# A Sample Glossary of Systems Analysis 

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# A SAMPLE GLOSSARY OF SYSTEMS ANALYSIS <br> (Prepared for the Preliminary Version of the Handbook of Applied Systems Analysis) 

## Compiled by:

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## INTRODUCTION

Glossary: A partial dictionary that gives, for a collection of terms, brief and inaccurate explanations.<br>- R.D. Specht

Every short statement....is misleading (with the possible exception of my present one).

- Alfred Marshall

Every activity -- and systems analysis is no exception -tends to develop its own vocabulary. Indeed, systems analysis, because of its interdisciplinary nature, has been more prone than most not only to invent new words for new concepts but also -and more often -- to borrow established terms from the disciplines it employs and to change their meaning, sometimes slightly, sometimes grossly, sometimes inconsistently. The result of this can be confusion, misunderstanding, and failure of communication.

This glossary is an attempt at resolving part of the ambiguity. Sometimes, the best that can be hoped is that the reader will be warned of a pitfall, for we cannot hope to fill them all in, or even to identify them all. For example, when a word in common use in systems analysis has three different meanings, whose differences are often not to be determined by context, there is little we can do beyond noting this unfortunate practice. Clearly, we are in no position to dictate "proper" usage to the disparate community of systems analysts. On the other hand, we have made judgments about the wise use of terminology -stressing some meanings and ignoring others. We hope that the result will be of use not only to the reader who is not well versed in the literature of systems analysis but also to all members of the systems analysis community.

The glossary, as it stands now, is tentative. It has been prepared for the preliminary version of the tandbook of Applied Systems Analysis, and the terms included are those used in the Handbook. We invite criticism and suggestions from our readers: what terms should be added or deleted? What definitions are incorrect or incomplete? Does the glossary "work" as intended?

The glossary, besides being part of the Handbook, is also the beginning of a major task: the compilation of a multilingual glossary of terms of systems analysis. We would therefore appreciate it if comments and proposed additions were divided into two parts: one with respect to the Handbook glossary, and the second with respect to the projected multilingual glossary.

## The Way It Works

The structure of the glossary is designed to highlight interrelations among concepts -- among the terms we sought to explain. The present sample consists of some 50 articles arranged in alphabetical order; approximately 170 terms are defined. A defined term is an "entry." Entries are marked by unaerscoring and double brackets [ [__]] and may head an article or occur within an article. Each term has only one entry, which may be located by referring to the index. If a term is simply underscored within an article, it is a cross reference, i.e., it is defined as an entry somewhere else in the glossary, and the index should be referred to. The final version of the index will use page numbers to indicate the location of entries and in addition will register all occurrences of a term (cross references as well as entries). A rough version of this expanded index is appended, as is a Russian-English index to the glossary's entries.

The glossary and its index were prepared by means of the ED and NROFF text processing programs on IIASA's UNIX Operating System. This accounts for some anomalies of punctuation and for the use of double brackets and underscoring, which may seem less than ideal. The final version will be typeset, and these unaesthetic elements eliminated.

## CLOSSARY INDEX

## TERM

## a fortiori analysis

 action, feasible action space actor alternative alternative, feasible analysis, a fortiori analysis, contingency aralysis, cost-benefit analysis, costeffectivenessanalysis, decision analysis, feasibility analysis, input-output (Leontief)
analysis, Leontief [Syn. for: input-output (Leontief) analysis]
analysis, policy
analysis, resource analysis, risk analysis, risk [Syn. for: risk assessment]
analysis, risk-benefit analysis, sensitivity analysis, value analytic model attribute, valuerelevant
benefit
causal model
chance-constrained problem
coefficient, technological

SEE:

competitive multiple objectives
computer simulation conditional forecast conflict situation conflicting objectives conjoint measurement theory
consequence
consequence, feasible consequence, multiattri~ bute
consequence, singleattribute
consequence space consequence tree constraint
constraint, elastic
constraint, long-run constraint, removable [Syn. for: elastic constraint]
constraint, short-run constraint, stiff constraint, unquestionable [Syn. for: stiff constraint]
contingency analysis correlation model cost
cost, opportunity
cost-benefit analysis
cost-effectiveness analysis
course of action
criterion
decision analysis
decision maker
decision maker, riskaverse
decision maker, riskneutral
decision maker, riskprone


TERM
SEE:
decision, primary
decision, secondary
decision taker [Syn.
for: decision maker]
decision theory
decision under certainty
decision under risk decision under uncertainty
decision variables
Lelphi method
cemiand
demand function
deterministic model
discount rate
discretization
diseconomy of scale
dominance
dynamic model
dynamic optimization problem
economy of scale
effectiveness
efficiency
elastic constraint environment
equilibrium price
estimation, model
evaluation
expected utility
experimentation
externality
feasibility analysis
feasible action
feasible alternative
feasible consequence
feasible objective
feasible set
feasible solution
forecast
forecast, conditional forecast, selffulfilling
secondary decision
secondary decision
................ decision maker
................ $d e c i s i o n ~ t h e o r y ~$
................ $d e c i s i o n ~ t h e o r y ~$
..................decision theory
................. optimization
................ . demand
. . . . . . . . . . . . . . . model
................. optimization
................economy of scale
........................

..................constraint
................. . demand
.................. . . model
utility
.................... systems analysis
................constraint
................... constraint
....................constraint
................constraint
...................constraint
.....................optimization
forecast
forecast
forecasting horizon
[Syn. for: forecasting lead]
forecasting lead
formal model
gamble [Syn. for: lottery]
game, multiperson
game theory
game, two-person
game, zero-sum
gaming
goal
hierarchy of objectives
horizon, forecasting [Syn, for: forecasting lead]
identification, model
impact
implementation input-output (Leontief)
analysis
input-output model
integer programming
interdependence matrix, technological
interest rate [Syn. for: discount rate]
iterative process
judgmental model
Leontief analysis [Syn.
for: input-output (Leontief) analysis]
linear model
linear programming long-run constraint lottery man-machine model man-machine simulation


TERM
marginal utility
max-max rule
max-min rule
model
model, analytic
model, causal
model, correlation
model, deterministic
model estimation
model, formal
model identification
model, input-output
model, judgmental
model, linear
model, man-machine
model, optimization
model parameters
model, role-playing
model, simulation
model, static
model, stochastic
model structure
multiattribute consequence
multiattribute utility function
multiattribute value function
multiobjective optimization
multiperson game multiple objectives nonlinear programming objective
objective, feasible
objective function
objective, proxy
objective, scalar-valued objective space objective, vector-valued objectives, conflicting objectives, hierarchy of

SEE:

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| :---: | :---: | :---: |
| ..................model <br> .................. . . model |  |  |
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| .................. . . model <br> ................. .model |  |  |
| . . . . . . . . . . . . . . model |  |  |
| ......................................... |  |  |
| ....................model |  |  |
| ................model |  |  |
| . input-output <br> (Leontief) analysis |  |  |
| ...............model |  |  |
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| ................model |  |  |
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|  |  |  |
| ..............utility |  |  |
| ...............value |  |  |
| .............optimization |  |  |
| ..............game theory |  |  |
| ....................objective optimization |  |  |
|  |  |  |
| ..............constraint |  |  |
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| ...............optimization |  |  |
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objectives, multiple operational research [Syn. for: operations research] operations research opportunity cost
optimal control problem [Syn. for: dynamic optimization problem]
optimal solution
optimization
optimization model
optimization, multiobjective
optimization problem, dynamic
optimization, singleobjective
optimum strategy
option [Syn. for: alternative]
outcome [Syn. for: consequence]
Pareto optimal
play
player [Syn. for: actor] player
policy analysis
prediction
price, equilibrium
primary decision probabilistic programming
probability, subjective program evaluation programming, integer programming, linear programming, nonlinear programming, stochastic proxy objective removable constraint [Syn. for: elastic constraint]

```
...............objective
operations research
..............optimization
...............optimization
................model
...............optimization
...............optimization
..............optimization
..............game theory
    alternative
...............consequence
...............optimization
...............game theory
.................role-playing
..............game theory
..............systems analysis
................forecast
...............demand
................secondary decision
..............optimization
..............decision theory
...............evaluation
................optimization
................optimization
...............optimization
..............optimization
..............objective
...............constraint
```

resource analysis
risk
risk analysis
risk analysis [Syn. for: risk assessment]
risk assessment
risk, decision under
risk-averse diecison maker
risk-benefit analysis
risk-neutral decision maker
risk-prone decision maker
role-playing
role-playing model satisficing
scalar-valued objective
scenario
secondary decision
self-fulfilling forecast
sensitivity analysis
short-run constraint
simulation
simulation, computer simulation, man-machine
simulation model
simulation, stochastic
single-attribute consequence
single-objective optimization
spillover
state of nature [Syn.
for: environment]
state of the world
static model
stiff constraint
stochastic model
stochastic programming
stochastic simulation
strategy, optimum
subjective probability

```
..................risk
            risk
            risk
....................risk
..............decision theory
...............utility
...............syst'ems analysis
...............utility
...............utility
.................model
..............optimization
................forecast
..............constraint
...............simulation
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...............model
................model
...............consequence
..............optimization
...............externality
...............environment
...............model
..............constraint
```



```
..............optimization
...............model
...............game theory
...............decision theory
```

Suboptimization
supply function
systems analysis
target
target point
target set
target value
technological coeffi~ cient
technological interdependence matrix

## trade-off

two-person game
uncertainty
uncertainty, decision under.
unquestionable constraint [Syn. for: stiff constraint]
utility
utility, expected
utility function, multiattribute
utility function
utility function [Syn. for: welfare function]
utility, marginal
utility theory
validation

## value

value analysis
value function, multiattribute
value function
value-relevant attribute vector-valued objective verification
welfare function zero-sum game


## [[a fortiori analysis]]

A fortiori analysis is a method of treating uncertainty that stacks the cards ajainst one alternative (often the one intuitively preferred) by resolving questions of uncertainty in favor of another alternative. If the initially preferred alternative is still preferable, one has a stronger case in its favor. See also: sensitivity analysis, contingency analysis.

## [[alternative]]

One of the inutually exclusive courses of action that are considered as means of attaining the objectives. Typically, the alternatives differ in their nature or character, not only in quantitative details. By mutually exclusive we mean that the alternatives are competitive in the sense that if $A$ is selected, $B$ cannot be chosen. A course of action that combines features selected from both $A$ and $B$ would be a new alternative. (The synonym "option" is often used in association with the decision maker, as in "the decision maker's options were...")

## [ [consequence]]

A consequence is a result of a course of action (or of a decision) taken by the decision maker (Synonym: outcome; see impact).

In analysis, the consequences of a course of action are determined (predicted) by the use of models.

The consequences that one would like to have, particularly those that contribute positively to the attainment of objectives, are referred to as [[benefits; ]] the consequences that one would like to avoid or mininize are [ [costs.]]

The consequences that do not bear very much on the main objectives and are not evaluated in the analysis but that may affect the objectives of other groups of people are referred to as spillovers or externalities.

A [[consequence tree]] is a graph showing what further consequences 'will be caused by some direct consequence of a course of action. For example, one alternative to stimulate the economy may be to lower taxes. This will result in an increase of average fanily income, which will in time influence the number of cars, which will have an impact on traffic conditions, on environmental pollution, and so on.

In the literature on decision theory it is customary to
speak about one [ [multiattribute consequence]] of a course of action instead of saying "the action has several consequences." Accordingly, the term [[single-attribute consequence]] is used when the course of action has only one consequence that is being considered (e.g., monetary profit). Within the context of decision theory, attributes are those features of a consequence that are taken into account in the evaluation of this consequence by the decision maker. One speaks, more precisely, about [ [value-relevant attributes.]]

In mathematical formulations one speaks about a mapping from the space of courses of action [[(action space)] into the space of consequences [ [(consequence space).]] In a deterministic case the mapping from action space to consequence space is a point-to-point mapping. This means that a given course of action has a ofiven and certain consequence. In a case of risk or uncertainty the mapping from action space to consequence space is a point-to-set mapping; that is, a given course of action may have any one of the consequences contained in a given set.

In analysis, the mapping from action space to consequence space is described by a model.

## [[constraint]]

Constraints are limitations imposed by nature or by man that do not permit certain actions to be taken. Constraints maymean that certain objectives cannot be achieved.

The actions, alternatives, consequences, and objectives that are not precluded by the constraints are referred to as [[feasible.] ]

In a particular analysis study, some constraints inay have to be considered [[stiff]] ór unquestionable, others - from among those imposed by prior decisions - may be [[elastic]] or removable if the analysis proves a zood case for it. For example, the natural water supply in a region is a stiff constraint, while the money or manpower allocated to fulfill a certain task may be an elastic constraint.

It is useful to distinguish [[short-run]] and [[long-run]] constraints: for example, existing legislation is a constraint in the short run, but not necessarily in the long run.

In mathematical terms, if the notions of action space, consequence space, and objective space are introduced, the constraints determine a [ [feasible set]] in each of those spaces.

## [[contingency analysis]]

Contingency analysis is a method of treating uncertainty that explores the effect on the alternatives of changes in the environment in which the alternatives are to function. This is a "what-if" type of analysis, with the what-ifs being external to the alternative, in contrast to a sensitivity analysis, where the parameters of the alternatives are varied.

See also: a fortiori analysis.

## [[course of action]]

A means available to the decision maker by which the objectives may be attained.

A systems analysis usually considers several possible courses of action, which are then referred to as alternatives or as the decision makers's options.

## [ [criterion]]

A criterion is a rule or standard by which to rank the alternatives in order of desirability. The use of "criterion" to inean "objective" is incorrect.

See objective.
[[decision maker]]

A decision maker is a person, or group of people (e.g., a conmittee), who makes the final choice among the alternatives. Synonyin: decision taker.

## [[decision theory]]

Decision theory is a body of knowledge and related analytical techniques of different degrees of formality designed to help a decision maker choose amons a set of alternatives in light of their possible consequences. Decision theory can apply to conditions of certainty, risk, or uncertainty. [[Decision under certainty]] means that each alternative leads to one and only one consequence, and a choice among alternatives is equivalent to a choice among consequences. In [[decision under risk]] each alternative will have one of several possible consequences, and the probability of occurrence for each consequence is known. Therefore, each alternative is associated with a probability distribution, and a choice among alternatives is equivalent to a choice among probability distributions. When the probability distributions are unknown, one speaks about [[decision under uncertainty.]]

Decision theory recognizes that the ranking produced by us-
ing a criterion has to be consistent with the decision maker's objectives and preferences. The theory offers a rich collection of techniques and procedures to reveal preferences and to introduce them into models of decisions. It is not concerned with defining objectives, designing the alternatives or assessing the consequences; it usually considers them as given from outside, or previously determined.

Given a set of alternatives, a set of consequences, and a correspondence between those sets, decision theory offers conceptually simple procedures for choice. In a decision situation under certainty the decision naker's preferences are simulated by a single-attribute or multiattribute value function that introduces ordering on the set of consequences and thus also ranks the alternatives.

Decision theory for risk conditions is based on the concept of utility (see utility, sense $B$ ). The decision maker's preferences for the mutually exclusive consequences of an alternative are described by a utility function that permits calculation of the expected utility for each alternative. The alternative with the highest expected utility is considered the most preferable.

For the case of uncertainty, decision theory offers two main approaches. The first exploits criteria of choice developed in a
broader context by game theory, is for example the [ [max-min rule,]] where we choose the alternative such that the worst possible consequence of the chosen alternative is better than (or equal to) the worst possible consequence of any other alternative, or the [[max-max rule]] where we choose the alternative such that the best possible consequence of the chosen alternative is better than (or equal to) the best possible consequence of any other alternative.

The second approach is to reduce the uncertainty case to the case of risk by using [[subjective probabilities,]] based on expert assessments or on anasis of previous decisions made in similar circumstances.

See also: gane theory, optimization, utility, value.
[[Delphi method]]

A technique to arrive at a group position regarding an issue under investigation, the Delphi method consists of a series of repeated interrogations, usually by means of questionnaires, of a group of individuals whose opinions or judgments are of interest. After the initial inter $\begin{aligned} & \text { ingation of each individual, each subse- }\end{aligned}$ quent interrogation is accompanied by information regarding the preceding round of replies, usually presented anonymously. The individual is thus encouraged to reconsider and, if appropriate,
to change his previous reply in light of the replies of other nembers of the group. After two or three rounds, the group position is determined by averaging.

## [ [demand]]

[A] As a term in economics, demand means the amount of a commodity (good or service) that would be purchased at a given price. An associated terin is [[demand function,]] which presents the de:nand-versus-price relationship. A demand function for a given commodity is compared with a corresponding [ [supply function]] to determine the [[equilibrium price:]] a price at waich the supply offered inatches the demand.
[B] In another usase, demand means the anount of a commodity required for a certain purpose. It often relates to the future, as in: "the world energy demand in the year 2030 will be 35 terawatts." Implicit in this statement is that the price of energy as well as other economic conditions will be such that 35 terawatts will be consumed (purchased) if technically available.

## [[discount rate]]

It is assumed that a monetary unit received today is worth more than a monetary unit to be received a year from now. This
assumption requires that, in order to deterinine the present value of future sums, the analyst use an interest rate to discount these future sums. If $i$ is the assumed annual interest or discount rate, expressed as a decimal, the present value of $x$ monetary units to be received $n$ years froll now is given by the formula:

```
Present value =
\[
\frac{x}{(l+i) n}
\]
```

Discount rates are used when comparing alternatives that differ in the time-character of their flows of costs and benefits; to compare them, costs and benefits are discounted to the same year. There are no clearcut rules as to what an appropriate discount rate should be in a ifiven case.

## [ [quininance]]

An alternative is said to be dominant with respect to a second alternative whenever one or more of the consequences of the first are superior (i.e., preferred according to some criterion) to the corresponding consequences of the second, and all others are equally valued.
[[economy of scale]]

Relative saving ("economy") realized when the size of a plant, enterprise, etc., is increased. For example, lower production cost of an automobile due to production of a large number of cars of the same type is due to economy of scale.

There may also exist a [ [diseconomy of scale,] where the increased size contributes to an increase in unit cost.

## [[effectiveness]]

In systems analysis, the effectiveness of an alternative is usually represented by an aggregative expression approximating the totality of output or performance aspects of that alternative that are relevant to goal attainment. Ideally, it is a single quantitative measure that can be used to evaluate the performance level achieved in attaining the objectives.

## [ [efficiency] ]

Progran A is said to $\dot{\text { i }}$ more efficient than program $B$ if, for a given cost, a chosen aggregated measure of its positive results (such as effectiveness or benefit) is greater than that for program B.

## [[environment]]

Enviromment is most often used as a synony of state of nature, a concept useful in modelins. It enbraces all external factors or forces that are beyond the influence of the decision maker but nevertheless affect the consequences of his action.

Environment is also occasionally used as a synonym of state of the world. The difference between the two concepts is that state of the world can include the consequences of a course of action as well as the external factors, while the state of nature comprises the external factors only.

## [[evaluation]]

Evaluation as used in a technical sense in the United States means assessinent of a government program's past or ongoing performance. The key issue in [[program evaluation]] is to determine the extent to which the progran, rather than other factors, has caused any changes that have been observed.

## [ [experimentation]]

In systems analysis, experimentation is the process of determining the results of a proposed course of action or progran
by conducting an experiment on a smaller scale in which the course of action is applied to a sample drawn from the future target group. An example would be a test of a new health policy in a restricted region instead of the whole country, or a test on a randonly selected sample of the population. The results are best when the experiment is controlled -- i.e., when the test and control groups are chosen before program implementation in such a way that they are as similar as possible. In this way, any differences that are observed during the experiment can be ascribed to the program.

Experimentation is used whenever current knowledge and understanding of factors such as social attitudes and group preferences are not sufficient to provide dependable model-based predictions. (See: model)

## [ [externality]]

An externality is a consequence not considered in analysis. An externality that affects the interests of other groups of people or other decision makers is referred to as a [[spillover.]] If the effects of an externality are appreciable, it may have to be taken into account (internalized) in the analysis.

The term externality derives from economics, where externalites are costs or benefits not taken into account in a transac-
tion or system of transactions. For example, the cost borne by others when an industry pollutes a strean would be referred to as an externality.

## [[forecast]]

A forecast is a statement, usually in probabilistic terms, about the future state or properties of a system based on a known past and present.

A [[conditional forecast]] states in probabilistic terms what the future will be if a course of action is taken.

A forecast that states with a high degree of confidence what the future will be is referred to as [[prediction.]]

A forecast that is a hypothesis rather than a formally justified inference from past data is referred to as a scenario.

Forecasting techniques range from expert judgements to mathematical forecasting models. The [[forecasting lead]] (forecasting horizon), is the length of time ahead of now for which one can make a reasonable forecast. It depends, in the general sense, on available data.

A forecast that makes itself come true is referred to as a [[self-fulfilling forecast.]] For example, a forecast for the ra-
pid growth of a certain city may encourage business to locate there, thus causing the forecast to be realized.

## [[game theory]]

Game theory is a branch of mathematical analysis developed to study decision making in [[conflict situations.] ] Such a situation exists when two or more decision makers who have different objectives act on the same system or share the same resources. There are [[two-person]] and [[multiperson games.]] Game theory provides a mathematical process for selecting an [ [optimum strategy]] (that is, an optimum decision or a sequence of decisions) in the face of an opponent who has a strategy of nis own.

In dame theory one usually makes the following assumptions:
(1) Each decision maker [["player"]] has available to him two or more well-specified choices or sequences of choices (called [["plays").]]
(2) Every possible combination of plays available to the players leads to a well-defined end-state (win, loss, or draw) that terminates the game.
(3) A specified payoff for each player is associated with each end-state $(a \quad[$ zero-sum gane]] means that the sum of payoffs to all players is zero in each end-state).
(4) Each decision maker has perfect knowledge of the game and of his opposition; that is, he knows in full detail the rules of the game as well as the payoffs of all other players.
(5) All decision makers are rational; that is, each player, given two alternatives, will select the one that yields him the greater payoff.

The last two assumptions, in particular, restrict the application of game theory in real-world conflict situations. Nonetheless, game theory has provided a means for analyzing many problems of interest in economics, management science, and other fields.

## [[impact]]

Impact is used in three different ways:
[A] as synonymous with conseguence;
[B] to mean any consequence (beneficial or adverse) that reaches teyond the direct purpose of a given course of action, as
> in: "the impact of the new steel plant on employment opportunities in the region;"

$[C]$ as in [B], but the meaning restricted to adverse consequences, as in: "the impact of industrial growth on the ecological environment."

## [[implementation]]

Implementation means the process of carrying out a course of action. Implementation starts at the decision and terminates when the objectives are attained.

## [[input-output (Leontief) analysis]]

Input-output (Leontief) analysis is a technique developed for quantitatively analyzing the interdependence of producing and consuming units in an economy. Input-output analysis studies the interrelations among producers as buyers of each other's outputs, as users of resources, and as sellers to final consumers. For example, if a planner wishes to expand the activities of some industry, or some component of final consumption, an input-output analysis can tell what amount of other manufactured goods, resources, and labor this requires.

In an [[input-output model]] the output product of each sector of the economy is set equal to the input consumption of that product by other industries plus the consumption by final consumers. All inputs and outputs are expressed in the same units (usually in monetary units per unit of time, for example in schillings/year). One denotes $a_{i j}$ the worth of output product of sector $i$ required as input by sector $j$ to produce one unit's worth of its product. Then, if we denote $x_{1}, x_{2}, \ldots x_{n}$ the output products of the sectors, the basic relation of the model is:

$$
x_{i}=\sum_{j=1}^{n} a_{i j} x_{j}+y_{i}
$$

where $y_{i}$ is the consumption of product $i$ by final consumers. In a model with three sectors, we have, for example, for the output product $x_{2}$ :

$$
x_{2}=a_{21} x_{1}+a_{22} x_{2}+a_{23} x_{3}+y_{2}
$$

which reads: "out of the total output $x_{2}$ the amount $a_{21} x_{1}$ is used by sector 1 to produce output $x_{1} \ldots$ and the amount $y_{2}$ is con-
sumed by final consumers."

The parameters $a_{i j}$ are referred to as [ttechnological coefficients.]] They are usually arranged into a table called the [ [technological interdependence matrix]] for the system being modeled.

## [[iterative process]]

An iterative process is a process for calculating a desired result by means of a repeated cycle of operations. An iterative process should be convergent, i.e., it should come closer to the desired result as the number of iterations increases.

## [ [model]]

A model is a device, scheme, or procedure typically used in systems analysis to predict the consequences of a course of action; a model usually aspires to represent the real world (to the degree needed in analysis) -- for example, a relation between some observed phenomena.

A model can be [[formal]] (e.g., a mathematical expression, a diagram, a takle) or [[judgmental]] (e.g.. as formed by the deductions and assessments contained in the mind of an expert).

Some models are [[causal]] -- i.e., they reflect causeeffect relationships. Others are [ [correlation models,]] which do not necessarily reveal whether some of the observed phenomena are the cause of the others. An example is correlation models used for weather forecasting; note that the farmer who predicts rain on the basis of some observed pheronena and his past experience is using a judumental correlation model.

A [[deterininistic model]] senerates the response to a diven input by one fixed law; a [[stochastic model]] picks up the response from a set of possible responses according to a fixed probability distribution (stochastic nodels are used to simulate the behavior of real systens under randon conditions.

A [[dynanic model]] can describe the tine-spread phenomena (dynanic prucesses) in a system. A [[static model]] describes the systen at a given instant of time and in an assumed state of equilibrium.

Among the formal, mathematical models an [[analytic model]] is formed by explicit equations. It may permit an analytic or numerical solution.

An analytic model is [[linear] if all equations in the model are linear.

We speak of a [[simulation model]] if the solution, i.e.,
the answer to the question which the analyst has posed, is obtained by experiments on the model rather than by an explicit solution algorithm. A typical example is [[stochastic simulation,] where one wants to obtain probabilistic properties of a system's response by evaluating the results of a large number of simulation runs on the model.

In some analyses the model by which one predicts the outcome of a course of action must take into account that this outcome depends also on actions taken by other decision makers. If the assumption can be made that those decision makers optimize some defined objective functions, and all the other aspects of the system can also be formalized, an [ [optimization model] (e.g., a linear programining model) can be used to determine the system's response to a course of action. In [[role-playing models]] those decision makers (and perhaps some other elements of the system as well) are simulated by human actors.

In a [ [man-machine model] $]$ an actor or actors play roles while other parts of the model are implemented on a computer.

A formal model has a [ [structure] (the form of an equation, for example) and [[parameters]] (the values of coefficients in an equation, for example). Determination of both the structure and parameters is [ [model identification;]] determination of parameters on the basis of experimental data is [[model estimation.] ]

The check of a proposed model against experimental data other than those used for parameter estimation is model validation. See also verification.

## [[objective]]

An objective is something that a decision maker seeks to accomplish or to obtain by aeans of his decision. A decision maker may have more than one objective (the [[multiple-objectives]] case).

An objective may be specified in a more or less general fashion, may be quantified or not quantified, and is usually part of a [ [hierarchy of objectives.]] The term [[goal]] is sometimes used to denote a very jeneral objective (at the top of the nierarchy) and [[target]] is used to inean a very definite objective. Example: "The goal of allocating money to the municipality was to increase the quality of urban life. The immediate objectives were to improve public transportation and fire services. A $10 \%$ reduction of average travel time from home to work and a $70 \%$ decrease of average alarm-to-action time taken by the fire brigades were set forth as targets".

The multiple objectives of a single decision maker are usually [[competitive:]] i.e., the improvement in one of them is associated with a deterioration in another (usually because of lim-

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ited resources or because of other constraints).
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Competitive objectives are sometimes referred to as [ [conflicting objectives.]] However, one should speak about a conflict and about conflicting objectives only if there are two or more decision makers who have different objectives and who act on the same system or share the same resources. In the example given above, the director of urban transportation and the director of city fire services have conflicting objectives. At the same time the mayor of the city, if he were the single decision maker, would look at these objectives as competitive.

If the two directors are left without a coordinating influence by the mayor (who would, for example, decide how to allocate the resources), a conflict situation may result. (see game theory).

With the mayor's interventions, the system becomes a hierarchy of decision makers, and the conflict may be resolved.

When the extent to which an objective is attained is measurable on some appropriate scale, one can speak about the degree of attainment of the objective.

In systems analysis, one often uses [[proxy objectives:]] objectives other than the original ones, but such that are
measurable and can be quantitatively discussed. A proxy objective should at least point in the same direction as the original one; for example, "reduction of mean travel time" in urban transportation is a proxy for "improved services."

In a mathematical description, the measures of the multiple objectives $Q_{1}, Q_{2}, \ldots, Q_{n}$ are considered to be coordinates of a point in the $n$-dimensional [lobjective space.]] Then, the [[target values] $T_{1}, T_{2}, \ldots, T_{n}$ prescribed for the $n$ objectives are considered to be coordinates of the [[target point]] in this space. When the target value requirements are set forth as some intervals rather than single numbers, they define a region in the objective space that is referred to as a [[target set.]]

## [ [operations research]]

Operations research (operational research in Britain) as understood today is essentially identical to systems analysis. Historically, it was a narrower area of activity that stressed guantitative methods and did not concern itself with trade-offs between objectives and means or with problems of equity. It was defined by the Operational Research Society of Great Britain as follows (Operational Research Quarterly, 13(3): 282, 1962):


#### Abstract

Operational research is the attack of modern science on coinplex probleins arising in the direction and management of large systems of men, machines, materials and money in industry, business, government and defence. Its distinctive approach is to develop a scientific model of the system, incorporating measurements 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.


## [[opportunity cost]]

Opportunity cost is defined as the advantage forgone as the result of the acceptance of an alternative. It is measured as the benefits that would result from the next best alternative use of the same resources that was rejected in favor of the one accepted. Opportunity cost is difficult, perhaps impossible, to measure precisely.

## [ [optimization] ]

Optimization is an activity that aims at findins the best (i.e., optimal) solution to a problem. For optimization to be areaningful there inust be an objective function (see below) to be
optimized and there must exist more than one [ffeasible solution.l] i.e.. a solution which does not violate the constraints.

The term optimization does not apply, usually, when the number of solutions permits the best to be chosen by inspection, using an appropriate criterion (see decision theory).

One distinguishes [[single-objective]] and [[multiobjective optimization.] In the first case the objective is [ [scalar-valued]] (it can be measured by a single number); in the second, the objective is [[vector-valued]] (its value is expressed by an $n$-tuple of numbers).

In mathematical terms, the formulation of an optimization problem involves [[decision variables,]] $x_{1}, x_{2}, \ldots, x_{n}$, the [ [objective function,]]

$$
Q=f\left(x_{1}, x_{2}, \ldots, x_{n}\right)
$$

and constraint relations, usually of the form

$$
g_{i}\left(x_{1}, x_{2}, \ldots, x_{n}\right) \leq 0, i=1,2, \ldots, m \quad .
$$

The [[optimal solution]] (or "solution to the optimization problem") are values of decision variables $\hat{x}_{1}, \hat{x}_{2}, \ldots, \hat{x}_{n}$ that satisfy the constraints and for which the objective function at-

Lains a maximun (or a minimum, in a minimization problen).

Very few optimization problems can be solved analytically, that is, $u y$ means of explicit formulae. In most practical cases appropriate computational techniques of optimization (numerical procedures of optimization) must be used. Annong those techniques [[linear programming]] permits the solution of problems in which the objective function and all constraint relations are linear; [ [nonlinear programming]] does not have this restriction, but can manage many fewer decision variables and constraints; [ [intezer programming]] serves to solve problems where the decision variables can take only integer values; [[stocha'stic] or [[probabilistic prozramming]] must be used for problems where the objective function or constraint relations contain random-valued parameters (in the latter case, the problen is referred to as a a [[chance-constrained problem).]]

A special class is [ [dynamic optimization problems,]] where the decision variables are not real numbers or integers but functions of one or more independent variables -- functions of time or space coordinates, for example. Dynamic optinization problems are sometimes referred to as "optimal control problems." There exist special techniques to solve such problems; they often make use of [[discretization]] of the independent variables, for example dividing the time axis into a number of intervals and considering the solutions to be constant uver those intervals.

A single-objective optinization problen may have (and usually does have) a single-valued, unique solution.

The solution to a multiobjective problem is, as a rule, not a particular value, but a set of values of decision variables such that, for each element in this set, none of the objective functions can be further increased without a decrease of some of the remaining objective functions (every such value of a decision variable is referred to as [[Pareto-optimal).]]

## [[resource analysis]]

The process of determining the economic resource impacts of alternative proposals for future courses of action. While in resource analysis, physical quantities are often ultimately translated into monetary terms, the real aim is to measure the probable "resource drain" on the economy that would result from various possible actions. The resource analyst must not only give attention to economic costs but also has to determine if it is feasible to obtain needed physical material and manpower in the required time period.

## [ [risk]]

[A] In decision theory and in statistics risk means
uncertainty for which the probability distribution is known. Accordingly, [[risk analysis]] means a study to determine the outcones of decisions along with their probabilities -- for exanple, answering the question: "what is the likelihood of achieving a $1,000,000$ schilling profit in this alternative?"

In systems analysis, a decision maker is often concerned with the probability that a project (the chosen alternative) cannot ve carried out with the time and money available. This risk of failure may differ from alternative to alternative and should be estimated as part of analysis.
[B] In another usaze, risk means an uncertain and strongly adverse impact, as in "the risks of nuclear power plants to the pojulation are...." In that case, risk analysis or [risk assessment]] is a study composed of two parts, the first dealing with the identification of the strongly adverse impacts, and the second with determination of their respective probabilities. Compare risk-benefit analysis.

## [ [role-playing]]

A type of simulation in which persons (referred to as [[actors]] or players), sometimes with the aid of computers, act out roles as parts of the system beinz analyzed.


#### Abstract

For example, experts in different fields tay be called upon to simulate the behavior (to predict the response) of specific segments of a regional or national economy being studied. A. role-playing simulation in waich the actors (players) act out roles as decision makers is called [ [gaming.]] In gaming, the players usually have different and conflicting objectives (in business gaming and war gaming, for example). The players may act as individuals or may be combined into coalitions, or opposing teans.


[[satisficing]]

Satisficing is an alternative to optimization for cases where there are multiple and competitive objectives in which one gives up the idea of obtaining a "best" solution.

In this approach one sets lower bounds for the various objectives that, if attained, will be "good enough" and then seeks a solution that will exceed these bounds. The satisficer's philosoptiy is that in real-world problens there are too many uncertainties and conflicts in values for there to be any hope of obtaining a true optimization and that it is far more sensible to set out to do "well enough" (but better than has been done previously).

## [[scenario]]

A scenario is an outline of a hypothesized chain of events. The terin is used to denote [A] a forecast based on loose assumptions rather than on a more formal inference from the past or [B] a synopsis of a proposed course of action.

## [[secondary decision]]

Secondary decisions are those choices made by the analyst that determine the way in which systems analysis of a given problem or issue will be performed. They include making the simplifying assumptions by which a complex issue will be made tractable in analysis, choosing the forms of models, selecting the techniques of computation and simulation, deciding what data have to De acquired, judging what support by experts of various disciplines to use in performing the analysis, and so on.

The secondary decisions are distinguished from [ [primary decisions,]] that is, the decisions to be taken by the decision maker and related to the object problem or issue to which a systems analysis is applied.

## [lsensitivity analysis]]

A procedure to determine the sensitivity of the outcomes of an alternative to changes in its parameters (as opposed to changes in the environment; see contingency analysis, a fortiori analysis). If a small change in a parameter results in relatively large changes in the outcomes, the outcomes are said to be sensitive to that parameter. This may mean that the parameter has to be determined very accurately or that the alternative has to be redesigned for low sensitivity.

## [ [simulation]]

Simulation is the term applied to the process of modeling the essential features of a situation and then predicting what is likely to happen by operating with the model case by case -i.e., by estimating the results of proposed actions from a series of imaginary experiments (imaginary because they are performed on the representation of the situation, the model, rather than on the situation itself).

Most frequently, the simulation is a [[computer simulation]] in which the representation is carried out numerically on a digital computer. It may also be done on an analoge computer or by means of a physical representation, say by a wooden airfoil in a wind tunnel. [[Man-machine simulation]] is a simulation that em-
ploys a man-machine model.
Also see: role playing, gaming.
[[state of the world]]

State of the world, in connection with a course of action, means the aggregate of natural, economic, social, cultural, and other conditions on which the presumed consequences must depend and to which the course of action must be matched. A forecast of the state of the world is required to predict the results of any course of action.

See environinent.

## [[suboptimization]]

Suboptimization refers to the analysis to assist a lower level decision as a step toward the attainment of a higher level objective to which the lower level decision is to contribute. Thus, an optimization of a city's streetcar operations would be a suboptimization if the higher level aim is to optimize the entire public transport system.

Analysts and decision makers must always suboptimize -- that is, consider actions that pertain to only part of the elenents that enter a problem -- neglecting some things and fixing others
arbitrarily. Even if all suboptimization problems relevant for a higher level problem are successfully solved, this will not mean, usually, that the higher level problem will be optimized. One could usually do better by treating all partial problems and their interrelationships, simultaneously.

## [[systems analysis]]

This term has many different meanings. In the sense adopted for the Handbook, systems analysis is an explicit formal inquiry carried out to help someone (referred to as the decision maker) identify a better course of action and make a better decision than he inight otherwise have made. The characteristic attributes of a problem situation where systems analysis is called upon are complexity of the issue and uncertainty of the outcome of any course of action that might reasonably be taken.

Systems analysis usually has some combination of the following: identification (and re-identification) of objectives, constraints, and alternative courses of action; examination of the probable consequences of the alternatives in terms of costs, benefits, and risks; presentation of the results in a comparative framework so that the decision maker can make an informed choice from anong the alternatives.

The typical use of systems analysis is to guide decisions on
issues such as national or corporate plans and programs, resource use and protection policies, research and development in technology, regional and urban developinent, educational systems, and health and other social services. Clearly, the nature of these problems requires an interdisciplinary approach.

There are several specific kinds or focuses of systems analysis, for which different terms are used.

A systems analysis related to public decisions is often referred to as a [policy analysis]] (in the United States the terins are used interchangeably).

A systems analysis that concentrates on comparison and ranking of alternatives on the basis of their known characteristics is referred to as [[decision analysis.]]

That part or aspect of systems analysis that concentrates on finding out whether an intended course of action violates any constraints is referred to as [[feasibility analysis.]]

A systems analysis in which the alternatives are ranked in terus of effectiveness for fixed cost or in terms of cost for equal effectiveness is referred to as [[cost-effectiveness analysis.]]
[[Cost-benefit analysis]] is a study where for each alternative the time stream of costs and the time stream of benefits
( woth in monetary units) are discounted (see: discount rate) to yield their present values. The comparison and ranking are made in terms of net benefits (benefits minus cost) or the ratio of benefits to costs.

In [ [risk-benefit analysis,]] cost (in monetary units) is assigned to each risk, so as to make possible a conparison of the discounted sum of these costs (and of other costs as well) with the discounted sum of benefits that are predicted to result from the decision. The risks considered are usually events whose probability of occurrence is low, but whose adverse consequences would be important (e.g., events such as an earthquake or explosion of a plant).

See: operations research.

## [ [trade-off] $]$

Trade-off means an exchange of one quality or thing for another. Thus, in comparing alternative configurations for transport aircraft, it may be possible to trade off speed for payload and still maintain the same total transport capability per month in the systera.

In value analysis and decision theory the concept of tradeoffs in the decision maker's preferences is used extensively as a basis for establishing multiattribute value functions and
multiattribute utility functions.
See: value, utility.

## [[uncertainty]]

Because of an unfortunate use of terminology, in systems analysis discourse, the word "uncertainty" has both a precise technical meaning and its loose natural meaning of an event or situation that is not certain.

In decision theory and statistics a precise distinction is made between a situation of risk and one of uncertainty. There is an uncontrollable random event inherent in both of these situations. The distinction is that in a risky situation the uncontrollable random event comes from a known probability distribution, whereas in an uncertain situation the probability distribution is unknown.

## [[utility]]

[A] In economics, utility means the real or fancied ability of a jood or service to satisfy a human want. An associated term is [ [welfare function] (synonyin: utility function -- not to be confused with utility function in decision theory; see below), which relates the utility derived by an individual or group to
the goods and services that it consumes. [ [Marginal utility]] is the change in utility due to a one-unit change in the quantity of a good or service consumed.
[B] In decision theory, utility is a measure of the desirability of consequences of courses of action that applies to decision making under risk -- that is, under uncertainty with known probabilities.

The concept of utility applies to both single-attribute and multiattribute consequences.

The fundamental assumption in [[utility theory]] is that the decision maker always chooses the alternative for which the expected value of the utility [ [(expected utility)]] is maximum.

If that assumption is accepted, utility theory can be used to predict or prescribe the choice that the decision maker will make, or should make, among the available alternatives. For that purpose, a utility has to be assigned to each of the possible (and mutually exclusive) consequences of every alternative. A [lutility function] is the rule by which this assignment is done, and depends on the preferences of the individual decision maker.

In utility theory, the utility measures $u$ of the conse-
quences are assumed to reflect a decision maker's preferences in the following sense:
(i) the numerical order of utilities for consequences preserves the decision maker's preference order among the consequences;
(ii) the numerical order of expected utilities of alternatives (referred to, in utility theory, as gambles or [[lotteries)]] preserves the decision maker's preference order among these alternatives (lotteries).

For example if alternative $A$ can have three mutually exclusive consequences, $x, y, z$, and the decision maker prefers $z$ to $y$ and $y$ to $x$, the utilities $u_{1}, u_{2}, u_{3}$ assigned to $x, y, z$ must be such that $u_{3}>u_{2}>u_{1}$.

If the probabilities of the consequences $x, y, z$ are $p_{1}, p_{2}, l-p_{1}-p_{2}$, respectively, the expected utility of alternative A is calculated as

$$
E(u \mid P)=p_{1} u_{1}+p_{2} u_{2}+\left(1-p_{1}-p_{2}\right) u_{3}
$$

where $P$ means the probability distribution, characteristic for the alterrative (i.e. $p_{1}, p_{2}, l-p_{1}-p_{2}$ ).

If the decision maker prefers alternative $B$, which has probability distribution $Q$, to alternative $A$, the utility assign-
ments in both alternatives must be such that

$$
E(u \mid Q)>E(u \mid P) .
$$

Utility theory provides a basis for the assignment of utilities to consequences by formulating necessary and sufficient conditions to satisfy (i) and (ii).

A utility function is defined mathematically as a function u(•) from the set of consequences $Y$ into the real numbers that provides for satisfaction of (i) and (ii).

There exist various methods for constructing utility functions. The best-known method is based on indifference judgments of the decision maker about specially constructed alternatives (lotteries).

Utility theory permits one to distinguish [ [risk-prone,]] [[risk-neutral]] and [[risk-averse decision makers.]]

For example, if the mutually exclusive payoffs $x_{1}, x_{2}, x_{3}$ of an alternative $A$ are all expressed in the same units (e.g.. schillings), the decision maker is risk-prone if he prefers the alternative $A$ (prefers the lottery) to receiving, with no risk, the expected value of the payoffs (calculated directly as $E(x \mid P)$ $\left.=p_{1} x_{1}+p_{2} x_{2}+\left(1-p_{1}-p_{2}\right) x_{3}\right)$. This preference can also be expressed as

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E(u|P) > u(E(x|P))
```

i.e., the expected utility of the lottery to the risk-prone decision inaker is larger than the utility of the expected value of the consequence.

The risk-neutral and risk-averse decision makers are defined accordingly.

Tne [[multiattribute utility function] is defined as a function $u($.$) froin the set of multiattribute consequences into$ the real numbers. This ineans that it applies to cases where each of the mutually exclusive consequences has several attributes. Multiattribute utility functions, besides having properties (i) and (ii), also express the decision maker's trade-offs among the attributes (compare multiattribute value function). Several special forins of multiattribute utility functions have been developed, including the additive and the multiplicative forms.

## [[validation]]

Validation is the process of increasing the confidence that the outputs of the model conform to reality in the required range. In some cases the model's output can be compared to data from historical sources or from an experiment conducted for validation. A model can never be completely validated; we can never
prove that its results conform to reality in all respects; it can only be invalidated. Predictive models can be validated only by judgment, since a model may fit past data well without having good predictive qualities.

## [ [value]]

Value can be either objective or subjective; in the latter case it means subjective worth or importance. For example, "the value of future benefits to the decision maker," "the value of clean air to the society".

For the purposes of analysis, the subjective values must be ineasured on some scale. These measures of value should be based on preferences expressed by the person or group of interest.

In [[value analysis,]] one considers that the value $v$ is related to the physical or other objective measure $y$ of a consequence by a subjectively defined [[value function,]] so that $\mathbf{v}=f(y)$. A value function usually departs from proportionality, i.e., it usually is a nonlinear dependence.

A typical example is the subjective value of money to an individual: the first 1,000 schillings in his savings account are probably of more value to him than the 1,000 schillings that
would increase the state of his account from 100,000 to 101,000 schillings.

The value of a multiattribute consequence with value-relevant attributes $y_{1}, Y_{2}, \ldots, Y_{n}$ can be expressed by a [lmultiattribute value function,]] $v\left(y_{1}, Y_{2}, \ldots Y_{n}\right)$.

A multiattribute value function must satisfy the following condition:

$$
v\left(y_{1}, y_{2}, \ldots, y_{n}\right) \geq v\left(y_{1}^{\prime}, y_{2}^{\prime}, \ldots, y_{n}^{\prime}\right)
$$

if and only if the multiattribute consequence $\left(y_{1}, Y_{2}, \ldots, y_{n}\right)$ is preferred or indifferent to ( $y_{1}^{\prime}, y_{2}^{\prime}, \ldots, y_{n}^{\prime}$ ).

Several theories exist according to which a multiattribute value function $v(\cdot)$ can in appropriate cases be expressed as an aggregate of single-attribute functions $v_{i}(\cdot)$. For example, the additive [lconjoint measurement theory]] assumes that

$$
v\left(y_{1}, y_{2}, \ldots, y_{n}\right)^{\prime}=\sum_{i=1}^{n} v_{i}\left(y_{i}\right)
$$

See also: utility, decision theory.

## [[verification]]

A (computer) model is said to be verified if it behaves in the way that the model builder wanted it to behave. This means that the instructions are correct and have been properly probrammed. One check for verification is to hold some of the variables constant to deterinine whether the output changes in anticipated ways as other variables are changed. Another typical check is to test how the model behaves in limit situations. Compare: validation.

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 удовАетворякпий

 （fēsitue corise－ auerice）



 динамичєскои посー тановке（dyriamic ofotimatizatiori －romblem）
 стохастнческими оrрョничョннлmи （charıce＂coristrairıed sroblem）


значение цели（tarset
value）
иrpa（Flas）


иГре mноrих Акц（mul－ tifersori same）



игро日вя итит вционндя модель（role－ Figuiris model）
иlРовое имитационное моделирование （role－rlayiris）
иrpok（flaser）
ндентиФикдция моде́ии （model ideritifica－ tiori）
иерархия целеи（hierar－ chy of objectives）
Мнит виионндя moमent （simulation model）
 irıs）
имитдция（simulation） исследовзние оперзции （oferatioris research）
исход（пFи MнOrnх
 tiattribute corise－ cuerice）
исход（принимаєmかx尸ешений）（corise－ （～小епіся）

（iterative frocess）
KOMnPomuc（tradeoff）
Конкрелно опредепеннвя珻At（tarset）

Cm ．

model
．．．．．．．．．．．rolemFlayiris ．．．．．．．．．．．．．．．． 5 ane theors

```
                                    model
```

*     * . . * * * . . * . . oh ohective
.................model

＋＋＋＋＋＋＋＋＋＋．5imılatiorı
．．．．．．．．．．．．．．．．．．．．．．．．．．．．tions research

```
*************OMiseruerice
```

$\ldots \ldots+\ldots+\ldots+\ldots$ coriseruerice

－••••••••••• tradeoff


（coriflict sit山ぁ tion）
КОНФАКК fiictirıs objec－ tives）
 （correlatiori model）
KPaIKO－CPOчHOE
оюрениченине （short－rivi cori．． strairit）
к户口терий（ョttritute）
к＂нтерий（criteriorı）
 Пюи оценке Рещения （value relevarit at－－ tribute
кyрс действий（alterria－ tive）
KypC действий（course of actiorı
 Акнеดнвя mоделb（Iiraar model）
 взнне（1iriear fro－ srammirıs）
 решение（decisiorı Makの一）
Аицоу ПРкнимакпее решение ，неятрдAtно ОTHOCMMETOK PMCK （risk－reatral deci－ sion maker）
 Feuenhey CKAOHMDE
 （risk－averse deci－ siori misker）
Акцоу принимвкмее
 PкCx $ب$（risk－qrorie Mecision maker）

CM．

．．．．．．．．．．．．．．．．ohjective
．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．







$\cdots+\cdots+\cdots+\omega^{+}+\cdots+$ model
．．．．．．．．．．．OFtimizatior
．．．．．．．．．．．．．．decisiorı maker


．．．．．．．．．．．．．．．．．．．．．．．．．．．．．ity
norefer（lottery）

（ $\quad$ ах－там rule）
такситинный крияерий
（max－mirt rule）
mafrumadbнas flonearocib
（marsirial utility）
Marpица，описывакмаяся
daname（techriolosi－
cal interdeferidence matrix）

МВшнкная КМКтация（сопー
Futer simulation）
maшкнная moдeab（comfut－ er model）
 method）


MOमе АЕЙ（irıfut－
outfrut 〈Leoritief
analysis）
 фчнкцкя поАезности （multiattribute
山tility furıction）
MHOPOKFMIEFKるAbHBA Функция цЕнНоСти （multiattrituute value furiction）
MHOXECTEO मON世CIKMEX）

м T． 4 （featitule set）
modent（model）
MOमEAb，PeanиэчеMaя кa 3 EM（ Cowfuter model）


САедственные сяяョи （causal model）

CM．

```
................utility
    ................decision theory
    ...............decisiort theory
    ...............utility
* ............... irifist..outfut <Leori-
    ti.ef') arialysis
................Eim|lation!
. . . . . . . . . . . . . .model
. .............. Nelwhi methor
. ..............irifut-outfut (Leori-
                                    tief) aralysis
...............value
...............constraint
...............model
................model
................model
```


## TE：PM音

 вание（rioriliriear frosframmiris）
$\cdots++\cdots+\cdots++++$ of timization
неопределеннос才t（uricer－ tairits）
 ИЗе вАинние Ре川ения на внешние систеты （ङFillover）
HEyчит甘Eatmor 川ipn aHaA－ И尹е последствие阝ешения（ョ以terrali－ ty）
GノPдиич氏ние（coristrairit） OमHOKPN1EFMぁAbHOE
 （sirısfe－attrituste corisequerice）
OAнOKPMTEPMAAbHGA иСход （sirısemattribute corisealderice）
ожидаемая полезность （exfected utilits）
OIPEAEAEHME MOnycinmbx
 r•A．（fezsibilits arıalษsis
ОПредєление ценности
 ных ヨначений
 ных велицин（value ョrialysis）
 （optimumistratess）
OпTMMAAbHOE pemehne（DFー timal solutiori）
ONTMMAAtM\＆no napeto （Fareto－oftimal）

Cm ．



．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．．aderice
$\ldots+\ldots+\ldots+\ldots+$ corisequerice $^{*}$


．．．．．．．．．．．．．．．．．Value




## TEMMH

 （oftimization model）
ontйinョaция（oftimizaー tiori）
оптимиョация при наличии одной целевой Функции（sirisle－ objective oftimiza－ tion）
осумеслвление（imflemen－ tatiori）
otкas oו поиска ofitmmant horo решения 〈与atisfic－ irıs）
оценка（evalıatiori）

небのaronfииауиых
BHEUHиX بСловияX（a
fortiori arialysis）
oценка moमenи（model es－ timatiort
napamerp（attribute）
napametph moaenk（model Farameters）
Париия（flay）
Hepementae（decision
variable）
MEPEXOA OI KEMFEPGBHOЙ K
дискретной noc－
тановке ョадачи
（discretizatiorl）
nnaiew（fayoff）
ПАаノехная Фчнкция
（wayoff furiction）
moneвноств（utility）
посаедсiвие nfинитаетых
Рをшенй 〈corise－
querice）
посиедствие pemenия（im－ Fact
notepn ot npиниmaemoro peweния（offorturia－ ty cost）

```
............... morsel
................oftimizatior!
...............OFtimization
*............... imFlemeritation
...............satisficins
................evaluation
...............a fortiori arialysis
.................model
................attribute
. . . . . . . . . . . . . model
*..............same theory
.4.............oftimization
*.+.*...+...... ortimization
*..............game theory
...............same theory
*...............utility
....... . . . . . . . conseamence
. . . . . . . . . . . . . imfract
............... offorturityy cost
```

| tepmbr | CM. |
| :---: | :---: |
| notpedhocti (demand) | . . . . . . . . . . . . . demarid |
| mpeackazahиe (frediction) | . . . . . . . . . . . . .forecast |
| Mринятие एенекий в чсловиях |  |
|  |  |
| he:onperenerhocim (decision under uricertainty) | . . . . decisiori theory |
| กFиняtке PEMEKий в |  |
| ycaobngx OMpereaer- |  |
| mocin (decision under certairity) | ............. ${ }^{\text {decision theory }}$ |
| прикяtие Pellenий |  |
| yciónях pиска (decision urider risk) | ..............decision theory |
| Mpobepka (verification) | ..............verification |
| Mpornos (forecast) | *............forecast |
| MPOCIPaнсוво antrephaime <br> (action sface) | *...........coriseauerice |
| MPOCIPAHCIEO MCXOAOE <br> (corisealerice sface) | ........... coriseauerice |
| nfocipahctbo पeneй (objective sface) | .............ohjective |
| пространсіво мелей (tarset set) | . .............objective |
| ITPOTMBOPRYKBHE LEAK (competitive multiFle objectives) | .............objective |
| ```pеализаиия (imflemerita- tior,``` | ............. implemeritation |
| pesmabiat npm mhornx крилерия (multiattribute coriseauerice) | * . . . . . . . . . coriseauerice |
| Peßynbial npurmmaemax Решений (coriseauerice) | *...........conseauenice |
| pemerиe (основное) (frimary decisior, | .............. secorıdary decisiorı |
| Pemerme o 1 omp kak npoводитв спстемный аналив (Eecoridary Secisiorl | . . . . . . . . . . . . . secorndary decision |

## териин

puck（risk）
ровкавесная цена （equilibrium frice）
 HOB（self－ fulfillins fore－ cast）
 te川ts analysis）
скалярнан оптимиョация （sirisle－objective ofotimization）
 valued objective）
Снижение بдельных ョaクpar 17\％и Расाиирении lifon зводствa（ecori－ omy of scale）
cociofमиe mupa（state of the world）
cocionhиe mupa（state of the world）
cociogние nFиFоमы（state of riature）
cпpoc（demarid）
cтarmчecká moमent （static model）
стохастическая имитация （stochastic simula＂ tion）
стохастическаи moдent （stochastic model）
стохастическое nporpam－ mиpobanne（frolia－ bil．istic frostam－ miris）
стохастическое nporpam－ mиFOEaHие（stochas－ tic Frosrammirig）
©трчкичра moдean（model structure）
cыdоптитвация（sutiof－－ timizatiori）

## CM．

．．．．．．．．．．．．．．．．．．．．risk．
．．．．．．．．．．．．．．．djemand
．．．．．．．．．．．．．．．．forecast
．．．．．．．．．．．．． 5 Sytems arialysis

．．．．．．．．．．．．．．．．．．oftimization
．．．．．．．．．．．．．．．．．ecorioms of scale
．．．．．．．．．．．．．．．envi roriment
．．．．．．．．．．．．．．．．．state of the world
．．．．．．．．．．．．．．．．envi rorımerit
．．．．．．．．．．．．．．．demarid
．．．．．．．．．．．．．．model
．．．．．．．．．．．．．．．model
．．．．．．．．．．．．．．．．．．morjel

．．．．．．．．．．．．．．．．oftimizatiorı
．．．．．．．．．．．．．．．model
．．．．．．．．．．．．．．．．．hoftimization

TEFMMH
cydьективная вероятноств
（suhjective sroha－ bility）
сценарий（sceriario）
теория игр（same theory） teofng moneョhocin（util－ ity theory）

（decision theors）
 изmepernй（corijoint measurement theory）
техноиогический ко：ФФиー Leн，（technolosical coefficient）

точка B MPOCTPaнCIEE целеウ（tarset Foint）
 TPal ПFи Pacinfernи прои三EOACIBE（dise－ coriomy of scale）
צCAOBHBM NPORHOB（coridi－ tional forecast）
ччасіник NrPt（actor）
учaciниK иrpt（decision mak．er）
 （flayer）
форmanthag moneab（for－ mal model）
Функцня סАагососוояния
（welfare furiction）
Функция выигрнй（Fачоff furictiorı）
Функция nonesiocin
（utility function）
Функмия TPEAAO※ения
（suFfiy furiction）
Фчнкция cпpoca（demand furiction）
Фунхния ненности（value
furictiori）
cm．


## термии

хараклєャислика（attri－ bute）
целеван фчнкция（оbјес… tive furiction）
цепи（multifle objec－ tives）
यелочисленное пPOTPEM－ mировaние（inteser Frosrammiris）
化へゅ（soal）
山enb（objective）

 вaнमaя donec KOHKPETKO）（Fro®y objective）

человеко－танинная итита… ция（man－machine simulatiorl）
че аовеко－mallинная тодель
（mari－machine model）
зкспериment（exferimen－－ tatiori）
зкспермменіирование（ек－ Ferimeritation）
зАастмчные orpaнкчения
（elastic cori．．
strairit）
3 Ффекiнвноств（effec－
tiveriess）
3甲Фекimenocib（efficieri－ ся）
．．．．．．．．．．．．．corıstrairit
CM．
．．．．．．．．．．．．．．．．attribute
．．．．．．．．．．．．．．．．．．oftimization
．．．．．．．．．．．．．．．．objective
．．．．．．．．．．．．．．．oftimization
．．．．．．．．．．．．．．．．objective
．．．．．．．．．．．．．．．．oh．jective
．．．．．．．．．．．．．．．．．objective
．．．．．．．．．．．．．．．．value
．．．．．．．．．．．．．．．．．simulation
．．．．．．．．．．．．．．model
．．．．．．．．．．．．．．exferimeritation
．．．．．．．．．．．．．experimentation
．．．．．．．．．．．．．．．．．effectiveriess
．．．．．．．．．．．．．．．．．．efficiericy

```
a fortiori analysis. *X Ent: contingency analysis
a fortiori analysis *E
action, feasibie **E(kwic for: feasible action) Ent: constraint
action süace, *X Ent: constraint
action seace **E Ent: consequence
actor ##s Ent: role-playing
actor *#X Ent: moodel
alternative *\lambda. Ent: dominance
ajrernative?" *X Ent: risk
alternative *x Ent: sensitivity analysis
alternative *x Ent: ctility
alternative * X Ent: a fortiozi analysis
alterma=ive *X Ent: effectiveness
aiternative. *X Ent: ofportunity cost
alternative, feasible **E(kwic for: feasible alternative) Ent: constraint
alternative, feasible **E(kwic for: fe
alternatives, * X Ent: cecision theory
alternatives, *X Ent: contingency analysis
altesmecives *X Ent: course of action
alteinicives *x Ent: criterion
alEE:na=ives. *X Ent: decision make=
analysis, a fortiori **E (kwic for: a fortiori analysis)
analysis, cortingency **E (kwic for: contingency analysis)
analysis, cost-tenefit **E(kwic For: cost-benefit analysis) Ent: systems analysis
analysis, cost-effectiveness **r(kwic for: cost-effectiveness analysis) Ent: systems analysis
Eral\varthetasis, cecision **E(knic for: decision analysis) Ent: systems analysis
amiysis, Eeasibility **E(fkic for: fessibility analysis) Ent: systems analysis
cnalysis, inzut-cutput (Leontief) **E (kwic for: input-output (Leor:ief) analysis)
anajusis, Leontief **S (kwik for: Leontief analysis) Ent: input-outfut (Leontief) analysis Syn. for: input-output (Leontief)
analysis, policy *#E(kwic for: policy analysis) Ent: systems analysis
analysis, resource **E (kwic for: resource analysis)
analysis, risk **E(kwic for: risk analysis) Ent: risk
aralvisls, risk **S (kwik for: risk analysis) Ent: risk Syn. for: risk assessment
ancl#sis, risk-benefit **E(kwic Eor: risk-benefitt analysis) Ent: systems analysis
en:i\dddot{sis, sensitivity **E (twic for: sensitivity analysis)}
analysis, value *E (kwic for: value analysis) Ent: value
analytic mocel *E Ent: r.odel
attribute, value-relevant **EE(kwic for: value-relevant attribute) Ent: consequence
benofit **E Ent: consequence
benefit **X Ent: efficiency
benefit **x Ent: discount rate
benefits *x Ent: externality
Eenefits *x Ent: value
Leriesits *X Ent: opgortunity cost
Lerefits, *x
Ent: systems analysis
ausal nooge
```

$\qquad$

```
cusal nociel
**E Ent: nodel
L Ent: optimization
coefficient, technoloqical **E(kwic for: technological coefficient) Ent: input-output (Leontief) analysis
conpetrtive rultiple objectives **E Ent: objective
comfletitlve objertives * X Ent: satisficing
congucer simulation *E Ent: simulation
coriicional forecast *E Ent: forecest
corili&E situation *X Ent: c&jective
```

```
conflict situation **E Ent: game theory
conflicting objectives. *E Ent: objective
conjolnt measurement theory melity Ent: value
consestence *X Ent: externality
conseyuence: *X Ent: impact
consev̧lence *E
conseçuence, feasible **E(kwic for: feasible consequence) Ent: constraint
conseguence, multiattribute **E(kwic for: multiattribute consequence) Ent: consequence
consequence, single-attribute **E(kwic for: single-attribute consequence) Ent: consequence
conseu:ence space, *x Ent: constraint
conscqucrce space **E Ent: consequence
conseguence tree *E Ent: consecuence
concecturces. *X Ent: decision theory
consecucaces * Ent: donirannce
conscuvences *X Ent: envirorment
consecuerces *X Ent: state of the world
consc:zuences *X Ent: utility
conscevencos, - *X Ent: constraint
cosecucrces *x Ent: model
conscucc:ces * Ent: systems analysis
cons=taint **X Ent: optimization
cunstrinint *E
constriint, elastic **E(kwic for: elastic constraint) Ent: constraint
constrainE, long-run **(kwic for: long-run constraint) Ent: constraint
constralnt, retovabie **S (hwlk fo:: vemovable constraint) Ent: constraint Syn. for: elastic constraint
constrannt, short-run **E(kwic cot: short-run constraint) Ent: constraint
constrimnt, stifit **E(kwic for: Stiff constraint) Ent: constraint
0.stralr:, <ngluestionable, **S (kwik for: unquestionable constraint) Ent: constraint Syn. for: stiff constraint
U:St5u:nts). *X Ent: objective
construlnts, *y Ent: systenis anelysis
ontingency analysis, *X Ent: sensitivity analysis
ontrngency analysis. *X Ent: a fortiori analysis
contıngency anclysis *E
orrelation model **E Ent: model
cost **E cnt: consequence
** ECt: discount rate
ost, opyurtunity **E (kwic for: opportunity cost)
cost-Eefefit analysis **E Ent: systems analysis
cost-effectiveness analysis. *E Ent: systems analysis
costs *X Ent: externality
costs, *X Ent: systems analysis
course of action *X Ent: experimentation
course Of acticn, *X Ent: state of the world
curse of riction * f fnt: consecuence
cuurse of action; *X Ënt: r.ode?
course of action. *X Ent: scanario
curse of action *X Ent: systems analysis
ccurse oE action **X Ent: impact
course of action *E
Ourses of action *X Ent: alternative
courses of action. *X Ent: resource analysis
criterion *X Ent: decision theozy
crlter10: * X Ent: optimization
criterlun **X Ent: dominance
Cri&ことion *S
む\epsilonこ:Eion analvsis. *E Ent: systems analysis
```

```
Cecision maker, *X Ent: alternative
decision maker *X Ent: deaision theory
decision maker
decision raker
cecisionmamer *X Ent: risk
decision maker
decision maker,"
decision maker
jecision maker
decision maker
cecision maker
decision maker
decision nater
cecision maler
decision maker, risk-averse **E(kwic for: risk-averse decison maker) Ent: utility
decis:on maker, risk-neutral **E(kwic for: risk-neutral decision maker) Ent: utility
decision maker, risk-prone **E(kwic for: risk-prone decision maker) Ent: utility
deczsicon makers *X Ent: role-flaying
decision mater's *X Ent: trade-off
cecision, primary t*E(kwic for: primary decision) Ent: secondary decision
decision, secondary **E(kwic for: secondary decision) Ent: secondary decision
decisior taker ***S Ent: decision maker Syn. for: decision maker
decision theory *x Ent: risk
decision theory *x Ent: traje-off
aecision theory *X Ent: uncertainty
decisiun theory, *X Ent: utility
cecision thecry; *X Ent: utility
desision theory. *X Ent: value
cecision theory *X Ent:consecuence
decision theory). *x Ent: optimization
decision theory *E
decision under certainty **E Ent: decision theory
decision under risk *E Ent: decision theory
decision Lnder uncertainty. *L Ent: decision theory
decision variables, *E Ent: optimization
Eelphi metrod *E
derand *E
denand function, *E Ent: demand
ceterministic model *E Ent: model
ciscount rate - **x Ent: systems analysis
aiscuunt rate *
aiscretization *E Ent: optimization
diseconcniy of scale, tE Ent: economy of scale
dorinance *E
ayramic mociel *E Ent: model
aynaric optimization problem **E Ent: optimization
econony of scale *E
effectiveress *X Ent: efficiency
effec:lvaness *E
E:f1cicncy #E
elastic coristraint **E Ent: constraint
environment: *X Ent: sensitivity analysis
ervironnéat. *X Ent: state of the world
enviromient *x Ent: contingency analysis
Environl:ent *E * * E Entiltrium frice: demana
```

```
estimation, model **E(kwic for: model estimation) Ent: model
evaluation *E
expected ctility *x Ent: jecision theory
expected utility **E Ent: utility
excerimentation *
exterralities.
externality *E * X E: consequence
ieasitility analysis. *E Ent: systems analysis
Eeasitility analysis. *E Ent: system
feasible action **E Ent: canstraint 
feasible alternative **E(kwic for: feasible alternative) Ent: constraint
fcasible consecuence **E(kwic for: feasible consequence) Ent: constrain
feasibie ubjective **E(kwic for: feasible objective) Ent: constraint
feasible set *E Ent: constraint
fezs:ule solution, *E Ert: Optimization
Ecrecast * * Ent: state of the world
forecast *X Ent: scenario
forecast *X
foracast, conditional
fosesast, conditional **E(kwic for: conditional forecast) Ent: forecast
forecast, s\inlf-fulfilling **E(kwic for: self-fulfilling forecast) Ent: forecast
forecasting horizon ***S Ent: forecast Syn, for: forecasting lead
forecastirg lead *E Ent: forecast
forecassirg lead *EE Ent: f..cミel
g Ei.:\le **** Ent: utility Syn for: lottery
g#Fe, Fultiferson **E(knice for: mulこiperson game) Ent: game theory
g#ne, multiferson **E(kric for: mul¿iperson game) Ent: game theory
game theory, *X Ent: decision theozy
game theory, *x Ent: decision "heory
game theory). *x Ent: objective
game theory *E
Game theory *E **E, two-serson **(kwic for: two-verson game) Ent: game theory
Gcre, two-gerson **E(kwic for: two-person game) Ent: game theor
yane, zerc-sum **E(kwic for: zero-sum game) Ent: game theory
jenir.g. ** Ent: simulation
Saning **E Ent: role-playing
goal *E Ent: objective
Hierarchy of objectives. *E Ent: objective
horizon, forecasting **S (kwik for: forecasting horizon) Ent: forecast Syn. for: forecasting lead
identification, model **E(kwic cor: model identification) Ent: model
Mmyact, ** Ent: risk
imjact). *x Ent: Ent: consequence
1ajactl.* *X
lm:act *E
ir.acets
* *X
Ent:
iruglementation *E
iriglementation *E
input-output (Leontief) analysis *E
irput-outgut model *E Ent: input-output (Leontief) analysis
intescr frogramaing *E Ent: optimization
interoejendence matrix, technological **E(kwic for: technological interdependence matrix) Ent: input-output (Leontief)
interest rate ***S Ent: discount rate Syn. for: discount rate
iterutive process *E
jucgrentas nozel **
Leonticf analysis ***S Ent: model
Lenear mocel ***
l:near model **E
linear programming
linear programming *E Ent: optimization
**S (kwik for: Leontief analysis) Ent: input-output (Leontief) analysis Syn. for: input-output (Leon-
Ent: model
lons-run constraint ***E Ent: model
lottery **E Ent: utilem Ent: constraint
lottery **E Ent: utility 
#
```

```
ma-machine simulation **E Ent: Simulation
marginal utility **E Ent: utility
max-max rule *E Ent: decision theory
max-mex rule *E Ent: decision theory
mox-inin rule. Ent: input-output (Leontief) analysis
mocel *x Ent: simulation
model *X Ent: validation
mocel *X Ent: verification
mocel *X Ent: verification
mogel **X Ent: experimentarion
fivel *E
m:Ojel, analytic **E(kwic for: analytic model) Ent: model
m:odel, analytic **E(kwicic for: causal model) Ent: model
mocel, ceusci **E(kwic for: causal model) Ent: model 
mocel, aeterministic **E(kwic for: deterministic model) Ent: model
macel, aeterministic **E(kwic for: deterministic model)
mocel, formal **E(kwic for: formal model) Ent: model
medel identification; *L Ent: mosel
Fveel, ingut-octput **E(kwic for: input-output model) Ent: input-output (Leon:ief) analysis
moE=1, jujgaental **E(kwic for: judsmental model) Ent: model
movel, lirecar **E(kwic for: linear model) Ent: model
~OEl, Ean-\pi_chine **E(xwic for: mar-machine model) Ent: model
*ocel, o*E(kwic for, optinization model) Ent:Model
mocel, oftimization **E(kwic for: optimization model) Ent: model
\picjel parameters **E Ent: model
mciel, yole-playing **E(kwic fos: role-playing model) Ent: mocei
miciel, simulation **E(kwic for: simulation model) Ent: model
mccel, static **E(kwic for: static model) Ent: model
mc=il, stochastic **E(knicc for: stochastic model) Ent: model
Fcこed structure **E Ent: Todel
#ovels *X Ent: decision theory
Fo<̇els, *X Ent: secondary decision
mojels. *X Ent: consequence
Fosels. *X Ent: forecasr
Auiriattribute consequence *E Ent: consequence
multiartribute corsequence **x Ent: utility
*ul:iattribute utiliEy function *E Ent: utility
multiatt=ibute utility functions. *x Ent: trade-off
muitiãtrribute value function, *E Ent: value
Rulriattritute value function *X Ent: decision theory
rulriattritute value function *x Ent: decision theory
multiattribute value function). *X Ent: utility
multiattribute value functions *X Ent: trade-off
muliiobjective optimization. *E EnE: optimization
multiperson yame **E Ent: game theozy
mul:H-E OWjectives ** Ent: objective
wultifle objectives **, Ent: satisficing
non+inear programeing *E Ent: ootimization
ckjective. *% Ent: criterion
oojective **X Ent: role-playing
cojective *E
ozject:ve, fcasible **E(kwic for: feasible objective) Ent: constraint
cojertive Eunction, *E Ent: ogtimization
objective, froxy **E(kwic for: proxy objective) Ent: objective
objective, scular-valued **E(kwic for: scalar-valued objective) Ent: optimization
objective space. *E Ent: objective
objective s:cece *X Ent: constraint
objective, vector-valued **E(kwic for: vector-valued objective) Ent: op:imization
```

objectives. . *x Ent: alternative
objectives *x Ent: decision theory
objectives *x Ent: game theory
objectives *x Ent: operatione research
objectives.
objectives
objectives
objectives.
jectives.
otjectives, conflicting ${ }^{\text {m }}$ E (kwic for: conflicting objectives.) Ent: objective objectives, hierarchy of **E(kwic for: hierarchy of objectives) Ent: objective objectives, multiple **E(kwic for: multiple objectives) Ent: objective oferational research $* * * S$ cnt: operations research Syn. for: operations research c:̈erat:ons research. *X Ent: systems analysis
oferetions rescarch
ozycrturity cost *E
ofinfial cuatrol problem ***S Ent: optimization Syn. for: dynamic optimization oftinl sulution *E Ent: optimization
oftionlzation, *X Ent: cecision theory
optiolzaticn *X Ent: Satisficing
OEミi..ization *X Ent: suboptimiza=ion
o巨timization nodel *E Ent: model.
oetimization, multiobjective **L(kwic for: multiobjective optimization) Ent: optimization ovtimization, multiobjective ** (kwic for: multiobjective optimization) Ent: optimization
optimication problem, dynanic **E(kwic for: cyamic optimization problem) Ent: optimization optimization problem, dynamic *E (kwic for: cynamic optimization problem) Ent: optimization
optinization, single-otjective $\# E(k w i c ~ f o r: ~ s i n g l e-o b j e c t i v e ~ o p t i m i z a t i o n) ~ E n t: ~ o p t i m i z a t i o n ~$ optir.u. strategy *E Ent: game theory
optir.ur. strategy $\quad$ Ent: game theory
option $* * *$ Ent: alternative Syn. for: alternative
oftions. * Ent Ent: course of action
oftions. ***s Ent: conscuence Syn for consequen
outcont *y Ent: conseçcence Syn. for: consequence
$\begin{array}{lll}\text { Outcones *X Ent: sensitivity analysis } \\ \text { Fareto optimal } \\ \text { EnE } & \text { Ent: optimization }\end{array}$
fareto optimal
play $* * i$
Ent: gane theory
player **e Ent: gane theory
plajer ***S Ent: role-playing Syn. for: actor
EOlicy analysis *E Ent: systems analysis
coler
Eolicy analysis *E Ent: Eurecest
Frice, equilibrium Ent. (kwic for: equilibrium price) Ent: demand
price, equilibrium
prifary decision Ent: secondary decision
prifary aecision
Frobatilistic programming $\quad$ En Ent : optimization

prozlem
proyraming, integer *E*E(kwic for: Integer programming) Ent: optimization
proeramaing, integer **E(kwic for: lnteger programming) Ent: optimization
programang, linear **E(kwic for: linear programming) Ent: optimization

projramming, stochastic **E(kwic for: stochastic programming) Ent Eptimization
Eroxy objective **E Ent: objective
Froxy objective **E Ent: objective
renovable constraint ***s Ent: constraint Syn. for: elastic constraint
resource analysis *E
risk, *X Ent: decision theory
risk * X Ent: uncertainty
Lisk *x Ent: utility

risk analysis *E Ent: risk
risk analysis＊＊＊S Ent：risk Syn．for：risk assessment
risx assessment＊E Ent：risk
risk，cecision under＊＊E（kwic for：decision under risk）Ent：decision theory
risk－averse cecison maker＊＊E Ent：urility
risk－benefit analysis．＊X Ent：risk
risi－terefit analysis＊＊E Ent：systems analysis
risk－nedtral decision maker＊＊E Ent：utility
risk－Erone decision maker＊＊E Ent：utility
risks；＊x Ent：systems analysis
role playiny，＊$X$ Ert：simulation
role－playing＊E
role－playing model＊＊E Ent：model
satisficiay＊E
＊＊E
Ent：optimization
scelar－valued objective＊＊E
seurasio．＊X Ent：forecast
sこerarlo＊E
secunüery decision＊E
selE－tulfilling torecast．＊E Ent：forecast
sensitivity analysis，＊X Ent：a fortiori analysis sens：tivity analysis，＊Ent：contingency analysis sensitivity analysis＊E
sncrt－ron constraint＊＊E Ent：constraint
sifulation＊$X$ Ent：role－playing
smmulation，＊X Ent：secordary decision
simulation＊E
simpation，computer＊＊E（kric fcr：computer simulation）Ent：simulation
simulation，man－machine A\＃E（kwic for：man－machine simulation）Ent：simulation
simulation model＊E Ent：mocel
sifulation，stochastic＊＊（inic for：stochastic simulation）Ent：model
sinyie－ztEibite conseguence $\quad \pi \bar{E}$ Ent：consequence
single－attribute consecuences＊＊XEnt：utility
single－o joctive optimization＊＊E
Ent：optimization
spillover．＊E Ent：externality
spillovers＊y Ent：consequence
state of nature＊＊＊S Ent：environment Syn．for：envizonment
state of the world＊＊X En＝：envirorment
state of the norid
static rojel＊E Ent：model
stizi constraint＊＊E Ent：constraint
stostuatic noojel＊E Ent：model
stcehastic programming＊＊E［nt：optimization
stocristic sinulation，＊E Ent：nodel
strategy，optimum＊＊E（kwic for：oftimum strategy）Ent：game theory
sutjective probability＊＊E Ent：de－ision theory
suとコうtinization＊E
sugly function＊E Ent：denand
soistems analusis，＊X Ert：experimertation
syseens snaivsis．＊X Ent：oferations research
systens analysis，＊X Ent：risk
systems enalysis＊Enc：secondary decision
systems analysis＊$x$ Ent：course of action
systeris analysis，＊x Ent：effrativeness
syster：s analysis＊x Ent：modsl
systems analysis，＊x Ent：obj？ctive
systcias anajysis＊E
tarjet＊Ent：objective

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```
target point. *E Ent: objective
target set. *E Ent: objective
ta:get value **E Ent: objective
zechnolojical coefficient **E Ent: input-output (Leontief) analysis
cecinological interdependence matrix *E Ent: input-output (Leontief) analysis
tief) analysis
race-orf *E
trjuc-offs *X Ent: operations research
traju-ofss *X Ent: utility
=ん0-%^rzon 5ane **E Ent: game theory
cozcitivi:ty:..* Ent: Eccision theory
LNcercumey *x Ent: risk
cocertaznty * X Ent: Ltility
```



```
<mecrta:nty & E.f: contingency analysis
```




```
*.N Ent: ce-zsion thcory
* A Ent: trここe-off
!こうこな;* * 
utility, expected **C(kwic for: expected utility) Ent: utility
Ltility function *X [nt= decision theory
iviliy function **E Ent: litility
UEil:tyfunction ***S Ent: utility Syn. for: welfare function
:tlity function, mule:attribute **E(kwic fo:: multiattribute utility Eunction) Ent: utility
CtiliEy, mergincl **E(kwic for: marginal utility) Ent: utility
LEility theozy *E Ent: ctility
valication. *X Ent: verification
valication. *X Ent: model
valication *E
value. *x Ent: decision theory
veide, *X Ent: trace-off
*El:e *
vawe analy'sis, *E Ent: vaiue
value Etalysis *X Ent: trade-off
value function, *Z Ent: value
alve fliction, multiattribute **e(kwic for: multiattribute value function) Ent: value
Value-relevant attriEute **E Ent: consequence
valuc-refevent attribute **y. Ent: value
vector-valued objective **E Ent: optimization
verlilcation. *X
    Ent: model
veificcation *s
welfare function *E Ent: utility
zero-sum game *E Ent: game theory
```

