | | |
|---|---|---|
| 52001 | **cycle (in gaming)** | The complete sequence of *events* for a player to make a single *move* in a *game*. |
| 52002 | **deterministic rule** | A *rule* where the results have no random element. |
| 52003 | **level of game** | The level in the hierarchy of management or control simulated by the *game*. |
| 52004 | **probabilistic rule** | A *rule* that states the results in terms of a probability density function. |
| 52005 | **resolution** | The smallest elements of management, time and other *game variables* represented in the *game*. |
| 52006 | **rule** | An objective statement of the results of any particular action or interaction of the participants in the *game*. |

## 5.3 Elements of games

| | | |
|---|---|---|
| 53001 | **critical event gaming** | A method of *gaming* in which *cycles* advance from significant event to significant event. |
| 53002 | **game interval** | The length of a *game* cycle measured in *game time*. |
| 53003 | **game parameter** | A measurable condition that is (assumed to be) constant with respect to *game time*. |
| 53004 | **game time** | A duration within the context of the *game*, as measured from the point of view of the simulated elements in the *game*. |
| 53005 | **game variable** | A measurable condition that is a function of *game time*. |
| 53006 | **playing time** | A duration within the context of the *game* measured in real time. |
| 53007 | **playing time ratio** | The ratio of the *playing time* to the corresponding *game time*. |
| 53008 | **starting condition** game direction | Instruction and information issued to players to initiate *play*. |
| 53009 | **state (of a game entity)** | A set of values for the *game variables* that describe an *entity* in the *game* at a given *game time*. |

| No. | Term | Definition |
|---|---|---|

## 5.4 Tactical situations

| | | |
|---|---|---|
| 54001 | **assurance** | A bargaining tactic designed to maintain the element of challenge that is inherent in the different preferences of the participants for outcomes in a conflict situation; and that does so in a way that minimizes the possibility that the challenge will be considered intimidating. |
| 54002 | **break point** | The critical level for the continued existence of a participant in a *game*, below which a player is considered unable to fulfil an assigned function. |
| 54003 | **conflict point** | A situation sometimes reached in bargaining where all (or most) participants are not moving towards a settlement. |
| 54004 | **power** | The (relative) ability to impose an outcome on other participants in a (complex) *game*. |
| 54005 | **quasi-natural event** | An *event* with unknown cause and no evident bias in favour of any individual participant in a *game*. |

## 5.5 Tactical moves

| | | |
|---|---|---|
| 55001 | **accommodation move** | A bargaining *move* designed to create an atmosphere conducive to settlement of a conflict. |
| 55002 | **coercive move** | A bargaining *move* designed to influence opponents to accept one's more preferred outcomes. |
| 55003 | **log-rolling** | An agreement between (usually) two participants where one supports the other in one problem situation, in return for a similar support in another. |
| 55004 | **pure communication move** | A *move* in bargaining involving only passage of information. |
| 55005 | **structural move** | A *bargaining move* that involves the narrowing or widening of the options of a participant, usually by committing assets or resources. |
| 55006 | **unilateral improvement** | An improvement in the outcome for a participant on a particular *scenario* by the unilateral action of the participant, possibly subject to sanctions by other participants. |

## 5.6 Types of game

### 5.6.1 Purpose

| | | |
|---|---|---|
| 56101 | **development game** | A *game* used to develop and perfect techniques of *play*, and to test the adequacy of proposed *rules*. |
| 56102 | **research game** | A *game*, the primary purpose of which is research into some given competitive situation or into possible techniques of *play*. |
| 56103 | **variation game** excursion | A *play* with some variation in starting or subsequent conditions from previous *plays*. |

### 5.6.2 Information

| | | |
|---|---|---|
| 56201 | **closed game** | A *game* where participants have only partial knowledge of their own and the other participants' situation. |
| 56202 | **game security** | Information denied to one, some or all participants prior to, or during, the *game*. |
| 56203 | **open game** | A *game* where all participants have full knowledge of each other's positions and actions. |

| No. | Term | Definition |
|---|---|---|
| **5.6.3 Opposition** | | |
| 56301 | **game against nature** | 1) A probabilistic situation where nature is responsible for all chance *events*.<br>2) A *game* where one of the players (nature) makes *moves* regardless of whether these *moves* hinder or help the opponents. |
| 56302 | **one-sided game** | A *game* where one of the opposing participants is played by the *controller* or computer. |
| **5.6.4 Rules for outcomes** | | |
| 56401 | **free game** | A *game* where the results of interactions between players are determined subjectively by the *controller* (on the basis of experience and judgement). |
| 56402 | **rigid game** | A *game* where the results of interactions between players are determined objectively by predetermined *rules*, data and procedures. |
| **5.6.5 Conformity** | | |
| 56501 | **controlled-play game** | A *game* where the tactical *moves* of the players need to conform to the *scenario*. |
| 56502 | **free-play game** | A *game* where the player is free to make any tactical *move* consistent with personal resources and the *game* objective. |

## 5.7 Gaming environment

| | | |
|---|---|---|
| 57001 | **conflict analysis** | A formal representation of the relationships between individuals and groups that have different, wholly or partially incompatible objectives and/or options for action. |
| 57002 | **controller** | The authority that determines the *parameters* of the *game* and evaluates the results. |
| 57003 | **drama methods** | A variety of different real-time dynamic approaches to depicting, or working with, problems and issues including approaches such as role play. |
| 57004 | **facilitating** | Assisting an individual or a group in the process of debate or decision-making about an issue or concern. |
| 57005 | **hypergame** | An extension of the concept of *game*, to recognize explicitly the possibility that different players may have different perceptions about the *strategies* and preferences of the various players. |
| 57006 | **metagame** | An extension of the concept of *game*, to include the processes leading to an agreement about the *rules* for the *game* to be played. |
| 57007 | **metagame analysis** | An analysis of a *metagame* situation, in the first stage of which the issues to be decided are identified, and the participants who directly or indirectly control these issues, together with the options available to each participant. In the second stage different *scenarios* are analysed, infeasibilities are identified, and threats and promises are explored. |

# Section 6. Forecasting

| No. | Term | Definition |
|---|---|---|

COMMENT. Forecasting includes many techniques that are subjects in their own right with their own terminology, for example *econometrics*. The specialist terminology for these subjects has not been included in this glossary.

## 6.1 Basic terms

| | | |
|---|---|---|
| 61001 | **econometrics** | The quantitative examination of economic relationships using statistical methods and the formulation of *models* to study economic phenomena. |
| 61002 | **forecast** | A prediction of the future value of a variable. |
| 61003 | **forecast base** | The value of a variable at the time a *forecast* is made. |
| 61004 | **forecast frequency** | The frequency with which *forecasts* are made. |
| 61005 | **forecast horizon** | The time span over which the *forecast* is made. |
| 61006 | **forecast intervals** | The time intervals into which the *forecast horizon* is divided. |
| 61007 | **forecast lead time** | The interval between the time when a *forecast* is made and the period to which the *forecast* refers. |

## 6.2 Basic time series terminology

| | | |
|---|---|---|
| 62001 | **difference series** | A transformation of a time series, $Z$, of $n$ observations creating a new time series, $W$, by taking, for a difference of order $s$, as follows.<br>$W_t = Z_t - Z_{t-s}, t = s,....n.$<br>Differences are employed to achieve *stationarity*. |
| 62002 | **distributive lags** | A description of the way the influence of a variable is spread over time. The distribution of the influence is assumed to follow a particular mathematical form, the details of which may then be estimated using statistical techniques. |
| 62003 | **endogenous variable** | A variable that may be *forecast* and controlled within the *model*. |
| 62004 | **exogenous variable** | A variable that is determined outside the *model*. It may be *forecast* but not altered by the *model*. |
| 62005 | **initial conditions** | A set of computational procedures for deriving the values of all necessary *model parameters* for a forecasting system from a set of historical data. |
| 62006 | **lag indicator** | An indicator whose peaks and troughs during the *forecast* period occur later than those of the *forecast model*. |
| 62007 | **lead indicator** | An indicator whose peaks and troughs during the *forecast period* occur sooner than those of the *forecast model*. |
| 62008 | **moving average** | The time series of arithmetic averages obtained by averaging the last $n$ successive terms in a time series, these terms being spaced at equal intervals.<br>NOTE Each average is usually obtained by dropping from the computation the oldest term used in the preceding group of $n$ terms and adding in its place the newest term to be included in the new $n$-group. |
| 62009 | **stationarity** | Characteristic of a process with a joint distribution that is invariant with regard to displacement in time.<br>NOTE The basic theory of forecasting assumes that time series data either exhibits *stationarity* or can be transformed to this state. |
| 62010 | **weighted moving average** | A moving average where weights are assigned to each term of the group of $n$ successive terms. Usually the weights are decreasing with increasing age of the data. |

| No. | Term | Definition |
|---|---|---|
| **6.3 Decomposition of time series** | | |
| 63001 | **Census II decomposition (XII)** | A *decomposition method* for time series designed by the US Bureau of the Census and used worldwide for deseasonalizing. |
| 63002 | **classical decomposition** | A simple method of separating *trend, seasonality, cycle* and randomness of time series. |
| 63003 | **decomposition methods** | Methods that seek to break the underlying pattern of a time series into cyclical, seasonal, *trend* and random components. The components are analysed individually, extrapolated and recombined to obtain *forecasts*. |
| 63004 | **seasonality** | The behaviour of a (*forecast*) variable that recurs from year to year.<br>NOTE 1 It is caused by the seasonal pattern about the underlying *trend*.<br>NOTE 2 Other cyclic patterns of behaviour may have time scales other than annual. |
| 63005 | **trend** | The behaviour of a time series showing a consistent increase or decrease over time. |
| **6.4 General forecasting methods** | | |
| 64001 | **adaptive forecasting model** | A *model* where the *parameters* are modified when new information becomes available. |
| 64002 | **aggregate model** | A *model* representing a situation at a global level in a single equation, or at least in a very limited number of equations. |
| 64003 | **benchmark forecast** | A *forecast* based on objective data ex ante *forecast* inputs prior to personal bias and negotiation. |
| 64004 | **Delphi** | A forecasting technique offering a systematic and rational means of obtaining the relevant intuitive insights of experts. |
| 64005 | **econometric forecasting** | The development of explanatory forecasting models using quantitative measures, including multiple regression techniques.<br>NOTE This approach employs a collection of causal relationships to describe the forecasting environment. |
| 64006 | **judgmental forecasting** | 1) The practice of developing *forecasts* based on the intellectual experience of the staff.<br>2) Informal forecasting with little or no formal analysis of quantitative data. |
| 64007 | **macro forecasting** | Forecasting global values as defined by the problem boundaries. (See also 93005 *boundary questions*.) |
| 64008 | **micro forecasting** | Forecasting at the unit operating level. |
| 64009 | **naive model** | A *model* that uses only the most recent available data as the future *forecast*. |
| 64010 | **parsimonious model** | A *model* with the least possible number of estimated coefficients. |
| 64011 | **quantitative forecasting** | The development of a forecasting *model* using statistical methods that analyse numeric data representing the historical records. (See also 61001 *econometrics*.) |
| 64012 | **time series forecasting** | Prediction of a variable value at equal time intervals into the future. |

| No. | Term | Definition |
|---|---|---|
| **6.5 Specific forecasting methods and models** | | |
| 65001 | **adaptive smoothing** | A *forecast model* that allows variable rather than fixed coefficients. |
| 65002 | **ARIMA** | A mnemonic for autoregressive (AR), integrated (I), *moving average* (MA), the name of a broad *class* of time series *models*. |
| 65003 | **Bayesian forecasting** | A forecasting, learning and analytical procedure that operates according to the principle of management by exception.<br>NOTE *Forecasts*, "what-if" analyses, information updating and retrospective "what happened" analyses are carried out using probability *models* applied routinely to regular data and exceptionally to expert information. The quality of performance is continually monitored, and when suspect, danger signals are issued often resulting in expert intervention. |
| 65004 | **Box-Jenkins forecasting** | A time series technique that makes use of the ARIMA *models* and derivatives for univariate and multivariate forecasting, using adaptive *parameters*. |
| 65005 | **exponential smoothing** | A method of systematically revising a *forecast model* where the revisions are carried out by assigning exponentially decreasing weights to older observations.<br>NOTE *Exponential smoothing* may be single smoothing for horizontal *trend* models, double smoothing for linear *trends* or triple smoothing for non-linear *trends*. |
| 65006 | **smoothing constants** | Coefficients in a forecasting *model* with values between 0 and 1 that control how quickly the *forecast* reacts to real changes in the observed data. |
| **6.6 Comparison of forecast and actual values** | | |
| 66001 | **A/F ratio** | Actual value of a variable divided by its *forecast* value. |
| 66002 | **error**<br>residual | The difference between a *forecast* and an actual value within the *model*. |
| 66003 | **error cost function** | A function that assigns a cost to the effect of an *error*.<br>NOTE The most frequently used form of the *error cost function* is quadratic. |
| 66004 | **feedback** | The use of *error* measure(s) in generating subsequent estimates. |
| 66005 | **forecast bias**<br>systematic error | An indication of the discrepancy when the magnitudes of *forecast errors* in one direction exceed those in the other direction. |
| 66006 | **forecast confidence level** | A measure of the confidence that a *forecast* lies within a defined interval. |
| 66007 | **forecasting randomness**<br>forecasting noise | The *errors* in *forecasting* due to unexplained variations. |
| 66008 | **judgmental adjustment** | A change to a *forecast*, taking into account additional (possibly subjective) information, that was not included in the *forecasting* technique. |
| 66009 | **mean absolute deviation (MAD)** | The arithmetic mean of the deviations from an origin when all deviations are given a positive sign.<br>NOTE For the standardized normal distribution the value of the *mean absolute deviation* is about 0.8. |
| 66010 | **mean absolute percentage error (MAPE)** | The *mean absolute deviation* (MAD) expressed as a percentage. |
| 66011 | **root mean squared error (RMSE)** | The square root of the average value of the square of all *errors*. |
| 66012 | **robustness, forecasting** | The insensitivity of a *forecast* to measurement *error*, assumption, mis-specification or any other disturbance. |
| 66013 | **tracking signal** | The result of a computation process based on the *error* in a *forecast*. It may be used to alert the forecaster to the need for intervention or to provide an automatic correction procedure. |

# Section 7. Graph theory

| No. | Term | Definition |
|---|---|---|
| **7.1 Basic terms** | | |
| 71001 | **arc** | A directed *edge*. |
| 71002 | **degree** | Of a *vertex*, the number of positive and/or negative *incidents* on that *vertex*. |
| 71003 | **distinct** | Differing in at least one relevant *attribute*.<br>NOTE Although this definition is not at variance with the dictionary definition, the term has been included here to highlight the precise usage in *graph* theory and mathematics in general. |
| 71004 | **edge** | An undirected connection of a *vertex* to another *vertex* or to itself. |
| 71005 | **graph** | A non-empty *set* V, of points called *vertices*, and a set E of *edges* that join some pairs of these points. |
| 71006 | **incident** | 1) An *edge* that connects to a *vertex* is said to be (an) *incident* on that *vertex*.<br>2) An *arc* orientated from *vertex* $V_1$ to *vertex* $V_2$ is said to be positively *incident* on $V_2$ and negatively *incident* on $V_1$. |
| 71007 | **intersection** | Of two *edges* or *arcs*, if in the plane representation of the *graph* they have one point in common that is not a *vertex*. |
| 71008 | **loop**<br>self-loop | An *edge* that is *incident* on only one *vertex*. |
| 71009 | **negative degree**<br>out-degree | The number of negative *incidents* on an out-degree *vertex*. |
| 71010 | **node** | A *vertex* for which two or more *arcs* have the same incidence.<br>NOTE There may be *arcs* present with the opposite incidence. |
| 71011 | **planar graph** | A *graph* that can be embedded in a plane such that its *edges* meet only at the *vertices*. |
| 71012 | **positive degree** | The number of positive *incidents* on an in degree *vertex*. |
| 71013 | **vertex** | One of the set of points in a *graph*. |
| **7.2 Terms relating to undirected graphs and graphs in general** | | |
| 72001 | **adjacent edges** | Two or more *edges* that have at least one *vertex* in common. |
| 72002 | **adjacent vertices** | Two vertices that are joined by at least one *edge*. |
| 72003 | **chain** | An *open edge sequence* where all the *edges* are distinct. |
| 72004 | **circuit** | A connected *subgraph* where every *vertex* is of *degree* 2. |
| 72005 | **closed edge sequence** | An *edge sequence* where $V_0$ is equal to $V_n$. |
| 72006 | **connected graph** | A *graph* where every pair of its *vertices* is joined by at least one simple *chain*. |
| 72007 | **cut point**<br>articulation point | A *vertex* in a *connected graph* such that the graph obtained by removing this *vertex* and its *incident edges* results in a *disconnected graph*. |
| 72008 | **degenerate graph** | A finite *graph* where the set of *edges* is empty. |
| 72009 | **disconnected graph** | A *graph* that is not connected. |
| 72010 | **dominating set of vertices** | A set $V_1$ of *vertices* is considered to be dominating if every *vertex* of the *graph* not included in $V_1$ is adjacent to at least one *vertex* included in $V_1$. |
| 72011 | **dual graph** | A graph $G_2$ where a *vertex set* $V_2$ replaces the *regions* of the plane representation of a *planar graph* $G_1$ and where the *edges* are formed by joining vertices in $V_2$ that are in adjacent regions once for each *edge* in $G_1$ that separates these *regions*.<br>NOTE 1 $G_1$ is called the primal graph. The *dual graph* of the *dual graph* is the primal graph. |

| No. | Term | Definition |
|---|---|---|
| | | NOTE 2 *Edges* connected to pendant *vertices* in the primal graph become *loops* in the *dual graph* that are *incident* on the *node* corresponding to the exterior *region*. |
| 72012 | **edge sequence** | A finite sequence of adjacent, not necessarily *distinct edges*, that are traversed between two vertices $V_0$ and $V_n$. |
| 72013 | **finite graph** | A *graph* with a finite number of *vertices* and *edges*. |
| 72014 | **fully connected graph**<br>maximal graph | A *graph* where every *distinct vertex* is adjacent to every other *distinct vertex*. |
| 72015 | **independent set of vertices** | A set of vertices such that no two of them are adjacent. |
| 72016 | **isolated vertex** | A *vertex* of *degree* zero. |
| 72017 | **isomorphic graphs** | Two (or more) *graphs* with one-to-one correspondence between their *vertex sets* such that adjacency is preserved. |
| 72018 | **K-regular graph** | An undirected *graph* where every *vertex* has *degree K* or a *directed graph* in which at every *vertex* the sum of the positive and negative *incidents* is equal to *K*. |
| 72019 | **length of an edge sequence** | The number of *edges* in an edge sequence. |
| 72020 | **non-separable graph** | A *graph* that contains no *cut point*. |
| 72021 | **open edge sequence** | An *edge sequence* where $V_0$ is not equal to $V_n$. |
| 72022 | **parallel edges** | Two or more *edges* having the same *incident vertices*. |
| 72023 | **regions**<br>faces | In a *planar graph*, the areas enclosed by the sets of *edges* forming the smallest possible *closed edge sequences*.<br>NOTE The portion of the plane outside the *graph* is also a *region* and is called the infinite, unbounded or exterior region. Which of the *regions* is the infinite region depends on how the *planar graph* has been represented in the plane. |
| 72024 | **regular graph** | An undirected *graph* where all *vertices* have the same *degree*. |
| 72025 | **separable graph** | A *graph* that contains at least one *cut point*. |
| 72026 | **simple chain** | An *edge sequence* where the *vertices* are *distinct*. |
| 72027 | **simple circuit** | An *edge sequence* where $V_0$ and $V_n$ are equal and all *vertices* are only visited once. |
| 72028 | **simple graph** | A *graph* with no *loops* or *parallel edges*. |
| 72029 | **spanning tree** | A *tree* that includes all the *vertices* in a *graph*. |
| 72030 | **strongly connected graph** | A *graph* where for every pair of vertices $V_i$ and $V_j$ there is *path* from $V_i$ to $V_j$ and a separate *path* from $V_j$ to $V_i$. |
| 72031 | **tree** | An undirected *subgraph* where any two *vertices* are connected by exactly one *chain*. |

| No. | Term | Definition |
|---|---|---|

## 7.3 Terms relating to directed graphs

| | | |
|---|---|---|
| 73001 | **acyclic graph** | A *directed graph* with no *cycles*. |
| 73002 | **adjacent arcs** | Two or more *arcs* that have the same incidence on a common *vertex*. |
| 73003 | **arc progression** | An *arc sequence* between a *vertex* $V_0$ and a *vertex* $V_n$ in an *acyclic graph*. |
| 73004 | **arc sequence** | A finite, unbroken sequence of *arcs*, not necessarily *distinct*, that are traversed in the direction $V_0$ to $V_n$. |
| 73005 | **balanced directed graph** | A *K-regular directed graph* where the number of positive *incidents* equals the number of negative *incidents* at every *vertex*. |
| 73006 | **branch** | A *path* where the first and last vertices are *nodes* or where only the first *vertex* is a *node*. |
| 73007 | **cycle (of a graph)** | An *arc sequence* where $V_0$ equals $V_n$. |
| 73008 | **cyclic graph** | A *directed graph* containing *cycles*. |
| 73009 | **directed graph** | A *graph* where all the members of the set of *edges* are *arcs*. |
| 73010 | **directed isomorphic graph** | Two (or more) directed graphs, for which the corresponding undirected *graphs* are isomorphic and the corresponding *arcs* preserve direction. |
| 73011 | **directed tree** | A directed *subgraph* for which the corresponding undirected *subgraph* is a *tree*. |
| 73012 | **(strictly) parallel arcs** | Two or more *arcs* having the same incidences at their common *vertices*. |
| 73013 | **path** | An *arc sequence* where all *arcs* are *distinct*. |
| 73014 | **regular directed graph** | A *balanced directed graph* where every *vertex* has the same positive *degree* and negative *degree* as every other *vertex*. |
| 73015 | **simple cycle** | An *arc sequence* where $V_0$ and $V_n$ are the same and all *vertices* are only visited once. |
| 73016 | **simple directed graph** | A *directed graph* with no *loops* or parallel *arcs*. |
| 73017 | **simple path** | A *path* where all the *vertices* are *distinct*. |

## 7.4 Additional terms

NOTE Several graph theory terms relating to the optimization of networks are included in section **2**.

| | | |
|---|---|---|
| 74001 | **bipartite graph** | A *graph* that can be partitioned into two *vertex sets* such that every *edge* has one end point in each set. |
| 74002 | **complementary graph** | The complementary *graph* $G_2$ of a simple *graph* $G_1$ is obtained by deleting the *edges* of $G_1$ from a *complete graph* having the same vertices as $G_1$. |
| 74003 | **complete bipartite graph** | A *bipartite graph* where each *vertex* in one set is adjacent to every *vertex* in the other set. |
| 74004 | **complete graph** | A *graph* where every pair of *distinct* vertices is joined by at least one *edge*. |
| 74005 | **component** | A fully connected *subgraph*. |
| 74006 | **subgraph** | A *graph* completely contained in another *graph*.<br>NOTE A *graph* $G_1$ is a *subgraph* of a *graph* G if $G_1$ is completely contained in G. |
| 74007 | **supergraph** | A *graph* completely containing another *graph*.<br>NOTE If $G_1$ is the *subgraph* of a *graph* G then G is the *supergraph* of $G_1$. |

# Section 8. Decision theory

## 8.1 Terms and definitions

| No. | Term | Definition |
|---|---|---|
| 81001 | **decision conference** | A gathering at which the *stakeholders* and their support staff combine to resolve a problem or reach a decision.<br>NOTE Support staff may include recorders, facilitators and analysts as necessary. |
| 81002 | **decision problem** | The problem of choosing one out of a mutually exclusive *set* of alternative actions $a_i$ (i = 1,....,m) when presented with a number of mutually exclusive *states of nature* $s_j$ (j = 1,....,n), when action $a_i$ in state $s_j$ results in consequence $x_{ij}$. |
| 81003 | **decision table** | A tabular representation of a *decision problem*, see Figure 3. |

General form of a decision table:

| | States of nature | | | |
|---|---|---|---|---|
| Actions | $s_1$ | $s_2$ | --- | $s_n$ |
| $a_1$ | $x_{1,1}$ | $x_{1,2}$ | --- | $x_{1,n}$ |
| $a_2$ | $x_{2,1}$ | $x_{2,2}$ | --- | $x_{2,n}$ |
| --- | --- | --- | --- | --- |
| $a_m$ | $x_{m,1}$ | $x_{m,2}$ | --- | $x_{m,n}$ |

**Figure 3 — Decision table**

| No. | Term | Definition |
|---|---|---|
| 81004 | **decision tree** | A pictorial representation of a *decision problem,* see Figure 4.<br>NOTE A multi-stage *decision problem* can be represented by introducing further decision points later in the *tree*. |

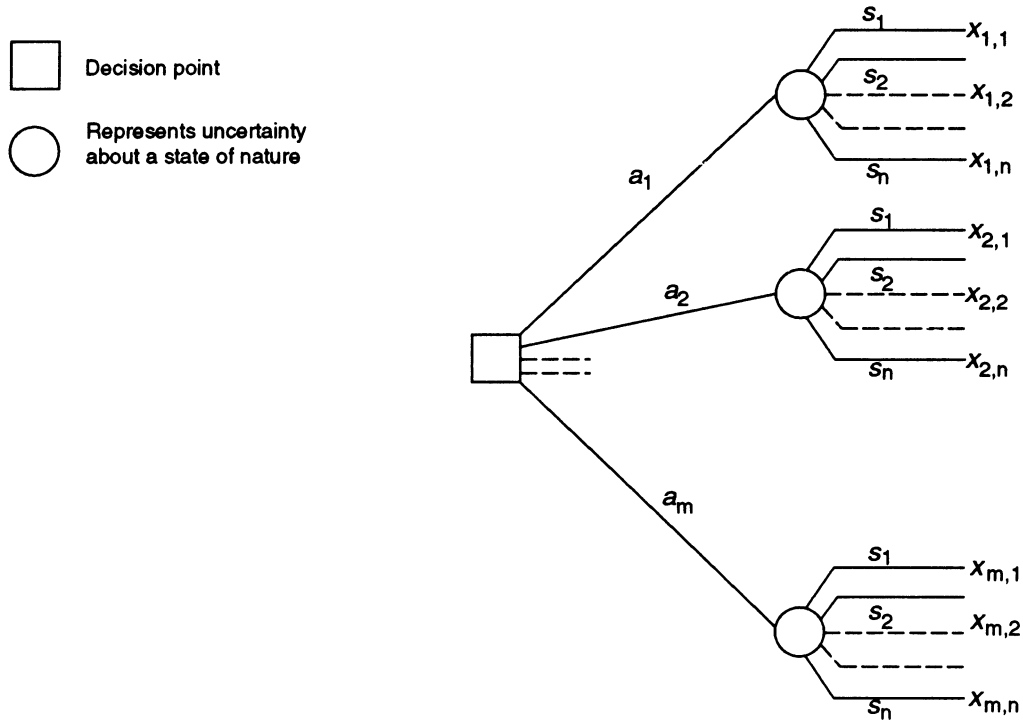


**Figure 4 — Decision tree**

| | | |
|---|---|---|
| 81005 | **decomposition (in decision theory)** | Breaking down a complex *decision problem* into its simpler component parts. [See also 24010 *decomposition (in LP)*.] |
| 81006 | **hazard** | A source of potential harm or a situation with a potential for harm in terms of human injury, damage to property, damage to the environment, or some combination of these. |
| 81007 | **independent (beliefs)** | A situation in which belief A remains unchanged regardless of the state of information about belief B. |
| 81008 | **payoff** | The consequences of a decision. |
| 81009 | **payoff table (in decision theory)** | The output from a *decision table*. |
| 81010 | **preferentially independent (attribute)** | A situation where, if *attribute* B is held constant, a greater level of *attribute* A is always preferred.<br>NOTE In this situation *attribute* A is said to be *preferentially independent* of *attribute* B. |
| 81011 | **regret** | A measure of the benefit lost by taking a particular action $a_i$ under state of nature $s_j$. |
| 81012 | **risk** | The combination of the frequency, or probability, and the consequence of a specified hazardous *event*.<br>NOTE The concept of *risk* always has two elements; the frequency with which a *hazard* occurs and the consequences of the hazardous *event*. *Risk* differs from uncertainty in that the range of outcomes are known and the probability of a particular outcome can be estimated. |

| No. | Term | Definition |
|---|---|---|
| 81013 | **risk analysis** | The systematic use of available information to identify *hazards* and to estimate *risk* to individuals or populations, property or the environment.<br>NOTE *Risk analysis* for a defined system consists of *hazard* identification and *risk* estimation. |
| 81014 | **risk assessment** | The overall process of *risk analysis* and *risk evaluation*. |
| 81015 | **risk averse** | Using a policy where reduction of *risk* is an important part of the choice. |
| 81016 | **risk evaluation** | The stage at which values and judgements enter the decision process explicitly or implicitly by including consideration of the importance of the estimated *risks* and the associated social, environmental and economic consequences in order to identify a range of alternatives for managing the *risks*. |
| 81017 | **risk management** | The systematic application of management policies, procedures and practices to the tasks of identifying, analysing, evaluating and controlling *risk*.<br>NOTE *Risk management* is a process whereby decisions are made to accept a known or assessed *risk* and/or the implementation of actions to reduce the consequences or probability of occurrence. |
| 81018 | **risk neutral** | Using a policy that ignores or is indifferent to *risk*. |
| 81019 | **risk prone** | A condition in which the decision maker's *utility function* is convex. |
| 81020 | **risk seeking** | Using a policy for maximizing the benefit and selecting the best outcome regardless of *risk*. |
| 81021 | **stakeholder** | A person or group of people who have a vested interest in the success of an organization and the environment in which the organization operates.<br>NOTE A vested interest is a permanent interest. |
| 81022 | **state of nature** | A particular set of values that external factors might assume.<br>NOTE 1 External factors are those that are not under the control of the decision maker or were unknown when the decision was made.<br>NOTE 2 In a *decision problem* it is assumed that the *states of nature* are mutually exclusive (no two states can be in effect at the same time) and collectively exhaustive (all possible states are incorporated). |
| 81023 | **transitivity** | The property of preferences such that if A is preferred to B and B is preferred to C, then A is preferred to C. |
| 81024 | **utility** | A measure of a decision maker's relative preference to the outcomes of a *decision problem*.<br>NOTE The assessment of *utility* is a complex activity involving quantification of subjective feelings and attitudes towards *risks* and benefits. |
| 81025 | **utility function** | The set or function of *utility* ($U$) values of the decision maker to the possible outcomes ($x_n$) of a *decision problem*, such that $U(x) > U(x_1)$, if and only if $x$ is preferred to $x_1$. |

# Section 9. Soft operational research

| No. | Term | Definition |
|---|---|---|
| **9.1 Basic terms** | | |
| 91001 | **hard OR** | A term used to characterize *operational research* methodologies or sets of techniques that are based largely on quantitative methods, including statistics, that are often aimed at *optimizing* solutions to complex problems in management. |
| 91002 | **soft OR** | Types of process, methodology, or sets of techniques of *operational research* that incorporate subjective or qualitative elements (contrasting and in some situations complementary to those of *hard OR*). They emphasize structuring problems rather than problem solving, and are concerned with finding requisite or *satisficing* solutions in problems situations particularly where relationships with people are involved.<br>NOTE Many of the techniques used in *soft OR* are themselves rigorous, although the data are not. |
| 91003 | **systems thinking** | The use of the notion of *system*, and its main *components* (element, relationship, boundary, input, output, *environment, feedback*) as means of organizing, structuring or modelling thoughts about real world situations. |
| **9.2 Soft systems methodology** | | |
| COMMENT. To help the user of the standard, the terms in **9.2** are presented in the order in which these concepts are carried out in Figure 5. | | |
| 92001 | **Soft Systems Methodology (SSM)** | An iterative method involving real world discussions of the problems and *systems thinking* aimed to produce *models* of the situation, so that informed debate and choice of action can occur. Substantial stages in this are *rich pictures, root definitions, conceptual modelling,* and comparisons of these *models* with real world actions, defining desirable and feasible changes, and taking actions. See also Figure 5. |
| 92002 | **rich picture** | In *Soft Systems Methodology,* a method of illustrating known hard factual data and soft subjective information about a particular unstructured situation. A cartoon-style representation is used to depict the elements, characteristics, relationships and communication links pertaining to a given situation. |
| 92003 | **root definition** | In *Soft Systems Methodology,* a precise written definition of the features and characteristics of a process that has been identified with a relevant *system* within a given situation.<br>NOTE Well-formulated *root definition* contains six elements. (See also 92004 *CATWOE*.) |
| 92004 | **CATWOE** | A mnemonic for the six elements of a well-formulated *root definition,* as follows.<br>Customer: persons affected by the purposeful activity.<br>Actor: performers of the purposeful activity.<br>Transformation: the purposeful activity that converts some input(s) to some output(s).<br>Weltanschauung the view of the world that makes the transformation process meaningful.<br>Owner: the person or set of persons with the executive power to change or stop the activity.<br>Environment: the external constraints that the system takes as given. |
| 92005 | **conceptual model** | In *Soft Systems Methodology,* a representation of the logical activities and processes that need to go on if the *system* is to function as described in its *root definition.* |

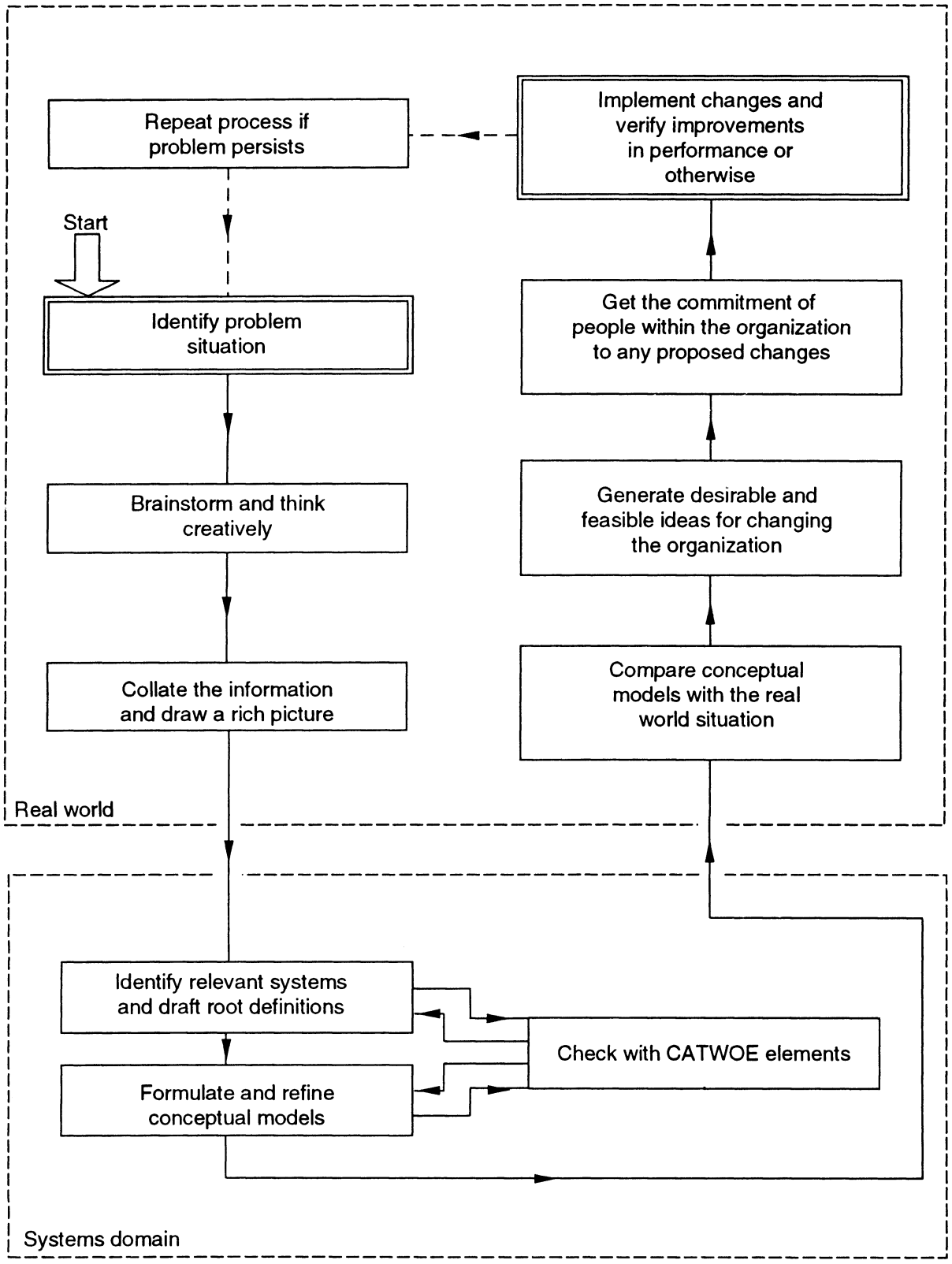


**Figure 5 — Soft systems methodology flowchart**

| No. | Term | Definition |
|---|---|---|
| **9.3 General soft OR terminology** | | |
| 93001 | **assumption rating** | The stage in *SAST* in which the importance and degree of certainty for each assumption are assessed. |
| 93002 | **assumption specification** | The stage in *SAST* in which the assumptions are identified for each *stakeholder* about their beliefs that their preferred *strategies* or solutions are best. |
| 93003 | **assumption surfacing** | The stage in *SAST* during which subgroups develop their preferred *strategy* or solution by successively carrying out *stakeholder analysis, assumption specification,* and *assumption rating*. |
| 93004 | **boundary judgement assumptions** | In *CSH*, assumptions about the boundary between the *system* of concern and the wider *environment* that help to make explicit the normative implications or value judgements involved in the *system* design. |
| 93005 | **boundary questions** | In *CSH*, a standard set of structured questions about the roles, concerns and problems of the people involved in or affected by a *system* design or planning proposal, that are used to identify the boundary judgements implicit in the design or proposal.<br>NOTE The questions may also be employed to ask what ought to be the case for the design or proposal under consideration, rather than asking what is the case. |
| 93006 | **closed system** | A theoretical concept in which a *system* has no interaction with its *environment*.<br>NOTE In practice this term is used to describe *systems* that have a relatively low interaction with their *environments*. |
| 93007 | **cognitive mapping** | A graphical representation describing an individual's or group's perception of a situation or issue. |
| 93008 | **Critical Systems Heuristics (CSH)** | An *heuristics* approach to the identification of a set of boundary judgements concerning a system design or planning proposal.<br>NOTE The *CSH* method promotes a debate among the relevant parties such as systems designers, planners and those affected, that aims to reach a consensus on the finalized *set* of boundary judgements. |
| 93009 | **environment** | The set of elements that are relevant to the *system*, but lie outside its boundary.<br>NOTE The *environment* places *constraints* upon the *system* and, while not itself being controlled by the *system*, is influenced by the *system*. |
| 93010 | **human activity system** | A *system* in which the main influences are the actions of people. |
| 93011 | **nominal group technique** | A method by which a set of people assign priorities to and generate ideas or suggestions about particular issues, problems or opportunities.<br>NOTE The *nominal group technique* is a form of structured brainstorming and has a succession of stages. First individuals make personal lists of what they consider the most important ideas; in successive stages individuals and *sets* combine into larger *sets* to share and debate these ideas. The aim is to reach a consensus on the most important ideas to go forward to the next round. The last round brings all the sets together as a whole group to produce a final list of ideas and assigned priorities. |
| 93012 | **open system** | A *system* that freely interacts with its *environment* providing an interchange of data, materials, etc. across the boundary. |
| 93013 | **problem structuring**<br>issue structuring | 1) An essential step in the OR study of the situation but particularly those involving complex relationships.<br>2) Approaches that concentrate on assisting the relevant participants to understand their problem situation.<br>NOTE when the term "problem" is inappropriate in a situation, the term "*issue structuring*" is often substituted. |

| No. | Term | Definition |
|---|---|---|
| 93014 | **robustness analysis** | A *problem/issue structuring* method for sequential decision making under uncertainty, if that provides a criterion for assessing the useful flexibility maintained by initial decision commitments.<br>NOTE Single and multiple *scenario* methodologies exist, as do versions that incorporate the extent to which problematic future configurations remain accessible. |
| 93015 | **scenario stability analysis** | An examination of a *scenario* to identify possibilities for *unilateral improvements* for different subsets of actors, and sanctions that other actors have available, and the exploration of questions of credibility and cooperation. |
| 93016 | **stakeholder analysis** | The stage in *SAST* in which the parties with an interest or involvement are identified. |
| 93017 | **Strategic Assumption Surfacing and Testing (SAST)** | A *problem/issue structuring* method for working with groups, for the purpose of generating and evaluating *strategies*. Initially subgroups state their assumptions explicitly (*assumption surfacing*); followed by a dialectic debate of the differences in *stakeholders*, assumptions and *assumption ratings*, that may result in assumption modification. Finally the third stage seeks synthesis: the drawing up of an agreed list of assumptions and the identification of research needed to resolve any remaining disagreements. |
| 93018 | **Strategic Choice Approach (SCA)** | An aid to group decision making, proceeding iteratively through the four phases of shaping, designing, comparing and choosing.<br>NOTE There are procedures for each of the phases that are carried out by the whole group, aided by a facilitator. |
| 93019 | **Strategic Option Development and Analysis (SODA)** | A *problem/issue structuring* method for group decision making, in which individual cognitive maps are elicited for participants, to be merged into a strategic map used to facilitate discussion and commitment. |
| 93020 | **subjective description** | A portrayal of a situation that includes the values and opinions of the relevant people involved, including possibly the analyst. |

# Index

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# List of references

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