

According to a 2001 survey by the National Association of Colleges and Employers, starting salary offers averaged \$46,466 a year for mathematics graduates with a bachelor's degree, and \$55,938 for those with a master's degree. Doctoral degree candidates averaged \$53,440.

In early 2001, the average annual salary for mathematicians employed by the Federal Government in supervisory, nonsupervisory, and managerial positions was \$76,460; for mathematical statisticians, it was \$76,530, and for cryptanalysts, \$70,840.

Related Occupations

Other occupations that require extensive knowledge of mathematics or, in some cases, a degree in mathematics include actuaries; statisticians; computer programmers; systems analysts, computer scientists, and database administrators; computer software engineers; and operations research analysts. A strong background in mathematics also facilitates employment as teachers—postsecondary, engineers, economists and survey and market researchers, financial analysts and personal financial advisors, and physicists and astronomers.

Sources of Additional Information

For more information about careers and training in mathematics, especially for doctoral-level employment, contact:

► American Mathematical Society, 201 Charles St., Providence, RI 02940. Internet: <http://www.ams.org>

For specific information on careers in applied mathematics, contact:

► Society for Industrial and Applied Mathematics, 3600 University City Science Center, Philadelphia, PA 19104-2688. Internet:

<http://www.siam.org/alterindex.htm>

Information on obtaining a mathematician position with the Federal Government is available from the Office of Personnel Management (OPM) through a telephone-based system. Consult your telephone directory under U.S. Government for a local number or call (912) 757-3000; Federal Relay Service: (800) 877-8339. The first number is not tollfree, and charges may result. Information also is available from the OPM Internet site: <http://www.usajobs.opm.gov>.

Operations Research Analysts

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Significant Points

- Individuals with a master's or Ph.D. degree in management science, operations research, or a closely related field should have good job prospects.
- Employment growth is projected to be slower than average because few job openings are expected to have the title *operations research analyst*.

Nature of the Work

Operations research and management science are terms that are used interchangeably to describe the discipline of applying advanced analytical techniques to help make better decisions and to solve problems. The procedures of operations research gave effective assistance during World War II in missions such as deploying radar, searching for enemy submarines, and getting supplies where they were most needed. Following the war, new analytical methods were developed and numerous peacetime applications emerged, leading to the use of operations research in many industries and occupations.

The prevalence of operations research in the Nation's economy reflects the growing complexity of managing large organizations that require the effective use of money, materials, equipment, and people. Operations research analysts help determine better ways to coordinate these elements by applying analytical methods from mathematics, science, and engineering. They solve problems in different ways and propose alternative solutions to management, which then chooses the course of action that best meets the organization's goals. In general, operations research analysts may be concerned with diverse issues such as top-level strategy, planning, forecasting, resource allocation, performance measurement, scheduling, design of production facilities and systems, supply chain management, pricing, transportation and distribution, and analysis of data in large databases.

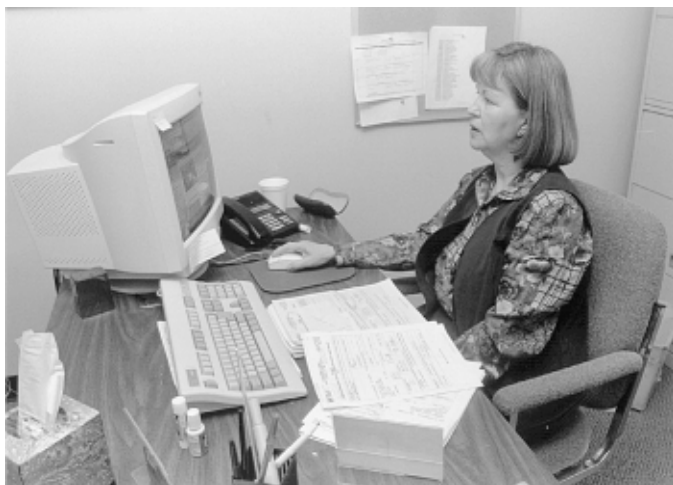
The duties of the operations research analyst vary according to the structure and management philosophy of the employer or client. Some firms centralize operations research in one department; others use operations research in each division. Operations research analysts also may work closely with senior managers to identify and solve a variety of problems. Some organizations contract operations research services with a consulting firm. Economists, systems analysts, mathematicians, industrial engineers, and others also may apply operations research techniques to address problems in their respective fields. (These occupations are discussed elsewhere in the *Handbook*.)

Regardless of the type or structure of the client organization, operations research in its classical role entails a similar set of procedures in carrying out analysis to support management's quest for performance improvement. Managers begin the process by describing the symptoms of a problem to the analyst, who then formally defines the problem. For example, an operations research analyst for an auto manufacturer may be asked to determine the best inventory level for each of the parts needed on a production line and to determine the number of windshields to be kept in inventory. Too many windshields would be wasteful and expensive, while too few could result in an unintended halt in production.

Operations research analysts study such problems, then break them into their component parts. Analysts then gather information about each of these parts from a variety of sources. To determine the most efficient amount of inventory to be kept on hand, for example, operations research analysts might talk with engineers about production levels, discuss purchasing arrangements with buyers, and examine data on storage costs provided by the accounting department.

With this information in hand, the analyst is ready to select the most appropriate analytical technique. Analysts could use several techniques—including simulation, linear and nonlinear programming, dynamic programming, queuing and other stochastic-process models, Markov decision processes, econometric methods, data envelopment analysis, neural networks, expert systems, decision analysis, and the analytic hierarchy process. Nearly all of these techniques, however, involve the construction of a mathematical model that attempts to describe the system being studied. The use of models enables the analyst to assign values to the different components, and clarify the relationships between components. These values can be altered to examine what may happen to the system under different circumstances.

In most cases, the computer program developed to solve the model must be modified and run repeatedly to obtain different solutions. A model for airline flight scheduling, for example, might include variables for the cities to be connected, amount of fuel required to fly the routes, projected levels of passenger demand, varying ticket and fuel prices, pilot scheduling, and maintenance costs. By locating the right combination of variable values, the analyst is able to produce the best flight schedule consistent with particular assumptions.



Operations research analysts often use computer-generated mathematical models to evaluate and improve an organization's efficiency.

Upon concluding the analysis, the operations research analyst presents to management recommendations based on the results. Additional computer runs to consider different assumptions may be needed before deciding on the final recommendation. Once management reaches a decision, the analyst usually works with others in the organization to ensure the plan's successful implementation.

Working Conditions

Operations research analysts generally work regular hours in an office environment. Because they work on projects that are of immediate interest to top management, operations research analysts often are under pressure to meet deadlines and work more than a 40-hour week.

Employment

Operations research analysts held about 47,000 jobs in 2000. Major employers include telecommunication companies, air carriers, computer and data processing services firms, financial institutions, insurance carriers, engineering and management services firms, and the Federal Government. Most operations research analysts in the Federal Government work for the U.S. Armed Forces, and many operations research analysts in private industry work directly or indirectly on national defense. About 1 out of 5 analysts work for engineering, management and public relations, and research and testing, agencies that do operations research consulting.

Training, Other Qualifications, and Advancement

Employers generally prefer applicants with at least a master's degree in operations research, engineering, business, mathematics, information systems, or management science, coupled with a bachelor's degree in computer science or a quantitative discipline such as economics, mathematics, or statistics. Dual graduate degrees in operations research and computer science are especially attractive to employers. Operations research analysts also must be able to think logically and work well with people, and employers prefer workers with good oral and written communication skills.

In addition to formal education, employers often sponsor training for experienced workers, helping them keep up with new developments in operations research techniques and computer science. Some analysts attend advanced university classes on these subjects at their employer's expense.

Because computers are the most important tools for in-depth analysis, training and experience in programming are required. Operations research analysts typically need to be proficient in database collection and management, programming, and in the development and use of sophisticated software programs.

Beginning analysts usually perform routine work under the supervision of more experienced analysts. As they gain knowledge and experience, they are assigned more complex tasks and given greater autonomy to design models and solve problems. Operations research analysts advance by assuming positions as technical specialists or supervisors. The skills acquired by operations research analysts are useful for higher level management jobs, so experienced analysts may leave the field to assume nontechnical managerial or administrative positions. Operations research analysts with significant experience might become consultants and some may even open their own consulting practice.

Job Outlook

Employment of operations research analysts is expected to grow more slowly than the average for all occupations through 2010, because few job openings in this field are expected to have the title *operations research analyst*. Job opportunities in operations research should be good, however, because of interest in improving productivity, effectiveness, and competitiveness, and because of the extensive availability of data, computers, and software. Many jobs in operations research have other titles such as *operations analyst, management analyst, systems analyst, or policy analyst*. Individuals who hold a master's or Ph.D. degree in operations research, management science, or a closely related field should find good job opportunities as the number of openings generated by employment growth and the need to replace those leaving the occupation is expected to exceed the number of persons graduating with these credentials.

Organizations today face pressure from growing domestic and international competition and must work to make their operations as effective as possible. As a result, businesses will increasingly rely on operations research analysts to optimize profits by improving productivity and reducing costs. As new technology is introduced into the marketplace, operations research analysts will be needed to determine how to utilize the technology in the best way.

Opportunities for operations research analysts exist in almost every industry because of the diversity of applications for their work. However, opportunities should be especially good in highly competitive industries, such as manufacturing, transportation, and telecommunications, and finance. As businesses and government agencies continue to contract out jobs to cut costs, many operations research analysts also will find opportunities as consultants, either working for a consulting firm or setting up their own practice. Opportunities in the military also exist, but will depend on the size of future military budgets. As the military develops new weapons systems and strategies, military leaders will rely on operations research analysts to test and evaluate their accuracy and effectiveness.

Earnings

Median annual earnings of operations research analysts were \$53,420 in 2000. The middle 50 percent earned between \$40,530 and \$70,790. The lowest 10 percent had earnings of less than \$31,860, while the highest 10 percent earned more than \$88,870. In 2000, median annual earnings in the industries employing the largest numbers of operations research analysts were:

Computer and data processing services	\$65,420
Federal Government	62,990
Aircraft and parts	52,960
Engineering and architectural services	47,480

The average annual salary for operations research analysts in the Federal Government in nonsupervisory, supervisory, and managerial positions was \$77,730 in 2001.

Related Occupations

Operations research analysts apply advanced analytical methods to large, complicated problems. Workers in other occupations that stress advanced analysis include systems analysts, computer scientists, and database administrators; computer programmers; engineers; mathematicians; statisticians; and economists and market and survey researchers. Because its goal is improved organizational effectiveness, operations research also is closely allied to managerial occupations, such as computer and information systems managers, and management analysts.

Sources of Additional Information

Information on career opportunities for operations research analysts is available from:

► Institute for Operations Research and the Management Sciences, 901 Elkridge Landing Rd., Suite 400, Linthicum, MD 21090. Internet: <http://www.informs.org>

For information on operations research careers in the Armed Forces and U.S. Department of Defense, contact:

► Military Operations Research Society, 101 South Whiting St., Suite 202, Alexandria, VA 22304. Internet: <http://www.mors.org>

Statisticians

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Significant Points

- Many individuals with degrees in statistics enter jobs that do not have the title statistician.
- A master's degree in statistics or mathematics is the minimum educational requirement for most jobs with this title.
- Although little or no change is expected in employment of statisticians over the 2000-10 period, job opportunities should remain favorable for individuals with statistical degrees.

Nature of the Work

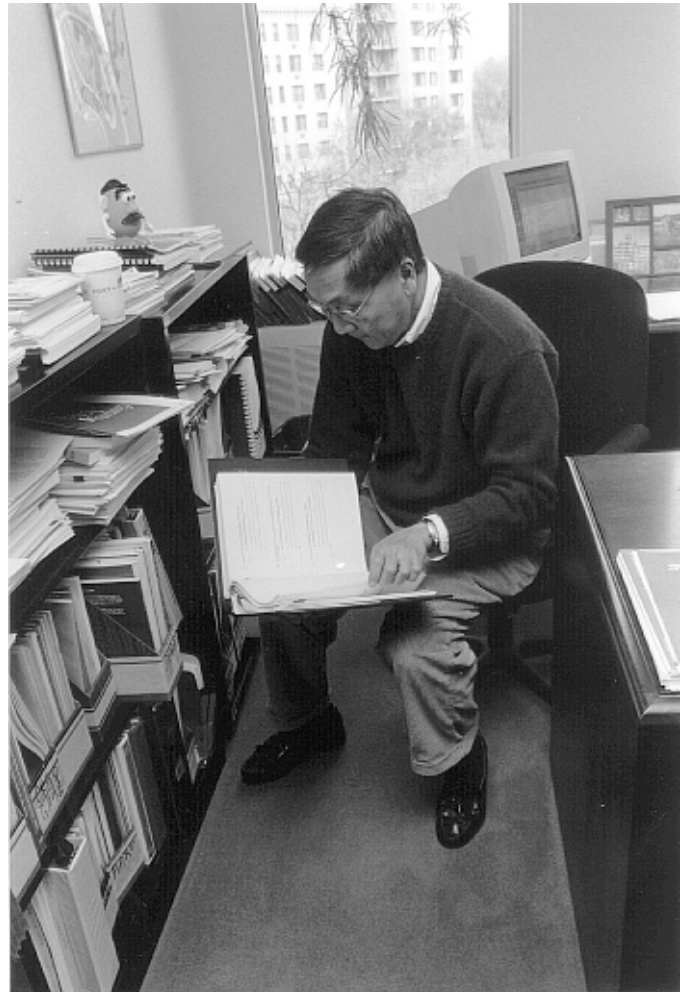
Statistics is the scientific application of mathematical principles to the collection, analysis, and presentation of numerical data. Statisticians contribute to scientific inquiry by applying their mathematical knowledge to the design of surveys and experiments; collection, processing, and analysis of data; and interpretation of the results. Statisticians often apply their knowledge of statistical methods to a variety of subject areas, such as biology, economics, engineering, medicine, public health, psychology, marketing, education, and sports. Many applications cannot occur without the use of statistical techniques, such as designing experiments to gain Federal approval of a newly manufactured drug.

One technique that is especially useful to statisticians is sampling—obtaining information about a population of people or group of things by surveying a small portion of the total. For example, to determine the size of the audience for particular programs, television-rating services survey only a few thousand families, rather than all viewers. Statisticians decide where and how to gather the data, determine the type and size of the sample group, and develop

the survey questionnaire or reporting form. They also prepare instructions for workers who will collect and tabulate the data. Finally, statisticians analyze, interpret, and summarize the data using computer software.

In business and industry, statisticians play an important role in quality control and product development and improvement. In an automobile company, for example, statisticians might design experiments to determine the failure time of engines exposed to extreme weather conditions by running individual engines until failure and breakdown. Working for a pharmaceutical company, statisticians might develop and evaluate the results of clinical trials to determine the safety and effectiveness of new medications. And at a computer software firm, statisticians might help construct new statistical software packages to analyze data more accurately and efficiently. In addition to product development and testing, some statisticians also are involved in deciding what products to manufacture, how much to charge for them, and to whom the products should be marketed. Statisticians also may manage assets and liabilities, determining the risks and returns of certain investments.

Numerous statisticians also are employed by nearly every government agency. Some government statisticians develop surveys that measure population growth, consumer prices, or unemployment. Other statisticians work for scientific, environmental, and agricultural agencies and may help to determine the amount of pesticides in drinking water, the number of endangered species living in a particular area, or the number of people afflicted with a particular



Statisticians work in many different fields organizing surveys, collecting data, and analyzing the results.