

The Operations Research Problem Solving Process

There are many different problem solving processes. In this course we will use a seven element operations research problem solving process as shown at the enclosure. This process is functionally similar to processes found in other references (see, for example, Hillier and Lieberman, *Introduction to Mathematical Programming*). The process should not be viewed as linear, though we present it as a list of fundamental actions grouped into three phases for ease of discussion.

The three phases of the process are *formulation*, *analysis*, and *interpretation*. During the formulation phase of the process, the analyst defines the problem, determines assessment criteria, and develops alternatives. These elements are followed by an analysis phase using modeling and optimization. The last phase, interpretation, encompasses making a decision and developing implementation plans. The paragraphs below explain the seven elements of the operations research problem solving process in greater detail. The activities that take place in each element are illustrated through some of the tools or methods commonly used. These tools and methods are identified by bold type.

Problem Definition. The purpose of the problem definition is to explore available resources, subjectively bound the goals, establish system inputs, and develop a statement of the problem. This step is characterized by **research**, **data analysis**, and creative application of the knowledge gained to scope and bound the problem. A **needs analysis** interprets and translates the primitive need into the effective need. **Objective trees** (goal trees) clarify and organize the goals and objectives. **Input-output analysis** defines applicable boundary conditions and helps lead to a technical statement of the problem by identifying applicable parameters, variables, and constraints.

Value System Design. The operations research analyst decides upon the objectives and criteria that will determine the recommended alternatives, and organizes objectives into a hierarchy or tree showing the relative importance of the objectives and the relationships between them. Useful tools for this effort are **weighted criteria trees**, **flow charts**, and **causal loop diagrams**. These tools help complete the **quality function deployment (QFD) matrix** and help generate alternatives in the next step. **System definition matrices** organize the information developed for the problem definition. The output from this step is an **engineering problem statement** that identifies goals, objectives, criteria, variables, parameters, and constraints.

Synthesis of Alternatives. In this step many different alternatives are developed as ways to potentially satisfy the need. Techniques used in this step include **nominal group techniques** (brainstorming, brainwriting, dynamic confrontation), **computer simulation**, **Zwicky's morphological box**, and others. This step also includes **feasibility screening** where unrealizable alternatives are discarded. The operations research analyst tries to develop alternatives that are significantly different and then describe them in sufficient detail to model and analyze in subsequent steps.

Systems Modeling and Analysis. The operations research analyst develops models to analyze and compare the various alternatives. Some methods and techniques that may be used in this step are **data analysis, probability theory**, econometric modeling (**time value of money, future worth, life-cycle costs**), **regression, forecasting, mathematical programming** (linear, nonlinear, integer, goal), **queueing, networks, reliability analysis**, and **simulation**.

Optimization of Alternatives. To make meaningful comparisons, the analyst optimizes or refines controllable parameters in each alternative system. Methods commonly used for optimization are **numerical iteration** (spreadsheet or program), **mathematical programming, derivative calculus, calculus of variations**, and **graphical methods**. The effect of changes in the state of nature is measured through **parametric sensitivity analysis**.

Decision Making. The analyst evaluates the alternatives with respect to the value system in a manner that allows comparison. The end result is to select one or more alternatives to take into the next phase of the life-cycle process. Some techniques and tools are **multi-attribute utility (MAU) theory, game theory, risk analysis, influence diagrams, decision analysis, data analysis**, and **statistical methods**. **Value system sensitivity analysis** measures the effect of changes in judgement.

Planning for Action. This means taking all necessary steps to implement the results of this phase of the life-cycle. Included actions are to write **reports**, prepare and deliver **briefings**, allocate and schedule resources (**PERT, resource planning, scheduling**), and, perhaps, promotional activities.