technician manpower 1966-80

Bulletin 1639
U.S. DEPARTMENT OF LABOR
Bureau of Labor Statistics

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March 1970

U.S. DEPARTMENT OF LABOR
George P. Shultz, Secretary

BUREAU OF LABOR STATISTICS
Geoffrey H. Moore, Commissioner

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Preface

This report presents the results of a study of engineering and science technician manpower requirements and supply conducted by the Bureau of Labor Statistics with the support of the National Science Foundation. It is the second major study of technician manpower undertaken by the Bureau with the assistance of the Foundation.

The report was prepared by Michael F. Crowley, with the assistance of Elinor W. Abramson, under the direction of Neal H. Rosenthal in the Bureau's Division of Manpower and Occupational Outlook. Daniel Hecker and Annie Lefkowitz participated in the research.

Contents

Highlights

More than 1 million new technicians will be required to meet manpower requirements resulting from employment growth and replacement needs between 1966 and 1980:

500,000 for growth, from nearly 900,000 employed in 1966 to approximately 1.4 million required in 1980, an increase of 57 percent.

150,000 to replace those employed in 1966 who will die or retire.

375,000 to replace those employed in 1966 who will transfer to other occupations.

Employment growth of technicians will vary among the different technician occupations:

Physics technicians and mathematics technicians are expected to show the fastest growth rates among the technician occupational specialties, 95 percent and 91 percent, respectively. Employment requirements for engineering technicians are expected to increase about 50 percent.

Growth will result from many factors including:

Increasing utilization of technicians relative to total employment, resulting from expansion of research and development activities and increasing complexity of industrial processes.

Rapid growth of industries employing large numbers of technicians.

Requirements for technicians in manufacturing are projected to increase at about the same rate of growth as that of technicians in all industries:

However, the rate of growth will vary among manufacturing industries. The rate of growth of technicians will be fastest in machinery (87 percent) and electrical equipment (74 percent).

Among other industries, greater-than-average growth rates in technician employment requirements are expected in engineering and architectural services (90 percent) and colleges and universities (84 percent).

The sources of technician manpower from which employment requirements must be met include graduates of preemployment technician training offered in post-secondary schools, under the Manpower Development and Training Act, and by employers; individuals with technician-related training obtained in 4-year college programs or in the Armed Forces; and employees who are upgraded from other occupations:

Graduates of preemployment technician training offered in post-secondary schools are the type of technician most desired by employers.

Upgrading is used to fill jobs primarily when workers are not available from other sources of training.

If the number of entrants to technician jobs from each source of supply were to remain at the 1965 level between 1966 and 1979 (1979 graduates will be the last ones available for employment in 1980), supply would be short of manpower requirements by about 300,000.

If past trends in the patterns of entry to technician jobs from preemployment and technician-related training continue, about 1.2 million workers would enter technician jobs from these sources between 1966 and 1979:

Only about 120,000 technicians or 10 percent of all entrants would have to be upgraded to meet manpower needs, compared with 33 percent in 1965.

Graduates of preemployment post-secondary training would increase to three-fifths of all entrants between 1966 and 1979, up from about 27 percent in 1965.

To achieve the continued rapid growth of preemployment post-secondary technician training, great efforts are needed to build new or expand existing technical institutes, junior colleges, and other post-secondary schools that train technicians; to attract students to these schools; and to assure a sufficient number of teachers to provide the training.

Several data gaps become apparent in analyzing technician manpower requirements and supply. These gaps or problem areas can be grouped in the following subject areas:

The identification of the reasons for specific utilization patterns by industry.

The need for greater occupational detail.

The relationship between training and entry jobs.

Identification of all methods of qualifying for entry jobs.

The need for statistics on occupational transfers.

Introduction

Up-to-date information on future manpower requirements for, and supply of, technicians is needed by vocational counselors, education planners, those responsible for national manpower policies and programs, and industry officials concerned with the effective utilization of their technical employees. This report presents information on projected requirements for, and supply of, technicians to 1980 and supersedes the 1975 projections published in the earlier comprehensive study of technicians conducted by the Bureau of Labor Statistics, *Technician Manpower: Requirements, Resources, and Training Needs,* Bulletin 1512, 1966.

This report provides new insights into the factors affecting the supply and demand for technicians by incorporating data that have become available since publication of the former report. It also uses the basic assumptions underlying the Bureau's projections of 1980 industry manpower requirements, including assumptions concerning technological change, the level of national unemployment, and the world's political situation. (See appendix B.) In addition to presenting projections of manpower requirements and supply, this report identifies problems in technician manpower and indicates areas for future study and research.

The projections of requirements for technicians in this study were based, in large part, on past utilization patterns of technicians relative to other workers. (See appendix B.) Therefore, the requirements projections reflect supply-demand conditions in the recent past. Should supply-demand conditions appear in the 1970's that differ from those of the early and mid-1960's, effects would be felt that are not reflected in this study. For example, if for an extended period of time the supply of techncians exceeds the demand, unlike the recent past, employers would most likely change their manpower utilization patterns to use more technicians than are reflected in the projections presented in this report.

Because of the various data gaps and weaknesses encountered in the study, the projections of requirements and the different analyses of supply indicate general order of magnitude and direction and not estimates of exact numbers. Many of these data gaps and weaknesses are detailed in chapter II, Directions for Future Research.

Chapter I

Employment and Outlook

Technicians play a vital role in our expanding, technically oriented economy. These workers directly or indirectly support scientists and engineers in every phase of their work, including the designing of equipment, the development of new products and processes, the production of goods, and the maintenance of machines and materials.

Engineering and science technician[1] jobs have a greater practical orientation and are more limited in scope than those of the professional engineer or scientist. Many technician jobs require the ability to analyze and solve engineering and science problems and to prepare reports on experiments or tests. Some of these jobs require considerable aptitude in mathematics; others require the ability to visualize objects in three dimensions and to sketch and draw. Sometimes, these jobs require manipulative abilities associated with the skilled crafts, but this ability is secondary to technical skills.

Many technicians work in research and development under the supervision of a scientist or engineer. In research and development activities, technicians help conduct experiments by setting up and operating complex equipment, or assisting in the design, fabrication, and assembling of experimental equipment and scientific instruments. In production operations, technicians may be engaged in quality control, inspection, and testing, or they may act as liaison between engineering and production departments. Others sell technical products, install and maintain complex machinery and equipment, or provide technical services to customers.

This report classifies engineering and science technicians into four occupational groups according to the specialty or scientific discipline to which they are most closely related--draftsmen; engineering and physical science technicians; life science technicians; and "other technicians," a miscellaneous group that includes computer programers and surveyors. Excluded from coverage are "technicians" who work with practitioners in the health fields caring for patients; workers in business related technologies and public services such as library assistants and legal secretaries; and workers classified as craftsmen such as instrument repairmen.

Employment, 1966

Nearly 900,000 engineering and science technicians were employed in the United States in 1966. Engineering and physical science technicians numbered nearly 420,000--more than 45 percent of all technicians. Draftsmen accounted for more than 270,000--about 3 out of every 10 technicians. Employment of life science technicians represented about 8 percent of the total, or about 70,000; and other technicians, about 14 percent of the total, numbered approximately 125,000. (See chart 1.)[2]

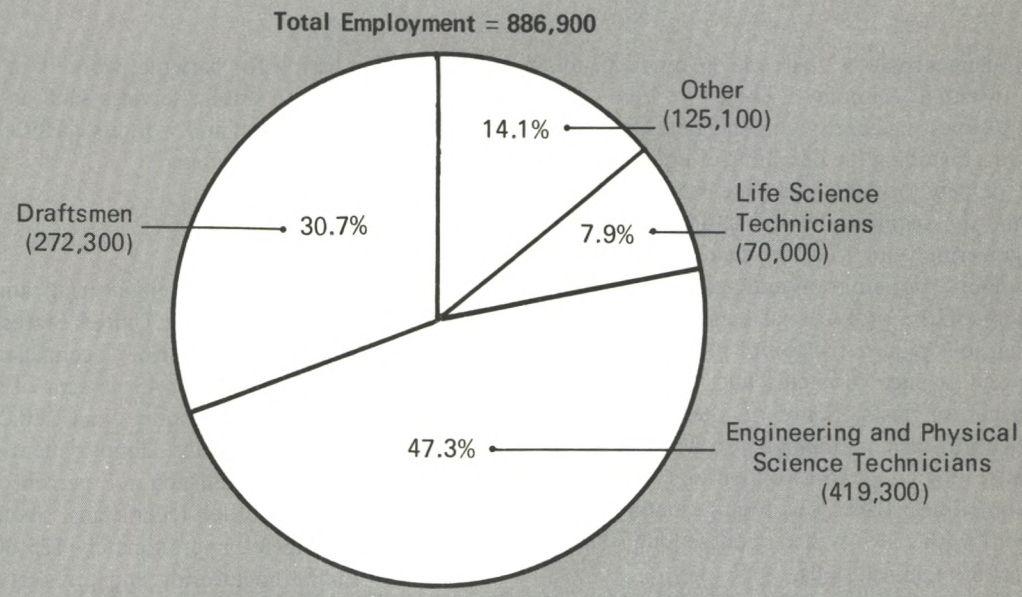
In the engineering and physical science category, the largest number (183,300) were electrical and electronic engineering technicians. Other engineering technicians, including mechanical and industrial engineering, accounted for about 116,000. Physical science technicians numbered slightly over 120,000. Included in this classification were chemical technicians, about 60,000; physics technicians, more than 10,000; mathematics technicians, over 5,000; and all other physical science technicians, approximately 44,000.

More than two-fifths of all technicians were employed in manufacturing in 1966, about 2 out of every 3 of whom worked in electrical equipment, machinery, chemicals and allied products, aircraft and parts, and fabricated metals products. The heavy concentration of technicians in these industries reflects the complexity of their products and manufacturing processes and their large research and development (R&D) programs. About 75 percent of all R&D

Footnotes appear on pp. 16-17.

Chart 1.

ESTIMATED EMPLOYMENT OF TECHNICIANS, BY OCCUPATION, 1966



Note: Because of rounding, sums of individual items may not equal totals.
Source: Bureau of Labor Statistics.

expenditures in private industry in 1966 were in these five manufacturing industries. [3]

Significant numbers of technicians also are employed in private nonmanufacturing industries. In 1966, almost 100,000 technicians were employed in engineering and architectural services, 40,000 in miscellaneous business services, and about 32,000 in the communications industries.

Nearly 165,000 technicians were government employees, mainly in the Federal Government. Colleges and universities employed about 32,000 technicians. A relatively small number (6,500) worked for nonprofit organizations.

Almost one-half of all engineering and physical science technicians were concentrated in manufacturing and reflected the large number employed in electrical equipment (64,000) and chemicals industries (24,000). About one-fourth were employed in government. Communications and miscellaneous business industries employed significant numbers.

Reflecting the need for drafting services throughout the goods producing sector of the economy, draftsmen also were concentrated heavily in manufacturing industries (132,500 or about one-half). A large number, about 68,000, also were employed in firms providing engineering and architectural services.

Life science technicians were concentrated in government and in colleges and universities; more than one-fourth were employed in each industry. The large number of life science technicians in these industries reflect large research and development programs concerned with problems such as heart disease, cancer, birth defects, and mental health.

The "other technician" category generally follows the industry distribution of the technician group as a whole. Notable exceptions are contract construction and engineering and architectural services, which employ relatively large numbers of surveyors.

Requirements, 1966-80

More than 1 million technicians will be needed between 1966 and 1980 to meet employment growth and to replace those technicians who will die, retire, or separate from the labor force for other reasons, or transfer to other occupations. Approximately 500,000 technicians, about

one-half of total technicians manpower needs, will result from employment growth; 375,000 will be needed to replace experienced technicians who will transfer to other fields of work; and 150,000 to replace those who will die, retire, or leave the labor force for other reasons.

Employment growth. Employment requirements for technicians are expected to increase about 500,000 between 1966 and 1980, and will rise to approximately 1.4 million from the nearly 900,000 employed in 1966. (See following tabulation.) This rise represents a growth of approximately 57 percent, or an annual average increase of about 4 percent. This projected 1966-80 annual average increase is slightly slower than that shown during the 1961-66 period (about 4.5 percent), and in large part reflects the anticipated slowdown in the rate of increase of research and development activities. Growth of requirements for technicians is expected to result from continued economic growth, especially in fields where the increasing complexity of new products and processes is expected to increase the demand for highly trained personnel——for example, the improvement of existing instruments and the development of complex new industrial instruments; the increasing use of numerical control in machining; the use of microcircuits; and electron beam or laser welding.

Growth also will stem from an anticipated expansion of research and development activities (R&D). Nevertheless, the rate of growth of technicians in research and development thought the 1970's is expected to be slower than during the late 1950's and 1960's because of an expected slowdown in the rate of growth of research and development expenditures. For example, from 1966 to 1980, requirements for scientists and engineers in research and development are projected to increase about two-thirds, However, from 1957 to 1966, a shorter time span, they increased nearly three-fourths.[4]

Although the factors described above will increase utilization of technicians relative to total employment, the ratio of technicians to scientists and engineers——one of the most common measures of technician utilization——is expected to approximate the 1966 level in 1980, about 63 technicians to every 100 scientists and engineers. This contrasts with most other recent studies of technicians, which have indicated that the ratio of technicians to scientists and engineers is expected to increase in the years ahead.[5] In view of the projected rapid increases in requirements for engineers and scientists and prospective shortages of these workers, employers can be expected to attempt to utilize more effectively their high level scientific and engineering staffs by hiring more technicians for repetitive techncial functions. Increased utilization of technicians would free high level scientists and engineers for professional work and reduce the cost of trained technical manpower because technicians generally are paid less than scientists and engineers. However, surveys conducted by the Bureau of Labor Statistics[6] indicate that the utilization patterns of technicians has remained relatively constant during the 1961-66 period in private industry as a whole. Nevertheless, among individual industries, the utilization patterns have shifted.[7] Among the explanations offered for the almost stable ratio of technicians to scientists and engineers in private industry, as a whole, over the 1961-66 period are: (1) The supply of technicians has been inadequate to meet the

Employment of technicians by occupational specialty, estimated 1966 and projected 1980 requirements

Occupation	1966 employment	Project 1980 requirements	Percent increase, 1966-80
Technicians, all occupations	886,900	1,395,700	57.4
Draftsmen	272,300	434,300	59.5
Engineering and physical science technicians	419,300	646,800	54.3
Engineering technicians	299,200	453,800	51.7
Chemical technicians	60,500	96,500	59.5
Physics technicians	10,600	20,700	95.3
Mathematics technicians	5,300	10,100	90.6
Other physical science technicians	43,900	65,700	49.7
Life science technicians	70,000	108,900	55.6
Other technicians	125,100	205,800	64.5

NOTE: Because of rounding, sums of individual items may not equal totals.

demand; (2) many technicians have been "upgraded" to scientist and engineering positions; and (3) the practices of some industries, either voluntary or involuntary, do not utilize effectively more technicians relative to scientists and engineers.

Changing employment requirements by technician occupation. Physics and mathematics technicians are expected to grow the fastest of all the technician specialties. Employment requirements for physics technician are expected to increase to 20,700 in 1980 from the 10,600 employed in 1966, an increase of about 95 percent. Mathematics technicians are expected to increase from about 5,300 to slightly over 10,000, an increase of about 90 percent. These rapid increases result from the need for technicians to support the rapidly increasing number of physicists and mathematicians engaged in research and development in colleges and universities, government, and in the machinery, electrical equipment, and aircraft industries.

Requirements for engineering technicians, the largest technician specialty, are expected to grow to more than 450,000 in 1980 from the nearly 300,000 employed in 1966—an increase of about 52 percent. This rate of growth is slower than that for all technicians, but because of the relative size of this field, more persons will be needed in this technician occupation from 1966-80 than in any other. Draftsmen, life science technicians, and other technicians are expected to increase about three-fifths, or about the same rate as all technicians in the economy.

Changing employment requirements by industry. Requirements for technicians in some industries are expected to increase more rapidly than the increase anticipated for all technicians in the economy (57 percent). Among the industries expected to show faster than average growth in technician employment are engineering and architectural services (91 percent) and colleges and universities (84 percent). (See chart 2.)

Technician requirements in manufacturing industries, as a whole, are expected to increase approximately 56 percent, about the same rate anticipated for technician growth in all industries combined. However, requirements for technicians in some manufacturing industries, including the machinery and electrical equipment industries, are expected to increase faster than the average for technicians in all manufacturing.

Growth of technician requirements in some industries will result primarily from increases in the utilization of technicians relative to total employment. In other industries, growth in technician requirements will result primarily from increases in total industry employment. For example, technician requirements in the ordnance industry are expected to increase 17 percent over the 1966-80 period, while total employment in this industry is expected to decline slightly. In this industry, the utilization rate of technicians to total employment is expected to increase from 7.5 per 100 in 1966 to 9.0 per 100 in 1980, reflecting, in part, the continuing complexity of modern weapons systems. In contrast, the anticipated 91-percent increase in technician requirements in engineering and architectural services is due almost entirely to expected increases in total industry employment. The utilization of technicians in this industry is expected to remain relatively constant at 37 per 100 employees between 1966 and 1968.

Replacements needs. In addition to technicians required because of increased requirements between 1966 and 1980, many others will be needed to replace those who are expected to retire, die, or transfer to other occupations. Losses due to deaths, retirements, and other separations from the labor force are expected to number about 150,000 between 1966 and 1980. Transfers are expected to result in even greater needs than deaths and retirements if technicians continue to leave the field at the same rate as they did in the early 1960's. These losses are expected to average about 3 percent of each year's employment, or about 375,000 over the entire 1966-80 period.

Supply

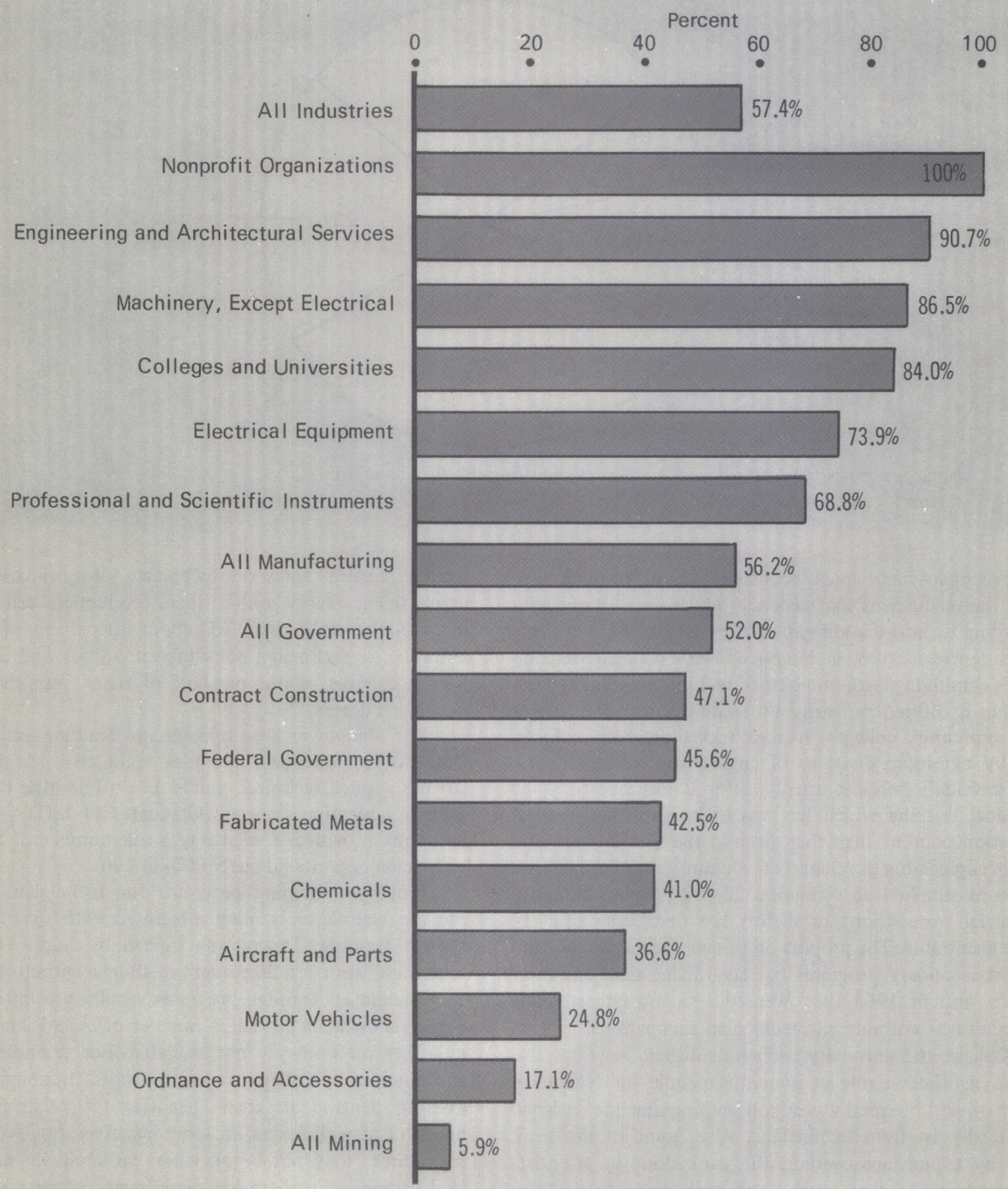
Workers acquire technician training in many ways. One way is through training taken expressly to prepare for entry level technician jobs—preemployment occupational training—which is offered by post-secondary schools; employers; and government, primarily under the Manpower Development and Training Act.

Workers also qualify for technician jobs in the Armed Forces or through training or experience designed to prepare them for other types of work. For example, those who do not complete bachelor's degree programs in engineering or science may qualify for some entry level technician jobs.

Another way of qualifying for technician work is through upgrading—experience in a technician-related job, often combined with some academic training. Upgradings have been the largest single source of new entrants to technician jobs in recent years. (See chart 3.) In 1965,[8] an estimated 24,000 workers were upgraded to technician occupations. Those who are upgraded included workers in other occupations who generally have completed some academic training. Often, these workers have attended night school part time, but some are dropouts of 4-year[9] and 2-year post-secondary schools; others have had military technician training.[10]

Chart 2.

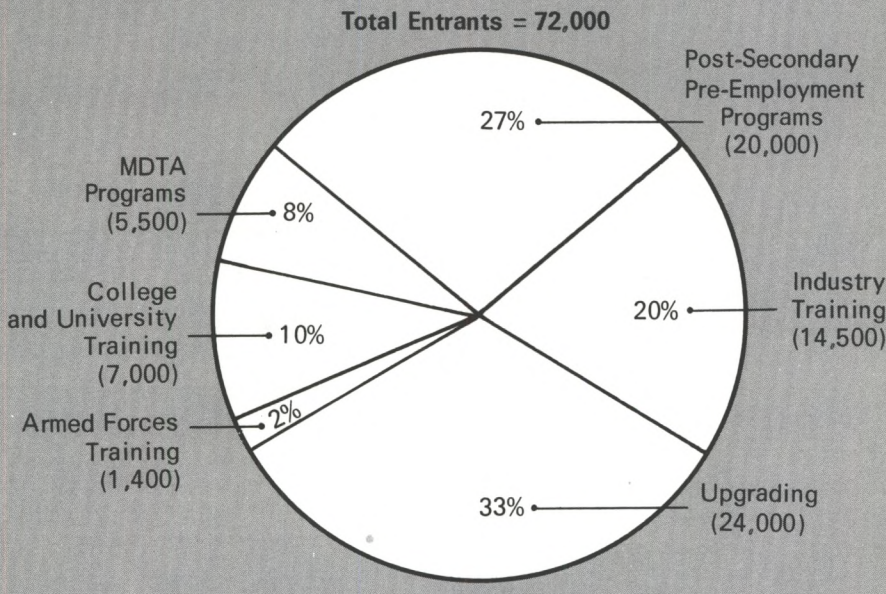
PERCENT INCREASE IN EMPLOYMENT REQUIREMENTS FOR TECHNICIANS 1966-80, SELECTED INDUSTRIES



Source: Bureau of Labor Statistics.

Chart 3.

NEW TECHNICIANS, BY SOURCE OF TRAINING, 1965



Note: Because of rounding, sums of individual items may not equal totals.
Source: Bureau of Labor Statistics

Preemployment post-secondary school training provides the technicians that generally are in greatest demand, according to information gathered by Bureau of Labor Statistics representatives in interviews with officials of companies employing large numbers of technicians. This type of training is offered primarily by technical institutes, junior and community colleges, area vocational-technical schools, and by extension divisions of engineering colleges. These post-secondary schools usually offer 2 years of full-time technical training which has less theorectical and general education content than that given in the first 2 years of a 4-year engineering or science curriculum.[11] In 1965,[12] these programs supplied an estimated 20,000 new entrants into technician occupations, or slightly less than 3 out of every 10 new entrants. The proportion of new technicians trained in post-secondary programs has been rising since the early 1960's, and in 1965 they were the second largest single source of new entrants into technician occupations.

College and university bachelor's degree programs also play a significiant role in preparing people for technician occupations;[13] several 4-year college programs are designed specifically to train technicians. Also, some of the work done by technicians overlaps the work done by scientists and engineers so that science and engineering curriculums qualify students for some technician jobs, primarily those emphasizing theory rather than production oriented or manipulative skills. In 1965, about 10 percent of all new entrants to technician jobs (about 7,000) had attended 4-year colleges; about one-half of these entrants held a bachelor's degree.[14]

The Manpower Development and Training Act of 1962 (MDTA), as amended, provides technician training that stresses applied technical courses but offers little theory or general education courses. Graduates of MDTA training programs provided a relatively small number of the new technician entrants (about 5,600) in 1965.

Employer training programs for technicians usually provide classroom training integrated with extensive on-the-job training. Technicians trained by employers represented an estimated 20 percent of all new entrants in 1965.

Technician training programs usually are initiated by employers when a sufficient number of technicians trained by other methods are not available. For example, junior and community colleges generally furnish training to meet existing demand in their localities for relatively large numbers of technicians. In some instances, however, training sources may not be providing an adequate supply of technicians. Furthermore, employers sometimes need

specialized skills that can be met only through their own training programs.

Information about career patterns of persons separated from the Armed Forces indicated that in 1965, fewer than 2 percent of all new entrants, or about 1,500, were hired directly after separation from the Armed Forces. Although the number of persons separated from the Armed Forces with military technician training in any given year is large, the proportion who enter civilian technician jobs directly is believed to be small. Training received in the Armed Forces usually is less theoretical than that given in civilian technical schools, and military equipment usually is unlike the equipment used in the civilian sector. However, some military technician training may be directly applicable to defense oriented activities. Most military technicians, therefore, must undergo additional training before they can enter civilian technician jobs.

Meeting manpower needs

Approximately 1 million technicians (1,034,000) will be required over the 1966-80 period to meet manpower needs for employment growth and replacement of workers employed in 1966 who will die, retire, or transfer to other occupations. How can these needs be met from the various sources of supply of technician manpower?

If the number of entrants to technician jobs from each source of supply would remain at the 1965 level between 1966 and 1979,[15] about 1 million persons would enter over the period. However, not all who enter technician jobs from 1966 to 1979 will remain in the field in 1980. After allowing for losses for transfers, retirements, or deaths, only about 800,000 of the 1 million new entrants between 1966 and 1979 still would be in the field in 1980.[16] An additional 300,000 workers would have to enter over the period to obtain a net 234,000[17] entrants needed to meet manpower requirements of 1,034,000.

If this gap between supply and demand of 300,000 workers were to be met by upgrading additional workers, upgradings would increase from 33 percent to nearly 50 percent of all entrants. However, interviews with company officials have indicated that employers may prefer to adjust their utilization patterns rather than upgrade large numbers of workers.

As noted earlier, employers would prefer to have the 300,000 additional technicians graduate from preemployment post-secondary school technician training programs. It would be preferable, therefore, if the additional 300,000 technicians that would be required to meet technician manpower needs were to come from this source. Graduates of preemployment post-secondary programs would total about 45 percent of all entrants during the 1966-79 period, compared to 27 percent in 1965. Upgradings would total 26 percent during the 1965-79 period, compared with 33 percent in 1965. To obtain this number of graduates, steps would have to be taken to build additional classrooms, to assure that sufficient number of teachers are available, and to attract additional students to the training programs. Increases in training of this magnitude are not unrealistic. During the early 1960's, training in preemployment post-secondary school increased at a much faster rate than that implied by this increase.

What would be the supply if past trends of entry from preeemployment and technician-related training continued? If the same proportion of 4-year college graduates and dropouts continue to enter technician jobs as in the recent past, the number of new technicians from these sources would increase about four-fifths between 1966 and 1979 as reflected in the rise in college enrollments and graduates projected by the U.S. Office of Education. Over the 1966-79 period, about 150,000 4-year college graduates and dropouts would enter technician jobs.

If the trend of increase in technician training programs as a proportion of all MDTA training continued, the number of technicians trained in such programs would increase about two-fifths between 1966 and 1979, and provide about 95,000 entrants over that period. The annual number of entrants from the Armed Forces has remained relatively constant during the 1960's, although a slight rise is expected at least through the early 1970's due to the increase in the size of the Armed Forces resulting from the Viet Nam War. By 1979, however, entrants from the Armed Forces are projected to approximate 1963 levels. When these factors are taken into consideration, about 21,500 persons would enter technician jobs during the 1966-79 period if the patterns of entry from Armed Forces separations continue as during the early to mid-1960's.

Several studies indicate that employers reduce their training activities as more technicians become available from preemployment post-secondary programs. Therefore, if training in preemployment post-secondary programs will expand over the 1966-79 period along the lines of recent years, employers may reduce slightly their technician training activities. Under these assumptions, about 175,000 new technicians would complete employer training programs between 1966 and 1979.

How many technician entrants can be expected to graduate from preemployment post-secondary training if past patterns of entry from this source of supply were to

continue during the 1966-79 period? If (1) the proportion of high school graudates who enroll in these programs were to increase as during the early 1960's and (2) the proportion of those who enter technician jobs were to remain about the same as during the early 1960's, about 750,000 new graduates would enter technician jobs over the 1966-79 period. As indicated above, great effort is needed to build new or expand existing technical institutes, junior colleges, and other post-secondary schools that train technicians; to attract students to the programs; and to assure a sufficient number of teachers to provide the training.

In summary, about 1.2 million workers would enter technician jobs from preemployment and technician-related training if past trends of entry continue.

Preemployment	1,020,000
Post-secondary preemployment training	750,000
Employer training	175,000
MDTA training	95,000
Technician-related	171,500
College and university (4-year) graduates and dropouts	150,000
Armed Forces training	21,500
Total	1,191,500

However, after losses resulting from deaths, retirements, and transfers to other occupations, only about 935,000 of these entrants would remain in the field in 1980. An additional 120,000 technicians would have to be upgraded to obtain a net 99,000 technicians needed to meet manpower needs of 1,034,000.[18] Upgradings of this magnitude would approximate only 10 percent of all entrants for the period, clearly a vast improvement in the technician manpower situation.

Prospective Relations Between Requirements for and Supply of Technicians, if Past Patterns of Entry Continue, 1966-80

REQUIREMENTS	
Total	1,034,000
Growth	509,000
Replacements: Deaths and retirements	150,000
Transfers	375,000
SUPPLY	
Net entrants	1,034,000
Gross entrants (1,320,000) minus loses resulting from deaths, retirements, and transfers (286,000)	
Net entrants from preemployment and technician related training	935,000
Gross entrants (1,191,500) minus losses resulting from deaths, retirements, and transfers (256,500)	
Net upgradings required	99,000
Gross entrants (120,000) minus losses resulting from deaths, retirements, and transfers (21,000)	

However, favorable conditions may not exist in all the various technician specialties. Some specialties may have shortages because employers have indicated increasing difficulty upgrading workers to technicians jobs in certain fields of technology or specialization (e.g., bio-medical equipment technology, nuclear medical technology, laser and electro-optical technology, and metallurgical technology) as a result of the growing complexity of industrial technology and research activities. The sources of training in these fields probably will not supply all those who are needed.

Any assessment of future supply-demand conditions for technicians revolves around the extent to which preemployment post-secondary training can be expanded. The efforts underlying the rapid expansion experienced during the 1960's must be continued through the 1970's if future manpower needs for technicians are to be met.

Chapter II

Directions for Future Research

During the research for this bulletin and other studies of technician manpower conducted by the Bureau of Labor Statistics, several data gaps have become apparent. Many of the gaps restrict the amount of occupational detail that can be presented in manpower studies; others affect the reliability of the data that are presented. This section points to some of the studies that can be conducted to fill these data gaps. The following areas are discussed: Manpower utilization, occupational detail, relationship of training to occupational needs, ways people qualify for technician jobs, and the transfer of technicians to other fields of work.

Manpower utilization

Over the past decade, several studies concerning the utilization of technicians have been conducted; in most of them, special emphasis was given to the ratio of technicians to scientists and engineers.[19] Nearly all such studies have indicated that employers expect or prefer the ratio of technicians in the future to increase relative to scientists and engineers. This conclusion was to be expected in view of a reported shortage, and the long lead time needed to train scientists and engineers. Employers could substitute technicians to perform the more routine tasks performed by the more highly trained technical staffs. However, employment surveys conducted by the Bureau of Labor Statistics have not shown an increase in the utilization of technicians relative to scientists and engineers between 1961 and 1966, a period in which scientists and engineers were for the most part in short supply. In fact, the employment of scientists and engineers has increased slightly faster than the employment of technicians since 1961 (23.5 percent compared with about 22.0 percent). Among individual industries, however, the trend varies. For example, in 1961, there were about 53 technicians per 100 scientists and engineers in the motor vehicle industry. By 1966, about 67 technicians were employed for every 100 scientists and engineers. In contrast, the number of technicians per 100 scientists and engineers in the chemicals industry declined from about 45 to 39 between 1961 and 1966.

In view of the reported scarcity of scientists and engineers[20] and accompanying economic factors such as high and rising salaries for scientists and engineers, research is needed to determine why the employment of technicians has grown more slowly than the employment of scientists and engineers. The question suggests many answers. (1) Perhaps employers cannot use efficiently a larger number of technicians relative to scientists and engineers. Today's manufacturing processes and research and development activities may demand relatively more scientists and engineers than technicians than in the past. (2) Perhaps firms have "upgraded" technicians to scientist and engineer jobs, particularly to engineering positions. For example, the reported shortage of engineers during the early to mid-1960's could have resulted in the promotion of high level technicians to engineering positions that entail a great deal of technician level work. (3) Perhaps technicians increasingly are being classified by employers as engineers because of the greater "status" accorded engineers. (4) The gap between the supply and demand for technicians may have been greater than the gap between the supply and demand for scientists and engineers.

Because the ratio of technicians to scientists and engineers is basic to projections of technician employment requirements, a decreasing ratio has a significant impact on employment projections. (See appendix A.) Therefore, utilization studies have a major bearing on future education plans and policies concerning technicians that would result from studies of supply and demand.

Occupational detail

One of the major shortcomings of existing technician manpower studies on a national scale is the lack of occupational detail. For example, this report presents statistics for only nine occupational groups, several of which include many job titles. The "other engineering technician" group includes mechanical, aeronautical, civil, and other kinds of engineering technicians, each of which has a number of different job titles. Such broad groupings of many different technician occupations makes impossible valid estimates of the employment size of the different technician occupations or improvement of the analysis of supply-demand relationships.

Government agencies should expand the number of occupational categories for which they collect technician information. The Bureau of Labor Statistics, the National Science Foundation, and the Bureau of the Census collect basic information on technician employment by occupation on a national scale. The Bureau of Labor Statistics in its annual surveys of scientific and technical personnel in private industry collects employment statistics for seven categories (before 1963, for four different occupational categories); the Bureau of the Census in the decennial census, four categories; and the National Science Foundation in surveys of colleges and universities and nonprofit organizations, three categories.

Some data on occupational detail are available from studies of specific localities.[21] These studies offer various possibilities for collecting more detailed information on a national scale. For example, *Technician Manpower in New York State,*[22] identifies 15 different groups of technician occupations.

One of the key problems in developing more detailed and reliable occupational employment statistics is that of definition. The word "technician" means many things to many people. Some studies define technicians more liberally than others and state that a new high school graduate may enter a technician job. Other studies, including those of the Bureau of Labor Statistics, indicate that technicians are workers who must have training comparable to that obtained in a 2-year technical institute. (See appendix B.) Within the many definitions of "technician," the workers covered may include not only those who support scientists and engineers, but also advertising copywriters, actuaries, credit analysts, hotel housekeepers, library assistants, legal secretaries, and PBX operator-receptionists. To further complicate the problem, different employers use different titles for individuals doing the same work. On the other hand, the same designation often is used to describe the work of technicians doing different jobs.

To eliminate these problems, definite guidelines should be established in developing all statistics on technician manpower. If guidelines are not used, the data will not be comparable, and analysts will not be able to build upon the information collected by others——a key research objective. Such a system is now being developed as part of a Bureau of the Budget committee's work on developing a standard occupational classification system.

Relationship of training to occupational specialty

One of the primary goals of a manpower study of technician requirements and supply is to alert educational planners to the specific occupational specializations for which training programs should be expanded, or perhaps, curtailed. Although this study and other comprehensive studies of technician manpower clearly indicate that efforts should be made to increase the number of graduates of preemployment post-secondary technician training programs, the specific technician specializations in which training should be concentrated are not identified. Thus, important information, such as whether emphasis should be placed on training electrical and electronics technicians, draftsmen, life science technicians, or other specific occupational fields, cannot be found in the most comprehensive national manpower studies on technicians.

Though graduates of post-secondary technician training programs currently constitute less than one-third of all new entrants, this type worker is in greatest demand. Any increase in training activity producing a growth rate of graduates of different curriculums in line with current trends probably would not have any ill effects either on the economy or on individual technician workers over the short run. For example, a student's employment prospects would be affected relatively little during the next few years, regardless of the technology studied, because all workers trained in these programs should have excellent job opportunities. However, from the point of view of employers and others who are looking for the most efficient distribution of trained manpower, any increase in technician training should be directed toward occupations in shortest supply and those expected to be in greatest demand in the future.

During this study, an attempt was made to develop estimates of the need for graduates of preemployment post-secondary curriculums by field of study. However, basic information for reliable estimates was not fully available and was impossible to develop within the staffing and time confines of the study.

To develop information on technological fields in which training should be concentrated, statistics are needed

on the proportion of graduates in each field of technology who enter each technician occupation, and also on the proportion of new entrants in each field who are graduates of preemployment programs. Having this type of information, analysts could estimate employers' relative needs for graduates by field of technology.

Followup studies. To increase our knowledge of the type of jobs obtained by graduates, a study should be done to followup the activities of graduates of technician programs. The results would identify the proportion of graduates who take further schooling, enter military activity, or get jobs. In particular, the specific occupation of those entering the labor force would be identified so that an estimate could be made of the extent to which new technicians will work in the technician specializations in which they have been trained.[23] Graduates of post-secondary preemployment training programs generally complete one of the following 10 curriculums: Aeronautical technology, architecture and civil technology, electrical technology, chemical technology, general engineering technology, industrial technology, mechanical technology, metallurgical technology, agriculture and forestry, and data processing. This list might indicate that graduates of electrical technology curriculums become electronic or electrical technicians, and that graduates of chemical technology become chemical technicians, etc. However, from the little available data on graduates of these programs reported by individual schools, this assumption is not correct. Some electronic technology graduates become industrial technicians, aeronautical technicians, or enter other nonelectronic technician specializations; some become draftsmen.

Not all graduates of technician training programs work as technicians. Some continue their education in advanced schools or colleges and train for higher-level occupations. Others accept jobs in occupations where they use only part or none of their training. Still others enter the Armed Forces and are temporarily out of the civilian labor force. Some women graduates become housewives after completing a technician training program and do not enter the labor force.

Ways people qualify for technician jobs

A. Preemployment Post-Secondary Training

Preemployment post-secondary technician training is available in several general types of institutions. The first type, institutions of higher education, include public and private schools conferring at least the associate of arts degree or its equivalent in organized occupational curriculums. These institutions are listed in the U.S. Office of Education's Directory of Higher Education. A second type, area vocational schools, includes public vocational programs supported under provisions of the Vocational Education Act of 1963. A third type includes schools offering 4-year bachelor of technology programs. A fourth includes "private" schools that provide technician training programs which are not included in either of the first two types above. The first two types of programs have been clearly identified and provide a major part of the technician training.[24] The latter two—bachelor of technology programs and private schools—need to be studied to determine the size and type of programs offered.

Bachelor of technology programs. Four-year programs in engineering technology are a relatively recent development, most of them having been established since 1950. In 1968, about 75 institutions offered one or more baccalaurate programs in engineering or industrial technology related to engineering. These programs have been identified, and an attempt made to assess the need for such programs.[25]

Limited contacts between BLS staff members and industry representatives have indicated some differences in the way employers utilize graduates of the bachelor of technology program. Sometimes, the graduates are hired as technicians, and at other times they are hired to fill engineering positions. Research is needed to determine to what extent graduates of bachelor of technology programs enter technician level jobs. A survey of individual graduates should be conducted, which would provide information on all the work roles of these graduates.

Private schools. In addition to those schools included within the categories that have traditionally been thought of as providing newly trained technicians are others which are primarily privately operated and typically award certificates upon completion of the program. They are not listed as institutions of higher education by the Office of Education and, therefore, do not fall into statistical counts of graduates, enrollments, and other data collected by the Office of Education. For lack of a better term, they are called "private" schools in this report, even though many privately operated schools are institutions of higher education.

No agency—public or private—collects data on the enrollments and graduates of private schools. Though believed to be large, the total number of such schools is not known. The National Association of Trade and Technical Schools, which does not include all private schools, has about 150 members, only two of which are listed as institutions of higher education by the U.S. Office of Education. However, not all of the remaining 148 schools offer technician training.

Identification of the number of technicians trained in private schools would shed some light on a key aspect of technician supply——upgradings. If private post-secondary schools provide a significant source of new technicians, then upgradings are greatly over-represented in the supply estimates presented in this and previous technician manpower studies because the number of upgradings was estimated as the residual of all other entrants and total entrants.

Much more should be known about private schools before their contribution to the supply of new technicians can be assessed. Programs should be established to collect data on the number of full- and part-time students in private schools, the number of graduates, the employment status and field of work of both graduates and dropouts, the employment status of part-time students, and the sources of student financial assistance. The last two items are important to determine the portion of students in these programs who participate in "company training" programs.

B. Upgradings

A national study is needed to identify the training and work experience in addition to formal preemployment post-secondary training that qualifies workers for technician jobs.

Estimated upgradings each year are subject to a wide range of errors because of the method used for their development. In 1962, over 50 percent or about 45,000 new entrants to technicians occupations were estimated to have been upgraded from the existing labor force, compared with one-third or about 24,000 in 1965.

Preliminary research has indicated, however, that workers who are upgraded may have obtained a significant amount of post-secondary technician training. Thus, more information should be known about their educational qualifications. One study [26] has indicated that some employers hire nearly one-half of their technicians from other firms, but not known is the number who are new entrants to the technician work force—workers in other occupations being upgraded to technician jobs, and workers returning to technician jobs after "trying out" work in another job. They could be technicians who only change their employment and therefore, are not additions to the technician work force.

Transfers to other fields of work

In addition to followup studies on the post-training work and study activities of technician graduates directly after graduation, more research should be undertaken about the employment of graduates after their technician training. The information disclosed by followup studies on the proportion of graduates who remain in technician occupations for several years would be important in developing estimates of the future supply of technician manpower.

Only very limited data are available on the number of technicians who transfer to other fields of work each year. As a result, estimates of future requirements arising from these transfers can be only approximations. Admittedly, the collection of data on technicians who transfer out of technician specializations would be very difficult. However, an attempt was made in the Postcensal Survey of Professional and Technical Personnel, which provides some useful information on transfers between 1960 and 1962. This study has been used to estimate transfers in this report. [27] Studies of transfers can be conducted in connection with the 1970 Census.

——FOOTNOTES——

1 The word "technician" is used interchangeably throughout this report with "engineering and science technicians."

2 See appendix table A-1 for data on employment of technicians by occupation and industry in 1966.

3 See *Reviews of Data on Science Resources, Research, and Development in Industry, 1966,* National Science Foundation, Washington, D.C., 20550, NSF 68-5.

4 See *Employment of Scientists and Engineers in the United States, 1950-66,* prepared jointly by the National Science Foundation and the Bureau of Labor Statistics, NSF 68-30.

5 See, for example, *Demand for Engineers and Technicians--1966,* Engineering Manpower Commission, New York, N.Y., 1966.

6 *Occupational Employment Statistics 1960-66* (BLS Bulletin 1579, 1968).

7 See ch. II, Directions for Future Research, for more information on the utilization of technicians.

8 The employment estimates for technicians in this study are early year estimates because most of the surveys underlying the estimates collected data on January employment. (See appendix B.) Because the number of upgradings is determined by developing a residual of total entrants minus entrants from all other sources of training, 1965 was the latest year for which estimates of upgradings could be developed at the time this study was prepared. A 1967 employment estimate was not available to develop estimates of growth between 1966 and 1967 which is necessary to estimate total entrants.

9 Dropouts from curriculums other than science or engineering because science and engineering dropouts who enter technician jobs are counted as part of entrants from technician-related training.

10 Because of the method of deriving the number of upgradings, the residual of total entrants and entrants from all other sources of training (appendix B), the upgradings totals probably include some students who have completed preemployment training programs in private technical schools that either are not considered institutions of higher education by the U.S. Office of Education or do not participate in Federal programs under the Vocational Educational Act of 1963. These graduates would not be included in estimates of preemployment training because they are not included in any statistics collected on graduates. See *Guide to Organized Occupational Curriculums in Higher Education,* U.S. Department of Health, Education and Welfare, Office of Education, OE-54012-62, Circular No. 771; and *Education Directory 1966-67* Pt. 3, Higher Education, U.S. Department of Health, Education and Welfare, Office of Education.

11 Graduates of preemployment training offered in 4-year Bachelor of Technology programs are counted as entrants from regular bachelor's degree programs because data are lacking to specifically separate these graduates from the data on degrees granted that are published by the U.S. Office of Education. The Engineering Manpower Commission of the Engineers Joint Council, however, has initiated the collection of statistics on 4-year bachelor's degree programs in technology *(Degrees in Engineering and Industrial Technology, 1967-68).* See ch. II, Direction for Future Research, p. 13.

12 Data on these and all other types of training presented here are for 1965 so that they are comparable to the latest estimates that could be developed for upgradings.

13 The supply data do not consider new bachelor's degree recipients who are doing technician work upon entry into professional fields because these workers are not counted in the employment estimates that serve as the base for the requirements projections.

14 See p. 15 for information concerning bachelor's degree programs in technology.

15 Graduates of training programs in 1979 will be the last available for employment in early 1980, the target year of the projections.

16 Estimated losses for deaths and retirements were based on age specific separation rates developed by BLS based on the work life experience of all workers, and a transfer rate of 3 percent a year, primarily based on data in the *Postcensal Survey of Professional and Technical Personnel.* For an explanation and illustration of the methods used to develop net supply estimates, see "Projections of Manpower Supply in a Specific Occupation," by Neal Rosenthal, *Monthly Labor Review,* November 1966.

17 66,000 of the 300,000 gross entrants would be lost to employment between 1966 and 1979 because of retirements, deaths, and transfers to other occupations.

18 21,000 of the 120,000 new entrants would be lost to employment between 1966 and 1979 because of retirements, deaths, and transfers to other occupations.

19 See, for example, *Technicians for Connecticut Industries,* State Department of Education, Hartford, Connecticut, Bulletin No. 82; *Technician Manpower in New York State,* New York State Department of Labor, Division of Research and Statistics, 1964; William J. Torpey, "Needs for Technicians," *Journal of Engineering Education,* The American Society for Engineering Education, July-August 1964; and *Demand for Engineers, Physical Scientists, and Technicians—1966, op. cit.,* footnote 5.

20 See, for example, the semiannual reports entitled *The Job Market for Engineers, Scientists, and Technicians,* published by the U.S. Department of Labor, Manpower Administration.

21 Most of these studies are conducted by State agencies. Some are conducted by local school systems, colleges and universities, and private consultant firms.

22 *Op. cit.,* footnote 19.

23 Such a study can be done on a national scale, similar to the study of graduates of 4-year college programs in 1958 conducted by the Bureau of Social Science Research in 1960 under the sponsorship of the National Science Foundation and published in 1963 under the title, *Two Years After the College Degree: Work and Further Study Patterns* (NSF 63-26).

24 See ch. III, *Technician Manpower: Requirements, Resources and Training Needs* (BLS Bulletin 1512, 1966), pp. 33-42.

25 See *Baccalaurate Programs in Engineering Technology: A Study of Their Emergency and of Some Characteristics of Their Content,* a background paper developed by Dr. Jesse Defore for the information of the participants in an Inventory Conference on Engineering Technology Education, Jan. 22-23, 1968, sponsored by the American Society of Engineering Education and supported by the National Science Foundation.

26 *A Survey of Technical Needs of Industry and Implications for Curriculum Development in Higher Education—1966.* Eckhard A. Jacobsen, Northern Illinois University, De Kalb, Ill.

27 See also *Technician Manpower: Requirements, Resources and Training Needs,* p. 52, *op. cit.,* footnote 24.

Appendix A

Statistical Tables

In the following tables, absolute figures usually are rounded, and percentages shown to one decimal place. Presentation of the figures in this form should not be construed as indicating that they have exactly this degree of precision.

Since all totals and percentages were calculated on the basis of unrounded figures, they do not always correspond exactly with those indicated by rounded figures on the tables.

Table A-1. Estimated employment of technicians, by occupation and industry, 1966

Industry	Total technicians	Draftsmen	Engineering and physical science technicians									Life science technicians	All other technicians
			Total	Engineering technicians			Physical science technicians						
				Total	Electronic	Other	Total	Chemical	Physics	Mathematics	Other		
All industries	886,900	272,300	419,300	299,200	183,300	115,900	120,300	60,500	10,600	5,300	43,900	70,000	125,100
Mining	10,200	3,600	3,000	1,700	900	800	1,300	300	-	-	1,000	-	3,600
Petroleum extraction	6,700	3,100	1,700	1,000	700	300	700	100	-	-	600	-	1,900
Other mining	3,500	500	1,300	700	200	500	600	200	-	-	400	-	1,700
Contract construction	34,600	21,000	6,400	6,100	5,300	800	300	200	-	100	-	-	7,200
Manufacturing	385,700	132,500	202,300	146,900	89,600	57,300	55,400	34,500	4,100	1,700	15,100	5,400	45,400
Ordnance	19,300	4,200	13,900	11,100	8,700	2,400	2,800	1,100	600	300	800	200	1,000
Food	4,300	700	1,500	500	300	200	1,000	900	-	-	100	700	1,400
Textile and apparel	3,100	500	1,300	500	400	100	800	700	-	-	100	-	1,300
Lumber and furniture	6,700	5,200	900	800	300	500	100	100	-	-	-	-	600
Paper	6,100	1,200	3,700	2,100	400	1,700	1,600	1,200	100	-	300	100	1,100
Chemicals	38,300	3,700	24,400	6,900	1,300	5,600	17,500	15,400	500	100	1,500	3,600	6,500
Petroleum refining	5,800	700	3,500	1,900	300	1,600	1,600	1,300	100	-	200	-	1,600
Rubber	5,000	1,300	2,800	1,400	200	1,200	1,400	1,100	100	-	200	-	900
Stone, clay, and glass	5,600	2,400	2,100	1,400	400	1,000	700	500	-	-	200	-	1,000
Primary metals	17,600	4,700	9,000	4,300	1,800	2,500	4,700	1,200	-	-	3,500	100	3,900
Fabricated metals	24,700	16,600	6,300	5,000	900	4,100	1,300	500	100	100	600	-	1,600
Machinery	67,400	35,600	24,700	20,800	11,600	9,200	3,900	1,700	300	300	1,600	100	7,000
Electrical equipment	100,900	27,600	64,100	55,400	46,600	8,800	8,700	3,700	1,400	500	3,100	200	9,000
Motor vehicles	15,700	6,100	8,600	7,100	100	7,000	1,500	600	100	100	700	-	1,000
Aircraft	34,400	9,900	21,600	18,100	9,000	9,100	3,500	1,300	400	300	1,500	100	2,800
Other transportation equipment	6,200	4,500	1,700	1,400	1,200	200	300	100	-	-	200	-	400
Professional and scientific instrument	20,200	6,000	10,000	7,000	5,600	1,400	3,000	2,200	300	-	500	300	3,800
Miscellaneous manufacturing	4,400	1,600	2,200	1,200	500	700	1,000	900	100	-	-	100	500
Transportation, communication, and public utilities	59,000	9,700	40,100	38,000	26,800	11,200	2,100	800	200	400	700	-	9,200
Railroads	4,700	1,800	1,500	1,300	700	600	200	200	-	-	-	-	1,400
Other transportation	2,800	400	1,200	1,100	1,100	-	100	-	-	-	100	-	1,200
Telecommunications	20,800	1,100	18,300	17,700	9,800	7,900	600	-	200	300	100	-	1,400
Radio and television	10,900	-	9,300	9,300	9,300	-	-	-	-	-	-	-	1,600
Public utilities	19,800	6,400	9,800	8,600	5,900	2,700	1,200	600	-	100	500	-	3,600
Other industries	200,700	85,000	52,700	35,900	29,900	6,000	17,000	8,400	2,200	1,600	4,800	25,700	37,400
Miscellaneous business services	39,900	10,800	22,400	11,500	10,200	1,300	10,900	5,200	1,600	700	3,400	800	5,900
Medical and dental laboratories	18,500	-	-	-	-	-	-	-	-	-	-	16,800	1,700
Nonprofit institutions	6,500	600	2,400	900	300	600	1,500	700	300	200	300	3,100	400
Engineering and architectural services	97,800	68,100	8,500	7,600	4,000	3,600	900	300	100	100	400	100	21,100
Other nonmanufacturing	38,000	5,500	19,400	15,900	15,400	500	3,700	2,200	200	600	700	4,900	8,300
Government	164,900	19,100	107,000	68,500	28,900	39,600	38,500	13,500	2,900	1,000	21,100	19,500	19,000
Federal	83,800	3,900	63,500	33,600	17,700	15,900	29,900	9,200	2,900	800	17,000	14,500	1,600
State	56,500	6,900	34,900	27,500	10,100	17,400	7,400	3,400	-	200	3,800	4,000	10,700
Local	24,600	8,300	8,600	7,400	1,100	6,300	1,200	900	-	-	300	1,000	6,700
Colleges and universities	31,800	1,400	7,800	2,100	1,900	200	5,700	2,800	1,200	500	1,200	19,300	3,300

NOTE: Because of rounding, sums of individual items may not equal totals.

Table A-2. Percent distribution of estimated employment of technicians, by occupation and industry, 1966

Industry	Total technicians	Drafts-men	Engineering and physical science technicians									Life science technicians	All other technicians
			Total	Engineering technicians			Physical science technicians						
				Total	Elec-tronics	Other	Total	Chemical	Physics	Mathe-matics	Other		
All industries	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mining	1.2	1.3	0.7	0.6	0.5	0.7	1.1	0.5	-	-	2.3	-	2.9
Petroleum extraction	.8	1.1	.4	.3	.4	.3	.6	.2	-	-	1.4	-	1.5
Other mining	.4	.2	.3	.2	.1	.4	.5	.3	-	-	.9	-	1.4
Contract construction	3.9	7.7	1.5	2.0	2.9	.7	.2	.3	-	1.9	-	-	5.8
Manufacturing	43.5	48.7	48.2	49.1	48.9	49.4	46.1	57.0	38.7	32.1	34.4	7.9	36.3
Ordnance	2.2	1.5	3.3	3.7	4.7	2.1	2.3	1.8	5.7	5.7	1.8	.3	.8
Food	.5	.3	.4	.2	.2	.2	.8	1.5	-	-	.2	1.0	1.1
Textile and apparel	.3	.2	.3	.2	.2	.1	.7	1.2	-	-	2.3	-	1.0
Lumber and furniture	.8	1.9	.2	.3	.2	.4	.1	.2	-	-	-	-	.5
Paper	.7	.4	.9	.7	.2	1.5	1.3	2.0	.9	-	.7	.1	.9
Chemicals	4.3	1.4	5.8	2.3	.7	4.8	14.5	25.5	4.7	1.9	3.4	5.1	5.2
Petroleum refining	.7	.3	.8	.6	.2	1.4	1.3	2.1	.9	-	.5	-	1.3
Rubber	.6	.5	.7	.5	.1	1.0	1.2	1.8	.9	-	.5	-	.7
Stone, clay, and glass	.6	.9	.5	.5	.2	.9	.6	.8	-	-	.5	-	.8
Primary matels	2.0	1.7	2.1	1.4	1.0	2.2	3.9	2.0	-	-	8.0	.1	3.1
Fabricated metals	2.8	6.1	1.5	1.7	.5	3.5	1.1	.8	.9	1.9	1.4	-	1.3
Machinery	7.6	13.1	5.9	7.0	6.3	7.9	3.2	2.8	2.8	5.7	3.6	.1	5.6
Electrical equipment	11.4	10.1	15.3	18.5	25.4	7.6	7.2	6.1	3.2	9.4	7.1	.3	7.2
Motor vehicles	1.8	2.2	2.1	2.3	.1	6.0	1.2	1.0	.9	1.9	1.6	-	.8
Aircraft	3.9	3.6	5.2	6.0	4.9	7.9	2.9	2.1	3.8	5.7	3.4	.1	2.2
Other transportation equipment	.7	1.7	.4	.5	.7	.2	.2	.2	-	-	.5	-	.3
Professional and scientific instruments	2.3	2.2	2.4	2.3	3.1	1.2	2.5	3.6	3.8	-	1.1	.4	3.0
Miscellaneous manufacturing	.5	.6	.5	.4	.3	.6	.8	1.5	.9	-	-	.1	.4
Transportation, communication, and public utilities	6.7	3.6	9.6	12.7	14.6	9.7	1.7	1.3	1.9	7.5	1.6	-	7.4
Railroads	.5	.7	.4	.4	.4	.5	.2	.3	-	-	-	-	1.1
Other transportation	.3	.1	.3	.4	.6	-	.1	-	-	-	.2	-	1.0
Telecommunications	2.3	.4	4.4	5.9	5.3	6.8	.5	-	1.9	5.7	.2	-	1.1
Radio and television	1.2	-	2.2	3.1	5.1	-	-	-	-	-	-	-	1.3
Public utilities	2.2	2.4	2.3	2.9	3.2	2.3	1.0	1.0	-	1.9	1.1	-	2.9
Other industries	22.6	31.2	12.6	12.0	16.3	5.2	14.1	13.9	20.8	30.2	10.9	36.7	29.9
Miscellaenous business services	4.5	4.0	5.3	3.8	5.6	1.1	9.1	8.6	15.1	13.2	7.7	1.1	4.7
Medical and dental laboratories	2.1	-	-	-	-	-	-	-	-	-	-	24.0	1.4
Nonprofit organizations	.7	.2	.6	.3	.2	.5	1.2	1.2	2.8	3.8	.7	4.4	.3
Engineering and architectural services	11.0	25.0	2.0	2.5	2.2	3.1	.7	.5	.9	1.9	.9	.1	16.9
Other nonmanufacturing	4.3	2.0	4.6	5.3	8.4	.4	3.1	3.6	1.9	11.3	1.6	7.0	6.6
Government	18.6	7.0	25.5	22.9	15.8	34.2	32.0	22.3	27.4	18.9	48.1	27.9	15.2
Federal	9.4	1.4	15.1	11.2	9.7	13.7	24.9	15.2	27.4	15.1	38.7	20.7	1.3
State	6.4	2.5	8.3	9.2	5.5	15.0	6.2	5.6	-	3.8	8.7	20.0	8.6
Local	2.8	3.0	2.1	2.5	.6	5.4	1.0	1.5	-	-	.7	1.4	5.4
Colleges and universities	3.6	.5	1.9	.7	1.0	.2	4.7	4.6	11.3	9.4	2.7	27.6	2.6

NOTE: Because of rounding, sums of individual items may not equal totals.

Table A-3. Projected 1980 employment requirements for technicians, by occupation and industry

Industry	Total technicians	Drafts-men	Engineering and physical science technicians							Life science technicians	All other technicians
			Total	Engineering technicians	Physical science technicians						
					Total	Chemical	Physics	Mathe-matics	Other		
All industries	1,395,700	434,300	646,800	453,800	193,000	96,500	20,700	10,100	65,700	108,900	205,800
Mining	10,800	3,700	3,300	1,800	1,500	400	-	-	1,100	-	3,800
Petroleum extraction	6,800	3,200	1,700	1,000	700	100	-	-	600	-	1,900
Other mining	4,000	500	1,600	800	800	300	-	-	500	-	1,900
Contract construction	50,900	30,900	9,500	9,000	500	400	-	100	-	-	10,600
Manufacturing	602,800	210,900	313,700	230,500	83,200	50,900	6,500	3,100	22,700	7,900	70,300
Ordnance	22,600	4,600	16,500	12,000	4,500	2,000	1,000	500	1,000	300	1,200
Food	5,700	800	1,900	600	1,300	1,200	-	-	100	1,100	1,900
Textile and apparel	4,000	600	1,700	600	1,100	1,000	-	-	100	-	1,700
Lumber and furniture	9,600	7,400	1,300	1,100	200	200	-	-	-	-	900
Paper	9,300	1,800	5,600	3,100	2,500	1,800	200	-	500	200	1,700
Chemicals	54,000	5,200	34,400	9,600	24,800	22,000	600	100	2,100	5,100	9,300
Petroleum refining	6,200	800	3,700	2,100	1,600	1,300	100	-	200	-	1,700
Rubber	7,600	2,000	4,200	2,200	2,000	1,600	100	-	300	-	1,400
Stone, clay, and glass	8,400	3,800	32,100	2,200	900	600	-	-	300	-	1,500
Primary metals	23,100	6,100	11,800	5,600	6,200	1,500	-	-	4,700	-	5,200
Fabricated metals	35,200	23,600	9,300	7,100	2,200	900	200	200	900	-	2,300
Machinery	125,700	66,300	46,100	38,800	7,300	3,000	600	700	3,000	200	13,100
Electrical equipment	175,500	48,100	111,500	96,700	14,800	6,400	2,200	800	5,400	300	15,600
Motor vehicles	19,600	7,600	10,800	8,800	2,000	800	200	100	900	-	1,200
Aircraft	47,000	13,500	29,500	24,600	4,900	1,600	600	600	2,100	100	3,900
Other transportation equipment	9,500	6,500	2,400	2,000	400	100	-	-	300	-	600
Professional and scientific instruments	34,100	10,100	17,000	11,800	5,200	3,700	600	100	800	600	6,400
Miscellaneous manufacturing	5,700	2,100	2,900	1,600	1,300	1,200	100	-	-	-	700
Transportation, communication, and public utilities	80,000	11,600	56,800	54,200	2,600	900	-	800	900	-	11,600
Railroads	4,200	1,600	1,400	1,200	200	200	-	-	-	-	1,200
Other transportation	4,000	600	1,700	1,600	100	-	-	-	100	-	1,700
Telecommunications	33,100	1,800	29,100	28,300	800	-	-	600	200	-	2,200
Radio and television	15,000	-	12,800	12,800	-	-	-	-	-	-	2,200
Public utilities	23,700	7,600	11,800	10,300	1,500	700	-	200	600	-	4,300
Other industries	342,000	146,500	83,400	54,400	29,000	14,800	3,800	2,800	7,600	38,900	73,200
Miscellaneous business services	60,900	15,500	34,600	16,500	18,100	8,900	2,700	1,200	5,300	1,600	9,200
Medical and dental laboratories	26,800	-	-	-	-	-	-	-	-	24,400	2,400
Nonprofit institutions	13,000	1,300	4,700	1,900	2,800	1,100	500	600	600	6,200	800
Engineering and architectural services	186,500	122,000	15,500	13,600	1,900	700	300	200	700	200	48,800
Other nonmanufacturing	54,800	7,700	28,600	22,400	6,200	4,100	300	800	1,000	6,500	12,000
Government	250,700	28,600	161,200	100,700	60,500	22,100	5,000	2,100	31,300	30,500	30,400
Federal	122,000	5,400	92,400	46,200	46,200	14,800	5,000	1,600	24,800	21,900	2,300
State	92,500	11,300	56,000	43,900	12,100	5,600	-	400	6,100	7,000	18,200
Local	36,200	11,900	12,800	10,600	2,200	1,700	-	100	400	1,600	9,900
Colleges and universities	58,500	2,100	18,900	3,200	15,700	7,000	5,400	1,200	2,100	31,600	5,900

NOTE: Because of rounding, sums of individual items may not equal totals.

Table A-4. Percent distribution of projected 1980 employment requirements for technicians, by occupation and industry

Industry	Total technicians	Drafts-men	Engineering and physical science technicians							Life science technicians	All other technicians
			Total	Engineering technicians	Physical science technicians						
					Total	Chemical	Physics	Mathe-matics	Other		
All industries	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mining	0.8	0.9	0.5	0.4	0.8	0.4	-	-	1.7	-	1.8
Petroleum extraction	.5	.7	.3	.2	.4	.1	-	-	.9	-	.9
Other mining	.3	.1	.2	.2	.4	.3	-	-	.8	-	.9
Contract construction	3.6	7.1	1.5	2.0	.3	.4	-	1.0	-	-	5.2
Manufacturing	43.2	48.6	48.5	50.8	43.1	52.7	31.4	30.7	34.6	7.3	34.2
Ordnance	1.6	1.1	2.6	2.6	2.3	2.1	4.8	5.0	1.5	.3	.6
Food	.4	.2	.3	.1	.7	1.2	-	-	.2	1.0	.9
Textile and apparel	.3	.1	.3	.1	.6	1.0	-	-	.2	-	.8
Lumber and furniture	.7	1.7	.2	.2	.1	.2	-	-	-	-	.4
Paper	.7	.4	.9	.7	1.3	1.9	1.0	-	.8	.2	.8
Chemicals	3.9	1.2	5.3	2.1	12.8	22.8	2.9	1.0	3.2	4.7	4.5
Petroleum refining	.4	.2	.6	.5	.8	1.3	.5	-	.3	-	.8
Rubber	.5	.5	.6	.5	1.0	1.7	.5	-	.5	-	.7
Stone, clay, and glass	.6	.9	.5	.5	.5	.6	-	-	.5	-	.7
Primary metals	1.7	1.4	1.8	1.2	3.2	1.6	-	-	7.2	-	2.5
Fabricated metals	2.5	5.4	1.4	1.6	1.1	.9	1.0	2.0	1.4	-	1.1
Machinery	9.0	15.3	7.1	8.6	3.8	3.1	2.9	6.9	4.6	.2	6.4
Electrical equipment	12.6	11.1	17.2	21.3	7.7	6.6	10.6	7.9	8.2	.3	7.6
Motor vehicles	1.4	1.7	1.7	1.9	1.0	.8	1.0	1.0	1.3	-	.6
Aircraft	3.4	3.1	4.6	5.4	2.5	1.7	2.9	5.9	3.2	.1	1.9
Other transportation equipment	.7	1.5	.4	.4	.2	.1	-	-	.5	-	.3
Professional and scientific instruments	2.4	2.3	2.6	2.6	2.7	3.8	2.9	1.0	1.2	.6	3.1
Miscellaneous manufacturing	.4	.5	.4	.4	.7	1.2	1.0	-	-	-	.3
Transportation, communication, and public utilities	5.7	2.7	8.8	11.9	1.3	.9	-	7.9	1.4	-	5.6
Railroads	.3	.4	.2	.3	-	.2	-	-	-	-	.6
Other transportation	.3	.1	.3	.4	.1	-	-	-	.2	-	.8
Telecommunications	2.4	.4	4.5	6.2	.1	-	-	5.9	.3	-	1.1
Radio and television	1.1	-	2.0	2.8	.4	-	-	-	-	-	1.1
Public utilities	1.7	1.7	1.8	2.3	.8	.7	-	2.0	.9	-	2.1
Other industries	24.5	33.7	12.9	12.0	15.0	15.3	18.4	27.7	11.6	35.7	35.6
Miscellaneous business services	4.4	3.6	5.3	3.6	9.4	9.2	13.0	11.9	8.1	1.5	4.5
Medical and dental laboratories	1.9	-	-	-	-	-	-	-	-	22.4	1.2
Nonprofit institutions	.9	.3	.7	.4	1.5	1.1	2.4	5.9	.9	5.7	.4
Engineering and architectural services	13.4	2.8	2.4	3.0	1.0	.7	1.4	2.0	1.1	.2	23.7
Other nonmanufacturing	3.9	1.8	4.4	4.9	3.2	4.2	1.4	7.9	1.5	6.0	5.8
Government	18.0	6.6	24.9	22.2	31.3	22.9	24.2	20.8	47.6	28.0	14.8
Federal	8.7	1.2	14.3	10.2	23.9	15.3	24.2	15.8	37.7	20.1	1.1
State	6.6	2.6	8.7	9.7	6.3	5.8	-	4.0	9.3	6.4	8.8
Local	2.6	2.7	2.0	2.3	1.1	1.8	-	1.0	.6	1.5	4.8
Colleges and universities	4.2	.5	2.9	.7	8.1	7.3	26.1	11.9	3.2	29.0	2.9

NOTE: Because of rounding, sums of individual items may not equal totals.

Table A-5. Ratio of technician to science and engineering employment, by industry, 1966

Industry	Average number of technicians per 100 scientists and engineers
All industries	63
Mining	35
Petroleum extraction	30
Other mining	48
Contract construction	67
Manufacturing	58
Ordnance	32
Food	36
Textile and apparel	48
Lumber and furniture	168
Paper	42
Chemicals	39
Petroleum refining	42
Rubber	45
Stone, clay, and glass	53
Primary metals	64
Fabricated metals	82
Machinery	83
Electrical equipment	70
Motor vehicles	67
Aircraft	41
Other transportation equipment	113
Professional and scientific instruments	57
Miscellaneous manufacturing	66
Transportation, communication, and public utilities	108
Railroads	104
Other transportation	52
Telecommunications	171
Radio and television	214
Public utilities	73
Other industries	97
Miscellaneous business services	70
Medical and dental laboratories	1,321
Nonprofit institutions	44
Engineering and architectual services	105
Other nonmanufacturing	91
Government	75
Federal	63
State	109
Local	73
Colleges and universities	18

Appendix B

Coverage, Definitions, and Projection Methods

Coverage and definitions

The definition of technicians used in this report is the same used in the periodic surveys of scientific and technical personnel in private industry, and State and local governments conducted by the Bureau of Labor Statistics.

> Technicians are: Persons actually engaged in technical work at a level which requires knowledge of physical, life, engineering, or mathematical sciences comparable to knowledge acquired through technical institute, junior college, or other formal post-high school training less extensive than 4-year college training, or through equivalent on-the-job training or experience. All persons working as draftsmen and surveyors are considered to be technicians.

Excluded from coverage are: (1) Technicians who work with physicians, dentists, and other practitioners in the health fields who are engaged in patient care; (2) workers who fall in the "spectrum of middle level manpower" in business--related technologies and public services such as library assistants and legal secretaries;[1] and (3) workers classified as craftsmen such as instrument repairmen and mechanics.

Methodology

Estimates of 1966 employment. The estimates of total technician employment in this report were derived by aggregating separate estimates made for each of the six sectors of the economy for which technician employment data are collected—private industry, the Federal Government, State governments, local governments, nonprofit organizations,[2] and colleges and universities.[3] For the private industry sector, a survey of scientific and technicial personnel (SPT) was conducted in 1966 by the Bureau of Labor Statistics. Published data from this survey differ slightly from estimates used in this study because adjustments were made to include those technicians in frims below a minimum specific size that were excluded from the survey. In total, adjustments for these "cutoffs" were made in 10 of the 31 industry groups for which separate estimates were developed in this study. The following tabulation shows the industries for which adjustments were made.

The most current employment data on technicians employed in State governments at the time this study was prepared were collected for 1964 by the Bureau of Labor Statistics. The most current data for local governments is

Industry	Number of employees in smallest size of firm sampled
Food and kindred products	10
Textile mill products and apparel:	
Textile mill products[1]	50
Apparel[1]	100
Paper and allied products	10
Rubber and miscellaenous plastics products	10
Stone, clay, glass, and concrete products:	
Hydraulic cement[1]	10
Stone, clay, and glass products[1]	4
Lumber and furniture	50
Contract construction	4
Miscellaneous manufacturing:	
Tabacco manufactures[1]	50
Printing, publishing, and allied industries[1]	100
Miscellaneous manufacturing industries[1]	10
Mining, except petroleum	10
Other transportation services:	
Local passenger transportation[1]	100
Trucking[1]	10
Water transportation[1]	10
Air transportation[1]	100
Pipeline transportation[1]	50

[1] A separate employment estimate was not developed for this industry.

Footnotes appear on p. 28.

for 1963, which also were collected by the Bureau. The data on technicians employed in colleges and universities are for 1965 from a survey conducted by the National Science Foundation (NSF) as were data on those employed in nonprofit organizations. Technician employment in the Federal Government in 1966 was obtained from the U.S. Civil Service Commission.

In sectors where 1966 survey results were not available, adjustments to available data were made to place all sectors on a comparable time basis. For example, estimates of employment of technicians in State governments in 1966 were based on a trend analysis of information in the BLS surveys of scientific and technical personnel in State governments in 1959, 1962, and 1964,[4] augmented by an analysis of the historical ratios of technicians to scientists and engineers in this sector. The scientist and engineer estimates used in the analysis were obtained from a study prepared by the NSF and the Bureau of Labor Statistics.[5] The knowledge gained from that study also was incorporated in the development of technician estimates. This same general methodology was followed to develop technician employment estimates for the local government, colleges and university, and nonprofit organization sectors.

Occupational distributions. Nine separate occupational categories for technicians are shown in this report for 1966. They are as follows: (1) Draftsmen, (2) electrical and electronic engineering technicians, (3) other engineering technicians, (4) chemical technicians, (5) physics technicians, (6) mathematics technicians, (7) other physical science technicians, (8) life science technicians, and (9) all other technicians.

However, each of the various surveys used to develop the 1966 employment estimates did not provide this degree of occupational detail. In surveys of private industry conducted by BLS, seven different categories are detailed; only three categories are presented in the college and university surveys. The occupational detail available in the different industry sectors surveys is shown below:

Private industry:

> Draftsmen, surveyors, electrical and electronic technicians, other engineering and physical science technicians, biological and agricultural technicians, medical and dental technicians, other technicians.

Federal Government:

> About 35 job titles used by the U.S. Civil Service Commission, such as draftsmen, electronics engineering technicians, mathematics technicians, biological technicians.[6]

State and local government:

> Draftsmen, surveyors, engineering technicians, physical science technicians, biological technicians,[7] medical and dental technicians, other technicians.

Nonprofit organizations

> Engineering and physical science technicians, life science technicians, other technicians.

Colleges and universities:

> Engineering and physical science technicians, life science technicians, other technicians.

In developing a comparable classification of occupational specialties for each of the six industry sectors, the occupational classification for draftsmen, life science technicians, and all other technicians were similar, and totals were readily available from the survey data. However, for the largest portion of all technicians, "engineering and physical science technicians," an employment distribution for the following occupational categories had to be derived:

1. Engineering technicians
   a. Electrical and electronic technicians
   b. Other engineering technicians
2. Chemical technicians
3. Physics technicians
4. Mathematics technicians
5. All other physical science technicians

The breakdown of the engineering and physical science group by more detailed occupational classifications was based on information from a postcensal survey.[8] However, the postcensal survey did not allow for a distribution of technicians by industry of employment. To develop estimates of employment in the more detailed occupational classifications by industry, it was necessary to use a statistical analysis suggested by Bureau statisticians which involved relating the postcensal data to estimated employment of all engineering and science technicians in each industry. (See *Technician Manpower: Requirements, Resources and Training Needs,* Chapter II, for additional information.)

Projecting technician manpower requirements. In general, a three-phase method was used to project technician manpower requirements.

In the first phase, projections were developed of employment requirements for wage and salary workers by industry as part of the Bureau's program of projecting

industry manpower requirements for the entire economy. These projections were based on general assumptions concerning the nature and composition of the economy in 1980. The major assumptions underlying these projections include: A national unemployment rate of 3 percent; a continuation of high rates of economic growth; continuing growth of research and development (R&D) expenditures, although at a slower rate of growth than shown in the late 1950's and early 1960's; a level of defense and space activities in the target year approximating those of 1963, somewhat higher than the levels before the Viet Nam buildup; and scientific and technological advances in recent years will continue at about the same rate.

The second phase of the projection method developed the ratio of scientists and engineers to total wage and salary worker employment, by detailed industry sector and for each year from 1950-66. These ratios were derived from published data on science and engineering employment by industry[9] and historical BLS wage and salary worker employment data.[10] The ratio of scientists and engineers to wage and salary workers in each industry was projected to 1980 on the basis of the past trend and applied to the 1980 estimates of wage and salary worker employment requirements, by industry, to yield first approximations of scientist and engineer manpower requirements. These first approximations were examined for reasonableness and consistency based on factors such as an analysis of trends in R&D and defense activities by industry, and the levels of such activities assumed in the industry employment projections.

The third phase developed ratios of technician employment in each occupational specialty to employment of scientists and engineers in related occupational specialties for 1966 and for as many earlier years as was possible from available data. They were developed for eight occupational categories and for each major industry sector and for 30 industries within the private sector. Projected 1980 employment requirements were not developed either for electronic and electrical engineering technicians or other engineering technicians because only 1966 employment and no trend data were available for these occupational classifications. The following list details the technician specialities, and specific scientific and engineering occupations to which they were related.

Technician occupation	Scientists and engineers
Draftsmen	Engineers
Engineering technicians	Engineers
Life science technicians	Life scientists
Mathematics technicians	Mathematicians
Chemical technicians	Chemists
Physics technicians	Physicists
Other physical science technicians	All scientists and engineers
All other technicians	All scientists and engineers

The ratios of technicians to scientists and engineers, by occupational specialty and industry, then were projected to 1980. The projected ratios were based primarily on past trends but were adjusted to reflect factors expected to influence the utilization of technicians relative to science and engineering manpower in the future, such as the functional distribution of scientist and engineer employment.[11]

Estimates of death and retirement losses to the occupation were developed by applying appropriate separation rates to the age distribution of the occupation. Separation rates resulting from retirements and deaths were developed from a series of tables of working life prepared by the U.S. Department of Labor[12] which follows through successive ages the experience of an initial cohort of 100,000 births.

Transfers out of the occupation may be measured either by followups of persons completing training for an occupation or by followups of a large group of individuals currently employed in an occupation.[13] For technicians, the transfer rate was developed primarily using the latter method.[14]

Estimating supply of technician manpower. In each of the different analyses of supply in this study, estimates of the number of workers who would enter technician occupations during the 1966-79 period under the stated assumptions were developed separately for each of the following sources of entry: Preemployment training in post-secondary occupational curriculums, employer training programs, and training programs provided under the Manpower Development and Training Act; technician-related training in natural science and engineering bachelor's degree curriculums in colleges and universities or in the Armed Forces; and workers upgraded from other occupations. For each source of supply (except upgradings), the basic technique used to estimate supply involved the following: The development of estimates for each year from 1966 to 1979 of (1) the number of persons completing the training, and the proportion of those who complete the training who will enter technician employment; and (2) the number of new entrants during 1966-79 period who will leave the occupation by 1980 because of death, retirement, or transfer to another occupation. The latter estimates were deducted from the total number of new entrants during the 1966-79 period to develop net supply in 1980. Estimates of the number of workers to be upgraded were estimated as the difference between total requirements for technicians and projected entrants from all other sources.[15]

—FOOTNOTES—

1 See *Technical Education in the Junior College, New Programs for New Jobs,* Norman C. Harris, American Association of Junior Colleges, 1964.

2 The nonprofit sector includes philanthropic foundations; voluntary health agencies; independent nonprofit institutions; certain Federal contract research centers; professional and technical societies; and science museums, zoological and botanical gardens, and arboritums.

3 Data are collected for early year employment in most of these surveys and, therefore, the estimates of current employment and projected 1980 requirements are early year estimates.

4 *Employment of Scientific and Technical Personnel in State Government Agencies, Report on a 1959 Survey,* National Science Foundation, NSF 61-17, 1961; *Employment of Scientific and Technical Personnel in State Government Agencies, 1962,* (BLS Bulletin 1412), June 1964; *Employment of Scientific, Professional, and Technical Personnel in State Governments,* January 1964 (BLS Bulletin 1557), 1967.

5 *Employment of Scientists and Engineers in the United States—1950-1966,* National Science Foundation, NSF 68-30.

6 See *Occupations of Federal White-Collar Workers, October 31, 1966,* U.S. Civil Service Commission, 1968.

7 Included with agricultural technicians in local government surveys.

8 Postcensal Survey of Professional and Technical Personnel. See *Technician Manpower: Requirements, Resources and Training Needs* for more information on the postcensal survey.

9 *Employment of Scientists and Engineers 1950-66, op. cit.,* footnote 4.

10 *Employment and Earnings Statistics for the United States, 1909-68* (BLS Bulletin 1312-6), August 1968.

11 The ratio of technicians to scientists and engineers differs among functions, as was illustrated by a study of the aerospace industry conducted by the Stanford Research Institute, *The Industry - Government Aerospace Relationship, Vol. II--Supporting Research,* prepared for Aerospace Industries Association of America, Inc., by Stanford Research Institute, Menlo Park, California, 1963. For a more detailed explanation of the method used to project technician manpowr requirements, see *Technician Manpower: Requirements, Resources, and Training Needs,* ch. IV, pp. 43-57.

12 *The Length of Working Life for Males, 1900-1960* (U.S. Department of Labor, Manpower Administration, 1963), Manpower Report 8.

13 The first method is illustrated in *Two Years After the College Degree--Work and Further Study Patterns.* The second method is illustrated in the *Postcensal Survey of Professional and Technical Personnel.*

14 For a more detailed explanation of the methods used to estimate losses to an occupation, see "Projections of Manpower Supply in a Specific Occupation," *op. cit.,* footnote 16.

15 For a more detailed explanation of the method used to estimate technician supply, see ch. V in *Technician Manpower: Requirements, Resources, and Training Needs, op. cit.,* pp. 58-77, footnote 11.

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