Computer and Mathematical Occupations

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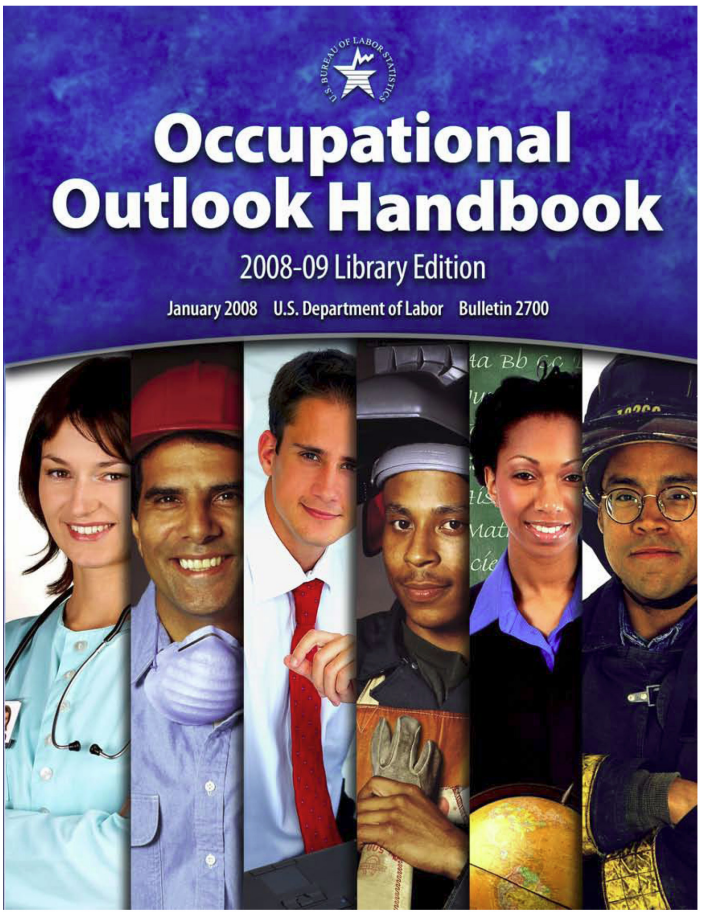


Occupations Included in this Reprint

Actuaries
Computer and information systems managers
Computer programmers
Computer scientists and database administrators
Computer software engineers
Computer support specialists and systems administrators
Computer systems analysts
Mathematicians
Operations research analysts
Statisticians

Actuaries

(O*NET 15-2011.00)

Significant Points

- A strong background in mathematics is essential; actuaries must pass a series of examinations to gain full professional status.
- About 6 out of 10 actuaries are employed in the insurance industry.
- Employment opportunities should remain good for those who qualify, because the stringent qualifying examination system restricts the number of candidates.

Nature of the Work

Through their knowledge of statistics, finance, and business, actuaries assess the risk of events occurring and help create policies that minimize risk and its financial impact on companies and clients. 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 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 either life and health insurance or property and casualty insurance. They produce probability tables or use more sophisticated dynamic modeling techniques that determine the likelihood that a potential 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 number 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 help to develop long-term-care insurance and annuity policies, the latter a growing investment tool for many individuals.

Actuaries in other financial service industries manage credit and help price corporate security offerings. They also devise new investment tools to help their firms compete with other financial service companies. Pension actuaries work under the provisions of the Employee Retirement Income Security Act (ERISA) of 1974 to evaluate pension plans covered by that Act and report on the plans' financial soundness to participants, sponsors, and Federal regulators. Actuaries working for the 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 that affects 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 by forecasting demand in competitive settings.

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 example, they may provide advice on how to lessen the risk of injury on the job. Consulting actuaries sometimes testify in court regarding the value of 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. Some 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.

Work environment. 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.

Training, Other Qualifications, and Advancement

Actuaries need a strong background in mathematics and statistics.

Actuaries need a strong foundation in mathematics, statistics, and general business. They generally have a bachelor's degree and are required to pass a series of exams in order to become certified.

Education and training. Actuaries need a strong background in mathematics and general business. Usually, actuaries earn an undergraduate degree in mathematics, statistics or actuarial science, or a business-related field such as finance, economics or business. While in college, students should complete coursework in economics, applied statistics and corporate finance, which is a requirement for professional certification. Furthermore, many students obtain internships to gain experience in the profession prior to graduation. 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. Companies increasingly prefer well-rounded individuals who, in addition to having acquired a strong technical background, have some training in business and liberal arts and possess strong communication skills.

Beginning actuaries often rotate among different jobs in an organization, such as marketing, underwriting, financial reporting and product development, to learn various actuarial operations and phases of insurance work. 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.

Licensure. Two professional societies sponsor programs leading to full professional status in their specialty: the Society of Actuaries (SOA) and the Casualty Actuarial Society (CAS). The SOA certifies actuaries in the fields of life insurance, health benefits systems, retirement systems, and finance and investment. The CAS gives a series of examinations in the property and casualty field, which includes car, homeowners, medical malpractice, workers compensation, and personal injury liability.

Three of 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, statistics, and other branches of mathematics and finance. 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.

Many candidates find work as an actuary immediately after graduation and work through the certification process while gaining some experience in the field. In fact, many employers pay the examination fees and provide their employees time to study. As actuaries pass exams, they are often rewarded with a pay increase. Despite the fact that employers are supportive during the exam process, home study is necessary and many actuaries study for months to prepare for each exam.

The process for gaining certification in the Casualty Actuarial Society is predominantly exam based. To reach the first level of certification, the Associate or ACAS level, a candidate must complete seven exams, attend one course on professionalism and complete the coursework in applied statistics, corporate finance, and economics required by both the SOA and CAS. This process generally takes from 4 to 6 years. The next level, the Fellowship or FCAS level, requires passing two additional exams in advanced topics, including investment and assets and dynamic financial analysis and the valuation of insurance. Most actuaries reach the fellowship level 2 to 3 years after attaining Associate status.

The certification process of the Society of Actuaries blends exams with computer learning modules and coursework. After taking the initial exams, candidates must choose a specialty: group and health benefits, individual life and annuities, retirement benefits, pensions, investments or finance/enterprise risk management. To reach the Associate or ASA level, a candidate must complete the initial four exams, the coursework in applied statistics, corporate finance and economics required by the SOA and CAS, eight computer modules with two corresponding assessments and a course in professionalism. This process generally takes from 4 to 6 years. To attain the Fellowship or FSA level, a candidate must pass two additional exams within a chosen specialty and must complete three computer modules and a professionalism course. Attaining Fellowship status usually takes an additional 2 to 3 years after becoming an Associate.

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 of the U.S. Treasury Department and the U.S. Department of Labor for the Enrollment of Actuaries. To qualify for enrollment, applicants must meet certain experience and examination requirements, as stipulated by the Board.

Other qualifications. 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 for Applications, SAS, or SQL, is also useful.

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, and finance that could affect insurance or investment practices. Good communication and interpersonal skills also are important, particularly for prospective consulting actuaries.

Advancement. 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. Increasingly, actuaries with knowledge

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Actuaries	15-2011	18,000	22,000	4,300	24

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

of business are beginning to rise to high-level positions within their companies, such as Chief Risk Officer, Chief Financial Officer, or other executive level positions. These generally require that actuaries use their abilities for assessing risk and apply it to the entire company as a whole. Furthermore, some experienced actuaries move into consulting, often by opening their own consulting firm. Some actuaries transfer to college and university faculty positions. (See the section on teachers—postsecondary elsewhere in the *Handbook*.)

Employment

Actuaries held about 18,000 jobs in 2006. Over half of all actuaries were employed by insurance carriers. Approximately 21 percent work for professional, scientific and technical consulting services. Others worked for insurance agents and brokers and in the management of companies and enterprises industry. A relatively small number of actuaries are employed by government agencies.

Job Outlook

Employment of actuaries is expected to grow rapidly through 2016. Job opportunities should remain good for those who qualify, because the stringent qualifying examination system restricts the number of candidates.

Employment change. Employment of actuaries is expected to increase by about 24 percent over the 2006-16 period, which is much faster than the average for all other occupations. Employment growth in the insurance industry—the largest employer of actuaries—is expected to continue at a stable pace, while more significant job growth is likely in other industries, such as health care and consulting firms.

Steady demand by the insurance industry should ensure that actuarial jobs in this key industry will remain stable during 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. The demand for actuaries in life insurance has been growing rapidly as a result of the rise in popularity of annuities, a financial product offered primarily by life insurance companies. In addition, the risk of terrorism and natural disasters has created a large demand for actuaries in property insurance.

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 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 employ their own actuaries are increasingly hiring consulting 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.

Despite the increase in employment overall, there has been some decline in the demand for pension actuaries. This is due in large part to the decline of defined benefit plans, which required review by an actuary, in favor of investment based retirement funds, such as 401ks.

Job prospects. Opportunities for actuaries should be good, particularly for those who have passed at least one or two of the initial exams. In addition, a small number of jobs will open up each year to replace actuaries who leave the occupation to retire or transfer new jobs. 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.

Earnings

Median annual earnings of actuaries were $82,800 in May 2006. The middle 50 percent earned between $58,710 and $114,570. The lowest 10 percent had earnings of less than $46,470 while the top 10 percent earned more than $145,600.

According to the National Association of Colleges and Employers, annual starting salaries for graduates with a bachelor's degree in actuarial science averaged $53,754 in 2007.

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 2007 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 $53,111. Associate actuaries, who direct and provide leadership in the design, pricing, and implementation of insurance products, received an average salary of $109,167. Actuaries at the highest technical level without managerial responsibilities reportedly were paid an average of $125,946.

Related Occupations

Actuaries need a strong background in mathematics, statistics, and related fields. Other workers whose jobs involve such 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 600, Schaumburg, IL 60173-2226.
Internet: **http://www.soa.org**

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

➤ Casualty Actuarial Society (CAS), 4350 N. Fairfaix Dr., Suite 250 Arlington, VA 22203.
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 information on a career as an actuary, contact:

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

Computer and Information Systems Managers

(O*NET 11-3021.00)

Significant Points

- Employment of computer and information systems managers is expected to grow faster than the average for all occupations through the year 2016.
- Many managers possess advanced technical knowledge gained from working in a computer occupation.
- Job opportunities will be best for applicants with a strong understanding of business and good communication skills.

Nature of the Work

In the modern workplace, it is imperative that technology works both effectively and reliably. Computer and information systems managers play a vital role in the implementation of technology within their organizations. They do everything from helping to construct a business plan to overseeing network security to directing Internet operations.

Computer and information systems managers plan, coordinate, and direct research and facilitate 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. This requires a strong understanding of both technology and business practices.

Computer and information systems managers direct the work of systems analysts, computer programmers, support specialists, and other computer-related workers. They 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, maintenance, and security of networks. They analyze the computer and information needs of their organizations 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 to ensure the organization does not lag behind competitors.

The duties of computer and information systems managers vary greatly. *Chief technology officers (CTOs)*, for example, evaluate the newest and most innovative technologies and determine how these can help their organizations. The chief technology officer 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 organizations. Once a useful tool has been identified, the CTO must determine an implementation strategy and sell that strategy to management.

Management information systems (MIS) directors or *information technology (IT) directors* manage computing resources for their organizations. They often work under the chief information officer and plan and direct the work of subordinate information technology employees. These managers ensure the availability, continuity, and security of data and information technology services in their organizations. In this capacity, they 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

Computer and information systems managers supervise other information technology employees.

recommendations based on their experience with an organization's technology.

Project managers develop requirements, budgets, and schedules for their firms' 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.

Work environment. Computer and information systems managers spend most of their time in offices. Most work at least 40 hours a week and some 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 with short deadlines or tight budgets. As networks continue to expand and more work is done remotely, computer and information systems managers have to communicate with and oversee offsite employees using modems, laptops, e-mail, and the Internet.

Like other workers who spend most of their time using computers, computer and information systems managers are susceptible to eyestrain, back discomfort, and hand and wrist problems such as carpal tunnel syndrome.

Training, Other Qualifications, and Advancement

Computer and information systems managers are generally experienced workers who have both technical expertise and an understanding of business and management principles. A strong educational background and experience in a variety of technical fields is needed.

Education and training. A bachelor's degree usually is required for management positions, although employers often prefer a graduate degree, especially an 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 preparation 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 offer degrees in management information systems. These degrees blend technical subjects with business, accounting, and communications courses. A few computer and information systems managers attain their positions with only an associate or trade school degree, but they must have sufficient experience and must have acquired additional skills on the job. To aid their professional advancement, many managers with an associate degree eventually earn a bachelor's or master's degree while working.

Certification and other qualifications. Computer and information systems managers need a broad range of skills. Employers look for managers who have experience with the specific software or technology 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 and, consequently, many computer and information systems managers are called on to make important business decisions. Managers need a keen understanding of people, management processes, and customers' needs.

Advanced 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 managers and potential customers. Therefore, many computer and information systems managers have worked as a systems analyst, for example, or as a computer support specialist, programmer, or other information technology professional.

Although certification is not necessarily required for most computer and information systems manager positions, there is a wide variety of certifications available that may be helpful in getting a job. These certifications are often product-specific, and are generally administered by software or hardware companies rather than independent organizations.

As computer systems become more closely connected with day-to-day operations of businesses, computer and information systems managers are also expected to be aware of business practices. They must possess strong interpersonal, communication, and leadership skills because they are required to interact not only with staff members, but also with other people inside and outside their organizations. They must possess team skills to work on group projects and other collaborative efforts. They also must have an understanding of how a business functions, how it earns revenue, and how technology relates to the core competencies of the business. As a result, many firms now prefer to give these positions to people who have spent time outside purely technical fields.

Advancement. Computer and information systems managers may advance to progressively higher leadership positions in the information technology department. A project manager might, for instance, move up to the chief technology officer position and then to chief information officer. On occasion, some may become managers in non-technical areas such as marketing, human resources, or sales because in high technology firms an understanding of technical issues is helpful in those areas.

Employment

Computer and information systems managers held about 264,000 jobs in 2006. About 1 in 4 computer managers worked in service-providing industries, mainly in computer

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-16	
				Number	Percent
Computer and information systems managers	11-3021	264,000	307,000	43,000	16

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

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; and other computer-related services, such as disaster recovery services and software installation. Other large employers include insurance and financial firms, government agencies, and manufacturers.

Job Outlook

The increasing use of technology in the workplace is projected to lead to faster than average growth in this occupation. Due to employment increases and because of the high demand for technical workers, prospects should be excellent for qualified job candidates.

Employment change. Employment of computer and information systems managers is expected to grow 16 percent over the 2006-16 decade, which is faster than the average for all occupations. New applications of technology in the workplace will continue to drive demand for workers, fueling the need for more managers.

Despite the downturn in the technology sector in the early part of the decade, the outlook for computer and information systems managers remains strong. To remain competitive, firms will continue to install sophisticated computer networks and set up more complex intranets and websites. Keeping a computer network running smoothly is essential to almost every organization.

Because so much business is carried out over computer networks, security will continue to be an important issue for businesses and other organizations. Although software developers continue to improve their products to remove vulnerabilities, attackers are becoming ever more complex in their methods. Organizations need to understand how their systems are vulnerable and how to protect their infrastructure and Internet sites from hackers, viruses, and other attacks. The emergence of security as a key concern for businesses should lead to strong growth for computer managers. Firms will increasingly hire security experts to fill key leadership roles in their information technology departments because the integrity of their computing environments is of utmost importance. As a result, there will be a high demand for managers proficient in computer security issues.

With 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. Workers who have experience in web applications and Internet technologies will become increasingly vital to their companies.

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, computer systems analysts, and computer scientists and database administrators elsewhere in the *Handbook*.)

Job prospects. Prospects for qualified computer and information systems managers should be excellent. Fast-paced occupational growth and the limited supply of technical workers will lead to a wealth of opportunities for qualified individuals. While technical workers remain relatively scarce in the United States, the demand for them continues to rise. This situation was exacerbated by the economic downturn in the early 2000s, when many technical professionals lost their jobs. Since then, many workers have chosen to avoid this work since it is perceived to have poor prospects.

Workers with specialized technical knowledge and strong communications skills will have the best prospects. People with management skills and an understanding of business practices and principles will have excellent opportunities, as companies are increasingly looking to technology to drive their revenue.

Earnings

Earnings for computer and information systems managers vary by specialty and level of responsibility. Median annual earnings of these managers in May 2006 were $101,580. The middle 50 percent earned between $79,240 and $129,250. Median annual earnings in the industries employing the largest numbers of computer and information systems managers in May 2006 were as follows:

Computer systems design and related services	$109,130
Management of companies and enterprises	105,980
Data processing, hosting, and related services	105,200
Insurance carriers	102,180
Colleges, universities, and professional schools	83,280

The Robert Half Technology 2007 Salary Guide lists the following annual salary ranges for various computer and information systems manager positions: Chief Technology Officer (CTO), $101,000-$157,750; Chief Security Officer, $97,500-$141,000; Vice President of Information Technology, $107,500-$157,750; Information Technology Manager, Technical Services Manager, $62,500-$88,250.

In addition, computer and information systems managers, especially those at higher levels, often receive employment-related benefits, such as expense accounts, stock option plans, and bonuses.

Related Occupations

The work of computer and information systems managers is closely related to that of computer programmers, computer software engineers, computer systems analysts, computer scientists and database administrators, 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:

➤ Association of Information Technology Professionals, 401 North Michigan Ave., Suite 2400, Chicago, IL 60611.
Internet: **http://www.aitp.org**

Computer Programmers

(O*NET 15-1021.00)

Significant Points

- Almost 8 out of 10 computer programmers held an associate's degree or higher in 2006; nearly half held a bachelor's degree, and 2 out of 10 held a graduate degree.
- Employment of computer programmers is expected to decline by four percent through 2016.
- Job prospects will be best for applicants with a bachelor's degree and experience with a variety of programming languages and tools.

Nature of the Work

Computer programmers write, test, and maintain the detailed instructions, called programs, that computers follow to perform their functions. Programmers also conceive, design, and test logical structures for solving problems by computer. With the help of other computer specialists, they figure out which instructions to use to make computers do specific tasks. Many technical innovations in programming—advanced computing technologies and sophisticated new languages and programming tools, for example—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, but computer programmers are individuals whose main job function is programming. Programmers usually write programs according to the specifications given by computer software engineers and systems analysts. (Sections on computer software engineers and on computer systems analysts appear elsewhere in the *Handbook*.) After engineers and analysts design software—describing how it will work—the programmer converts that design into a logical series of instructions that the computer can follow. The programmer codes these instructions in a conventional programming language such as COBOL; an artificial intelligence language such as Prolog; or one of the more advanced object-oriented languages, such as Java, C++, or ACTOR.

Different programming languages are used depending on the purpose of the program. 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, such as Java programmers, or by the type of function they perform or environment in which they work—for example, database programmers, mainframe programmers, or Web programmers.

Programmers also update, repair, modify, and expand existing programs. Some, especially those working on large projects that involve 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 a program. Programmers working on smaller projects often use "programmer environments," applications that increase productivity by combining compiling, code walk through, code generation, test data generation, and debugging functions. Programmers also use libraries of basic code that can be modified or customized for a specific application. This approach yields more reliable and consistent programs and increases programmers' productivity by eliminating some routine steps.

Programs vary widely depending on the type of information they will access or generate. For example, the instructions involved in updating financial records are very different from those required to simulate flight for pilot training. Simple programs can be written in a few hours, but some programs draw data from many existing systems or use complex mathematical formulas. These programs may take more than a year to create. In most cases, several programmers work together as a team under a senior programmer's supervision.

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 problems for as long as a program is used.

Programmers working on a mainframe, a large centralized computer, may prepare instructions for a computer operator who will run the program. (A section on computer operators appears elsewhere in the *Handbook*.) Programmers also may contribute to the instruction manual for a program.

Programmers in software development companies may work directly with experts from various fields to create specialized 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. Programming of packaged software constitutes one of the most rapidly growing segments of the computer services industry.

Increasingly, advanced software platforms are bridging the gap between computer programmers and computer users. New platforms, such as spreadsheet, accounting, and enterprise resource planning applications, have created demand for computer specialists who have first-hand knowledge of a user-base. These workers use such platforms to develop programs that meet the specific needs of this base. Computer programmers often are responsible for creating the software platform, and then fine-tuning the final program after it has been made.

Computer 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 also may revise existing packaged software or customize generic applications purchased from vendors. *Systems programmers*, in contrast, write programs to maintain and control computer systems software for operating systems, networked systems, and database systems. These workers make changes in the instructions that determine how the network, workstations, and central processing unit of a 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 determine the source of problems that may occur with their programs.

In some organizations, workers known as *programmer-analysts* are responsible for both the systems analysis and programming. (A more detailed description of the work of programmer-analysts is presented in the section on computer systems analysts elsewhere in the *Handbook*.)

Work environment. Programmers spend the majority of their time in front of a computer terminal, and work in clean, comfortable offices. Telecommuting is becoming more common, however, as technological advances allow more work to be done from remote locations.

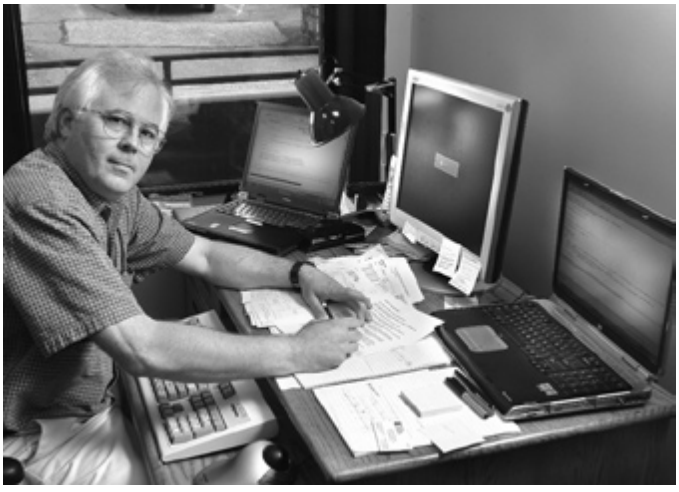
Most computer programmers work about 40 hours per week. Long hours or weekend work may be required, however, to meet deadlines or fix unexpected technical problems. About four percent work part-time, compared with about 15 percent for all occupations.

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.

Training, Other Qualifications, and Advancement

A bachelor's degree commonly is required for computer programming jobs, although a two-year degree or certificate may be adequate for some positions. Employers favor applicants who already have relevant programming skills and experience. Skilled workers who keep up to date with the latest technology usually have good opportunities for advancement.

Education and training. Most programmers have a bachelor's degree, but a two-year degree or certificate may be adequate for some jobs. 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, finance, or another area of business. In 2006, more than 68 percent of computer programmers had a bachelor's degree or higher, but as the level of education and training required by employers continues to rise, this proportion is expected to increase.



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

Employers who use computers for scientific or engineering applications usually prefer college graduates who have a degree in computer or information science, mathematics, engineering, or the physical sciences. Employers who use computers for business applications prefer to hire people who have had college courses in management information systems and business, and who possess strong programming skills. A graduate degree in a related field is required for some jobs.

Most systems programmers hold a four-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 being able 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.

In addition to educational attainment, employers highly value relevant programming skills, as well as experience. Although knowledge of traditional programming languages still is important, employers are placing an emphasis on newer, object-oriented languages and tools such as C++ and Java. Additionally, employers seek people familiar with fourth- and fifth-generation languages that involve graphic user interface and systems programming. College graduates who are interested in changing careers or developing an area of expertise may return to a two-year community college or technical school for specialized training. In the absence of a degree, substantial specialized experience or expertise may be needed.

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.

Certification and other qualifications. When hiring programmers, employers look for people with the necessary programming skills who can think logically and pay close attention to detail. Programming calls for patience, persistence, and the ability to perform exacting analytical work, especially under pressure. Ingenuity and creativity 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 non-technical personnel. Business skills are also important, especially for those wishing to advance to managerial positions.

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Computer programmers	15-1021	435,000	417,000	-18,000	-4

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

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, 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 various other organizations.

Advancement. For skilled workers who keep up to date with the latest technology, 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 may be promoted to managerial positions. Programmers with specialized knowledge and experience with a language or operating system may work in research and development and may even become computer software engineers. As employers increasingly contract with outside firms to do programming jobs, more opportunities should arise for experienced programmers with expertise in a specific area to work as consultants.

Employment

Computer programmers held about 435,000 jobs in 2006. Programmers are employed in almost every industry, but the largest concentration is in computer systems design and related services. Large numbers of programmers also work for software publishers, financial institutions, insurance carriers, educational institutions, government agencies, and management of companies and enterprises. Many computer programmers work independently as consultants on a temporary or contract basis, some of whom are self-employed. About 17,000 computer programmers were self-employed in 2006.

Job Outlook

Employment of computer programmers is expected to decline slowly. Job prospects should be best for those with a bachelor's degree and experience with a variety of programming languages and tools.

Employment change. Employment of computer programmers is expected to decline slowly, decreasing by 4 percent from 2006 to 2016. 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 mean that more programming functions can be performed by other types of information workers, such as computer software engineers.

Another factor contributing to employment decline will be the offshore outsourcing of programming jobs. Because they can transmit their programs digitally, computer programmers can perform their job function from anywhere in the world, allowing companies to employ workers in countries that have lower prevailing wages. Computer programmers are at a much higher risk of having their jobs outsourced abroad than are workers involved in more complex and sophisticated information technology functions, such as software engineering. Much of the work of computer programmers requires little localized or specialized knowledge and can be made routine once knowledge of a particular programming language is mastered—and computer programming languages have become known internationally.

Nevertheless, employers will continue to need some local programmers, especially those 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 implement business 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 likely will stem 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, a growing emphasis on cybersecurity will lead to increased demand for programmers who are familiar with digital security issues, and are skilled in using appropriate security technology.

Job prospects. Although employment is projected to decline, numerous job openings will result from the need to replace programmers who leave the labor force or transfer to other occupations. Prospects for these openings should be best for applicants with a bachelor's degree and experience with a variety of programming languages and tools. The languages that are in demand today include C++, Java, and other object-oriented languages, as well as newer, domain-specific languages that apply to computer networking, database management, and Internet application development. As technology evolves, however, and newer, more sophisticated tools emerge, programmers will need to update their skills in order to remain competitive. Obtaining vendor-specific or language-specific certification also can provide a competitive edge.

Jobs for both systems and applications programmers should be most plentiful in computer consulting businesses. These establishments are part of the computer systems design and

related services industry, which is projected to be among the fastest growing industries in the economy over the 2006 to 2016 period.

Earnings

Median annual earnings of wage-and-salary computer programmers were $65,510 in May 2006. The middle 50 percent earned between $49,580 and $85,080 a year. The lowest 10 percent earned less than $38,460, and the highest 10 percent earned more than $106,610. Median annual earnings in the industries employing the largest numbers of computer programmers in May 2006 are shown below:

Software publishers	$79,270
Computer systems design and related services	67,880
Management of companies and enterprises	67,170
Insurance carriers	65,650

According to the National Association of Colleges and Employers, starting salary offers for computer programmers averaged $49,928 per year in 2007.

According to Robert Half Technology, a firm providing specialized staffing services, average annual starting salaries in 2007 ranged from $55,250 to $90,250 for applications development programmers/analysts, and from $60,250 to $94,750 for software developers. Average starting salaries for mainframe systems programmers ranged from $52,250 to $70,750.

Related Occupations

Other professional workers who deal extensively with data include computer software engineers, computer scientists and database administrators, computer systems analysts, statisticians, mathematicians, engineers, commercial and industrial designers, 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, 2 Penn Plaza, Suite 701, New York, NY 10121-0701.
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**

➤ University of Washington Computer Science and Engineering Department, AC101 Paul G. Allen Center, Box 352350, 185 Stevens Way, Seattle, WA 98195-2350.
Internet: **http://www.cs.washington.edu/WhyCSE**

Computer Scientists and Database Administrators

(O*NET 15-1011.00, 15-1061.00, 15-1081.00, 15-1099.99)

Significant Points

- Education requirements range from an associate degree to a doctoral degree.
- Employment is expected to increase much faster than the average as organizations continue to expand their use of technology.
- Workers must be able to learn new technologies quickly for these constantly evolving occupations.

Nature of the Work

The rapid and widespread use of computers and information technology has generated a need for highly trained workers proficient in various job functions. These computer specialists include computer scientists, database administrators, and network systems and data communication analysts. Job tasks and occupational titles used to describe these workers evolve rapidly and continually, reflecting new areas of specialization or changes in technology, as well as the preferences and practices of employers.

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. The areas of computer science research range from complex theory to hardware design to programming-language design. Some researchers work on multidisciplinary projects, such as developing and advancing uses of virtual reality, extending human-computer interaction, or designing robots. They may work on design teams with electrical engineers and other specialists.

Computer science researchers employed by academic institutions (covered in the statement on teachers—postsecondary, elsewhere in the *Handbook*) have job functions that are similar in many ways to those employed by other organizations. In general, researchers in academic settings have more flexibility to focus on pure theory, while those working in other organizations usually focus on projects that have the possibility of producing patents and profits. However, some researchers in non-academic settings have considerable latitude in determining the direction of their research.

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 needs and set up new computer databases. In many cases, database administrators must integrate data from outdated systems into a new system. They also test and coordinate modifications to the system when needed, and troubleshoot problems when they occur. 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 many databases are connected to the Internet, database administrators also must plan and coordinate security measures with network administrators. With the growing volume of sensitive data and the increasing interconnectedness of computer networks, data integrity, backup systems, and database security have become increasingly important aspects of the job of database administrators.

Network systems and data communications analysts, also referred to as *network architects*, design, test, and evaluate systems such as local area networks (LANs), wide area networks (WANs), the Internet, intranets, and other data communications systems. Systems are configured in many ways and 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, often requiring both hardware and software solutions. For example, a network may involve the installation of several pieces of hardware, such as routers and hubs, wireless adaptors, and cables, while also requiring the installation and configuration of software, such as network drivers. Analysts also may research related products and make necessary hardware and software recommendations.

Telecommunications specialists focus on the interaction between computer and communications equipment. These workers design voice and data communication systems, supervise the installation of the systems, and provide maintenance and other services to clients after the systems are 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 *Web developers*, also called *Web designers*, are responsible for day-to-day site creation and design.

Work environment. Computer scientists and database administrators normally work in offices or laboratories in comfortable surroundings. They typically work about 40 hours a week, the same as many other professional or office workers. However, evening or weekend work may be necessary to meet deadlines or to solve specific problems. Telecommuting is increasingly common for many computer professionals as networks expand, allowing more work to be done from remote locations through modems, laptops, electronic mail, and the Internet. However, some work still must be done in the office for security or other reasons.

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

Training, Other Qualifications, and Advancement

Rapidly changing technology requires an increasing level of skill and education on the part of workers in these occupations. Employers look for professionals with an ever-broader background and range of skills, including technical knowledge and also communication and other interpersonal skills.

Education and training. While there is no universally accepted way to prepare for a job as a network 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. Most computer scientist positions require a Ph.D. degree, as their main job function is research. Computer scientists having only a bachelor's or master's degree are generally limited in their ability to advance.

For database administrator and network systems and data communication analyst positions, most employers seek applicants who have bachelor's degrees 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 coursework and business computing courses. Employers increasingly prefer applicants with a master's degree in business administration (MBA) with a concentration in information systems, as more

Computer scientists work at the very forefront of technology.

firms move their business to the Internet. For some network systems and data communication analysts, such as webmasters, an associate degree or certificate is sufficient, although more advanced positions might require a computer-related bachelor's degree.

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 geared more 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.

Despite employers' preference for those with technical degrees, individuals with post-secondary degrees in a variety of other subjects may find employment in these occupations. Given the rapid pace of technological change, a degree generally has more value as a demonstration of an individual's ability to learn, rather than as a certification of a certain skill set. Generally speaking, coursework in computer science and an undergraduate degree are sufficient qualifications, especially if the applicant has a reasonable amount of experience.

Certification and other qualifications. Computer scientists and database administrators 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 also is important. Although computer specialists sometimes work independently, they frequently work in teams on large projects. As a result, 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.

Jobseekers can enhance their employment opportunities by earning certifications, most of which are offered through private companies, with many related to specific products. 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 database management with a certain software package. Voluntary certification also is available through various organizations associated with computer specialists. Professional certification may afford a jobseeker a competitive advantage.

Because technology is so closely connected to the functioning of businesses, many workers in these occupations come from elsewhere in the business or industry to become computer specialists. This background can be very useful, in that it helps them to better understand how their networking and database tools are being used within the organization.

Advancement. Computer scientists may advance into managerial or project leadership positions. Many having advanced degrees choose to leave private industry for academic positions. 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.

Employment

Computer scientists and database administrators held about 542,000 jobs in May 2006, including about 58,000 who were self-employed. Employment was distributed among the detailed occupations as follows:

Network systems and data communication analysts	262,000
Computer specialists, all other	136,000
Database administrators	119,000
Computer and information scientists, research	25,000

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 scientists and database administrators 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 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 network systems and data communication 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 consulting firm, or with the network systems analysts themselves. Such jobs may last from several months to 2 years or more. This growing practice enables companies to bring in people with the exact skills they need

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Computer scientists and database administrators	—	542,000	742,000	200,000	37
Computer and information scientists, research	15-1011	25,000	31,000	5,400	22
Database administrators	15-1061	119,000	154,000	34,000	29
Network systems and data communications analysts	15-1081	262,000	402,000	140,000	53
Computer specialists, all other	15-1099	136,000	157,000	21,000	15

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

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.

Job Outlook

Computer scientists and database administrators are projected to be one of the fastest growing occupations over the next decade. Strong employment growth combined with a limited supply of qualified workers will result in excellent employment prospects for this occupation and a high demand for their skills.

Employment change. The computer scientists and database administrators occupation is expected to grow 37 percent from 2006 to 2016, much faster than average for all occupations. Employment of these computer specialists is expected to grow as organizations continue to adopt and integrate increasingly sophisticated technologies. Job increases will be driven by very rapid growth in computer systems design and related services, which is projected to be one of the fastest growing industries in the U.S. economy.

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 scientists and database administrators. Firms will continue to seek out computer specialists who are able to implement the latest technologies and are able to apply them to meet the needs of businesses as they struggle to maintain a competitive advantage.

As computers continue to become more central to business functions, more sophisticated and complex technology is being implemented across all organizations, fueling demand for computer scientists and database administrators. There is growing demand for network systems and data communication 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. Because of the increasing reliance on the Internet among businesses, information security is an increasing concern.

The development of new technologies 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. It also means more security specialists are needed to protect their systems. 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.

Job prospects. Computer scientists and database administrators should continue to enjoy excellent job prospects. As technology becomes more sophisticated and complex, however, these positions will 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 favorable employment prospects. College graduates with a bachelor's degree in computer science, computer engineering, information science, or MIS also should enjoy favorable prospects, 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 business skills, individuals with a combination of experience inside and outside the IT arena will have the best job prospects.

In addition to growth, many job openings will arise from the need to replace workers who move into managerial positions or other occupations or who leave the labor force.

Earnings

Median annual earnings of computer and information scientists, research, were $93,950 in May 2006. The middle 50 percent earned between $71,930 and $118,100. The lowest 10 percent earned less than $53,590, and the highest 10 percent earned more than $144,880. Median annual earnings of computer and information scientists employed in computer systems design and related services in May 2006 were $95,340.

Median annual earnings of database administrators were $64,670 in May 2006. The middle 50 percent earned between $48,560 and $84,830. The lowest 10 percent earned less than $37,350, and the highest 10 percent earned more than $103,010. In May 2006, median annual earnings of database administrators employed in computer systems design and related services were $72,510, and for those in management of companies and enterprises, earnings were $67,680.

Median annual earnings of network systems and data communication analysts were $64,600 in May 2006. The middle 50 percent earned between $49,510 and $82,630. The lowest 10 percent earned less than $38,410, and the highest 10 percent earned more than $101,740. Median annual earnings in the industries employing the largest numbers of network systems and data communications analysts in May 2006 are shown below:

Wired telecommunications carriers	$72,480
Management of companies and enterprises	68,490
Management, scientific, and technical consulting services	67,830
Computer systems design and related services	67,080
State government	52,020

Median annual earnings of all other computer specialists were $68,570 in May 2006. Median annual earnings of all other computer specialists employed in computer systems design and related services were $67,370, and, for those in management of companies and enterprises, earnings were $63,610 in May 2006.

Robert Half International, a firm providing specialized staffing services, noted the following salary ranges for computer-related occupations in their 2007 Salary Guide:

Database manager	$84,750 - $116,000
Network architect	78,000 - 112,250
Database developer	73,500 - 103,000
Senior web developer	71,000 - 102,000
Database administrator	70,250 - 102,000
Network manager	68,750 - 93,000
Web developer	54,750 - 81,500
LAN/WAN administrator	51,000 - 71,500
Web administrator	49,750 - 74,750
Web designer	47,000 - 71,500
Telecommunications specialist	47,500 - 69,500

Related Occupations

Others who work with large amounts of data are computer programmers, computer software engineers, computer and information systems managers, engineers, mathematicians, statisticians, and actuaries.

Sources of Additional Information

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**

➤ Software & Information Industry Association, 1090 Vermont Ave. NW., 6th floor, Washington, DC 20005.
Internet: **http://www.siia.net**

Computer Software Engineers

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

Significant Points

- Computer software engineers are one of the occupations projected to grow the fastest and add the most new jobs over the 2006-16 decade.
- Excellent job prospects are expected for applicants with at least 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 that occur in computer technology.

Nature of the Work

Computer software engineers apply the principles of computer science and mathematical analysis to the design, development, testing, and evaluation of the software and systems that make computers work. The tasks performed by these workers evolve quickly, reflecting new areas of specialization or changes in technology, as well as the preferences and practices of employers. (A separate section on computer hardware engineers appears in the engineers section of the *Handbook*.)

Software engineers can be involved in the design and development of many types of software, including computer games, word processing and business applications, operating systems and network distribution, and compilers, which convert programs to machine language for execution on a computer.

Computer software engineers begin by analyzing users' needs, and then design, test, and develop software to meet those needs. During this process they create the detailed sets of instructions, called algorithms, that tell the computer what to do. They also may be responsible for converting these instructions into a computer language, a process called programming or coding, but this usually is the responsibility of *computer programmers*. (A separate section on computer programmers appears elsewhere in the *Handbook*.) Computer software engineers must be experts in operating systems and middleware to ensure that the underlying systems will work properly.

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, maintenance, and expansion of an organization's computer systems. Working with the organization, they coordinate each department's computer needs—ordering, inven-

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

tory, billing, and payroll recordkeeping, for example—and make suggestions about its technical direction. They also might set up the organization's intranets—networks that link computers within the organization and ease communication among various departments.

Systems software engineers also work for companies that configure, implement, and install the computer systems of other organizations. These workers may be members of the marketing or sales staff, serving as the primary technical resource for sales workers. They also may help with sales and provide customers with technical support. Since the selling of complex computer systems often requires substantial customization to meet the needs of the purchaser, software engineers help to identify and explain needed changes. In addition, systems software engineers are responsible for ensuring security across the systems they are configuring.

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 to release a product.

Work environment. Computer software engineers normally work in clean, comfortable offices or in laboratories in which computer equipment is located. Software engineers who work for software vendors and consulting firms frequently travel overnight to meet with customers. Telecommuting is also becoming more common, allowing workers to do their jobs from remote locations.

Most software engineers work at least 40 hours a week, but about 17 percent work more than 50 hours a week. Software engineers also may have to work evenings or weekends to meet deadlines or solve unexpected technical problems.

Like other workers who spend long hours typing at a computer, software engineers are susceptible to eyestrain, back discomfort, and hand and wrist problems such as carpal tunnel syndrome.

Training, Other Qualifications, and Advancement

Most employers prefer applicants who have at least a bachelor's degree and experience with a variety of computer systems and technologies. In order to remain competitive, computer software engineers must continually strive to acquire the latest technical skills. Advancement opportunities are good for those with relevant experience.

Education and training. Most employers prefer applicants who have at least a bachelor's degree and broad knowledge of, and experience with, a variety of computer systems and technologies. The usual college major for applications software engineers is computer science or software engineering. Systems software engineers often study computer science or computer information systems. Graduate degrees are preferred for some of the more complex jobs. In 2006, about 80 percent of workers had a bachelor's degree or higher.

Academic programs in software engineering may offer the program as a degree option or in conjunction with computer science degrees. Because of increasing emphasis on computer security, software engineers with advanced degrees in areas such as mathematics and systems design will be sought after by software developers, government agencies, and consulting firms.

Students seeking software engineering jobs enhance their employment opportunities by participating in internships or co-ops. These experiences provide students with broad knowledge and experience, making them more attractive to employers. Inexperienced college graduates may be hired by large computer and consulting firms that train new employees in intensive, company-based programs.

Certification and other qualifications. Systems software vendors offer certification and training programs, but most training authorities say that program certification alone is not sufficient for the majority of software engineering jobs.

People 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 technology advances, employers will need workers with the latest skills. Computer software engineers must continually strive to acquire new skills if they wish to remain in this dynamic field. To help keep up with changing technology, workers may take continuing education and professional development seminars offered by employers, software vendors, colleges and universities, private training institutions, and professional computing societies. Computer software engineers also need skills related to the industry in which they work. Engineers working for a bank, for example, should have some expertise in finance so that they understand banks' computer needs.

Advancement. As with most occupations, advancement opportunities for computer software engineers increase with experience. Entry-level computer software engineers are likely to test designs. As they become more experienced, engineers may begin helping to design and develop software. Eventually, they may advance to become a project manager, manager of information systems, or chief information officer, especially if they have business skills and training. Some computer software engineers with several years of experience or expertise find lucrative opportunities working as systems designers or independent consultants.

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Computer software engineers	15-1030	857,000	1,181,000	324,000	38
Computer software engineers, applications	15-1031	507,000	733,000	226,000	45
Computer software engineers, systems software	15-1032	350,000	449,000	99,000	28

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

Employment

Computer software engineers held about 857,000 jobs in 2006. Approximately 507,000 were computer applications software engineers, and about 350,000 were computer systems software engineers. Although they are employed in most industries, the largest concentration of computer software engineers—more than 29 percent—is in computer systems design and related services. Many computer software engineers also work for establishments in other industries, such as software publishers, government agencies, manufacturers of computers and related electronic equipment, financial institutions, insurance providers, and management of companies and enterprises.

An increasing number of computer software engineers work as independent consultants on a temporary or contract basis, many of whom are self-employed. About 17,000 computer software engineers were self-employed in 2006.

Job Outlook

Job prospects should be excellent, as computer software engineers are expected to be among the fastest-growing occupations through the year 2016.

Employment change. Employment of computer software engineers is projected to increase by 38 percent over the 2006 to 2016 period, which is much faster than the average for all occupations. This occupation will generate about 324,000 new jobs, over the projections decade, one of the largest employment increases of any occupation.

Employment growth will result as businesses and other organizations adopt and integrate new technologies and seek to maximize the efficiency of their computer systems. Competition among businesses will continue to create incentive for sophisticated technological innovations, and organizations will need more computer software engineers to implement these changes.

Demand for computer software engineers will also increase as computer networking continues to grow. For example, expanding Internet technologies have spurred demand for computer software engineers who can develop Internet, intranet, and World Wide Web applications. Likewise, electronic data-processing systems in business, telecommunications, government, and other settings continue to become more sophisticated and complex. Implementing, safeguarding, and updating computer systems and resolving problems will fuel the demand for growing numbers of systems software engineers.

New growth areas will also continue to arise from rapidly evolving technologies. The increasing uses of the Internet, the proliferation of Web sites, and mobile technology such as wireless Internet have created a demand for a wide variety of new products. As individuals and businesses rely more on hand-held computers and wireless networks, it will be necessary to integrate current computer systems with this new, more mobile technology.

In addition, 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 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 integrate them into older systems.

As with other information technology jobs, outsourcing of software development to other countries may temper somewhat employment growth of computer software engineers. Firms may look to cut costs by shifting operations to foreign countries with lower prevailing wages and highly educated workers. Jobs in software engineering are less prone to being offshored than are jobs in other computer specialties, however, because software engineering requires innovation and intense research and development.

Job prospects. As a result of rapid employment growth over the 2006 to 2016 decade, job prospects for computer software engineers should be excellent. Those with practical experience and at least a bachelor's degree in computer engineering or computer science should have the best opportunities. Employers will continue to seek computer professionals with strong programming, systems analysis, interpersonal, and business skills. In addition to jobs created through employment growth, many job openings will result from the need to replace workers who move into managerial positions, transfer to other occupations, or leave the labor force. Consulting opportunities for computer software engineers also should continue to grow as businesses seek help to manage, upgrade, and customize their increasingly complicated computer systems.

Earnings

In May 2006, median annual earnings of wage-and-salary computer applications software engineers were $79,780. The middle 50 percent earned between $62,830 and $98,470. The lowest 10 percent earned less than $49,350, and the highest 10 percent earned more than $119,770. Median annual earnings in the industries employing the largest numbers of computer applications software engineers in May 2006 were as follows:

Software publishers	$84,560
Computer systems design and related services	78,850
Management, scientific, and technical consulting services	78,850
Management of companies and enterprises	78,580
Insurance carriers	74,230

In May 2006, median annual earnings of wage-and-salary computer systems software engineers were $85,370. The middle 50 percent earned between $67,620 and $105,330. The lowest 10 percent earned less than $53,580, and the highest 10 percent earned more than $125,750. Median annual earnings in the industries employing the largest numbers of computer systems software engineers in May 2006 are as follows:

Research and development in the physical, engineering, and life sciences	$97,220
Scientific research and development services	97,180
Computer and peripheral equipment manufacturing	93,240
Software publishers	87,450
Computer systems design and related services	84,660
Data processing, hosting, and related services	78,270

According to the National Association of Colleges and Employers, starting salary offers for graduates with a bachelor's degree in computer engineering averaged $56,201 in 2007. Starting salary offers for graduates with a bachelor's degree in computer science averaged $53,396.

According to Robert Half Technology, starting salaries for software engineers in software development ranged from $66,500 to $99,750 in 2007. For network engineers, starting salaries ranged from $65,750 to $90,250.

Related Occupations

Other workers who use mathematics and logic extensively include computer systems analysts, computer scientists and database administrators, computer programmers, computer hardware engineers, computer support specialists and systems administrators, engineers, commercial and industrial designers, statisticians, mathematicians, and actuaries.

Sources of Additional Information

Additional information on a career in computer software engineering is available from the following organizations:

➤ Association for Computing Machinery (ACM), 2 Penn Plaza, Suite 701, NY 10121-0701.
Internet: **http://www.acm.org**

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

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

➤ University of Washington Computer Science and Engineering Department, AC101 Paul G. Allen Center, Box 352350, 185 Stevens Way, Seattle, WA 98195-2350.
Internet: **http://www.cs.washington.edu/WhyCSE**

Computer Support Specialists and Systems Administrators

(O*NET 15-1041.00, 15-1071.00, 15-1071.01)

Significant Points

- Growth in computer support specialist jobs will be about as fast as the average, while growth in network and computer system administrator jobs will be much faster than average
- There are many paths of entry to these occupations.
- Job prospects should be best for college graduates with relevant skills and experience; certifications and practical experience are essential for people without degrees.

Nature of the Work

In the last decade, computers have become an integral part of everyday life at home, work, school, and nearly everywhere else. Of course, almost every computer user encounters a problem occasionally, whether it is the annoyance of a forgotten password or the disaster of a crashing hard drive. The explosive use of computers has created demand for specialists who provide advice to users, as well as for the 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 by using automated diagnostic programs, and resolve recurring difficulties. Support specialists 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, for which they provide computer support to clients on a contract basis.

Technical support specialists respond to inquiries from their organizations' computer users and may run automatic diagnostics programs to resolve problems. They also install, modify, clean, and repair computer hardware and software. In addition, they may write training manuals and train computer users in how to use new computer hardware and software. These workers also oversee the daily performance of their company's computer systems and evaluate how useful software programs are.

Help-desk technicians respond to telephone calls and e-mail messages from customers looking for help with computer problems. In responding to these inquiries, 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. They 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 and *computer systems administrators* design, install, and support an organization's computer systems. They are responsible for local-area networks (LAN), wide-area networks (WAN), network segments, and Internet and intranet systems. They work in a variety of environments, including professional offices, small businesses, government organizations, and large corporations. They maintain network hardware and software, analyze problems, and monitor networks to ensure their availability to system users. These workers gather data to identify customer needs and then use the information to identify, interpret, and evaluate system and network requirements. Administrators also may plan, coordinate, and implement network security measures.

Systems administrators are responsible for maintaining network efficiency. They ensure that the design of an organization's computer system allows all of the components, including computers, the network, and software, to work properly together. Furthermore, they monitor and adjust the performance of existing networks and continually survey the current computer site to determine future network needs. Administrators also troubleshoot problems reported by users and by automated network monitoring systems and make recommendations for future system upgrades.

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

Work environment. Computer support specialists and systems administrators normally work in well-lighted, comfortable offices or computer laboratories. They usually work about 40 hours a week, but if their employer requires computer support over extended hours, they may be "on call" for rotating evening or weekend work. 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.

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

Computer support specialists and systems administrators constantly interact with customers and fellow employees as they answer questions and give 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 provide technical support from remote locations. 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 among computer support specialists.

Training, Other Qualifications, and Advancement

A college degree is required for some computer support specialist positions, but certification and relevant experience may be sufficient for others. A bachelor's degree is required for many network and computer systems administrator positions. For both occupations, strong analytical and communication skills are essential.

Education and training. 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. Training requirements for computer support specialist positions vary, but many employers prefer to hire applicants with some formal college education. A bachelor's degree in computer science or information systems is a prerequisite for some jobs; other jobs, however, may require only a computer-related associate degree. And for some jobs, relevant computer experience and certifications may substitute for formal education. For systems administrator jobs, many employers seek applicants with bachelor's degrees, although not necessarily in a computer-related field.

A number of companies are becoming more flexible about requiring a college degree for support positions. In the absence of a degree, however, certification and practical experience are essential. Certification training programs, offered by a variety of vendors and product makers, may help some people to qualify for entry-level positions.

Other qualifications. People 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, over the phone, or in person. Strong writing skills are useful in preparing manuals for employees and customers.

Advancement. Beginning computer support specialists usually work for organizations that deal directly with customers or

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Computer support specialists and systems administrators	—	862,000	1,016,000	155,000	18
Computer support specialists	15-1041	552,000	624,000	71,000	13
Network and computer systems administrators	15-1071	309,000	393,000	83,000	27

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

in-house users. Support specialists may advance into 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 software engineers, designing products rather than assisting users. Computer support specialists in hardware and software companies often enjoy great upward mobility; advancement sometimes comes within months of becoming employed.

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 to more senior-level positions. For example, senior network and computer systems administrators may make presentations to executives and managers on the security of the company computer 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 involved in system and network design.

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

Employment

Computer support specialists and systems administrators held about 862,000 jobs in 2006. Of these, approximately 552,000 were computer support specialists and about 309,000 were network and computer systems administrators. Although they worked in a wide range of industries, about 23 percent of all computer support specialists and systems administrators were employed in professional, scientific, and technical services industries, principally computer systems design and related services. Substantial numbers of these workers were also employed in administrative and support services companies, financial institutions, insurance companies, government agencies, educational institutions, software publishers, telecommunications organizations, health care organizations, and management of companies and enterprises.

Employers of computer support specialists and systems administrators range from startup companies to established industry leaders. As computer networks become an integral part of business, industries not typically associated with computers—such as construction—increasingly need computer support workers.

Job Outlook

Employment of computer support specialists and systems administrators is expected to increase faster than the average. Job prospects should be best for those with a college degree and relevant experience.

Employment change. Employment of computer support specialists and systems administrators is expected to increase by 18 percent from 2006 to 2016, which is much faster than the average for all occupations. In addition, this occupation is expected to add 155,000 jobs over the projection decade.

Employment of computer support specialists is expected to increase by 13 percent from 2006 to 2016, which is about as fast as the average for all occupations. Demand for these workers will result as organizations and individuals continue to adopt increasingly sophisticated technology. Job growth will continue to be driven by the ongoing 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. Growth will not be as explosive as during the previous decade, however, because the information technology industry is maturing and because some of these jobs are expected to be outsourced offshore where prevailing wages are lower. Physical location is not as important for computer support specialists as it is for other occupations because these workers can provide assistance remotely and support services are provided around the clock across time zones.

Job growth among computer support specialists reflects the rapid evolution of technology. As computers and software become more complex, support specialists will be needed to provide technical assistance to customers and other users. The adoption of new mobile technologies, such as the wireless Internet, will continue to create a need for these workers to familiarize and educate computer users. Consulting jobs for computer support specialists also should continue to increase as businesses seek help managing, upgrading, and customizing ever more complex computer systems.

Employment of network and computer systems administrators is expected to increase by 27 percent from 2006 to 2016, which is much faster than the average for all occupations. Computer networks have become an integral part of business, and demand for these workers will increase as firms continue to invest in new technologies. The wide use of electronic commerce and the increasing adoption of mobile technologies mean that more establishments will use the Internet to conduct business online. This growth translates into a need for systems administrators

who can help organizations use technology to communicate with employees, clients, and consumers.

Demand for computer security specialists will grow as businesses and government continue to invest heavily in "cyber security," protecting vital computer networks and electronic infrastructures from attack. The information security field is expected to generate many new system administrator jobs over the next decade as firms across all industries place a high priority on safeguarding their data and systems.

Employment of network and computer systems administrators, however, may be tempered somewhat by offshore outsourcing, as firms transfer work to countries with lower-prevailing wages and highly skilled work forces. Systems administrators may increasingly be able to manage computer systems from remote locations as technology advances.

Job prospects. Job prospects should be best for college graduates who possess the latest technological skills, particularly graduates who have supplemented their formal education with relevant work experience. Employers will continue to seek computer specialists who possess strong fundamental computer skills combined with good interpersonal and communication skills. Due to the demand for computer support specialists and systems administrators over the next decade, those who have strong computer skills but do not have a college degree should continue to qualify for some entry-level positions.

Earnings

Median annual earnings of wage-and-salary computer support specialists were $41,470 in May 2006. The middle 50 percent earned between $32,110 and $53,640. The lowest 10 percent earned less than $25,290, and the highest 10 percent earned more than $68,540. Median annual earnings in the industries employing the largest numbers of computer support specialists in May 2006 were as follows:

Software publishers	$46,270
Management of companies and enterprises	42,770
Computer systems design and related services	42,510
Colleges, universities, and professional schools	40,130
Elementary and secondary schools	37,880

Median annual earnings of wage-and-salary network and computer systems administrators were $62,130 in May 2006. The middle 50 percent earned between $48,520 and $79,160. The lowest 10 percent earned less than $38,610, and the highest 10 percent earned more than $97,080. Median annual earnings in the industries employing the largest numbers of network and computer systems administrators in May 2006 were as follows:

Wired telecommunications carriers	$70,790
Computer systems design and related services	66,680
Management of companies and enterprises	66,020
Colleges, universities, and professional schools	54,590
Elementary and secondary schools	53,750

According to Robert Half Technology, starting salaries in 2007 ranged from $27,500 to $37,000 for help-desk workers. Starting salaries for desktop support analysts ranged from $46,500 to $65,250. For systems administrators, starting salaries ranged from $50,000 to $75,750.

Related Occupations

Other computer specialists include computer programmers, computer software engineers, computer systems analysts, and computer scientists and database administrators. Other workers who respond to customer inquiries are customer service representatives.

Sources of Additional Information

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

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

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

➤ The League of Professional System Administrators, 15000 Commerce Parkway, Suite C, Mount Laurel, NJ 08054.
Internet: **http://lopsa.org/**

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

Computer Systems Analysts

(O*NET 15-1051.00)

Significant Points

- Employers generally prefer applicants who have at least a bachelor's degree in computer science, information science, or management information systems (MIS).
- Employment is expected to increase much faster than the average and more new jobs are expected to arise than in all but a few other occupations.
- Very good job prospects are expected as organizations continue to adopt increasingly sophisticated technologies.

Nature of the Work

All organizations rely on computer and information technology to conduct business and operate efficiently. Computer systems analysts help organizations to use technology effectively and to incorporate rapidly changing technologies into their existing systems. The work of computer systems analysts evolves rapidly, reflecting new areas of specialization and changes in technology.

Computer systems analysts solve computer problems and use computer technology to meet the needs of an organization. They may design and develop new computer systems by choosing and configuring hardware and software. They may also devise ways to apply existing systems' resources to additional tasks. Most systems analysts work with specific types of com-

puter systems—for example, business, accounting, or financial systems or scientific and engineering systems—that vary with the kind of organization. Analysts who specialize in helping an organization select the proper system software and infrastructure are often called *system architects*. Analysts who specialize in developing and fine-tuning systems often are known as *systems designers*.

To begin an assignment, systems analysts consult managers and users to define the goals of the system. Analysts then design a system to meet those goals. They specify the inputs that the system will access, decide how the inputs will be processed, and format the output to meet users' needs. Analysts use techniques such as structured analysis, data modeling, information engineering, mathematical model building, sampling, and cost accounting to make sure their plans are efficient and complete. They also may prepare cost-benefit and return-on-investment analyses to help management decide whether implementing the proposed technology would be financially feasible.

When a system is approved, systems analysts determine what computer hardware and software will be needed to set it 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 in-depth testing may be called *software quality assurance analysts*. In addition to running tests, these workers 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. They also create custom applications tailored to their organization's tasks. Because they are responsible for both programming and systems analysis, these workers must be proficient in both areas. (A separate section on computer programmers appears elsewhere in the *Handbook*.) As this dual proficiency becomes more common, analysts are increasingly working with databases, object-oriented programming languages, client–server applications, and multimedia and Internet technology.

One challenge created by expanding computer use is the need for different computer systems to communicate with each other. Systems analysts work to make the computer systems within an organization, or across organizations, compatible so that information can be shared. Many systems analysts are involved with these "networking" tasks, connecting all the computers internally, in an individual office, department, or establishment, or externally, as when setting up e-commerce networks to facilitate business among companies.

Work environment. Computer systems analysts work in offices or laboratories in comfortable surroundings. They usually work about 40 hours a week—about the same as many other professional or office workers. Evening or weekend work may be necessary, however, to meet deadlines or solve specific problems. Many analysts telecommute, using computers to work from remote locations.

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

Computer systems analysts use information technology to help meet the needs of an organization.

Training, Other Qualifications, and Advancement

Training requirements for computer systems analysts vary depending on the job, but many employers prefer applicants who have a bachelor's degree. Relevant work experience also is very important. Advancement opportunities are good for those with the necessary skills and experience.

Education and training. When hiring computer systems analysts, employers usually prefer applicants who have at least a bachelor's degree. For more technically complex jobs, people with graduate degrees are preferred.

The level and type of education that employers require reflects changes in technology. Employers often scramble to find workers capable of implementing the newest technologies. Workers with formal education or experience in information security, for example, are currently in demand because of the growing use of computer networks, which must be protected from threats.

For jobs in a technical or scientific environment, employers often seek applicants who have at least a bachelor's degree in a technical field, such as computer science, information science, applied mathematics, engineering, or the physical sciences. For jobs in a business environment, employers often seek applicants with at least a bachelor's degree in a business-related field such as management information systems (MIS). Increasingly, employers are seeking individuals who have a master's degree in business administration (MBA) with a concentration in information systems.

Despite the preference for technical degrees, however, people who have degrees in other majors may find employment as systems analysts if they also have technical skills. Courses in computer science or related subjects combined with practical experience can qualify people for some jobs in the occupation.

Employers generally look for people with expertise relevant to the job. For example, systems analysts who wish to work for a bank should have some expertise in finance, and systems analysts who wish to work for a hospital should have some knowledge of health management.

Technological advances come so rapidly in the computer field that continuous study is necessary to remain competitive. Em-

ployers, hardware and software vendors, colleges and universities, and private training institutions offer continuing education to help workers attain the latest skills. Additional training may come from professional development seminars offered by professional computing societies.

Other qualifications. Employers usually look for people who have broad knowledge and experience related to computer systems and technologies, strong problemsolving and analytical skills, and the ability to think logically. In addition, because they often deal with a number of tasks simultaneously, the ability to concentrate and pay close attention to detail is important. Although these workers sometimes work independently, they frequently work in teams on large projects. Therefore, they must have good interpersonal skills and be able to communicate effectively with computer personnel, users, and other staff who may have no technical background.

Advancement. With experience, systems analysts may be promoted to senior or lead systems analyst. Those who possess leadership ability and good business skills also can become computer and information systems managers or can advance into other management positions such as manager of information systems or chief information officer. Those with work experience and considerable expertise in a particular subject or application may find lucrative opportunities as independent consultants, or may choose to start their own computer consulting firms.

Employment

Computer systems analysts held about 504,000 jobs in 2006. 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. Computer systems analysts are also employed by governments; insurance companies; financial institutions; hospitals; management, scientific, and technical consulting services firms; data processing services firms; professional and commercial equipment wholesalers; universities; and management of companies and enterprises.

A growing number of systems analysts are employed on a temporary or contract basis; many of these individuals are self-employed, working independently as contractors or consultants. About 29,000 computer systems analysts were self-employed in 2006.

Job Outlook

Employment is expected to grow much faster than the average for all occupations. As a result of this rapid growth, job prospects should be very good.

Employment change. Employment of computer systems analysts is expected to grow by 29 percent from 2006 to 2016, which is much faster than the average for all occupations. In addition, the 146,000 new jobs that are expected to arise over the projections decade will be substantial. Demand for these workers will increase as organizations continue to adopt and integrate increasingly sophisticated technologies. Job growth will not be as rapid as during the preceding decade, however, as the information technology sector matures and as routine work is increasingly outsourced offshore to foreign countries with lower prevailing wages.

The growth of electronic commerce and the integration of Internet technologies into business have resulted in a growing need for specialists who can develop and support Internet and intranet applications. Moreover, falling prices of computer hardware and software should continue to induce more businesses to expand their computerized operations and incorporate new technologies.

The demand for computer networking within organizations will also drive demand for computer systems analysts. The introduction of the wireless Internet, known as WiFi, and of personal mobile computers has created a need for new systems that can integrate these technologies into existing networks. Explosive growth in these areas is expected to fuel demand for analysts who are knowledgeable about systems integration and network, data, and communications security.

As more sophisticated and complex technology is implemented across all organizations, demand for systems analysts will remain strong. These workers will be called upon to solve problems and to integrate new technologies with existing ones. Also, the increasing importance being placed on "cyber-security"—the protection of electronic information—will result in a need for workers skilled in information security.

As with other information technology jobs, employment growth may be tempered somewhat as some computer systems analyst jobs are outsourced offshore. Firms may look to cut costs by shifting operations to foreign countries with lower prevailing wages and highly educated workers who have strong technical skills.

Job prospects. Job prospects should be very good. Job openings will occur as a result of strong job growth and from the need to replace workers who move into managerial positions or other occupations, or who leave the labor force. 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 have the best prospects. College graduates with a bachelor's degree in computer science, computer engineering, information science, or management information systems also should enjoy very good prospects, particularly if they have supplemented their formal education with practical experience. Because employers continue to seek computer specialists who can combine strong technical skills

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Computer systems analysts	15-1051	504,000	650,000	146,000	29

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

with good interpersonal and business skills, graduates with non-computer-science degrees who have had courses in computer programming, systems analysis, and other information technology subjects also should continue to find jobs in computer fields.

Earnings

Median annual earnings of wage-and-salary computer systems analysts were $69,760 in May 2006. The middle 50 percent earned between $54,320 and $87,600 a year. The lowest 10 percent earned less than $42,780, and the highest 10 percent earned more than $106,820. Median annual earnings in the industries employing the largest numbers of computer systems analysts in May 2006 were:

Professional and commercial equipment and supplies merchant wholesalers	$81,080
Computer systems design and related services	71,680
Management of companies and enterprises	71,090
Insurance carriers	69,990
State government	61,340

According to the National Association of Colleges and Employers, starting offers for graduates with a bachelor's degree in computer science averaged $53,396. Starting offers for graduates with a bachelor's degree in information sciences and systems averaged $50,852. For those with a degree in management information systems/business data processing, starting offers averaged $47,648.

According to Robert Half Technology, starting salaries for systems analysts ranged from $64,000 to $87,000 in 2007. Starting salaries for business systems analysts ranged from $61,250 to $86,500. Starting salaries for developer/programmer analysts ranged from $55,250 to $90,250.

Related Occupations

Other workers who use computers extensively and who use logic and creativity to solve business and technical problems include computer programmers, computer software engineers, computer and information systems managers, engineers, mathematicians, statisticians, operations research analysts, management analysts, and actuaries.

Sources of Additional Information

Further information about computer careers is available from:

➤ Association for Computing Machinery (ACM), 2 Penn Plaza, Suite 701,New York, NY 10121-0701.
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**

➤ University of Washington Computer Science and Engineering Department, AC101 Paul G. Allen Center, Box 352350, 185 Stevens Way, Seattle, WA 98195-2350.
Internet: **http://www.cs.washington.edu/WhyCSE**

Mathematicians

(O*NET 15–2021.00)

Significant Points

- A Ph.D. in mathematics usually is the minimum educational requirement, except in the Federal Government.
- Master's degree and Ph.D. holders with a strong background in mathematics and a related field, such as computer science or engineering, should have better employment opportunities in related occupations.
- Average employment growth is expected for mathematicians.

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, dividing 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, engineering, and the physical, life, and social sciences. For example, they may analyze the most efficient way to schedule airline routes between cities, the effects 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—codes—designed to transmit military, political, financial, or law enforcement-related information.

Applied mathematicians start with a practical problem, envision its separate elements, 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.

Applied mathematicians start with a practical problem, envision its separate elements, and then reduce the elements to mathematical variables.

Individuals with titles other than mathematician do much of the work in applied mathematics. In fact, because mathematics is the foundation on which so many other academic disciplines are built, the number of workers using mathematical techniques is much greater than the number formally called 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, are actually specialists in a particular branch of mathematics. (For more information, see the statements on actuaries, operations research analysts, and statisticians elsewhere in the *Handbook*.) Applied mathematicians are frequently required to collaborate with other workers in their organizations to find common solutions to problems.

Work environment. Mathematicians usually work in comfortable offices. They often are part of interdisciplinary teams 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 may conduct research alone or in close collaboration with other mathematicians. Collaborators may work together at the same institution or from different locations, using technology such as e-mail to communicate. Mathematicians in academia also may be aided by graduate students.

Training, Other Qualifications, and Advancement

A Ph.D. degree in mathematics usually is the minimum educational requirement for prospective mathematicians, except in the Federal Government.

Education and training. In the Federal Government, entry-level job candidates usually must have at least a bachelor's degree with a major in mathematics or 24 semester hours of mathematics courses. Outside the Federal Government, bachelor's degree holders in mathematics usually are not qualified for most jobs, and many seek advanced degrees in mathematics or a related discipline.

Most colleges and universities offer a bachelor's degree in 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 advise or require students majoring in mathematics to take courses in a closely related field, 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 private industry, candidates for mathematician jobs typically need a Ph.D., although there may be opportunities for those with a master's degree. Most of the positions designated for mathematicians are in research and development laboratories, as part of technical teams.

In 2007, there were more than 300 graduate programs, offering both master's and doctoral degrees, in pure or applied mathematics around the country. In graduate school, students conduct research and take advanced courses, usually specializing in a subfield of mathematics.

Other qualifications. For jobs in applied mathematics, training in the field in which 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 to have good reasoning to identify, analyze, and apply basic principles to technical problems. Communication skills also are important, as mathematicians must be able to interact and discuss proposed solutions with people who may not have extensive knowledge of mathematics.

Advancement. 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*.)

The majority of those with a 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.

Employment

Mathematicians held about 3,000 jobs in 2006. Many people with mathematical backgrounds also worked in other

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Mathematicians	15-2021	3,000	3,300	300	10

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

occupations. For example, there were about 54,000 jobs as postsecondary mathematical science teachers in 2006.

Many mathematicians work for Federal or State governments. The U.S. Department of Defense is the primary Federal employer, accounting for about 37 percent of the mathematicians employed by the Federal Government. Many of the other mathematicians employed by the Federal Government work for the National Aeronautics and Space Administration (NASA).

In the private sector, major employers include scientific research and development services and management, scientific, and technical consulting services. Some mathematicians also work for software publishers, insurance companies, and in aerospace or pharmaceutical manufacturing.

Job Outlook

Employment of mathematicians is expected to grow as fast as the average. However, keen competition for jobs is expected.

Employment change. Employment of mathematicians is expected to increase by 10 percent during the 2006–16 decade, as fast as the average for all occupations. 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.

Job prospects. Job competition will remain keen because employment in this occupation is relatively small and few new jobs are expected. Master's degree and Ph.D. holders with a strong background in mathematics and a related discipline, such as engineering or computer science, and who apply mathematical theory to real-world problems will have the best job prospects in related occupations.

Holders of a master's degree in mathematics will face very strong competition for jobs in theoretical research. Because the number of Ph.D. degres awarded in mathematics continues to exceed the number of available university positions—especially those that are tenure tracked—many graduates will need to find employment in industry and government.

Additionally, employment in theoretical mathematical research is sensitive to general economic fluctuations and to changes in government spending. Job prospects will be greatly influenced by changes in public and private funding for research and development.

Earnings

Median annual earnings of mathematicians were $86,930 in May 2006. The middle 50 percent earned between $62,970 and $106,250. The lowest 10 percent had earnings of less than $43,500, while the highest 10 percent earned more than $132,190.

In early 2007, the average annual salary for mathematicians employed by the Federal Government in supervisory, nonsupervisory, and managerial positions was $93,539; for mathematical statisticians, $96,121; and for cryptanalysts, the average was $90,435.

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, computer scientists and database administrators, computer software engineers, and operations research analysts. A strong background in mathematics also facilitates employment as teachers—postsecondary; teachers—preschool, kindergarten, elementary, middle, 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 02904-2294. 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 positions as mathematicians with the Federal Government is available from the Office of Personnel Management through USAJOBS, the Federal Government's official employment information system. This resource for locating and applying for job opportunities can be accessed through the Internet at **http://www.usajobs.gov** or through an interactive voice response telephone system at (703) 724-1850 or TDD (978) 461-8404. These numbers are not tollfree, and charges may result. For advice on how to find and apply for Federal jobs, see the *Occupational Outlook Quarterly* article "How to get a job in the Federal Government," online at:

http://www.bls.gov/opub/ooq/2004/summer/art01.pdf

Operations Research Analysts

(O*NET 15-2031.00)

Significant Points

- While a bachelor's degree is the minimum requirement, employers generally prefer applicants with at least a master's degree in operations research or a closely related field.
- Computer programming skills and keeping up to date with technological advances and improvements in analytical methods are essential.
- Employment growth is projected to be as fast as the average for all occupations.
- Individuals with a master's or Ph.D. degree in operations research or a closely related subject should find opportunities in a number of occupations that use their computer, mathematical, and problem-solving skills.

Nature of the Work

"Operations research" and "management science" are terms that are used interchangeably to describe the discipline of using advanced analytical techniques to make better decisions and to solve problems. The procedures of operations research were first formalized by the military. They have been used in wartime to effectively deploy radar, search for enemy submarines, and get supplies to where they are most needed. In peacetime and in private enterprises, operations research is used in planning business ventures and analyzing options by using statistical analysis, data and computer modeling, linear programming, and other mathematical techniques.

Large organizations are very complex. They must effectively manage money, materials, equipment, and people. Operations research analysts find better ways to coordinate these elements by applying analytical methods from mathematics, science, and engineering. Analysts often find many possible solutions for meeting the goals of a project. These potential solutions are presented to managers, who choose the course of action that they think best.

Operations research analysts are often involved in top-level strategizing, planning, and forecasting. They help to allocate resources, measure performance, schedule, design production facilities and systems, manage the supply chain, set prices, coordinate transportation and distribution, or analyze large databases.

The duties of the operations research analyst vary according to the structure and management of the organization they are assisting. 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. Analysts often have one area of specialization, such as working in the transportation or the financial services industry.

Operations research analysts start a project by listening to managers describe a problem. Then, analysts ask questions and formally define 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 stock. Too many windshields would be wasteful and expensive, whereas too few could halt production.

Analysts would study the problem, breaking it into its components. Then they would gather information from a variety of sources. To determine the optimal inventory, 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.

Relevant information in hand, the analysts determine the most appropriate analytical technique. Techniques used may include a Monte Carlo 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 involve the construction of a mathematical model that attempts to describe the system being studied. So, the problem of the windshields, for example, would be described as a set of equations that try to model real-world conditions.

The use of models enables the analyst to explicitly describe the different components and clarify the relationships among them. The descriptions can be altered to examine what may happen to the system under different circumstances. In most cases, a computer program is developed to numerically evaluate the model.

Usually the model chosen is modified and run repeatedly to obtain different solutions. A model for airline flight scheduling, for example, might stipulate such things as connecting cities, 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 assessing different possible schedules, the analyst is able to determine the best flight schedule consistent with particular assumptions.

Operations research analysts need strong computer, mathematical, and problem-solving skills.

Based on the results of the analysis, the operations research analyst presents recommendations to managers. The analyst may need to modify and rerun the computer program to consider different assumptions before presenting the final recommendation. Once managers reach a decision, the analyst usually works with others in the organization to ensure the plan's successful implementation.

Work environment. Operations research analysts generally work regular hours in an office environment. However, because they work on projects that are of immediate interest to top managers, operations research analysts often are under pressure to meet deadlines and may work more than 40 hours a week.

Training, Other Qualifications, and Advancement

A college degree in operations research generally is required. Computer programming skills are essential.

Education and training. 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. There are more than 130 programs in operations research and related studies in colleges and universities across the United States.

Continuing education is important for operations research analysts. Keeping up to date with technological advances and improvements in analytical methods is vital for maintaining their problem-solving skills.

Other qualifications. Computers are the most important tools used by operations research analysts, so analysts must have training and experience in programming. Analysts typically also need to be proficient in database collection and management, and the development and use of sophisticated software packages.

Operations research analysts must be able to think logically, work well with people, and write and speak well.

Advancement. Beginning analysts usually perform routine work under the supervision of more experienced analysts. As novices gain knowledge and experience, they are assigned more complex tasks and are given greater autonomy to design models and solve problems.

Operations research analysts can advance by becoming technical specialists or supervisors on more complicated projects. Analysts also gain valuable insights into the industry where they work and may assume higher level managerial or administrative positions. Operations research analysts with significant experience or expertise may become consultants, and some open their own consulting practices.

Employment

Operations research analysts held about 58,000 jobs in 2006. Major employers include computer systems design firms; insurance carriers and other financial institutions; telecommunications companies; management, scientific, and technical consulting services firms; and Federal, State, and local governments. Most 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.

Job Outlook

Employment of operations research analysts is projected to grow as fast as the average for all occupations. Individuals with a master's or Ph.D. degree in operations research or a closely related subject should find job opportunities in a number of occupations that use their computer, mathematical, and problem-solving skills.

Employment change. Employment of operations research analysts is expected to grow 11 percent, as fast as the average for all occupations between 2006 and 2016. Demand for operations research analysis should continue to grow. Organizations increasingly will be faced with the pressure of growing domestic and international competition and must work to make their operations as effective as possible. As a result, businesses increasingly will 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 use the technology in the best way.

Additionally, technological advancements have extended the availability of data access and storage, making information more readily available. Advancements in computing capabilities and analytical software have made it cheaper and faster for analysts to solve problems. As problem solving becomes cheaper and faster with technological advances, more firms will have the ability to employ or consult with analysts.

Job prospects. Graduates with degrees in operations research or closely related fields should find opportunities in a number of occupations where their computer, mathematical, and problem-solving skills are needed—operations research analyst, systems analyst, computer scientist, or management analyst, for example. In addition to job growth, some openings will result from the need to replace analysts retiring or leaving the occupation permanently for other reasons. Analysts who keep up with the latest technological advancements and software will have the best opportunities.

Jobs for operations research analysts exist in almost every industry because of the diversity of applications for their work. As businesses and government agencies continue to contract out jobs to cut costs, opportunities for operations research analysts will be best in management, scientific, and technical con-

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Operations research analysts	15-2031	58,000	65,000	6,200	11

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

sulting firms. Opportunities in the military exist as well, but will depend on the size of future military budgets. Military leaders rely on operations research analysts to test and evaluate the accuracy and effectiveness of new weapons systems and strategies. (See the *Handbook* statement on job opportunities in the Armed Forces.)

Earnings

Median annual earnings of operations research analysts were $64,650 in May 2006. The middle 50 percent earned between $48,820 and $85,760. The lowest 10 percent had earnings of less than $38,760, while the highest 10 percent earned more than $108,290. Median annual earnings of operations research analysts working in management, scientific, and technical consulting services were $69,870.

The average annual salary for operations research analysts in the Federal Government in nonsupervisory, supervisory, and managerial positions was $91,207 in 2007.

Employer-sponsored training is often another part of an analyst's compensation. Some analysts attend advanced university classes on these subjects at their employer's expense.

Related Occupations

Operations research analysts apply advanced analytical methods to large, complicated problems. Economists, computer systems analysts, mathematicians, and engineers also use advanced analysis and often apply the principles of operations research. Workers in other occupations that also stress advanced analysis include computer scientists and database administrators, computer programmers, statisticians, 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

For information on career opportunities and a list of degree programs for operations research analysts, contact:

➤ Institute for Operations Research and the Management Sciences, 7240 Parkway Dr., Suite 310, Hanover, MD 21076. Internet: **http://www.informs.org**

For information on operations research careers and degree programs in the Armed Forces, contact:

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

Information on obtaining positions as operations research analysts with the Federal Government is available from the Office of Personnel Management through USAJOBS, the Federal Government's official employment information system. This resource for locating and applying for job opportunities can be accessed through the Internet at **http://www.usajobs.opm.gov** or through an interactive voice response telephone system at (703) 724-1850 or TDD (978) 461-8404. These numbers are not toll free, and charges may result. For advice on how to find and apply for Federal jobs, see the *Occupational Outlook Quarterly* article "How to get a job in the Federal Government," online at:
http://www.bls.gov/opub/ooq/2004/summer/art01.pdf

Statisticians

(O*NET 15-2041.00)

Significant Points

- About 30 percent of statisticians work for Federal, State, and local governments; other employers include scientific research and development services and finance and insurance firms.
- A master's degree in statistics or mathematics is the minimum educational requirement for most jobs as a statistician.
- Employment of statisticians is projected to grow about as fast as average.
- Individuals with a degree in statistics should have opportunities in a variety of fields.

Nature of the Work

Statistics is the scientific application of mathematical principles to the collection, analysis, and presentation of numerical data. Statisticians apply their mathematical and statistical knowledge to the design of surveys and experiments; the collection, processing, and analysis of data; and the interpretation of the experiment and survey results. Opinion polls, statements of accuracy on scales and other measuring devises, and information about average earnings in an occupation are all usually the work of statisticians.

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 statistical techniques, such as the design of experiments to gain Federal approval of a newly manufactured drug. Statistics might be needed to show whether the seemingly good results of a drug were likely because of the drug rather than just the effect of random variation in patient outcomes.

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

Individuals with a degree in statistics should have opportunities in a variety of fields.

results of clinical trials to determine the safety and effectiveness of new medications. 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 figure out the average level 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 to analyze economic data may have the title econometrician, while statisticians in public health and medicine may hold titles such as biostatistician or biometrician.

Work environment. Statisticians generally work regular hours in an office environment. Sometimes, they may work more hours to meet deadlines.

Some statisticians travel to provide advice on research projects, supervise and set up surveys, or gather statistical data. While advanced communications devices such as e-mail and teleconferencing are making it easier for statisticians to work with clients in different areas, there still are situations that require the statistician to be present, such as during meetings or while gathering data.

Training, Other Qualifications, and Advancement

A master's degree in statistics or mathematics is the minimum educational requirement, but research and academic jobs generally require a Ph.D., Federal Government jobs require at least a bachelor's degree.

Education and training. A master's degree in statistics or mathematics usually is the minimum educational requirement for most statistician jobs. Research and academic positions usually require a Ph.D. in statistics. Beginning positions in industrial research often require a master's degree combined with several years of experience.

Jobs with the Federal Government require at least a bachelor's degree. The training required for employment as an entry-level statistician in the Federal Government 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.

In 2007, more than 200 universities offered a degree program in statistics, biostatistics, or mathematics. 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.

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

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.

Advancements in technology have made a great impact on statistics. Statistical modeling continues to become quicker and easier because of increased computational power and new analytical methods or software. Continuing education is important for statisticians; they need to stay abreast emerging technologies to perform well.

Other qualifications. 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.

Advancement. 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. Opportunities for promotion

Projections data from the National Employment Matrix

Occupational Title	SOC Code	Employment, 2006	Projected employment, 2016	Change, 2006-2016	
				Number	Percent
Statisticians	15-2041	22,000	24,000	1,900	9

NOTE: Data in this table are rounded. See the discussion of the employment projections table in the *Handbook* introductory chapter on *Occupational Information Included in the Handbook*.

are greater for people with advanced degrees. Master's and Ph.D. degree holders usually enjoy independence in their work and may engage in research; develop statistical methods; or, after a number of years of experience in a particular area, become statistical consultants.

Employment

Statisticians held about 22,000 jobs in 2006. About 20 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 10 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, insurance carriers, and pharmaceutical and medicine manufacturing.

Job Outlook

Average employment growth is projected. Individuals with a degree in statistics should have opportunities in a variety of fields.

Employment change. Employment of statisticians is projected to grow 9 percent from 2006 to 2016, about as fast as the average for all occupations. The demand for individuals with a background is statistics is expected to grow, although some jobs will be in occupations with titles other than "statistician."

The use of statistics is widespread and growing. Statistical models aid in decision making in both private industry and government. There will always be a demand for the skills statistical modeling provides. Technological advances are expected to spur demand for statisticians. Ever faster computer processing allows statisticians to analyze greater amounts of data much more quickly, and to gather and sort through large amounts of data that would not have been analyzed in the past. As these processes continue to become more efficient and less expensive, an increasing number of employers will want to employ statisticians to take advantage of the new information available.

Biostatisticians should experience employment growth, primarily because of the booming pharmaceuticals business. As pharmaceutical companies develop new treatments and medical technologies, biostatisticians will be needed to do research and clinical trials.

Job prospects. Individuals with a degree in statistics should have opportunities in a variety of fields. For example, many jobs involve the analysis and interpretation of data from economics, biological science, psychology, computer software engineering, education, and other disciplines. Additional job openings will become available as statisticians transfer to other occupations, retire, or leave the workforce 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.

Those who meet State certification requirements may become high school statistics teachers, for example. (For additional information, see the statement on teachers—preschool, kindergarten, elementary, middle, and secondary elsewhere in the *Handbook*.)

Earnings

Median annual wage-and-salary earnings of statisticians were $65,720 in May 2006. The middle 50 percent earned between $48,480 and $87,850. The lowest 10 percent earned less than $37,010, while the highest 10 percent earned more than $108,630.

The average annual salary for statisticians in the Federal Government was $85,690 in 2007, while mathematical statisticians averaged $96,121.

Some employers offer tuition reimbursement.

Related Occupations

People in diverse occupations work with statistics. Among these are actuaries; mathematicians; operations research analysts; computer scientists and database administrators; computer systems analysts; computer programmers; computer software engineers; engineers; economists, market and survey researchers, and other social scientists; and financial analysts and personal financial advisors. Some statisticians also work as secondary school teachers or postsecondary teachers.

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 02904. Internet: **http://www.ams.org**

Information on obtaining positions as statisticians with the Federal Government is available from the Office of Personnel Management through USAJOBS, the Federal Government's official employment information system. This resource for locating and applying for job opportunities can be accessed through the Internet at **http://www.usajobs.opm.gov** or through an interactive voice response telephone system at (703) 724-1850 or TDD (978) 461-8404. These numbers are not toll free, and charges may result. For advice on how to find and apply for Federal jobs, see the *Occupational Outlook Quarterly* article "How to get a job in the Federal Government," online at: **http://www.bls.gov/opub/ooq/2004/summer/art01.pdf**