Computer and Mathematical Occupations

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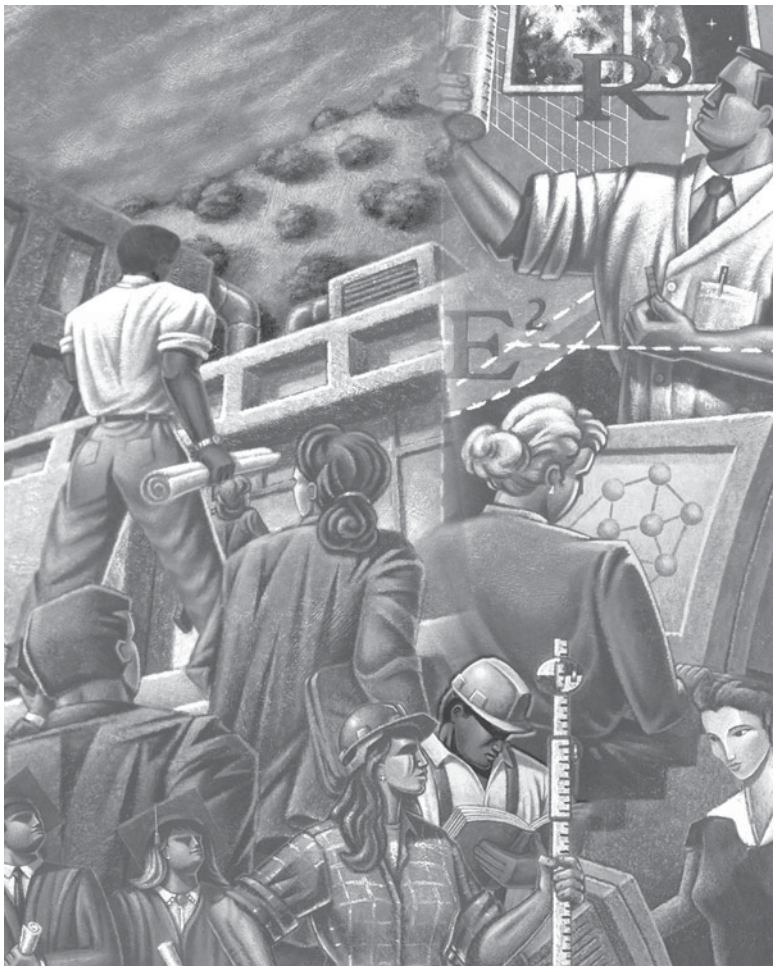


Occupations Included in this Reprint

Actuaries

(0*NET 15-2011.00)

Significant Points

- A strong background in mathematics is essential.
- About 6 out of 10 actuaries are employed in the insurance industry.
- Employment opportunities will be good despite the limited number of openings in this small occupation, as stringent qualifying requirements limit the number of new entrants.

Nature of the Work

One of the main functions of actuaries is to help businesses assess the risk of certain events occurring and formulate policies that minimize the cost of that risk. For this reason, actuaries are essential to the insurance industry. Actuaries assemble and analyze data to estimate the probability and likely cost of the occurrence of an event such as death, sickness, injury, disability, or loss of property. Actuaries also address financial questions, including those involving the level of pension contributions required to produce a certain retirement income level and the way in which a company should invest resources to maximize return on investments in light of potential risk. Using their broad knowledge of statistics, finance, and business, actuaries help design insurance policies, pension plans, and other financial strategies in a manner which will help ensure that the plans are maintained on a sound financial basis.

Most actuaries are employed in the insurance industry, specializing in life and health insurance or property and casualty insurance. They produce probability tables which determine the likelihood that a potential future event will generate a claim. From these tables, they estimate the amount a company can expect to pay in claims. For example, property and casualty actuaries calculate the expected amount of claims resulting from automobile accidents, which varies depending on the insured person's age, sex, driving history, type of car, and other factors. Actuaries ensure that the price, or premium, charged for such insurance will enable the company to cover claims and other expenses. This premium must be profitable, yet competitive with other insurance companies. Within the life and health insurance fields, actuaries are helping to develop long-term-care insurance and annuity policies, the latter a growing investment tool for many individuals.

Actuaries in other financial services industries manage credit and help price corporate security offerings. They also devise new investment tools to help their firms compete with other financial services companies. Pension actuaries working under the provisions of the Employee Retirement Income Security Act (ERISA) of 1974 evaluate pension plans covered by that Act and report on the plans' financial soundness to participants, sponsors, and Federal regulators. Actuaries working in government help manage social programs such as Social Security and Medicare.

Actuaries may help determine company policy and may need to explain complex technical matters to company executives, government officials, shareholders, policyholders, or the public in general. They may testify before public agencies on proposed legislation affecting their businesses or explain changes in contract provisions to customers. They also may help companies develop plans to enter new lines of business or new geographic markets with existing lines of business by forecasting demand in competitive settings.

Both staff actuaries employed by businesses and consulting actuaries provide advice to clients on a contract basis. The duties of most consulting actuaries are similar to those of other actuaries. For example, some may evaluate company pension plans by calculating the future value of employee and employer contributions and determining whether the amounts are sufficient to meet the future needs of retirees. Others help companies reduce their insurance costs by lowering the level of risk the companies take on. For instance, they may provide advice on how to lessen the risk of injury on the job, which will lower worker's compensation costs. Consulting actuaries sometimes testify in court regarding the value of the potential lifetime earnings of a person who is disabled or killed in an accident, the current value of future pension benefits (in divorce cases), or other values arrived at by complex calculations. Many consulting actuaries work in reinsurance, a field in which one insurance company arranges to share a large prospective liability policy with another insurance company in exchange for a percentage of the premium.

Working Conditions

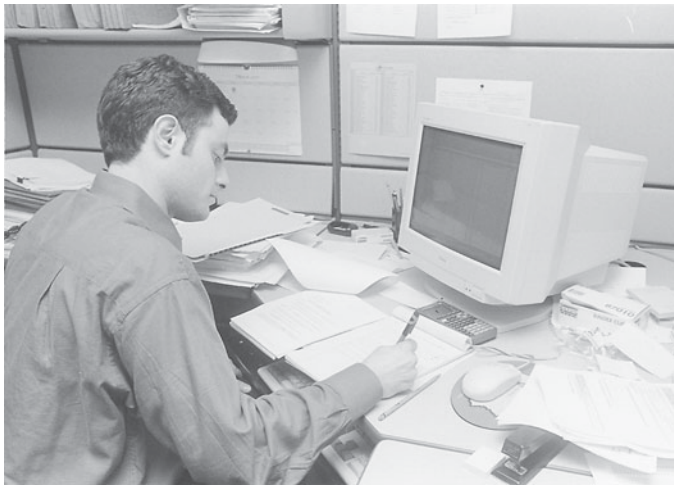
Actuaries have desk jobs, and their offices usually are comfortable and pleasant. They often work at least 40 hours a week. Some actuaries, particularly consulting actuaries, may travel to meet with clients. Consulting actuaries also may experience more erratic employment and be expected to work more than 40 hours per week.

Employment

Actuaries held about 15,000 jobs in 2002, with more than 1 in 2 actuaries employed by insurance carriers. Others work for pension funds and insurance agents and brokers. A growing number of actuaries work for firms providing a variety of corporate services, especially management and public relations, or for firms offering consulting services. A relatively small number of actuaries are employed by security and commodity brokers or by government agencies.

Training, Other Qualifications, and Advancement

Actuaries need a strong background in mathematics and general business. Applicants for beginning actuarial jobs usually



Actuaries analyze the probability that an adverse event will occur.

have a bachelor's degree in mathematics, actuarial science, statistics, or a business-related discipline, such as economics, finance, or accounting. About 100 colleges and universities offer an actuarial science program, and most offer a degree in mathematics, statistics, economics, or finance. Some companies hire applicants without specifying a major, provided that the applicant has a working knowledge of mathematics, including calculus, probability, and statistics, and has demonstrated this knowledge by passing one or two actuarial exams required for professional designation. Courses in economics, accounting, finance, and insurance also are useful. Companies increasingly prefer well-rounded individuals who, in addition to having acquired a strong technical background, have some training in liberal arts and business and possess strong communication skills.

In addition to knowledge of mathematics, computer skills are becoming increasingly important. Actuaries should be able to develop and use spreadsheets and databases, as well as standard statistical analysis software. Knowledge of computer programming languages, such as Visual Basic, also is useful.

Two professional societies sponsor programs leading to full professional status in their specialty. The first, the Society of Actuaries (SOA), administers a series of actuarial examinations in the life insurance, health benefits systems, retirement systems, and finance and investment fields. The Casualty Actuarial Society (CAS), as the name indicates, gives a series of examinations in the property and casualty field, which includes fire, accident, medical malpractice, worker's compensation, and personal injury liability.

The first four exams in the SOA and CAS examination series are jointly sponsored by the two societies and cover the same material. For this reason, students do not need to commit themselves to a specialty until they have taken the initial examinations, which test an individual's competence in probability, calculus, statistics, and other branches of mathematics. The first few examinations help students evaluate their potential as actuaries. Many prospective actuaries begin taking the exams in college with the help of self-study guides and courses. Those who pass one or more examinations have better opportunities for employment at higher starting salaries than those who do not.

After graduating from college, most prospective actuaries gain on-the job experience at an insurance company or consulting firm, while at the same time working to complete the examination process. Actuaries are encouraged to finish the entire series of examinations as soon as possible, advancing first to the Associate level (with an ASA or ACAS designation) and then to the Fellowship level (FSA or FCAS designation). Advanced topics in the casualty field include investment and assets, dynamic financial analysis, and valuation of insurance. Candidates in the SOA examination series must choose a specialty-group and health benefits, individual life and annuities, pensions, investments, or finance. Examinations are given twice a year, in the spring and the fall. Although many companies allot time to their employees for study, home study is required to pass the examinations, and many actuaries study for months to prepare for each examination. It is likewise common for employers to pay the hundreds of dollars for examination fees and study materials. Most actuaries reach the Associate level within 4 to 6 years and the Fellowship level a few years later.

Specific requirements apply to pension actuaries, who verify the financial status of defined benefit pension plans for the Federal Government. These actuaries must be enrolled by the Joint Board for the Enrollment of Actuaries. To qualify for enrollment, applicants must meet certain experience and examination requirements, as stipulated by the Board.

To perform their duties effectively, actuaries must keep up with current economic and social trends and legislation, as well as with developments in health, business, finance, and economics that could affect insurance or investment practices. Good communication and interpersonal skills also are important, particularly for prospective consulting actuaries.

Beginning actuaries often rotate among different jobs in an organization to learn various actuarial operations and phases of insurance work, such as marketing, underwriting, and product development. At first, they prepare data for actuarial projects or perform other simple tasks. As they gain experience, actuaries may supervise clerks, prepare correspondence, draft reports, and conduct research. They may move from one company to another early in their careers as they advance to higher positions.

Advancement depends largely on job performance and the number of actuarial examinations passed. Actuaries with a broad knowledge of the insurance, pension, investment, or employee benefits fields can rise to administrative and executive positions in their companies. Actuaries with supervisory ability may advance to management positions in other areas, such as underwriting, accounting, data processing, marketing, and advertising. Some actuaries assume college and university faculty positions. (See the statement on teachers—postsecondary elsewhere in the *Handbook*.)

Job Outlook

Employment of actuaries is expected to grow as fast as the average for all occupations through 2012. Employment opportunities should remain good for those who qualify, because the stringent qualifying examination system restricts the number of candidates. Employment growth in the insurance industry is expected to continue at a stable pace, while more significant job growth is likely in some other industries. In addition, a small number of jobs will open up each year to replace actuaries who leave the occupation to retire or who find new jobs.

Steady demand by the insurance industry—the largest employer of actuaries—should ensure that actuary jobs in this key industry will not decrease over the projection period. Although relatively few new jobs will be created, actuaries will continue to be needed to develop, price, and evaluate a variety of insurance products and calculate the costs of new risks. Recently, employment of actuaries in life insurance had begun to decline, but the growing popularity of annuities, a financial product offered primarily by life insurance companies, has resulted in some job growth in this specialty. Also, new actuarial positions have been created in property-casualty insurance to analyze evolving risks, such as terrorism.

Some new employment opportunities for actuaries should also become available in the health-care field as health-care issues and Medicare reform continue to receive growing attention. Increased regulation of managed health-care companies and the desire to contain health-care costs will continue to provide job opportunities for actuaries, who will also be needed to evaluate the risks associated with new medical issues, such as genetic testing and the impact of new diseases. Others in this field are involved in drafting health-care legislation.

A significant proportion of new actuaries will find employment with consulting firms. Companies that may not find it cost effective to hire their own actuaries are increasingly hiring con-

sulting actuaries to analyze various risks. Other areas with notable growth prospects are information services and accounting services. Also, because actuarial skills are increasingly seen as useful to other industries that deal with risk, such as the airline and the banking industries, additional job openings may be created in these industries.

The best job prospects for entry-level positions will be for those candidates who have passed at least one or two of the initial actuarial exams. Candidates with additional knowledge or experience, such as computer programming skills, will be particularly attractive to employers. Most jobs in this occupation are located in urban areas, but opportunities vary by geographic location. Opportunities should be best in Illinois, New Jersey, New York, and Connecticut—the four States in which about one-third of all actuary jobs are concentrated.

Earnings

Median annual earnings of actuaries were $69,970 in 2002. The middle 50 percent earned between $50,510 and $99,820. The lowest 10 percent had earnings of less than $39,700, while the top 10 percent earned more than $137,650.

According to the National Association of Colleges and Employers, annual starting salaries for graduates with a bachelor's degree in actuarial science averaged $40,396 in 2003.

Insurance companies and consulting firms give merit increases to actuaries as they gain experience and pass examinations. Some companies also offer cash bonuses for each professional designation achieved. A 2003 survey by Life Office Management Association, Inc., of the largest U.S. insurance and financial services companies indicated that the average base salary for an entry-level actuary was $46,991. Associate actuaries, who direct and provide leadership in the design, pricing, and implementation of insurance products, received an average salary of $99,446. Actuaries at the highest technical level without managerial responsibilities reportedly were paid an average of $104,235.

Related Occupations

Actuaries need a strong background in mathematics, statistics, and related fields. Other workers whose jobs involve related skills include accountants and auditors, budget analysts, economists, market and survey researchers, financial analysts and personal financial advisors, insurance underwriters, mathematicians, and statisticians.

Sources of Additional Information

Career information on actuaries specializing in pensions is available from

➤ American Society of Pension Actuaries, 4245 N. Fairfax Dr., Suite 750, Arlington, VA 22203. Internet: **http://www.aspa.org**

For information about actuarial careers in life and health insurance, employee benefits and pensions, and finance and investments, contact

➤ Society of Actuaries (SOA), 475 N. Martingale Rd., Suite 800, Schaumburg, IL 60173-2226. Internet: **http://www.soa.org**

For information about actuarial careers in property and casualty insurance, contact

➤ Casualty Actuarial Society (CAS), 1100 N. Glebe Rd., Suite 600, Arlington, VA 22201. Internet: **http://www.casact.org**

The SOA and CAS jointly sponsor a Web site for those interested in pursuing an actuarial career. Internet: **http://www.BeAnActuary.org**

For general facts about actuarial careers, contact

➤ American Academy of Actuaries, 1100 17th St. NW., 7th Floor, Washington, DC 20036. Internet: **http://www.actuary.org/index.htm**

Computer and Information Systems Managers

(0*NET 11-3021.00)

Significant Points

- Projected job growth stems primarily from rapid growth among computer-related occupations.
- Employers prefer managers with formal education and advanced technical knowledge acquired through computer-related work experience.
- Job opportunities should be best for applicants with a master's degree in business administration or management information systems with technology as a core component.

Nature of the Work

The need for organizations to incorporate existing and future technologies in order to remain competitive has become a more pressing issue over the last several yearsg. As electronic commerce becomes more common, how and when companies use technology are critical issues. Computer and information systems managers play a vital role in the technological direction of their organizations. They do everything from constructing the business plan to overseeing network security to directing Internet operations.

Computer and information systems managers plan, coordinate, and direct research and design the computer-related activities of firms. They help determine both technical and business goals in consultation with top management, and make detailed plans for the accomplishment of these goals. For example, working with their staff, they may develop the overall concepts of a new product or service, or may identify how an organization's computing capabilities can effectively aid project management.

Computer and information systems managers direct the work of systems analysts, computer programmers, support specialists, and other computer-related workers. These managers plan and coordinate activities such as installation and upgrading of hardware and software, programming and systems design, development of computer networks, and implementation of Internet and intranet sites. They are increasingly involved with the upkeep and maintenance and security of networks. They analyze the computer and information needs of their organization, from an operational and strategic perspective, and determine immediate and long-range personnel and equipment requirements. They assign and review the work of their subordinates, and stay abreast of the latest technology in order to assure the organization does not lag behind competitors.

The duties of computer and information systems managers vary with their specific titles. *Chief technology officers*, for example, evaluate the newest and most innovative technologies and determine how these can help their organization. The chief technology officer, who often reports to the organization's chief information officer, manages and plans technical standards and tends to the daily information technology issues of the firm. (Chief information officers are covered in a separate *Handbook* statement on top executives.) Because of the rapid pace of technological change, chief technology officers must constantly be on the lookout for developments that could benefit their organization. They are responsible for demonstrating to a company how information technology can be used as a competitive tool that not only cuts costs, but also increases revenue and maintains or increases competitive advantage.

Management information systems (*MIS) directors* manage information systems and computing resources for their entire organization. They may also work under the chief information officer and plan and direct the work of subordinate information technology employees. These managers oversee a variety of user services such as an organization's help desk, which employees can call with questions or problems. MIS directors also may make hardware and software upgrade recommendations based on their experience with an organization's technology. Helping to assure the availability, continuity, and security of data and information technology services are key responsibilities for these workers.

Project managers develop requirements, budgets, and schedules for their firm's information technology projects. They coordinate such projects from development through implementation, working with internal and external clients, vendors, consultants, and computer specialists. These managers are increasingly involved in projects that upgrade the information security of an organization.

LAN/WAN (Local Area Network/Wide Area Network) *managers* provide a variety of services, from design to administration, of an organization's local area network, which connects staff within an organization. These managers direct the network, and its related computing environment, including hardware, systems software, applications software, and all other computer-related configurations.

Computer and information system managers need strong communication skills. They coordinate the activities of their unit with

Computer and information systems managers supervise information systems and computing resources for their entire organization.

those of other units or organizations. They confer with top executives; financial, production, marketing, and other managers; and contractors and equipment and materials suppliers.

Working Conditions

Computer and information systems managers spend most of their time in an office. Most work at least 40 hours a week and may have to work evenings and weekends to meet deadlines or solve unexpected problems. Some computer and information systems managers may experience considerable pressure in meeting technical goals within short timeframes or tight budgets. As networks continue to expand and more work is done remotely, computer and information system managers have to communicate with and oversee offsite employees using modems, laptops, e-mail, and the Internet.

Like other workers who sit continuously in front of a keyboard, computer and information system managers are susceptible to eyestrain, back discomfort, and hand and wrist problems such as carpal tunnel syndrome.

Employment

Computer and information systems managers held about 284,000 jobs in 2002. About 2 in 5 works in service-providing industries, mainly in computer systems design and related services. This industry provides services related to the commercial use of computers on a contract basis, including custom computer programming services; computer systems integration design services; computer facilities management services, including computer systems or data-processing facilities support services for clients; and other computer-related services, such as disaster recovery services and software installation. Other large employers include insurance and financial services firms, government agencies, and manufacturers.

Training, Other Qualifications, and Advancement

Strong technical knowledge is essential for computer and information systems managers, who must understand and guide the work of their subordinates, yet also explain the work in nontechnical terms to senior management and potential customers. Therefore, these management positions usually require work experience and formal education similar to that of other computer occupations.

Many computer and information systems managers have experience as systems analysts; others may have experience as computer support specialists, programmers, or other information technology professionals. A bachelor's degree usually is required for management positions, although employers often prefer a graduate degree, especially a master's degree in business administration (MBA) with technology as a core component. This degree differs from a traditional MBA in that there is a heavy emphasis on information technology in addition to the standard business curriculum. This is becoming important because more computer and information systems managers are making important technology decisions as well as business decisions for their organizations. Some universities specialize in offering degrees in management information systems, which blend technical core subjects with business, accounting, and communications courses. A few computer and information systems managers may have only an associate degree if they have sufficient experience and were able to learn additional skills on the job. To aid their professional advancement, though, many managers with an associate degree eventually earn a bachelor's or master's degree while working.

Computer and information systems managers need a broad range of skills. In addition to technical skills, employers also seek managers with strong business skills. Employers want managers who have experience with the specific software or technology to be used on the job, as well as a background in either consulting or business management. The expansion of electronic commerce has elevated the importance of business insight, because many managers are called upon to make important business decisions. Managers need a keen understanding of people, management processes, and customers' needs.

Computer and information systems managers must possess strong interpersonal, communication, and leadership skills because they are required to interact not only with their staff, but also with other people inside and outside their organization. They also must possess team skills to work on group projects and other collaborative efforts. Computer and information systems managers increasingly interact with persons outside their organization, reflecting their emerging role as vital parts of their firm's executive team.

Computer and information systems managers may advance to progressively higher leadership positions in their field. Some may become managers in non-technical areas such as marketing, human resources, or sales. In high technology firms, managers in non-technical areas often must possess the same specialized knowledge as do managers in technical areas.

Job Outlook

Employment of computer and information systems managers is expected to grow much faster than the average for all occupations through the year 2012. Technological advancements will boost the employment of computer-related workers; as a result, the demand for managers to direct these workers also will increase. In addition, job openings will result from the need to replace managers who retire or move into other occupations. Opportunities for obtaining a management position will be best for workers possessing an MBA with technology as a core component, or a management information systems degree, advanced technical knowledge, and strong communication and administrative skills.

Despite the recent downturn in the economy, especially in technology-related sectors, the outlook for computer and information systems managers remains strong. In order to remain competitive, firms will continue to install sophisticated computer networks and set up more complex Internet and intranet sites. Keeping a computer network running smoothly is essential to almost every organization. Firms will be more willing to hire managers who can accomplish that.

The security of computer networks will continue to increase in importance as more business is conducted over the Internet. The security of the Nation's entire electronic infrastructure has come under renewed focus in light of recent threats. Organizations need to understand how their systems are vulnerable and how to protect their infrastructure and Internet sites from hackers, viruses, and other acts of cyber-terrorism. The emergence of "cyber-security" as a key issue facing most organizations should lead to strong growth for computer managers. Firms will increasingly hire cyber-security experts to fill key leadership roles in their information technology departments, because the integrity of their computing environment is of the utmost concern. As a result, there will be a high demand for managers proficient in computer security issues.

Due to the explosive growth of electronic commerce and the capacity of the Internet to create new relationships with customers, the role of computer and information systems managers will continue to evolve in the future. Persons in these jobs will continue to become more vital to their companies. The expansion of the wireless Internet will spur the need for computer and information systems managers with both business savvy and technical proficiency.

Opportunities for those who wish to become computer and information systems managers should be closely related to the growth

of the occupations they supervise and the industries in which they are found. (See the statements on computer programmers; computer software engineers; computer support specialists and systems administrators; and computer systems analysts, database administrators, and computer scientists elsewhere in the *Handbook*.)

Earnings

Earnings for computer and information systems managers vary by specialty and level of responsibility. Median annual earnings of these managers in 2002 were $85,240. The middle 50 percent earned between $64,150 and $109,950. The lowest 10 percent earned less than $47,440, and the highest 10 percent earned more than $140,440. Median annual earnings in the industries employing the largest numbers of computer and information systems managers in 2002 were:

Computer systems design and related services	$94,240
Management of companies and enterprises	91,710
Insurance carriers	89,920
Depository credit intermediation	75,160
Colleges, universities, and professional schools	68,100

According to Robert Half International, average starting salaries in 2003 for high-level information technology managers ranged from $82,750 to $151,500. According to a 2003 survey by the National Association of Colleges and Employers, starting salary offers for those with an MBA, a technical undergraduate degree, and 1 year or less of experience averaged $54,643; for those with a master's degree in management information systems/business data processing, the starting salary averaged $43,750.

In addition, computer and information systems managers, especially those at higher levels, often receive more employment-related benefits—such as expense accounts, stock option plans, and bonuses—than do non-managerial workers in their organizations.

Related Occupations

The work of computer and information systems managers is closely related to that of computer programmers; computer software engineers; computer systems analysts, database administrators, and computer scientists; and computer support specialists and systems administrators. Computer and information systems managers also have some high-level responsibilities similar to those of top executives.

Sources of Additional Information

For information about a career as a computer and information systems manager, contact the sources of additional information for the various computer occupations discussed elsewhere in the *Handbook*.

Computer Programmers

(0*NET 15-1021.00)

Significant Points

- Nearly half of all computer programmers held a bachelor's degree in 2002; about 1 in 5 held a graduate degree.
- Employment is expected to grow much more slowly than that of other computer specialists.
- Prospects should be best for college graduates with knowledge of a variety of programming languages and tools; those with less formal education or its equivalent in work experience should face strong competition for programming jobs.

Nature of the Work

Computer programmers write, test, and maintain the detailed instructions, called programs, that computers must follow to perform their functions. They also conceive, design, and test logical structures for solving problems by computer. Many technical innovations in programming—advanced computing technologies and sophisticated new languages and programming tools—have redefined the role of a programmer and elevated much of the programming work done today. Job titles and descriptions may vary, depending on the organization. In this occupational statement, *computer programmer* refers to individuals whose main job function is programming; this group has a wide range of responsibilities and educational backgrounds.

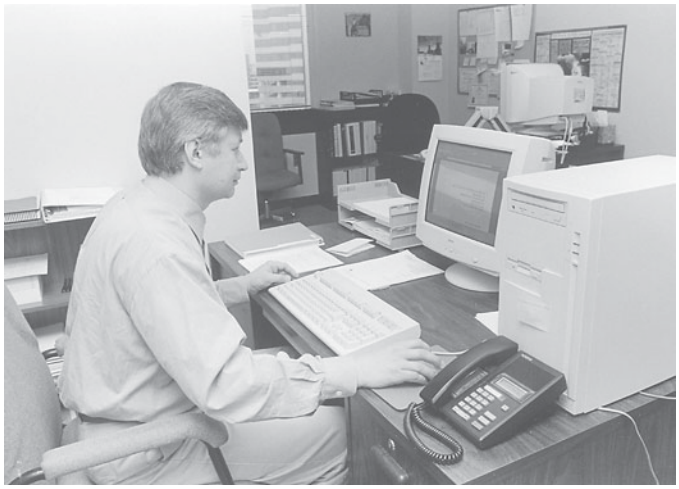
Computer programs tell the computer what to do—which information to identify and access, how to process it, and what equipment to use. Programs vary widely depending upon the type of information to be accessed or generated. For example, the instructions involved in updating financial records are very different from those required to duplicate conditions on board an aircraft for pilots training in a flight simulator. Although simple programs can be written in a few hours, programs that use complex mathematical formulas, whose solutions can only be approximated, or that draw data from many existing systems may require more than a year of work. In most cases, several programmers work together as a team under a senior programmer's supervision.

Programmers write programs according to the specifications determined primarily by computer software engineers and systems analysts. (Separate statements on computer software engineers and on computer systems analysts, database administrators, and computer scientists appear elsewhere in the *Handbook*.) After the design process is complete, it is the job of the programmer to convert that design into a logical series of instructions that the computer can follow. The programmer then codes these instructions in a conventional programming language, such as COBOL; an artificial intelligence language, such as Prolog; or one of the most advanced object-oriented languages such as Java, C++, or Smalltalk. Different programming languages are used depending on the purpose of the program. COBOL, for example, is commonly used for business applications, whereas Fortran (short for "formula translation") is used in science and engineering. C++ is widely used for both scientific and business applications. Many programmers at the enterprise level are also expected to know platform-specific languages used in database programming. Programmers generally know more than one programming language and, because many languages are similar, they often can learn new languages relatively easily. In practice, programmers often are referred to by the language they know, as are Java programmers, or the type of function they perform or environment in which they work, which is the case for database programmers, mainframe programmers, or Web programmers.

Many programmers update, repair, modify, and expand existing programs. When making changes to a section of code, called a *routine*, programmers need to make other users aware of the task that the routine is to perform. They do this by inserting comments in the coded instructions, so that others can understand the program. Many programmers use computer-assisted software engineering (CASE) tools to automate much of the coding process. These tools enable a programmer to concentrate on writing the unique parts of the program, because the tools automate various pieces of the program being built. CASE tools generate whole sections of code automatically, rather than line by line. Programmers also utilize libraries of pre-written code, which can then be modified or customized for a specific application. This also yields more reliable and consistent programs and increases programmers' productivity by eliminating some routine steps.

Programmers test a program by running it to ensure that the instructions are correct and that the program produces the desired outcome. If errors do occur, the programmer must make the appropriate change and recheck the program until it produces the correct results. This process is called testing and debugging. Programmers may continue to fix these problems throughout the life of a program. Programmers working in a mainframe environment, which involves a large centralized computer, may prepare instructions for a computer operator who will run the program. (A separate statement on computer operators appears elsewhere in the *Handbook*.) They also may contribute to a manual for persons who will be using the program.

Programmers often are grouped into two broad types—applications programmers and systems programmers. *Applications programmers* write programs to handle a specific job, such as a program to track inventory within an organization. They may also revise existing packaged software or customize generic applications called middleware. *Systems programmers*, on the other hand, write programs to maintain and control computer systems software, such as operating systems, networked sys-



Computer programmers write, test, and maintain the detailed instructions that computers follow.

tems, and database systems. These workers make changes in the sets of instructions that determine how the network, workstations, and central processing unit of the system handle the various jobs they have been given, and how they communicate with peripheral equipment such as terminals, printers, and disk drives. Because of their knowledge of the entire computer system, systems programmers often help applications programmers to determine the source of problems that may occur with their programs.

Programmers in software development companies may work directly with experts from various fields to create software—either programs designed for specific clients or packaged software for general use—ranging from games and educational software to programs for desktop publishing and financial planning. Much of this type of programming takes place in the preparation of packaged software, which constitutes one of the most rapidly growing segments of the computer services industry.

In some organizations, particularly small ones, workers commonly known as *programmer-analysts* are responsible for both the systems analysis and the actual programming work. (A more detailed description of the work of programmer-analysts is presented in the statement on computer systems analysts, database administrators, and computer scientists elsewhere in the *Handbook.*) Advanced programming languages and new object-oriented programming capabilities are increasing the efficiency and productivity of both programmers and users. The transition from a mainframe environment to one that is based primarily on personal computers (PCs) has blurred the once rigid distinction between the programmer and the user. Increasingly, adept end-users are taking over many of the tasks previously performed by programmers. For example, the growing use of packaged software, such as spreadsheet and database management software packages, allows users to write simple programs to access data and perform calculations.

Working Conditions

Programmers generally work in offices in comfortable surroundings. Many programmers may work long hours or weekends to meet deadlines or fix critical problems that occur during off hours. Given the technology available, telecommuting is becoming common for a wide range of computer professionals, including computer programmers. As computer networks expand, more programmers are able to make corrections or fix problems remotely by using modems, e-mail, and the Internet to connect to a customer's computer.

Like other workers who spend long periods in front of a computer terminal typing at a keyboard, programmers are susceptible to eyestrain, back discomfort, and hand and wrist problems, such as carpal tunnel syndrome.

Employment

Computer programmers held about 499,000 jobs in 2002. Programmers are employed in almost every industry, but the largest concentrations are in computer systems design and related services and in software publishers, which includes firms that write and sell software. Large numbers of programmers also can be found in management of companies and enterprises, telecommunications companies, manufacturers of computer and electronic equipment, financial institutions, insurance carriers, educational institutions, and government agencies.

A large number of computer programmers are employed on a temporary or contract basis or work as independent consultants, as companies demand expertise with new programming languages or specialized areas of application. Rather than hiring programmers as permanent employees and then laying them off after a job is completed, employers can contract with temporary help agencies, consulting firms, or directly with programmers themselves. A marketing firm, for example, may require the services of several programmers only to write and debug the software necessary to get a new customer resource management system running. This practice also enables companies to bring in people with a specific set of skills—usually in one of the latest technologies—as it applies to their business needs. Bringing in an independent contractor or consultant with a certain level of experience in a new or advanced programming language, for example, enables an establishment to complete a particular job without having to retrain existing workers. Such jobs may last anywhere from several weeks to a year or longer. There were 18,000 self-employed computer programmers in 2002.

Training, Other Qualifications, and Advancement

While there are many training paths available for programmers, mainly because employers' needs are so varied, the level of education and experience employers seek has been rising, due to the growing number of qualified applicants and the specialization involved with most programming tasks. Bachelor's degrees are commonly required, although some programmers may qualify for certain jobs with 2-year degrees or certificates. The associate degree is an increasingly attractive entry-level credential for prospective computer programmers. Most community colleges and many independent technical institutes and proprietary schools offer an associate degree in computer science or a related information technology field.

Employers are primarily interested in programming knowledge, and computer programmers can become certified in a programming language such as C++ or Java. College graduates who are interested in changing careers or developing an area of expertise also may return to a 2-year community college or technical school for additional training. In the absence of a degree, substantial specialized experience or expertise may be needed. Even when hiring programmers with a degree, employers appear to be placing more emphasis on previous experience.

Some computer programmers hold a college degree in computer science, mathematics, or information systems, whereas others have taken special courses in computer programming to supplement their degree in a field such as accounting, inventory control, or another area of business. As the level of education and training required by employers continues to rise, the proportion of programmers with a college degree should increase in the future. As indicated by the following tabulation, 65 percent of computer programmers had a bachelor's or higher degree in 2002.

	Percent
High school graduate or equivalent or less	7.7
Some college, no degree	15.2
Associate degree	11.6
Bachelor's degree	48.6
Graduate degree	16.7

Required skills vary from job to job, but the demand for various skills generally is driven by changes in technology. Employers using computers for scientific or engineering applications usually prefer college graduates who have degrees in

computer or information science, mathematics, engineering, or the physical sciences. Graduate degrees in related fields are required for some jobs. Employers who use computers for business applications prefer to hire people who have had college courses in management information systems (MIS) and business and who possess strong programming skills. Although knowledge of traditional languages still is important, employers are placing increasing emphasis on newer, object-oriented programming languages and tools, such as C++ and Java. Additionally, employers are seeking persons familiar with fourth- and fifth-generation languages that involve graphic user interface (GUI) and systems programming. Employers also prefer applicants who have general business skills and experience related to the operations of the firm. Students can improve their employment prospects by participating in a college work-study program or by undertaking an internship.

Most systems programmers hold a 4-year degree in computer science. Extensive knowledge of a variety of operating systems is essential for such workers. This includes being able to configure an operating system to work with different types of hardware and having the skills needed to adapt the operating system to best meet the needs of a particular organization. Systems programmers also must be able to work with database systems, such as DB2, Oracle, or Sybase.

When hiring programmers, employers look for people with the necessary programming skills who can think logically and pay close attention to detail. The job calls for patience, persistence, and the ability to work on exacting analytical work, especially under pressure. Ingenuity, creativity, and imagination also are particularly important when programmers design solutions and test their work for potential failures. The ability to work with abstract concepts and to do technical analysis is especially important for systems programmers, because they work with the software that controls the computer's operation. Because programmers are expected to work in teams and interact directly with users, employers want programmers who are able to communicate with nontechnical personnel.

Entry-level or junior programmers may work alone on simple assignments after some initial instruction, or they may be assigned to work on a team with more experienced programmers. Either way, beginning programmers generally must work under close supervision. Because technology changes so rapidly, programmers must continuously update their knowledge and skills by taking courses sponsored by their employer or by software vendors, or offered through local community colleges and universities.

For skilled workers who keep up to date with the latest technology, the prospects for advancement are good. In large organizations, programmers may be promoted to lead programmer and be given supervisory responsibilities. Some applications programmers may move into systems programming after they gain experience and take courses in systems software. With general business experience, programmers may become programmer-analysts or systems analysts or be promoted to a managerial position. Other programmers, with specialized knowledge and experience with a language or operating system, may work in research and development on multimedia or Internet technology, for example. As employers increasingly contract out programming jobs, more opportunities should arise for experienced programmers with expertise in a specific area to work as consultants.

Certification is a way to demonstrate a level of competence, and may provide a jobseeker with a competitive advantage. In addition to language-specific certificates that a programmer can obtain, product vendors or software firms also offer certification and may require professionals who work with their products to be certified. Voluntary certification also is available through other various organizations.

Job Outlook

Employment of programmers is expected to grow about as fast as the average for all occupations through 2012. Jobs for both systems and applications programmers should be most plentiful in data processing service firms, software houses, and computer consulting businesses. These types of establishments are part of computer systems design and related services and software publishers, which are projected to be among the fastest growing industries in the economy over the 2002-12 period. As organizations attempt to control costs and keep up with changing technology, they will need programmers to assist in conversions to new computer languages and systems. In addition, numerous job openings will result from the need to replace programmers who leave the labor force or transfer to other occupations such as manager or systems analyst.

Employment of programmers, however, is expected to grow much more slowly than that of other computer specialists. With the rapid gains in technology, sophisticated computer software now has the capability to write basic code, eliminating the need for more programmers to do this routine work. The consolidation and centralization of systems and applications, developments in packaged software, advances in programming languages and tools, and the growing ability of users to design, write, and implement more of their own programs means that more of the programming functions can be transferred from programmers to other types of workers. Furthermore, as the level of technological innovation and sophistication increases, programmers are likely to face increasing competition from programming businesses overseas, to which much routine work can be contracted out at a lower cost.

Nevertheless, employers will continue to need programmers who have strong technical skills and who understand an employer's business and its programming requirements. This means that programmers will have to keep abreast of changing programming languages and techniques. Given the importance of networking and the expansion of client/server, Web-based, and wireless environments, organizations will look for programmers who can support data communications and help to implement electronic commerce and Intranet strategies. Demand for programmers with strong object-oriented programming capabilities and technical specialization in areas such as client/server programming, wireless applications, multimedia technology, and graphic user interface (GUI) should arise from the expansion of intranets, extranets, and Internet applications. Programmers also will be needed to create and maintain expert systems and embed these technologies in more products. Finally, growing emphasis on cyber-security will lead to increased demand for programmers who are familiar with digital security issues and skilled in using appropriate security technology.

As programming tasks become increasingly sophisticated and additional levels of skill and experience are demanded by employers, graduates of 2-year programs and people with less than a 2-year degree or its equivalent in work experience should face strong competition for programming jobs. Competition for entry-level positions, however, also can affect applicants with a bachelor's degree. Prospects should be best for college graduates with knowledge of, and experience working with, a variety

of programming languages and tools—including C++ and other object-oriented languages such as Java, as well as newer, domain-specific languages that apply to computer networking, database management, and Internet application development. Obtaining vendor-specific or language-specific certification also can provide a competitive edge. Because demand fluctuates with employers' needs, jobseekers should keep up to date with the latest skills and technologies. Individuals who want to become programmers can enhance their prospects by combining the appropriate formal training with practical work experience.

Earnings

Median annual earnings of computer programmers were $60,290 in 2002. The middle 50 percent earned between $45,960 and $78,140 a year. The lowest 10 percent earned less than $35,080; the highest 10 percent earned more than $96,860. Median annual earnings in the industries employing the largest numbers of computer programmers in 2002 were:

Professional and commercial equipment and supplies merchant wholesalers	$70,440
Software publishers	66,870
Computer systems design and related services	65,640
Management of companies and enterprises	59,850
Data processing, hosting, and related services	59,300

According to the National Association of Colleges and Employers, starting salary offers for graduates with a bachelor's degree in computer programming averaged $45,558 a year in 2003.

According to Robert Half International, a firm providing specialized staffing services, average annual starting salaries in 2003 ranged from $51,500 to $80,500 for applications development programmers/analysts, and from $55,000 to $87,750 for software developers. Average starting salaries for mainframe systems programmers ranged from $53,250 to $68,750 in 2003.

Related Occupations

Other professional workers who deal extensively with data include computer software engineers; computer systems analysts, database administrators, and computer scientists; statisticians; mathematicians; engineers; financial analysts and personal financial advisors; accountants and auditors; actuaries; and operations research analysts.

Sources of Additional Information

State employment service offices can provide information about job openings for computer programmers. Municipal chambers of commerce are an additional source of information on an area's largest employers.

Further information about computer careers is available from:

➤ Association for Computing Machinery (ACM), 1515 Broadway, New York, NY 10036. Internet: **http://www.acm.org**

➤ Institute of Electrical and Electronics Engineers Computer Society, Headquarters Office, 1730 Massachusetts Ave. NW., Washington, DC 20036-1992. Internet: **http://www.computer.org**

➤ National Workforce Center for Emerging Technologies, 3000 Landerholm Circle SE., Bellevue, WA 98007. Internet: **http://www.nwcet.org**

Computer Software Engineers

(0*NET 15-1031.00, 15-1032.00)

Significant Points

- Computer software engineers are projected to be one of the fastest growing occupations over the 2002-12 period.
- Highly favorable opportunities are expected for college graduates with at least a bachelor's degree in computer engineering or computer science and with practical work experience.
- Computer software engineers must continually strive to acquire new skills in conjunction with the rapid changes in computer technology.

Nature of the Work

The explosive impact of computers and information technology on our everyday lives has generated a need to design and develop new computer software systems and to incorporate new technologies in a rapidly growing range of applications. The tasks performed by workers known as computer software engineers evolve quickly, reflecting new areas of specialization or changes in technology, as well as the preferences and practices of employers. Computer software engineers apply the principles and techniques of computer science, engineering, and mathematical analysis to the design, development, testing, and evaluation of the software and systems that enable computers to perform their many applications. (A separate statement on computer hardware engineers appears elsewhere in the *Handbook*.)

Software engineers working in applications or systems development analyze users' needs and design, construct, test, and maintain computer applications software or systems. Software engineers can be involved in the design and development of many types of software, including software for operating systems and network distribution, and compilers, which convert programs for execution on a computer. In programming, or coding, software engineers instruct a computer, line by line, how to perform a function. They also solve technical problems that arise. Software engineers must possess strong programming skills, but are more concerned with developing algorithms and analyzing and solving programming problems than with actually writing code. (A separate statement on computer programmers appears elsewhere in the *Handbook*.)

Computer applications software engineers analyze users' needs and design, construct, and maintain general computer applications software or specialized utility programs. These workers use different programming languages, depending on the purpose of the program. The programming languages most often used are C, C++, and Java, with Fortran and COBOL used less commonly. Some software engineers develop both packaged systems and systems software or create customized applications.

Computer systems software engineers coordinate the construction and maintenance of a company's computer systems and plan their future growth. Working with a company, they coordinate each department's computer needs—ordering, inventory, billing, and payroll recordkeeping, for example—and make suggestions about its technical direction. They also might set up the company's intranets—networks that link computers within the organization and ease communication among the various departments.

Systems software engineers work for companies that configure, implement, and install complete computer systems. They may be members of the marketing or sales staff, serving as the primary technical resource for sales workers and customers. They also may be involved in product sales and in providing their customers with continuing technical support.

Computer software engineers often work as part of a team that designs new hardware, software, and systems. A core team may comprise engineering, marketing, manufacturing, and design people who work together until the product is released.

Working Conditions

Computer software engineers normally work in well-lighted and comfortable offices or computer laboratories in which computer equipment is located. Most software engineers work at least 40 hours a week; however, due to the project-oriented nature of the work, they also may have to work evenings or weekends to meet deadlines or solve unexpected technical problems. Like other workers who sit for hours at a computer, typing on a keyboard, software engineers are susceptible to eyestrain, back discomfort, and hand and wrist problems such as carpal tunnel syndrome.

As they strive to improve software for users, many computer software engineers interact with customers and coworkers. Computer software engineers who are employed by software vendors and consulting firms, for example, spend much of their time away from their offices, frequently traveling overnight to meet with customers. They call on customers in businesses ranging from manufacturing plants to financial institutions.

As networks expand, software engineers may be able to use modems, laptops, e-mail, and the Internet to provide more technical support and other services from their main office, connecting to a customer's computer remotely to identify and correct developing problems.

Employment

Computer software engineers held about 675,000 jobs in 2002. About 394,000 were computer applications software engineers,

Computer software engineers design, create, and modify computer applications.

and about 281,000 were computer systems software engineers. Although they are employed in most industries, the largest concentration of computer software engineers, about 30 percent, is in computer systems design and related services. Many computer software engineers also work for establishments in other industries, such as government agencies, manufacturers of computers and related electronic equipment, and colleges and universities.

Employers of computer software engineers range from startup companies to established industry leaders. The proliferation of Internet, e-mail, and other communications systems expands electronics to engineering firms traditionally associated with unrelated disciplines. Engineering firms specializing in building bridges and power plants, for example, hire computer software engineers to design and develop new geographic data systems and automated drafting systems. Communications firms need computer software engineers to tap into growth in the personal communications market. Major communications companies have many job openings for both computer software applications and computer systems engineers.

An increasing number of computer software engineers are employed on a temporary or contract basis, with many being self-employed, working independently as consultants. Some consultants work for firms that specialize in developing and maintaining client companies' Web sites and intranets. Consulting opportunities for software engineers should grow as businesses need help managing, upgrading, and customizing increasingly complex computer systems. About 21,000 computer software engineers were self-employed in 2002.

Training, Other Qualifications, and Advancement

Most employers prefer to hire persons who have at least a bachelor's degree and broad knowledge of, and experience with, a variety of computer systems and technologies. Usual degree concentrations for applications software engineers are computer science or software engineering; for systems software engineers, usual concentrations are computer science or computer information systems. Graduate degrees are preferred for some of the more complex jobs.

Academic programs in software engineering emphasize software and may be offered as a degree option or in conjunction with computer science degrees. Increasing emphasis on computer security suggests that software engineers with advanced degrees that include mathematics and systems design will be sought after by software developers, government agencies, and consulting firms specializing in information assurance and security. Students seeking software engineering jobs enhance their employment opportunities by participating in internship or co-op programs offered through their schools. These experiences provide the students with broad knowledge and experience, making them more attractive candidates to employers. Inexperienced college graduates may be hired by large computer and consulting firms that train new hires in intensive, company-based programs. In many firms, new employees are mentored, and their mentors have an input into the new hires' evaluations.

For systems software engineering jobs that require workers who have a college degree, a bachelor's degree in computer science or computer information systems is typical. For systems engineering jobs that place less emphasis on workers having a computer-related degree, computer training programs leading to certification are offered by systems software vendors, including Microsoft, Novell, and Oracle. These programs usually last from 1 to 4 weeks, but the worker is not required to attend classes in order to sit for a certification exam; several study guides also are available to help prepare for the exams. Nonetheless, many training authorities feel that program certification alone is not sufficient for most software engineering jobs.

Professional certification is now offered by the Institute of Electrical and Electronics Engineers (IEEE) Computer Society. To be classified as a Certified Software Development Professional, individuals need a bachelor's degree and work experience that demonstrates that they have mastered a relevant body of knowledge, and must pass a written exam.

Persons interested in jobs as computer software engineers must have strong problem-solving and analytical skills. They also must be able to communicate effectively with team members, other staff, and the customers they meet. Because they often deal with a number of tasks simultaneously, they must be able to concentrate and pay close attention to detail.

As is the case with most occupations, advancement opportunities for computer software engineers increase with experience. Entry-level computer software engineers are likely to test and verify ongoing designs. As they become more experienced, computer software engineers may be involved in designing and developing software. Eventually, they may advance to become a project manager, manager of information systems, or chief information officer. Some computer software engineers with several years of experience or expertise find lucrative opportunities working as systems designers or independent consultants or starting their own computer consulting firms.

As technological advances in the computer field continue, employers demand new skills. Computer software engineers must continually strive to acquire such skills if they wish to remain in this extremely dynamic field. To help them keep up with the changing technology, continuing education and professional development seminars are offered by employers and software vendors, colleges and universities, private training institutions, and professional computing societies.

Job Outlook

Computer software engineers are projected to be one of the fastest growing occupations from 2002 to 2012. Rapid employment growth in the computer systems design and related services industry, which employs the greatest number of computer software engineers, should result in highly favorable opportunities for those college graduates with at least a bachelor's degree in computer engineering or computer science and practical experience working with computers. Employers will continue to seek computer professionals with strong programming, systems analysis, interpersonal, and business skills.

Despite the recent downturn among firms specializing in information technology, employment of computer software engineers is expected to increase much faster than the average for all occupations, as businesses and other organizations adopt and integrate new technologies and seek to maximize the efficiency of their computer systems. Job growth will not be as rapid as during the previous decade, however, as the software industry begins to mature and as routine software engineering work is increasingly outsourced overseas. Competition among businesses will continue to create an incentive for increasingly sophisticated technological innovations, and organizations will

need more computer software engineers to implement these changes. In addition to jobs created through employment growth, many job openings will result annually from the need to replace workers who move into managerial positions, transfer to other occupations, or leave the labor force.

Demand for computer software engineers will increase as computer networking continues to grow. For example, the expanding integration of Internet technologies and the explosive growth in electronic commerce—doing business on the Internet—have resulted in rising demand for computer software engineers who can develop Internet, intranet, and World Wide Web applications. Likewise, expanding electronic data-processing systems in business, telecommunications, government, and other settings continue to become more sophisticated and complex. Growing numbers of systems software engineers will be needed to implement, safeguard, and update systems and resolve problems. Consulting opportunities for computer software engineers also should continue to grow as businesses seek help to manage, upgrade, and customize their increasingly complex computer systems.

New growth areas will continue to arise from rapidly evolving technologies. The increasing uses of the Internet, the proliferation of Web sites, and "mobile" technology such as the wireless Internet have created a demand for a wide variety of new products. As individuals and businesses rely more on handheld computers and wireless networks, it will be necessary to integrate current computer systems with this new, more mobile technology. Also, information security concerns have given rise to new software needs. Concerns over "cyber security" should result in businesses and government continuing to invest heavily in security software that protects their networks and vital electronic infrastructure from attack. The expansion of this technology in the next 10 years will lead to an increased need for computer engineers to design and develop the software and systems to run these new applications and that will allow them to be integrated into older systems.

As with other information technology jobs, employment growth of computer software engineers may be tempered somewhat by an increase in contracting out of software development abroad. Firms may look to cut costs by shifting operations to foreign countries with highly educated workers who have strong technical skills.

Earnings

Median annual earnings of computer applications software engineers who worked full time in 2002 were about $70,900. The middle 50 percent earned between $55,510 and $88,660. The lowest 10 percent earned less than $44,830, and the highest 10 percent earned more than $109,800. Median annual earnings in the industries employing the largest numbers of computer applications software engineers in 2002 were:

Software publishers	$76,450
Navigational, measuring, electromedical, and control instruments manufacturing	75,890
Computer systems design and related services	71,890
Architectural, engineering, and related services	70,090
Management of companies and enterprises	67,260

Median annual earnings of computer systems software engineers who worked full time in 2002 were about $74,040. The middle 50 percent earned between $58,500 and $91,160. The lowest 10 percent earned less than $45,890, and the highest 10 percent earned more than $111,600. Median annual earnings in the industries employing the largest numbers of computer systems software engineers in 2002 are shown below:

Scientific research and development services	$82,270
Software publishers	77,120
Navigational, measuring, electromedical, and control instruments manufacturing	76,200
Computer systems design and related services	73,460
Wired telecommunications carriers	68,510

According to the National Association of Colleges and Employers, starting salary offers for graduates with a bachelor's degree in computer engineering averaged $51,343 in 2003, and those with a master's degree averaged $64,200. Starting salary offers for graduates with a bachelor's degree in computer science averaged $47,109.

According to Robert Half International, starting salaries for software engineers in software development ranged from $64,250 to $97,000 in 2003.

In addition to typical benefits, computer software engineers may be provided with profit sharing, stock options, and a company car with a mileage allowance.

Related Occupations

Other workers who use mathematics and logic extensively include computer systems analysts, database administrators, and computer scientists; computer programmers; financial analysts and personal financial advisors; computer hardware engineers; computer support specialists and systems administrators; statisticians; mathematicians; management analysts; actuaries; and operations research analysts.

Sources of Additional Information

Additional information on a career in computer software engineering is available from any of the following sources:

➤ Association for Computing Machinery (ACM), 1515 Broadway, New York, NY 10036. Internet: **http://www.acm.org**

➤ Institute of Electronics and Electrical Engineers Computer Society, Headquarters Office, 1730 Massachusetts Ave. NW., Washington, DC 20036-1992. Internet: **http://www.computer.org**

➤ National Workforce Center for Emerging Technologies, 3000 Landerholm Circle SE., Bellevue, WA 98007. Internet: **http://www.nwcet.org**

Computer Support Specialists and Systems Administrators

(0*NET 15-1041.00, 15-1071.00)

Significant Points

- Computer support specialists and systems administrators are projected to be among the fastest growing occupations over the 2002-12 period.
- There are many paths of entry to these occupations.
- Job prospects should be best for college graduates who are up to date with the latest skills and technologies; certifications and practical experience are essential for persons without degrees.

Nature of the Work

In the last decade, computers have become an integral part of everyday life, used for a variety of reasons at home, in the workplace, and at schools. And almost every computer user encounters a problem occasionally, whether it is the disaster of a crashing hard drive or the annoyance of a forgotten password. The explosion of computer use has created a high demand for specialists to provide advice to users, as well as day-to-day administration, maintenance, and support of computer systems and networks.

Computer support specialists provide technical assistance, support, and advice to customers and other users. This occupational group includes *technical support specialists* and *help-desk technicians.* These troubleshooters interpret problems and provide technical support for hardware, software, and systems. They answer telephone calls, analyze problems using automated diagnostic programs, and resolve recurrent difficulties. Support specialists may work either within a company that uses computer systems or directly for a computer hardware or software vendor. Increasingly, these specialists work for help-desk or support services firms, where they provide computer support to clients on a contract basis.

Technical support specialists are troubleshooters, providing valuable assistance to their organization's computer users. Because many nontechnical employees are not computer experts, they often run into computer problems that they cannot resolve on their own. Technical support specialists install, modify, clean, and repair computer hardware and software. They also may work on monitors, keyboards, printers, and mice.

Technical support specialists answer telephone calls from their organizations' computer users and may run automatic diagnostics programs to resolve problems. They also may write training manuals and train computer users how to properly use new computer hardware and software. In addition, technical support specialists oversee the daily performance of their company's computer systems and evaluate software programs for usefulness.

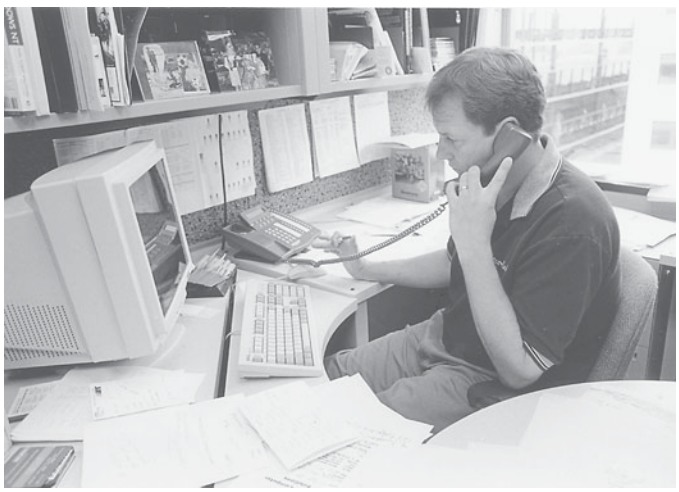
Help-desk technicians assist computer users with the inevitable hardware and software questions not addressed in a product's instruction manual. Help-desk technicians field telephone calls and e-mail messages from customers seeking guidance on technical problems. In responding to these requests for guidance, help-desk technicians must listen carefully to the customer, ask questions to diagnose the nature of the problem, and then patiently walk the customer through the problem-solving steps.

Help-desk technicians deal directly with customer issues, and companies value them as a source of feedback on their products. These technicians are consulted for information about what gives customers the most trouble, as well as other customer concerns. Most computer support specialists start out at the help desk.

Network or *computer systems administrators* design, install, and support an organization's LAN (local-area network), WAN (wide-area network), network segment, Internet, or intranet system. They provide day-to-day onsite administrative support for software users in a variety of work environments, including professional offices, small businesses, government, and large corporations. They maintain network hardware and software, analyze problems, and monitor the network to ensure its availability to system users. These workers gather data to identify customer needs and then use that information to identify, interpret, and evaluate system and network requirements. Administrators also may plan, coordinate, and implement network security measures.

Systems administrators are the information technology employees responsible for the efficient use of networks by organizations. They ensure that the design of an organization's computer site allows all of the components, including computers, the network, and software, to fit together and work properly. Furthermore, they monitor and adjust performance of existing networks and continually survey the current computer site to determine future network needs. Administrators also troubleshoot problems as reported by users and automated network monitoring systems and make recommendations for enhancements in the implementation of future servers and networks.

In some organizations, *computer security specialists* may plan, coordinate, and implement the organization's information security. These workers may be called upon to educate users on computer security, install security software, monitor the network for security breaches, respond to cyber attacks, and in some cases, gather data and evidence to be used in prosecuting cyber crime. This and other growing specialty occupations reflect the increasing emphasis on client-server applications, the expansion of Internet and intranet applications, and the demand for more end-user support.



Computer support specialists provide technical assistance, support, and advice to computer users.

Working Conditions

Computer support specialists and systems administrators normally work in well-lit, comfortable offices or computer laboratories. They usually work about 40 hours a week, but that may include being "on call" via pager or telephone for rotating evening or weekend work if the employer requires computer support over extended hours. Overtime may be necessary when unexpected technical problems arise. Like other workers who type on a keyboard for long periods, computer support specialists and systems administrators are susceptible to eyestrain, back discomfort, and hand and wrist problems such as carpal tunnel syndrome.

Due to the heavy emphasis on helping all types of computer users, computer support specialists and systems administrators constantly interact with customers and fellow employees as they answer questions and give valuable advice. Those who work as consultants are away from their offices much of the time, sometimes spending months working in a client's office.

As computer networks expand, more computer support specialists and systems administrators may be able to connect to a customer's computer remotely, using modems, laptops, e-mail, and the Internet, to provide technical support to computer users. This capability would reduce or eliminate travel to the customer's workplace. Systems administrators also can administer and configure networks and servers remotely, although this practice is not as common as it is with computer support specialists.

Employment

Computer support specialists and systems administrators held about 758,000 jobs in 2002. Of these, about 507,000 were computer support specialists and about 251,000 were network and computer systems administrators. Although they worked in a wide range of industries, 35 percent of all computer support specialists and systems administrators were employed in professional and business services industries, principally in computer systems design and related services. Other organizations that employed substantial numbers of these workers include banks, government agencies, insurance companies, educational institutions, and wholesale and retail vendors of computers, office equipment, appliances, and home electronic equipment. Many computer support specialists also worked for manufacturers of computers, semiconductors, and other electronic components.

Employers of computer support specialists and systems administrators range from startup companies to established industry leaders. With the continued development of the Internet, telecommunications, and e-mail, industries not typically associated with computers—such as construction—increasingly need computer-related workers. Small and large firms across all industries are expanding or developing computer systems, creating an immediate need for computer support specialists and systems administrators.

Training, Other Qualifications, and Advancement

Due to the wide range of skills required, there are many paths of entry to a job as a computer support specialist or systems administrator. While there is no universally accepted way to prepare for a job as a computer support specialist, many employers prefer to hire persons with some formal college education. A bachelor's degree in computer science or information systems is a prerequisite for some jobs; however, other jobs may require only a computer-related associate degree. For systems administrators, many employers seek applicants with bachelor's degrees, although not necessarily in a computer-related field.

Many companies are becoming more flexible about requiring a college degree for support positions because of the explosive demand for specialists. However, certification and practical experience demonstrating these skills will be essential for applicants without a degree. Completion of a certification training program, offered by a variety of vendors and product makers, may help some people to qualify for entry-level positions. Relevant computer experience may substitute for formal education.

Beginning computer support specialists usually work for organizations that deal directly with customers or in-house users. Then, they may advance into more responsible positions in which they use what they have learned from customers to improve the design and efficiency of future products. Job promotions usually depend more on performance than on formal education. Eventually, some computer support specialists become applications developers, designing products rather than assisting users. Computer support specialists at hardware and software companies often enjoy great upward mobility; advancement sometimes comes within months of initial employment.

Entry-level network and computer systems administrators are involved in routine maintenance and monitoring of computer systems, typically working behind the scenes in an organization. After gaining experience and expertise, they often are able to advance into more senior-level positions, in which they take on more responsibilities. For example, senior network and computer systems administrators may present recommendations to management on matters related to a company's network. They also may translate the needs of an organization into a set of technical requirements, based on the available technology. As with support specialists, administrators may become software engineers, actually involved in the designing of the system or network and not just the day-to-day administration.

Persons interested in becoming a computer support specialist or systems administrator must have strong problem-solving, analytical, and communication skills because troubleshooting and helping others are vital parts of the job. The constant interaction with other computer personnel, customers, and employees requires computer support specialists and systems administrators to communicate effectively on paper, via e-mail, or in person. Strong writing skills are useful when preparing manuals for employees and customers.

As technology continues to improve, computer support specialists and systems administrators must keep their skills current and acquire new ones. Many continuing education programs are offered by employers, hardware and software vendors, colleges and universities, and private training institutions. Professional development seminars offered by computing services firms also can enhance one's skills and advancement opportunities.

Job Outlook

Employment of computer support specialist is expected to increase faster than the average for all occupations through 2012, as organizations continue to adopt and integrate increasingly sophisticated technology. Job growth will continue to be driven by the continued expansion of the computer system design and related services industry, which is projected to remain one of the fastest growing industries in the U.S. economy, despite recent job losses. Job growth will not be as explosive as during the previous decade, however, as these jobs are being increasingly outsourced overseas.

Employment growth among computer support specialists reflects the rapid pace of improved technology. As computers and software become more complex, support specialists will be needed to provide technical assistance to customers and other users. New mobility technologies, such as the wireless Internet, will continue to create a demand for these workers to familiarize and educate computer users. Consulting opportunities for computer support specialists also should continue to grow as businesses increasingly need help managing, upgrading, and customizing more complex computer systems. However, growth in employment of support specialists may be tempered somewhat as firms continue to cut costs by shifting more routine work abroad to countries where workers are highly skilled but labor costs are lower. Physical location is not as important for these workers as it is for others, because computer support specialists can provide assistance remotely and support services can be provided around the clock.

Employment of systems administrators is expected to increase much faster than average as firms will continue to invest heavily in securing computer networks. Companies are looking for workers knowledgeable about the function and administration of networks. Such employees have become increasingly hard to find as systems administration has moved from being a separate function within corporations to one that forms a crucial element of business in an increasingly high-technology economy. Also, demand for computer security specialists will grow as businesses and government continue to invest heavily in "cyber-security," protecting vital computer networks and electronic infrastructure from attack.

The growth of electronic commerce means that more establishments use the Internet to conduct their business online. This translates into a need for information technology specialists who can help organizations use technology to communicate with employees, clients, and consumers. Explosive growth in these areas also is expected to fuel demand for specialists knowledgeable about network, data, and communications security.

Job prospects should be best for college graduates who are up to date with the latest skills and technologies, particularly if they have supplemented their formal education with some relevant work experience. Employers will continue to seek computer specialists who possess a strong background in fundamental computer skills, combined with good interpersonal and communication skills. Due to the rapid growth in demand for computer support specialists and systems administrators, those who have strong computer skills but do not have a bachelor's degree should continue to qualify for some entry-level positions. However, certifications and practical experience are essential for persons without degrees.

Earnings

Median annual earnings of computer support specialists were $39,100 in 2002. The middle 50 percent earned between $29,760 and $51,680. The lowest 10 percent earned less than $23,060, and the highest 10 percent earned more than $67,550. Median annual earnings in the industries employing the largest numbers of computer support specialists in 2002 were:

Professional and commercial equipment and supplies merchant wholesalers	$46,740
Software publishers	42,870
Computer systems design and related services	41,110
Management of companies and enterprises	40,850
Elementary and secondary schools	33,480

Median annual earnings of network and computer systems administrators were $54,810 in 2002. The middle 50 percent earned between $43,290 and $69,530. The lowest 10 percent earned less than $34,460, and the highest 10 percent earned more than $86,440. Median annual earnings in the industries employing the largest numbers of network and computer systems administrators in 2002 were:

Wired telecommunications carriers	$59,710
Computer systems design and related services	58,790
Management of companies and enterprises	58,610
Data processing, hosting, and related services	56,140
Elementary and secondary schools	48,350

According to Robert Half International, starting salaries in 2003 ranged from $27,500 to $56,500 for help-desk support staff, and from $51,000 to $67,250 for more senior technical support specialists. For systems administrators, starting salaries in 2003 ranged from $49,000 to $70,250.

Related Occupations

Other computer-related occupations include computer programmers; computer software engineers; and computer systems analysts, database administrators, and computer scientists.

Sources of Additional Information

For additional information about a career as a computer support specialist, contact:

➤ Association of Computer Support Specialists, 218 Huntington Rd., Bridgeport, CT 06608. Internet: **http://www.acss.org**

➤ Association of Support Professionals, 122 Barnard Ave., Watertown, MA 02472.

For additional information about a career as a systems administrator, contact:

➤ System Administrators Guild, 2560 9th St., Suite 215, Berkeley, CA 94710. Internet: **http://www.sage.org**

Further information about computer careers is available from:

➤ National Workforce Center for Emerging Technologies, 3000 Landerholm Circle SE., Bellevue, WA 98007. Internet: **http://www.nwcet.org**

Computer Systems Analysts, Database Administrators, and Computer Scientists

(0*NET 15-1011.00, 15-1051.00, 15-1061.00, 15-1081.00, 15-1099.99)

Significant Points

- Education requirements range from a 2-year degree to a graduate degree.
- Employment is expected to increase much faster than the average as organizations continue to adopt increasingly sophisticated technologies.
- Job prospects are favorable.

Nature of the Work

The rapid spread of computers and information technology has generated a need for highly trained workers to design and develop new hardware and software systems and to incorporate new technologies. These workers—computer systems analysts, database administrators, and computer scientists—include a wide range of computer specialists. Job tasks and occupational titles used to describe these workers evolve rapidly, reflecting new areas of specialization or changes in technology, as well as the preferences and practices of employers.

Systems analysts solve computer problems and apply computer technology to meet the individual needs of an organization. They help an organization to realize the maximum benefit from its investment in equipment, personnel, and business processes. Systems analysts may plan and develop new computer systems or devise ways to apply existing systems' resources to additional operations. They may design new systems, including both hardware and software, or add a new software application to harness more of the computer's power. Most systems analysts work with specific types of systems—for example, business, accounting, or financial systems, or scientific and engineering systems—that vary with the kind of organization. Some systems analysts also are known as *systems developers* or *systems architects*.

Systems analysts begin an assignment by discussing the systems problem with managers and users to determine its exact nature. Defining the goals of the system and dividing the solutions into individual steps and separate procedures, systems analysts use techniques such as structured analysis, data modeling, information engineering, mathematical model building, sampling, and cost accounting to plan the system. They specify the inputs to be accessed by the system, design the processing steps, and format the output to meet users' needs. They also may prepare cost-benefit and return-on-investment analyses to help management decide whether implementing the proposed technology will be financially feasible.

When a system is accepted, systems analysts determine what computer hardware and software will be needed to set the system up. They coordinate tests and observe the initial use of the system to ensure that it performs as planned. They prepare specifications, flow charts, and process diagrams for computer programmers to follow; then, they work with programmers to "debug," or eliminate, errors from the system. Systems analysts who do more indepth testing of products may be referred to as *software quality assurance analysts*. In addition to running tests, these individuals diagnose problems, recommend solutions, and determine whether program requirements have been met.

In some organizations, *programmer-analysts* design and update the software that runs a computer. Because they are responsible for both programming and systems analysis, these workers must be proficient in both areas. (A separate statement on computer programmers appears elsewhere in the *Handbook*.) As this dual proficiency becomes more commonplace, these analysts increasingly work with databases, object-oriented programming languages, as well as client-server applications development and multimedia and Internet technology.

One obstacle associated with expanding computer use is the need for different computer systems to communicate with each other. Because of the importance of maintaining up-to-date information-accounting records, sales figures, or budget projections, for example—systems analysts work on making the computer systems within an organization, or among organizations, compatible so that information can be shared among them. Many systems analysts are involved with "networking," connecting all the computers internally—in an individual office, department, or establishment—or externally, because many organizations now rely on e-mail or the Internet. A primary goal of networking is to allow users to retrieve data from a mainframe computer or a server and use it on their desktop computer. Systems analysts must design the hardware and software to allow the free exchange of data, custom applications, and the computer power to process it all. For example, analysts are called upon to ensure the compatibility of computing systems between and among businesses to facilitate electronic commerce.

Networks come in many variations, so *network systems and data communications analysts* are needed to design, test, and evaluate systems such as local area networks (LANs), wide area networks (WANs), the Internet, intranets, and other data communications systems. Systems can range from a connection between two offices in the same building to globally distributed networks, voice mail, and e-mail systems of a multinational organization. Network systems and data communications analysts perform network modeling, analysis, and planning; they also may research related products and make necessary hardware and software recommendations. *Telecommunications spe-*

Computer systems analysts solve computer problems and use computer technology to meet the needs of an organization.

cialists focus on the interaction between computer and communications equipment. These workers design voice and data communication systems, supervise the installation of those systems, and provide maintenance and other services to clients after the system is installed.

The growth of the Internet and the expansion of the World Wide Web (the graphical portion of the Internet) have generated a variety of occupations related to the design, development, and maintenance of Web sites and their servers. For example, *webmasters* are responsible for all technical aspects of a Web site, including performance issues such as speed of access, and for approving the content of the site. *Internet developers* or W*eb developers*, also called W*eb designers*, are responsible for day-to-day site design and creation.

Computer scientists work as theorists, researchers, or inventors. Their jobs are distinguished by the higher level of theoretical expertise and innovation they apply to complex problems and the creation or application of new technology. Those employed by academic institutions work in areas ranging from complexity theory, to hardware, to programming-language design. Some work on multidisciplinary projects, such as developing and advancing uses of virtual reality, extending human-computer interaction, or designing robots. Their counterparts in private industry work in areas such as applying theory, developing specialized languages or information technologies, or designing programming tools, knowledge-based systems, or even computer games.

With the Internet and electronic business generating large volumes of data, there is a growing need to be able to store, manage, and extract data effectively. *Database administrators* work with database management systems software and determine ways to organize and store data. They identify user requirements, set up computer databases, and test and coordinate modifications to the systems. An organization's database administrator ensures the performance of the system, understands the platform on which the database runs, and adds new users to the system. Because they also may design and implement system security, database administrators often plan and coordinate security measures. With the volume of sensitive data generated every second growing rapidly, data integrity, backup systems, and database security have become increasingly important aspects of the job of database administrators.

Working Conditions

Computer systems analysts, database administrators, and computer scientists normally work in offices or laboratories in comfortable surroundings. They usually work about 40 hours a week—the same as many other professional or office workers do. However, evening or weekend work may be necessary to meet deadlines or solve specific problems. Given the technology available today, telecommuting is common for computer professionals. As networks expand, more work can be done from remote locations through modems, laptops, electronic mail, and the Internet.

Like other workers who spend long periods in front of a computer terminal typing on a keyboard, computer systems analysts, database administrators, and computer scientists are susceptible to eyestrain, back discomfort, and hand and wrist problems such as carpal tunnel syndrome or cumulative trauma disorder.

Employment

Computer systems analysts, database administrators, and computer scientists held about 979,000 jobs in 2002; including about 89,000 who were self-employed. Employment was distributed among the following detailed occupations:

Computer systems analysts	468,000
Network systems and data communications analysts	186,000
Database administrators	110,000
Computer and information scientists, research	23,000
All other computer specialists	192,000

Although they are increasingly employed in every sector of the economy, the greatest concentration of these workers is in the computer systems design and related services industry. Firms in this industry provide services related to the commercial use of computers on a contract basis, including custom computer programming services; computer systems integration design services; computer facilities management services, including computer systems or data-processing facilities support services for clients; and other computer-related services, such as disaster recovery services and software installation. Many computer systems analysts, database administrators, and computer scientists are employed by Internet service providers, web search portals, and data-processing, hosting, and related services firms. Others work for government, manufacturers of computer and electronic products, insurance companies, financial institutions, and universities.

A growing number of computer specialists, such as systems analysts and network and data communications analysts, are employed on a temporary or contract basis; many of these individuals are self-employed, working independently as contractors or consultants. For example, a company installing a new computer system may need the services of several systems analysts just to get the system running. Because not all of the analysts would be needed once the system is functioning, the company might contract for such employees with a temporary help agency or a consulting firm or with the systems analysts themselves. Such jobs may last from several months up to 2 years or more. This growing practice enables companies to bring in people with the exact skills the firm needs to complete a particular project, rather than having to spend time or money training or retraining existing workers. Often, experienced consultants then train a company's in-house staff as a project develops.

Training, Other Qualifications, and Advancement

Rapidly changing technology requires an increasing level of skill and education on the part of employees. Companies look for professionals with an ever-broader background and range of skills, including not only technical knowledge, but also communication and other interpersonal skills. This shift from requiring workers to possess solely sound technical knowledge emphasizes workers who can handle various responsibilities. While there is no universally accepted way to prepare for a job as a systems analyst, computer scientist, or database administrator, most employers place a premium on some formal college education. A bachelor's degree is a prerequisite for many jobs; however, some jobs may require only a 2-year degree. Relevant work experience also is very important. For

more technically complex jobs, persons with graduate degrees are preferred.

For systems analyst, programmer-analyst, and database administrator positions, many employers seek applicants who have a bachelor's degree in computer science, information science, or management information systems (MIS). MIS programs usually are part of the business school or college and differ considerably from computer science programs, emphasizing business and management-oriented course work and business computing courses. Employers are increasingly seeking individuals with a master's degree in business administration (MBA), with a concentration in information systems, as more firms move their business to the Internet. For some network systems and data communication analysts, such as webmasters, an associate's degree or certificate is sufficient, although more advanced positions might require a computer-related bachelor's degree. For computer and information scientists, a doctoral degree generally is required due to the highly technical nature of their work.

Despite employers' preference for those with technical degrees, persons with degrees in a variety of majors find employment in these computer occupations. The level of education and type of training that employers require depend on their needs. One factor affecting these needs is changes in technology. Employers often scramble to find workers capable of implementing "hot" new technologies. Those workers with formal education or experience in information security, for example, are in demand because of the growing need for their skills and services. Another factor driving employers' needs is the timeframe during which a project must be completed.

Most community colleges and many independent technical institutes and proprietary schools offer an associate's degree in computer science or a related information technology field. Many of these programs may be more geared toward meeting the needs of local businesses and are more occupation specific than are 4-year degree programs. Some jobs may be better suited to the level of training that such programs offer. Employers usually look for people who have broad knowledge and experience related to computer systems and technologies, strong problem-solving and analytical skills, and good interpersonal skills. Courses in computer science or systems design offer good preparation for a job in these computer occupations. For jobs in a business environment, employers usually want systems analysts to have business management or closely related skills, while a background in the physical sciences, applied mathematics, or engineering is preferred for work in scientifically oriented organizations. Art or graphic design skills may be desirable for webmasters or Web developers.

Jobseekers can enhance their employment opportunities by participating in internship or co-op programs offered through their schools. Because many people develop advanced computer skills in a non-computer-related occupation and then transfer those skills to a computer occupation, a background in the industry in which the person's job is located, such as financial services, banking, or accounting, can be important. Others have taken computer science courses to supplement their study in fields such as accounting, inventory control, or other business areas. For example, a financial analyst who is proficient in computers might become a computer support specialist in financial systems development, while a computer programmer might move into a systems analyst job.

Computer systems analysts, database administrators, and computer scientists must be able to think logically and have good communication skills. Because they often deal with a number of tasks simultaneously, the ability to concentrate and pay close attention to detail is important. Although these computer specialists sometimes work independently, they frequently work in teams on large projects. They must be able to communicate effectively with computer personnel, such as programmers and managers, as well as with users or other staff who may have no technical computer background.

Computer scientists employed in private industry may advance into managerial or project leadership positions. Those employed in academic institutions can become heads of research departments or published authorities in their field. Systems analysts may be promoted to senior or lead systems analyst. Those who show leadership ability also can become project managers or advance into management positions such as manager of information systems or chief information officer. Database administrators may advance into managerial positions, such as chief technology officer, on the basis of their experience managing data and enforcing security. Computer specialists with work experience and considerable expertise in a particular subject or a certain application may find lucrative opportunities as independent consultants or may choose to start their own computer consulting firms.

Technological advances come so rapidly in the computer field that continuous study is necessary to keep one's skills up to date. Employers, hardware and software vendors, colleges and universities, and private training institutions offer continuing education. Additional training may come from professional development seminars offered by professional computing societies.

Certification is a way to demonstrate a level of competence in a particular field. Some product vendors or software firms offer certification and require professionals who work with their products to be certified. Many employers regard these certifications as the industry standard. For example, one method of acquiring enough knowledge to get a job as a database administrator is to become certified in a specific type of database management. Voluntary certification also is available through various organizations associated with computer specialists. Professional certification may afford a jobseeker a competitive advantage.

Job Outlook

Computer systems analysts, database administrators, and computer scientists are expected to be among the fastest growing occupations through 2012. Employment of these computer specialists is expected to grow much faster than the average for all occupations as organizations continue to adopt and integrate increasingly sophisticated technologies. Job increases will be driven by very rapid growth in computer system design and related services, which is projected to be one of the fastest-growing industries in the U.S. economy. In addition, many job openings will arise annually from the need to replace workers who move into managerial positions or other occupations or who leave the labor force. Job growth will not be as rapid as during the previous decade, however, as the information technology sector begins to mature and as routine work is increasingly outsourced overseas.

Despite the recent economic downturn among information technology firms, workers in the occupation should still enjoy favorable job prospects. The demand for networking to facilitate the sharing of information, the expansion of client-server environments, and the need for computer specialists to use their knowledge and skills in a problem-solving capacity will be major factors in the rising demand for computer systems analysts, database administrators, and computer scientists. Moreover, falling prices of computer hardware and software should continue to induce more businesses to expand their computerized operations and integrate new technologies into them. In order to maintain a competitive edge and operate more efficiently, firms will keep demanding computer specialists who are knowledgeable about the latest technologies and are able to apply them to meet the needs of businesses.

Increasingly, more sophisticated and complex technology is being implemented across all organizations, which should fuel the demand for these computer occupations. There is a growing demand for system analysts to help firms maximize their efficiency with available technology. Expansion of electronic commerce—doing business on the Internet—and the continuing need to build and maintain databases that store critical information on customers, inventory, and projects are fueling demand for database administrators familiar with the latest technology. Also, the increasing importance being placed on "cybersecurity"—the protection of electronic information—will result in a need for workers skilled in information security.

The development of new technologies usually leads to demand for various kinds of workers. The expanding integration of Internet technologies into businesses, for example, has resulted in a growing need for specialists who can develop and support Internet and intranet applications. The growth of electronic commerce means that more establishments use the Internet to conduct their business online. The introduction of the wireless Internet, known as WiFi, creates new systems to be analyzed and new data to be administered. The spread of such new technologies translates into a need for information technology professionals who can help organizations use technology to communicate with employees, clients, and consumers. Explosive growth in these areas also is expected to fuel demand for specialists who are knowledgeable about network, data, and communications security.

As technology becomes more sophisticated and complex, employers demand a higher level of skill and expertise from their employees. Individuals with an advanced degree in computer science or computer engineering or with an MBA with a concentration in information systems should enjoy highly favorable employment prospects. College graduates with a bachelor's degree in computer science, computer engineering, information science, or MIS also should enjoy favorable prospects for employment, particularly if they have supplemented their formal education with practical experience. Because employers continue to seek computer specialists who can combine strong technical skills with good interpersonal and business skills, graduates with non-computer-science degrees, but who have had courses in computer programming, systems analysis, and other information technology areas, also should continue to find jobs in these computer fields. In fact, individuals with the right experience and training can work in these computer occupations regardless of their college major or level of formal education.

Earnings

Median annual earnings of computer systems analysts were $62,890 in 2002. The middle 50 percent earned between $49,500 and $78,350 a year. The lowest 10 percent earned less than $39,270, and the highest 10 percent earned more than $93,400. Median annual earnings in the industries employing the largest numbers of computer systems analysts in 2002 were as follows:

Federal Government	$68,370
Computer systems design and related services	67,690
Data processing, hosting, and related services	64,560
Management of companies and enterprises	63,390
Insurance carriers	59,510

Median annual earnings of database administrators were $55,480 in 2002. The middle 50 percent earned between $40,550 and $75,100. The lowest 10 percent earned less than $30,750, and the highest 10 percent earned more than $92,910. In 2002, median annual earnings of database administrators employed in computer system design and related services were $66,650, and, for those in management of companies and enterprises, earnings were $59,620.

Median annual earnings of network systems and data communication analysts were $58,420 in 2002. The middle 50 percent earned between $44,850 and $74,290. The lowest 10 percent earned less than $34,880, and the highest 10 percent earned more than $92,110. Median annual earnings in the industries employing the largest numbers of network systems and data communications analysts in 2002 were as follows:

Computer systems design and related services	$65,800
Management of companies and enterprises	63,050
State government	45,110

Median annual earnings of computer and information scientists, research, were $77,760 in 2002. The middle 50 percent earned between $58,630 and $98,490. The lowest 10 percent earned less than $42,890, and the highest 10 percent earned more than $121,650. Median annual earnings of computer and information scientists employed in computer systems design and related services in 2002 were $78,730.

Median annual earnings of all other computer specialists were $54,070 in 2002. Median annual earnings of all other computer specialists employed in computer system design and related services were $49,590, and, for those in scientific research and development services, earnings were $70,150 in 2002.

According to the National Association of Colleges and Employers, starting offers for graduates with a master's degree in computer science averaged $62,806 in 2003. Starting offers averaged $47,109 for graduates with a bachelor's degree in computer science; $45,346 for those with a degree in computer programming; $41,118 for those with a degree in computer systems analysis; $40,556 for those with a degree in management information systems; and $38,282 for those with a degree in information sciences and systems.

According to Robert Half International, starting salaries in 2003 ranged from $69,750 to $101,750 for database administrators. Salaries for networking and Internet-related occupations ranged from $45,500 to $65,750 for LAN administrators and from $51,250 to $73,750 for Internet /Intranet developers. Starting salaries for security professionals ranged from $62,500 to $91,750 in 2003.

Related Occupations

Other workers who use logic and creativity to solve business and technical problems are computer programmers, computer software engineers, computer and information systems managers, financial analysts and personal financial advisors, urban and regional planners, engineers, mathematicians, statisticians, operations research analysts, management analysts, and actuaries.

Sources of Additional Information

Further information about computer careers is available from any of the following organizations:

➤ Association for Computing Machinery (ACM), 1515 Broadway, New York, NY 10036. Internet: **http://www.acm.org**

➤ Institute of Electrical and Electronics Engineers Computer Society, Headquarters Office, 1730 Massachusetts Ave. NW., Washington, DC 20036-1992. Internet: **http://www.computer.org**

➤ National Workforce Center for Emerging Technologies, 3000 Landerholm Circle SE., Bellevue, WA 98007. Internet: **http://www.nwcet.org**

Mathematicians

(0*NET 15-2021.00)

Significant Points

- A Ph.D. degree in mathematics usually is the minimum education needed, except in the Federal Government.
- Employment is expected to contract, reflecting the decline in the number of jobs with the title mathematician; competition will be keen for the limited number of jobs.
- Master's and Ph.D. degree holders with a strong background in mathematics and a related discipline, such as computer science or engineering, should have better employment opportunities in related occupations.

Nature of the Work

Mathematics is one of the oldest and most fundamental sciences. Mathematicians use mathematical theory, computational techniques, algorithms, and the latest computer technology to solve economic, scientific, engineering, physics, and business problems. The work of mathematicians falls into two broad classes—theoretical (pure) mathematics and applied mathematics. These classes, however, are not sharply defined, and often overlap.

Theoretical mathematicians advance mathematical knowledge by developing new principles and recognizing previously unknown relationships between existing principles of mathematics. Although these workers seek to increase basic knowledge without necessarily considering its practical use, such pure and abstract knowledge has been instrumental in producing or furthering many scientific and engineering achievements. Many theoretical mathematicians are employed as university faculty, and divide their time between teaching and conducting research. (See the statement on teachers—postsecondary, elsewhere in the *Handbook*.)

Applied mathematicians, on the other hand, use theories and techniques, such as mathematical modeling and computational methods, to formulate and solve practical problems in business, government, and engineering, and in the physical, life, and social sciences. For example, they may analyze the most efficient way to schedule airline routes between cities, the effect and safety of new drugs, the aerodynamic characteristics of an experimental automobile, or the cost-effectiveness of alternative manufacturing processes. Applied mathematicians working in industrial research and development may develop or enhance mathematical methods when solving a difficult problem. Some mathematicians, called cryptanalysts, analyze and decipher encryption systems designed to transmit military, political, financial, or law enforcement-related information in code.

Applied mathematicians start with a practical problem, envision the separate elements of the process under consideration, and then reduce the elements to mathematical variables. They often use computers to analyze relationships among the variables and solve complex problems by developing models with alternative solutions.

Much of the work in applied mathematics is done by individuals with titles other than mathematician. In fact, because mathematics is the foundation upon which so many other academic disciplines are built, the number of workers using mathematical techniques is much greater than the number formally designated as mathematicians. For example, engineers, computer scientists, physicists, and economists are among those who use mathematics extensively. Some professionals, including statisticians, actuaries, and operations research analysts, actually are specialists in a particular branch of mathematics. Frequently, applied mathematicians are required to collaborate with other workers in their organizations to achieve common solutions to problems. (For more information, see the statements on actuaries, operations research analysts, and statisticians elsewhere in the *Handbook*.)

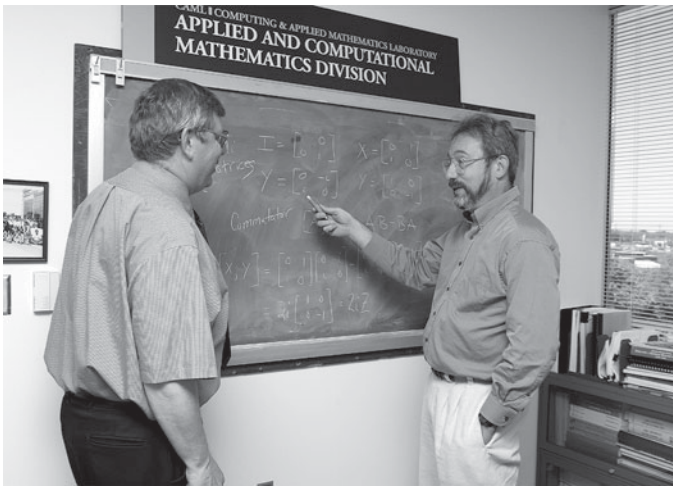
Working Conditions

Mathematicians usually work in comfortable offices. They often are part of an interdisciplinary team that may include economists, engineers, computer scientists, physicists, technicians, and others. Deadlines, overtime work, special requests for information or analysis, and prolonged travel to attend seminars or conferences may be part of their jobs. Mathematicians who work in academia usually have a mix of teaching and research responsibilities. These mathematicians often conduct research alone, or are aided by graduate students interested in the topic being researched.

Employment

Mathematicians held about 2,900 jobs in 2002. In addition, about 20,000 persons held full-time mathematics faculty positions in colleges and universities in 2002, according to the American Mathematical Society.

Many nonfaculty mathematicians work for Federal or State governments. The U.S. Department of Defense is the primary Federal employer, accounting for about three-fourths of the mathematicians employed by the Federal Government. Most other mathematicians employed by the Federal Government work for the National Aeronautics and Space Administration (NASA). In the private sector, major employers include insurance carriers, scientific research and development services, and management, scientific, and technical consulting services. Within manufacturing, the aerospace and pharmaceutical industries are the key employers. Some mathematicians also work for investment banks, insurance companies, and securities and commodity exchanges.



Mathematicians often use theory to explain mathematical relationships in the real world.

Training, Other Qualifications, and Advancement

A Ph.D. degree in mathematics usually is the minimum education needed for prospective mathematicians, except in the Federal Government. In the Federal Government, entry-level job candidates usually must have a 4-year degree with a major in mathematics or a 4-year degree with the equivalent of a mathematics major—24 semester hours of mathematics courses.

In private industry, candidates for mathematician jobs typically need a master's or Ph.D. degree. Most of the positions designated for mathematicians are in research and development laboratories, as part of technical teams. Research scientists in such positions engage either in basic research on pure mathematical principles or in applied research on developing or improving specific products or processes. The majority of those with a bachelor's or master's degree in mathematics who work in private industry do so not as mathematicians, but in related fields such as computer science, where they have titles such as computer programmer, systems analyst, or systems engineer.

A bachelor's degree in mathematics is offered by most colleges and universities. Mathematics courses usually required for this degree include calculus, differential equations, and linear and abstract algebra. Additional courses might include probability theory and statistics, mathematical analysis, numerical analysis, topology, discrete mathematics, and mathematical logic. Many colleges and universities urge or require students majoring in mathematics to take courses in a field that is closely related to mathematics, such as computer science, engineering, life science, physical science, or economics. A double major in mathematics and another related discipline is particularly desirable to many employers. High school students who are prospective college mathematics majors should take as many mathematics courses as possible while in high school.

In 2003, about 225 colleges and universities offered a master's degree as the highest degree in either pure or applied mathematics; about 200 offered a Ph.D. degree in pure or applied mathematics. In graduate school, students conduct research and take advanced courses, usually specializing in a subfield of mathematics.

For jobs in applied mathematics, training in the field in which the mathematics will be used is very important. Mathematics is used extensively in physics, actuarial science, statistics, engineering, and operations research. Computer science, business and industrial management, economics, finance, chemistry, geology, life sciences, and behavioral sciences are likewise dependent on applied mathematics. Mathematicians also should have substantial knowledge of computer programming, because most complex mathematical computation and much mathematical modeling are done on a computer.

Mathematicians need good reasoning ability and persistence in order to identify, analyze, and apply basic principles to technical problems. Communication skills are important, as mathematicians must be able to interact and discuss proposed solutions with people who may not have an extensive knowledge of mathematics.

Job Outlook

Competition is keen for the limited number of jobs as mathematicians. Employment of mathematicians is expected to decline through 2012, reflecting the decline in the number of jobs with the title mathematician. However, master's and Ph.D. degree holders with a strong background in mathematics and a related discipline, such as engineering or computer science, should have better opportunities. Many of these workers have job titles that reflect their occupation, such as systems analyst, rather than the title mathematician, reflecting their primary educational background.

Advancements in technology usually lead to expanding applications of mathematics, and more workers with knowledge of mathematics will be required in the future. However, jobs in industry and government often require advanced knowledge of related scientific disciplines in addition to mathematics. The most common fields in which mathematicians study and find work are computer science and software development, physics, engineering, and operations research. More mathematicians also are becoming involved in financial analysis. Mathematicians must compete for jobs, however, with people who have degrees in these other disciplines. The most successful jobseekers will be able to apply mathematical theory to real-world problems, and possess good communication, teamwork, and computer skills.

Private industry jobs require at least a master's degree in mathematics or in one of the related fields. Bachelor's degree holders in mathematics usually are not qualified for most jobs, and many seek advanced degrees in mathematics or a related discipline. However, bachelor's degree holders who meet State certification requirements may become primary or secondary school mathematics teachers. (For additional information, see the statement on teachers—preschool, kindergarten, elementary, middle, and secondary, elsewhere in the *Handbook*.)

Holders of a master's degree in mathematics will face very strong competition for jobs in theoretical research. Because the number of Ph.D. degrees awarded in mathematics continues to exceed the number of university positions available, many of these graduates will need to find employment in industry and government.

Earnings

Median annual earnings of mathematicians were $76,470 in 2002. The middle 50 percent earned between $56,160 and $91,520. The lowest 10 percent had earnings of less than $38,930, while the highest 10 percent earned over $112,780.

According to a 2003 survey by the National Association of Colleges and Employers, starting salary offers averaged $40,512 a year for mathematics graduates with a bachelor's degree, and $42,348 for those with a master's degree. Doctoral degree candidates averaged $55,485.

In early 2003, the average annual salary for mathematicians employed by the Federal Government in supervisory, nonsupervisory, and managerial positions was $80,877; that for mathematical statisticians was $83,472; and for cryptanalysts, the average was $78,662.

Related Occupations

Other occupations that require extensive knowledge of mathematics or, in some cases, a degree in mathematics include actuaries; statisticians; computer programmers; computer systems analysts, database administrators, and computer scientists; computer software engineers; and operations research analysts. A strong background in mathematics also facilitates employment as teachers—postsecondary; teachers—preschool, kindergarten, middle, elementary, and secondary; engineers; economists; market and survey 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**

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 (703) 724-1850; 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

(0*NET 15-2031.00)

Significant Points

- Employers generally prefer applicants with at least a master's degree in operations research or a closely related field, such as computer science, engineering, business, mathematics, information systems, or management science.
- Employment growth is projected to be slower than average, reflecting slow growth in the number of jobs with the title "operations research analyst."
- Individuals with a master's or Ph.D. degree in management science or operations research should have good job opportunities as operations research analysts or in closely related occupations, such as systems analysts, computer scientists, or management analysts.

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 have given effective assistance during wartime missions, such as deploying radar, searching for enemy submarines, and getting supplies where they were most needed. New analytical methods have been developed and numerous peacetime applications have 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, the design of production facilities and systems, supply chain management, pricing, transportation and distribution, and the analysis of 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 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 to improve performance. 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 ascertain the optimal 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, breaking them into their components. Analysts then gather information about each of the components 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 storage-cost data provided by the accounting department.

With the relevant information in hand, the analyst is ready to select the most appropriate analytical technique. Analysts can use any of 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 among them. The 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, the 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 values for the variable, the analyst is able to produce the best flight schedule consistent with particular assumptions.

Upon concluding the analysis, the operations research analyst presents management with recommendations based on the results. Additional computer runs to consider different assumptions may be needed before the analyst presents the final recommendation. Once management reaches a decision, the

Operations research analysts study organizational efficiency and suggest ways to improve an organization's performance.

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 61,700 jobs in 2002. Major employers include telecommunication companies, aerospace manufacturers, computer systems design firms, financial institutions, insurance carriers, engineering and management services firms, and Federal and State governments. More than 4 out of 5 operations research analysts in the Federal Government work for the Department of Defense, and many in private industry work directly or indirectly on national defense. About 1 out of 5 analysts works in architectural, engineering, or related services; computer systems design and related services; management, scientific, and technical consulting services; and scientific research and development firms that offer consulting services in the field of operations research.

Training, Other Qualifications, and Advancement
Employers generally prefer applicants with at least a master's degree in operations research or a closely related field, such as computer science, 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 supporting formal education in one manner or another, 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 performing 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 the development and use of sophisticated software packages.

Beginning analysts usually perform routine work under the supervision of more experienced analysts. As the novices 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 a variety of higher level management jobs, so experienced analysts may leave the field to assume nontechnical managerial or administrative positions. Operations research analysts with significant experience may 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 2012, reflecting slow growth in the number of jobs with the title "operations research analyst." Job opportunities in operations research should be good, however, because organizations throughout the economy will strive to improve their 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," and "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 because the number of openings generated by employment growth and the need to replace those leaving the occupation are expected to exceed the number of persons graduating with those credentials.

Organizations face pressure today 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, 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 will exist as well, 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. (See the *Handbook* statement on job opportunities in the Armed Forces.)

Earnings
Median annual earnings of operations research analysts were $56,920 in 2002. The middle 50 percent earned between $43,220 and $74,460. The lowest 10 percent had earnings of less than $34,140, while the highest 10 percent earned more than $92,430.

The average annual salary for operations research analysts in the Federal Government in nonsupervisory, supervisory, and managerial positions was $83,740 in 2003.

Related Occupations
Operations research analysts apply advanced analytical methods to large, complicated problems. Workers in other occupations that stress advanced analysis include computer systems analysts, database administrators, and computer scientists; computer programmers; engineers; mathematicians; statisticians; 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 Management Science, 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 the U.S. Department of Defense, contact

➤ Military Operations Research Society, 1703 N. Beauregard St., Suite 450, Alexandria, VA 22311. Internet: **http://www.mors.org**

Information on obtaining an operations research analyst 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 (703) 724-1850; 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**.

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 as a statistician.
- Although slower than average growth is expected in employment of statisticians, job opportunities should remain favorable for individuals with degrees in statistics.

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 and statistical knowledge to the design of surveys and experiments; collection, processing, and analysis of data; and interpretation of the results. Statisticians may 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 economic, social, political, and military decisions cannot be made without the use of statistical techniques, such as the design of 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 in 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.

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 disease. Statisticians also are employed in national defense agencies, determining the accuracy of new weapons and the likely effectiveness of defense strategies.

Because statistical specialists are employed in so many work areas, specialists who use statistics often have different professional designations. For example, a person using statistical methods on economic data may have the title econometrician, while statisticians in public health and medicine may hold titles such as biostatistician, biometrician, or epidemiologist.

Working Conditions

Statisticians usually work regular hours in comfortable offices. Some statisticians travel to provide advice on research projects, supervise and set up surveys, or gather statistical data. Some may have duties that vary widely, such as designing experiments or performing fieldwork in various communities. Statisticians who work in academia generally have a mix of teaching and research responsibilities.

Employment

Statisticians held about 20,000 jobs in 2002. Eighteen percent of these jobs were in the Federal Government, where statisticians were concentrated in the Departments of Commerce, Agriculture, and Health and Human Services. Another 16 percent were found in State and local governments, including State colleges and universities. Most of the remaining jobs were in private industry, especially in scientific research and development services; office administrative services; insurance carriers; management, scientific, and technical consulting services; and business, professional, labor, and political organizations; and pharmaceutical and medicine manufacturing. In addition, many professionals with a background in statistics were among the 20,000 full-time mathematics faculty in colleges and universities in 2002, according to the American Mathematical Society. (See the statement on teachers—postsecondary, elsewhere in the *Handbook*.)

Training, Other Qualifications, and Advancement

Although more employment opportunities are becoming available to individuals with a bachelor's degree in statistics, a master's degree in statistics or mathematics is usually the mini-

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

mum educational requirement for most statistician jobs. Research and academic positions in institutions of higher education, for example, require at least a master's degree, and usually a Ph.D., in statistics. Beginning positions in industrial research often require a master's degree combined with several years of experience.

The training required for employment as an entry-level statistician in the Federal Government, however, is a bachelor's degree, including at least 15 semester hours of statistics or a combination of 15 hours of mathematics and statistics, if at least 6 semester hours are in statistics. Qualifying as a mathematical statistician in the Federal Government requires 24 semester hours of mathematics and statistics, with a minimum of 6 semester hours in statistics and 12 semester hours in an area of advanced mathematics, such as calculus, differential equations, or vector analysis.

Many other schools also offered degrees in mathematics, operations research, and other fields that included a sufficient number of courses in statistics to qualify graduates for some beginning positions in the Federal Government. Required subjects for statistics majors include differential and integral calculus, statistical methods, mathematical modeling, and probability theory. Additional courses that undergraduates should take include linear algebra, design and analysis of experiments, applied multivariate analysis, and mathematical statistics.

In 2002, approximately 140 universities offered a master's degree program in statistics or biostatistics, and about 90 offered a doctoral degree program. Many other schools also offered graduate-level courses in applied statistics for students majoring in biology, business, economics, education, engineering, psychology, and other fields. Acceptance into graduate statistics programs does not require an undergraduate degree in statistics, although good training in mathematics is essential.

Because computers are used extensively for statistical applications, a strong background in computer science is highly recommended. For positions involving quality and productivity improvement, training in engineering or physical science is useful. A background in biological, chemical, or health science is important for positions involving the preparation and testing of pharmaceutical or agricultural products. Courses in economics and business administration are helpful for many jobs in market research, business analysis, and forecasting.

Good communications skills are important for prospective statisticians in industry, who often need to explain technical matters to persons without statistical expertise. An understanding of business and the economy also is valuable for those who plan to work in private industry.

Beginning statisticians generally are supervised by an experienced statistician. With experience, they may advance to positions with more technical responsibility and, in some cases, supervisory duties. However, opportunities for promotion are greater for persons with advanced degrees. Master's and Ph.D. degree holders usually enjoy independence in their work and become qualified to engage in research, develop statistical methods, or, after a number of years of experience in a particular area, become statistical consultants.

Job Outlook

Slower than average growth is expected in employment of statisticians over the 2002-12 period. However, job opportunities should remain favorable for individuals with degrees in statistics, although many of these positions will not carry the explicit job title statistician. This is especially true of jobs that involve the analysis and interpretation of data from other disciplines such as economics, biological science, psychology, or computer software engineering. Despite the limited number of jobs resulting from growth, a number of openings will become available as statisticians transfer to other occupations or retire or leave the work force for other reasons.

Among graduates with a master's degree in statistics, those with a strong background in an allied field, such as finance, biology, engineering, or computer science, should have the best prospects of finding jobs related to their field of study. Federal agencies will hire statisticians in many fields, including demography, agriculture, consumer and producer surveys, Social Security, healthcare, and environmental quality. Competition for entry-level positions in the Federal Government is expected to be strong for persons just meeting the minimum qualification standards for statisticians, because the Federal Government is one of the few employers that considers a bachelor's degree to be an adequate entry-level qualification. Those who meet State certification requirements may become high school statistics teachers. (For additional information, see the statement on teachers—preschool, kindergarten, elementary, middle, and secondary elsewhere in the *Handbook*.)

Manufacturing firms will hire statisticians with master's and doctoral degrees for quality control of various products, including pharmaceuticals, motor vehicles, aircraft, chemicals, and food. For example, pharmaceutical firms employ statisticians to assess the safety and effectiveness of new drugs. To address global product competition, motor vehicle manufacturers will need statisticians to improve the quality of automobiles, trucks, and their components by developing and testing new designs. Statisticians with knowledge of engineering and the physical sciences will find jobs in research and development, working with teams of scientists and engineers to help improve design and production processes to ensure consistent quality of newly developed products. Many statisticians also will find opportunities developing statistical software for computer software manufacturing firms.

Business firms will rely heavily on workers with a background in statistics to forecast sales, analyze business conditions, and help to solve management problems in order to maximize profits. In addition, consulting firms increasingly will offer sophisticated statistical services to other businesses. Because of the widespread use of computers in this field, statisticians in all industries should have good computer programming skills and knowledge of statistical software.

Earnings

Median annual earnings of statisticians were $57,080 in 2002. The middle 50 percent earned between $40,510 and $76,500. The lowest 10 percent had earnings of less than $30,380, while the highest 10 percent earned more than $91,680.

The average annual salary for statisticians in the Federal Government in nonsupervisory, supervisory, and managerial positions was $75,979 in 2003, while mathematical statisticians averaged $83,472. According to a 2003 survey by the National Association of Colleges and Employers, starting salary offers for mathematics/statistics graduates with a bachelor's degree averaged $40,512 a year.

Related Occupations

People in a wide range of occupations work with statistics. Among these are actuaries; mathematicians; operations research analysts; computer systems analysts, database administrators,

and computer scientists; computer programmers; computer software engineers; engineers; economists; market and survey researchers; financial analysts and personal financial advisors; and life, physical, and social scientists.

Sources of Additional Information

For information about career opportunities in statistics, contact:

➤ American Statistical Association, 1429 Duke St., Alexandria, VA 22314. Internet: **http://www.amstat.org**

For more information on doctoral-level careers and training in mathematics, a field closely related to statistics, contact:

➤ American Mathematical Society, 201 Charles St., Providence, RI 02940. Internet: **http://www.ams.org**

Information on obtaining a statistician 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 (703) 724-1850; 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**.