Operations research

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Operations research, operational research, or simply OR, is the use of mathematical models, statistics and algorithms to aid in decision-making. It is most often used to analyze complex real-world systems, typically with the goal of improving or optimizing performance. It is one form of applied mathematics.

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Operations research in context

The terms operations research and management science are often used synonymously. When a distinction is drawn, management science generally implies a closer relationship to the problems of business management.

Operations research also closely relates to industrial engineering. Industrial engineering takes more of an engineering point of view, and industrial engineers typically consider OR techniques to be a major part of their toolset.

Some of the primary tools used by operations researchers are statistics, optimization, stochastics, queueing theory, game theory, graph theory, and simulation. Because of the computational nature of these fields OR also has ties to computer science, and operations researchers regularly use custom-written or off-the-shelf software.

Operations research is distinguished by its ability to look at and improve an entire system, rather than concentrating only on specific elements (though this is often done as well). An operations researcher faced with a new problem is expected to determine which techniques are most appropriate given the nature of the system, the goals for improvement, and constraints on time and computing power. For this and other reasons, the human element of OR is vital. Like any tools, OR techniques cannot solve problems by themselves.

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Areas of application

A few examples of applications in which operations research is currently used include the following:

- designing the layout of a factory for efficient flow of materials
- constructing a telecommunications network at low cost while still guaranteeing quality service if particular connections become very busy or get damaged

- determining the routes of school buses so that as few buses are needed as possible
- designing the layout of a computer chip to reduce manufacturing time (therefore reducing cost)
- managing the flow of raw materials and products in a supply chain based on uncertain demand for the finished products

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Professional societies

The International Federation of Operational Research Societies (IFORS) is an umbrella organization for operations research societies worldwide. Significant among these are the Institute for Operations Research and the Management Sciences (INFORMS) and the Operational Research Society (ORS). EURO is the association of European Operational Research Societies (EURO). CORS is the Canadian Operations Research Society (CORS). ASOR is the Australian Society for Operations Research (ASOR). MORS is the Military Operations Research Society (MORS)--based in the United States since 1966 with the objective of enhancing the quality and usefulness of military operations research analysis in support of defense decisions. ORSP is the Operations Research Society of the Philippines.

In 2004, INFORMS began an initiative to better market the OR profession, including a website entitled The Science of Better, which provides an introduction to OR and examples of successful applications of OR to industrial problems.

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Origins and the name

Although foundations were laid earlier, the field of operations research as we know it arose during World War II, as military planners in the United Kingdom (including Frederick Lanchester, Patrick Blackett and Frank Yates) and in the United States looked for ways to make better decisions in such areas as logistics and training schedules. After the war it began to be applied to similar problems in industry.

It is known as "operational research" in the United Kingdom ("operational analysis" within the UK military and Ministry of Defence, where OR stands for "operational requirements") and as "operations research" in most other English-speaking countries, though OR is a common abbreviation everywhere. The name is somewhat unfortunate, since OR is no longer concerned only with operations, nor does its application involve any research in the traditional sense (though OR research is still carried out to find new or better techniques).

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Examples

Blackett's team made a number of crucial analyses which aided the war effort. Britain introduced the convoy system to reduce shipping losses, but while the principle of using warships to accompany merchant ships was generally accepted, it was unclear whether it was better for convoys to be small or large. Convoys travel at the speed of the slowest member, so small convoys can travel faster. It was also argued that small convoys would be harder for German U-boats to detect. On the other hand, large convoys could deploy more warships against an attacker and also the

proportion of merchant ships sunk by a U-boat would be lower. Blackett's staff clearly showed that:

- large convoys were more efficient
- the probability of detection by U-boat was statistically unrelated to the size of the convoy
- slow convoys were at greater risk (though considered overall, large convoys were still to be preferred)

In another piece of work, Blackett's team analysed a report of a survey carried out by RAF Bomber Command. For the survey Bomber Command inspected all bombers returning from bombing raids over Germany over a particular period. All damage inflicted by German air defenses was noted and the recommendation was given that armour be added in the most heavily damaged areas.

Blackett's team instead made the surprising and counter-intuitive recommendation that the armour be placed in the areas which were completely untouched by damage, according to the survey. They reasoned that the survey was biased, since it only included aircraft that successfully came back from Germany. The untouched areas were probably vital areas, which if hit would result in the loss of the aircraft.