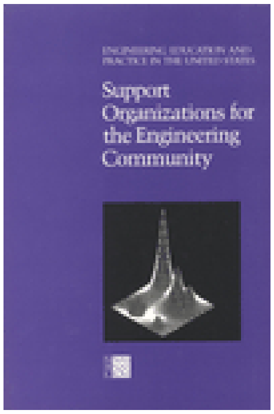

Support Organizations for the Engineering Community

Panel on Support Organizations for the Engineering Community, Committee on the Education and Utilization of the Engineer, National Research Council

ISBN: 0-309-58164-8, 80 pages, 6 x 9, (1985)

Engineering Education and Practice in the United States

Support Organizations for the Engineering Community

Panel on Support Organizations for the Engineering Community
Committee on the Education and Utilization of the Engineer
Commission on Engineering and Technical Systems
National Research Council

NATIONAL ACADEMY PRESS
Washington, D.C. 1985

NATIONAL ACADEMY PRESS 2101 Constitution Ave., NW Washington, DC 20418

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Support for this work has been provided by the National Science Foundation, the Department of the Air Force, the Department of the Army, the Department of Energy, the Department of the Navy, and the National Aeronautics and Space Administration. Additionally, assistance has been provided through grants from the Eastman Kodak Company, Exxon Corporation, the General Electric Company, the IBM Corporation, the Lockheed Corporation, the Monsanto Company, and the Sloan Foundation.

Library of Congress Catalog Card Number 85-62632

ISBN 0-309-03629-1

Printed in the United States of America

Preface

The Panel on Support Organizations for the Engineering Community was one of the subcommittees of the National Research Council's Committee on the Education and Utilization of the Engineer. The report of the parent committee has been published;* the work of this panel is presented in this report and should be considered as part of the larger committee effort. In many cases, the findings and work of other subcommittees were used as the basis for the work of this panel.

The panel's initial goal was to identify and examine the support organizations that exist to meet the needs of both individual engineers in performing their specific tasks and the community of engineers in contributing to society as a whole. However, the panel perceived that the identification of those current and projected needs of engineers that affect their ability to perform was fundamental to any meaningful evaluation of support organizations.

Recognizing that the nature of the study precluded an exhaustive investigation, the panel nevertheless set forth to identify those needs that appeared to be most significant to individual engineers and also those that emerged as concerns expressed by the profession as a whole. The identification and evaluation of the support mechanisms existing

* *Engineering Education and Practice in the United States: Foundations of Our Techno-Economic Future* (Washington, D.C.: National Academy Press, 1985).

or required to address these needs then followed as a logical outgrowth of this first effort. In this identification, the panel made no effort to be exhaustive and precise in enumerating all specific organizations; rather, references were to generic classes or illustrative examples of organization types.

Where support organizations did not exist to meet expressed needs, this lack was noted. On the other hand, it was considered beyond the scope of this panel's work to propose new support organizations or to provide extensive evaluations or critiques of existing groups.

The panel was organized into five task force work groups, each dealing with a different sector of the engineering profession: (1) academia, (2) government, (3) industry, (4) private practice, and (5) society at large. Each of the task forces considered factors that related both to the sector and to individuals working within the sector.

Once the study was under way, the panel decided to address the needs and support mechanisms of the society-at-large sector in a different fashion because it was characterized by unique and diversified issues. Furthermore, limited time permitted addressing only the media-related segment of this area. Time constraints also precluded an extensive consideration of legislative/regulatory/ societal organizations and their impacts on the engineering community. Thus, these issues are clearly identified in the various sector reports as being of critical importance and are suggested as an area of further study.

Thanks are extended to all those who contributed to the deliberations of the panel. Particular appreciation is expressed for the leadership of the chairmen of the individual task forces and to Paula B. Wells for her contribution in the preparation of the report. The wisdom and insight of Jerrier A. Haddad and William H. Michael, Jr., were of great value in the integration of the panel's efforts into the work of the parent committee.

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NEEDS OF THE ENGINEERING PROFESSION

Common Sector Needs

Many engineering support needs were found to be common to all the sectors—academia, government, industry, private practice, and society at large —studied by the Panel on Support Organizations for the Engineering Community. In a number of instances, the support mechanisms themselves were also common. Because of their shared nature, a brief discussion of these common needs and concerns seems appropriate.

Technical Competence.

Maintaining technical competence has a high priority for practicing members of the engineering community. This issue has become increasingly critical because of the ever-accelerating expansion of scientific and technical knowledge. This need not only manifests itself in the effective execution of state-of-the-art engineering work, but in the informed review and quality control of such work. Interestingly enough, practicing engineers express little need for continuing education resulting in academic credit. Short courses, seminars, and workshops appear to be regarded as the most effective mechanisms for providing continuing technical education opportunities. It must be recognized, however, that 1-or 2-day seminars merely skim the surface of a new technology. To be successful, they must leave the engineer motivated toward further study and well informed concerning additional technical or instructional resources.

A number of support organizations address this need. Their effectiveness depends upon the investment of time, effort, and money that individual engineers or the employer are willing to dedicate. Typical support organizations include professional societies, technical societies, educational institutions, trade associations, and government agencies.

Information Exchange.

The rapid, simultaneous, and multifaceted advances occurring in scientific and technological knowledge have resulted in a formidable information overload for practicing engineers. The wealth of technical literature is overwhelming and increasingly unmanageable due to volume and diversity. Yet engineers are expected, practically instantaneously, to know of, understand, and use new concepts, new material, and new constraints.

Fortunately, as the volume of rapidly changing technologies grows, communication means are also improving rapidly. Computer/word-processing systems can now transfer vast amounts of information, and access to such information is becoming more readily available.

This rapid trend toward computerization has resulted in a major corollary need: technical competence in the computerization process itself. This need is particularly significant to practicing engineers who were not exposed to computer skills as part of their academic background.

The support organizations that must meet this need are similar to those related to maintaining technical competence, and include the professional and technical societies, educational institutions, government agencies, and the media.

Professional Development.

Engineers regard themselves as professionals and as such feel a need to associate with their colleagues for the purpose of strengthening their profession as a whole, identifying and resolving common problems, presenting a positive image of engineering to the general public, examining opportunities for career development, developing policy statements related to their profession, and sharpening their professional skills.

Engineers also have an ongoing need to maintain a strong sense of pride and continue the contributions to society that are hallmarks of the engineering profession. This atmosphere requires interaction among the various engineering disciplines employed in the various sectors of the engineering community.

Frequently, the urgency of maintaining technical competence over shadows the need to enhance the stature and contribution of the profession as a whole. The professional and technical organizations must take the lead in meeting this need, although engineering educational institutions also should seek to establish the concept of professionalism as part of the educational process.

Professional Standards.

Professional standards and ethics are subjects of major concern to all engineers, in regard to both intraprofessional conduct and responsibility to the public. Differing from the question of general ethics, which involves basic philosophical questions about human existence, professional ethics involve guidelines for the solution of ethical problems related to the practice of a profession, problems that arise from day to day for its members. Codes of ethics have been developed by the various technical and professional engineering organizations, but a strong need for review, interpretation, and discussion of these standards appears to exist within all engineering sectors, either in the sector as a whole or in its individual engineers. This need has been accentuated by isolated but widely publicized instances of unethical conduct on the part of prominent engineers.

There also appears to be an acknowledged need for greater emphasis on ethics within the engineering college curriculum. Engineering students generally demonstrate a high degree of interest and concern when given the opportunity to discuss ethics within the profession.

The professional and technical societies are the basic resources for promulgation and monitoring of codes of practice and ethical conduct. State registration laws provide the legal framework for enforcement of those standards affecting public welfare and safety, but the question of intraprofessional ethics and conduct is frequently outside that domain.

Existing support organizations include professional and technical societies, engineering educational institutions, state legislatures, and state boards of registration.

Specific Sector Needs

Although sharing these common concerns, each sector of the engineering profession is also characterized by a unique set of needs. For example, marketing development skills are vital to the engineer in private practice and in some types of industry but of lesser concern to engineering college faculty or government employees. On the other hand, opportunities for attending professional meetings and seminars may be much more limited for faculty and government engineers because of legislative, funding, and/or administrative regulations.

Financial compensation is another example of varying needs. The marketplace generally determines pay scales in the private sector, while compensation in the public sector (government or academia) is usually determined by legislation.

Some needs, while common in a general sense, are sector-specific with regard to priority and significance. Management capability, for example, is noted as an essential skill by all sectors, particularly as related to ongoing career development. The private practice group, however, viewed this need as absolutely critical to the continued viability of the sector itself. Because of this intense concern, it is included as a specific concern of private practice engineering.

It is interesting to note that the needs of one sector of the engineering profession may potentially conflict with the needs of another sector. Although government-employed engineers express a desire to increase their state-of-the-art technical competence by performing hands-on technical work, negative pressures are exerted by engineers in private practice who regard this type of technical involvement as competition and therefore threatening.

The following summary presents those specific needs identified as significant to a particular sector of the engineering community. (These needs are in addition to the common needs and concerns previously described.) Detailed discussion of the rationale supporting each sector-specific need, as well as the major support organizations and mechanisms required to meet those needs, is included in later chapters of this report.

Academic Sector.

The Academic Sector Task Force, comprising representatives of both academia and other areas, identified the needs and support organizations and mechanisms felt to be most important for both the individuals within the academic community and/or the academic community as a whole. These were as follows:

1. Improved identification and description of engineering as a profession and preparation for success with engineering curricula for primary and secondary school students.
2. Establishment of pre-engineering program structure and standards for junior, community, and other colleges.
3. Meeting the financial needs of undergraduate and graduate engineering students, which are intensified by the rigor and duration of engineering degree programs.
4. Availability of high-quality, effective, up-to-date curricula for undergraduate and graduate students.
5. Improved financial compensation packages for engineering faculty.

6. Provision of adequate instructional support resources for engineering faculty, including physical facilities, support staffs, and equipment.
7. Support to maintain continued technical competence, professional recognition, opportunities for advancement, and assurance of stability.
8. Administrative and operational support for engineering educational institutions.
9. Long-range planning for engineering education institutions.

Government Sector.

The Government Sector Task Force comprised federal, state, and local government engineers who have been addressing similar issues on a continuing basis. The group identified a number of primary needs and the support mechanisms to fulfill such needs both for the individual engineer and for the entire engineering profession within the government sector. In establishing these primary needs, the various levels of government—federal, state, and local—were recognized, and those needs pertinent and common to all levels were given priority. A list of those needs follows:

1. Attainment of requisite management skills to enable discharging the supervisory and administrative responsibilities inherent in public administration.
2. Attainment of communication skills to enable effective interchange with the public.
3. Maintenance and enhancement of technical engineering skills in the face of a lack of incentives and indifference by nontechnical management.
4. Enhancement of professional development to permit generating and maintaining an atmosphere of trust and confidence with the public.
5. Recognition of the contribution of government engineers in protecting the health and welfare of the citizenry through public works.
6. Opportunities to perform sufficient in-house technical engineering tasks to permit maintenance of technical capability, while continuing to utilize an appropriate level of engineering resources from the private sector.
7. Improved working climate, including job stability, opportunities for advancement, salaries, and personnel operating regulations.
8. Development of necessary skills in establishing and administering policy to serve the public interest more effectively in a regulatory role.

9. Additional interface between engineers in the private sector and those in government to facilitate better understanding.

Industry Sector.

Because of the diversity and magnitude of the industry segment of the engineering community, this task force utilized questionnaires as a means of obtaining a consensus regarding the needs of the engineer in industry. Five specific industry groups were included in the survey: aerospace, aluminum (metal processing), chemical/petroleum, electric power generation, and electronics/computing.

An attempt also was made to include the automotive and steel industries, but their particular circumstances during the time frame in which the survey was conducted precluded their participation. In addition, representatives of the construction industry were provided with the results of the survey and subsequently expressed concurrence with the conclusions.

A basic study questionnaire was developed by the task force and distributed through key individuals to the various industry groups. These individuals, in turn, probed the viewpoints of both management and practicing engineers with regard to needs and available support organizations. Seventy-five companies responded to the questionnaire. The results were analyzed to determine which needs were perceived as most important, as well as to identify the key support organizations. Several of the needs expressed in the questionnaires were also identified by other sectors, including technical training, increased emphasis on professional standards, and professional development. The additional needs stressed by the industry sector are as follows:

1. Opportunities and techniques for open communication and data exchange between companies to encourage advancement of technology while maintaining competitive and proprietary positions.
2. Research and development capital for high-risk but potentially high-benefit engineering projects.
3. Opportunities to obtain positive visibility and appreciation from other professionals and the public for engineering achievement.
4. Recruitment opportunities to identify and acquire qualified personnel to fill engineering positions.

Private Sector.

The Private Sector Task Force comprised both consulting engineers and key staff representatives of two professional organizations. Together they reached a consensus regarding the primary needs of engineers in private practice, resulting both from concerns common to all sectors and from issues unique to this group.

This sector is somewhat unusual in that the engineering component of each firm is the complete organizational entity; it is not a segment of a larger organization, as in the case of the government, industrial, and academic sectors. The constraints on engineers in this sector are generally external, and resolving those constraints involves the organization as a whole.

In addition, most private practice engineering firms are small businesses; 80 to 85 percent have fewer than 26 employees. In such firms, the principals/owners are both the technical experts and the business managers. The following list of specific needs reflects these special characteristics of the private sector:

1. Development of management skills essential to maintaining a profitable operation.
2. Education and training of consulting engineering firms in techniques and strategies that will permit them to successfully compete both with their peers and with the growing number of private companies and public agencies currently offering to provide services that were once the exclusive province of the consulting profession.
3. Development of adequate risk management tools to enable engineers in private practice to minimize exposure to risk, to avoid claims for damages, and to defend themselves in the event of litigation.
4. Guidance and assistance in achieving versatility and profitability while maintaining integrity and objectivity in the face of significant change related to nontraditional interpretation of the roles of the private practice engineer.

SUPPORT ORGANIZATIONS FOR THE ENGINEERING PROFESSION

Common Sector Support Organizations

Since there is a strong thread of commonality of needs in the various sectors, the accompanying commonality of support organizations is not surprising. Furthermore, these same support organizations play a major role in addressing the needs specific to each particular sector.

One of the most interesting and perhaps most important findings of this study is the degree to which the engineering community is dependent upon various components of society at large for responses to its needs.

Government, both legislative and administrative at all levels; broad-spectrum educational institutions; financial and legal entities; the media, written and electronic—all of these entities play a significant role in the support (or lack of support) of the engineering community. Through all sectors, the dependence on support from organizations in the society at large is apparent. The broad development of concepts and approaches by which this support can be generated or increased is beyond the scope of this study. However, the general lack of public understanding and appreciation of engineers and engineering is discussed in the chapter on society at large. Furthermore, the report of that task force concludes that there is a major information gap with regard to engineering and technology; the media often have trouble producing accurate information related to scientific or technological data. The single biggest problem in overcoming this information gap is perceived to be the media's lack of easily accessible sources—responsible experts able and willing to answer questions, articulately and factually, on the fast-breaking developments in our increasingly technological society.

The panel took special note of the role played by voluntary engineering associations and societies in support of both the individual engineer and the engineering profession. There are over 50 individual societies and associations at the national/international level representing the interests of and providing support to engineers and engineering. Typical of the support provided are development and dissemination of technical information; continuing education seminars, symposia, and home study; salary surveys and employment guidelines; general news and information about the profession, a specific technology, or area of practice; college scholarships in engineering; precollege guidance; representation of engineering interests in public policy before legislatures and government agencies; public information about engineers and engineering achievements; honors and awards for engineers and engineering; employment referral services; setting of technical standards for engineering practice; assistance on matters relating to engineering practice; personal and business services (insurance, car rental, etc.); developing and enforcing standards for engineering education; and many more, depending on the interests of members.

The engineering societies and associations fall into four major groupings. First, there are those focused primarily on an established or emerging engineering discipline. The American Society of Civil Engineers, American Society of Mechanical Engineers, Institute of Electrical and Electronics Engineers, and the American Institute of Chemical Engineers are commonly referred to as the "founder societies"; they are the foremost examples of this first group. Such societies traditionally have been most concerned about promoting the exchange of technical information in the discipline concerned. Concurrently, they have engaged in technical and professional activities of interest to their members, including establishing technical standards, setting standards of professional conduct, promoting the public image of engineers and engineering, ensuring the quality of engineering education pertaining to their discipline, and many other matters, depending on the interest of their members at any given point.

The second group of engineering societies and associations are those focused on practice in a broad occupational field. Examples in this category are the Society of Automotive Engineers, American Institute of Aeronautics and Astronautics, American Society for Agricultural Engineering, American Society of Naval Engineers, American Institute of Plant Engineers, American Railway Engineering Association, and American Society for Engineering Education, among others. This group develops and promulgates technical and nontechnical information about engineering practice within the occupational area concerned, but also engages in other technical and professional activities based on the interests of its members.

The third and fastest-growing group includes those organizations focused on a specific technology or group of technologies or upon one of the specific materials or forces of nature referred to in classical definitions of engineering. Examples of this group are the American Society of Metals; American Society for Heating, Refrigerating, and Air-Conditioning Engineers; Society for Plastics Engineers; American Nuclear Society; American Welding Society; American Society of Safety Engineers; Society of Manufacturing Engineers; Association of Energy Engineers; and many others. They engage in activities to promote the development and sharing of the body of engineering and scientific knowledge necessary to their specific technologies and, as do the others, pursue other technical and nontechnical goals in accordance with the interests of their members.

The final group is composed of those associations and societies formed either by individual engineers or by groups of societies to accomplish a specific purpose. The National Society of Professional Engineers was formed to promote the professional and nontechnical interests of engineers and the profession with emphases on professional standards (registration and ethics), the image of engineering, the quality of engineering, and involvement in public policy. The Accreditation Board for Engineering and Technology (ABET) was formed to accredit engineering education programs and to serve as the quality control mechanism for engineering education. The National Council of Engineering Examiners (NCEE) was formed to coordinate the state licensing process.

From time to time, attempts have been made to form an umbrella organization to represent the entire profession, much as the American Medical Association is seen by some as representing the entire medical profession. However, given the diversity of interests and purposes of the individual engineering societies and associations noted above, umbrella or unity engineering organizations have achieved mixed results. The major difficulty appears to be in deciding on which issues and by which methods the umbrella should represent the profession. The recent restructuring of the American Association of Engineering Societies (AAES) appears to be merely an extension of past experiences.

Both on purely technical issues and on nontechnical public policy issues, there are almost always a variety of possible options that respective elements of the profession may consider acceptable and even preferable. It is difficult to distill all options to produce a single solution for which an umbrella group can represent the entire profession. The diversity of views expressed by individual engineering societies is most often complementary or equally acceptable. Seldom is there outright contradiction. Furthermore, it is doubtful whether distillation of options to produce a single solution is even possible, given the nature of engineering. And, if it were possible, it is uncertain whether it is desirable. The panel has therefore concluded that an umbrella engineering society is not likely to be a major support mechanism in the near future.

It is estimated that approximately 50 national/international engineering societies and associations represent approximately 1 million of the 1.4 million practicing engineers in the United States (see the report of the Panel on Infrastructure Diagramming and Modeling). That estimate, however, results from an aggregation of the individual memberships of the societies and does not take into account overlapping memberships. For example, it is not uncommon for an engineer to hold memberships in as many as five separate engineering societies or associations, depending on his or her individual interests or needs. No known purging of overlapping memberships among the engineering societies has been accomplished; however, a reasonable estimate of the actual number of engineers represented by professional/technical engineering societies is 400,000 to 600,000. If this estimate is accurate, it means that only about one-third of the practicing engineers in the United States have direct access to the support offered by those societies.

Because the activities of professional/technical engineering societies reflect the interests of their members, it is not surprising that the panel discovered no overriding discontent as to their support for individual engineers or for the profession.

The significant conclusion of the panel is that professional/technical engineering societies, as voluntary associations of their members, have reflected and will continue to reflect the interests of those members. As such, they are dynamic organizations whose activities vary as their member interests vary. Their form, composition, and activities are appropriately determined from within and are not readily subject to prescription by outside groups, unless that prescription reflects on active or latent interest of the members.

Specific Sector Support Organizations

Review of the sector-specific support organizations identified verifies the strong role played by the professional and technical societies. Their functions are not only related to those technical needs unique within the sector but to the relationship of the sector to the society at large. An additional commonality is evident in those nonengineering support organizations identified by each sector task force.

Academic Sector.

A number of support organizations have been identified that attempt to respond to the needs of the academic sector:

Organizations	
Professional/technical societies	Engineering institutions
Legislative bodies/lay boards	University/college administrations
Government agencies	
Private foundations	Industry
Media	ABET
Mechanisms	
Model curricula	Program standards
Industrial interaction	Co-op internship programs
Grants and scholarships for tuition	Program funding
	Sponsored research
Accreditation standards	Professional/technical meetings
Grants and subsidies for programs	TV and radio
Publications	

Here, as in the case of the government sector, many of the needs of engineers in academia must be met by organizations external to the engineering community. Of particular importance is the support provided through the allocation of adequate resources for sound engineering programs. Also important is the correct interpretation of engineering and the engineering curriculum to potential students and their advisors and counselors.

Government Sector. The support organizations and mechanisms that exist for meeting the various special needs of the engineer in government include the following:

Organizations

Employing organizations	Professional/technical societies
Educational institutions	Media
Trade associations	Legislative bodies

Mechanisms

Academic curricula	Conferences and seminars
Continuing education courses	Hands-on training
Professional meetings	Public acknowledgment and support
Improved compensation packages	Streamlined regulations
Interactions with nonengineers	Codes of ethics
Work standards	

The number of support organizations outside the engineering community is significant. The government engineer is particularly dependent upon positive attitudes in society at large for a good working climate and for recognition of work well done.

Industry Sector. The industrial sector identified the following key support organizations and mechanisms:

Organizations

Employing organizations	Professional/technical societies
Government agencies	Investment groups

Mechanisms

Workshops/seminars	Guidance programs
Technical publications	Tax incentives
Grants	Loans
Achievement awards	Press releases/documentaries

An important function of external support organizations required by the industrial sector is the acknowledgment of the contributions of industry to the quality of life and growth of the economy and the corresponding recognition of what makes these contributions possible.

Private Practice Sector. The key support organizations and mechanisms identified by the private sector include the following:

Organizations	
Professional/technical societies	Trade associations
Educational institutions	Liability insurance carriers
Investment bankers	Legislative bodies
Government agencies	
Mechanisms	
Continuing education	Technical literature
Seminars/short courses	Model contract documents
Academic curricula	Procurement procedures

The private sector is affected significantly by the public at large, which in effect is its clientele. Consequently, support organizations play an important role in advising the public of the role of consulting engineers and in documenting the positive contribution of this sector of the engineering community.

CONCLUSIONS

The detailed work of the Panel on Support Organizations for the Engineering Community has been documented in a series of reports that present the findings of each sector task force (Chapters 1 through 5). For an understanding of the needs and support organizations for each sector, the reader is directed to these chapters. However, a number of significant general conclusions can be drawn from these reports:

1. A wide variety of needs exist for each sector of the engineering community, which must be met by specific types of support organizations.
2. There is a significant degree of commonality in the statement of needs of each sector, substantiating the concept of engineering as a unified profession despite the wide diversity of engineering skills and knowledge.
3. Similarly, there are many support organizations that serve the broad needs of the engineering community.
4. Each sector of the engineering community must deal with a unique set of constraints and influences; as such, each possesses special needs that must be met through its own network of support organizations. Many support organizations, however, are responsive to needs in several sectors.
5. The technical/professional organizations appear to be quite effective in meeting the needs of the engineering community. To a fair

extent, however, the effectiveness of their support is based upon the participation of the organization's membership or on the ability of the organization to communicate to nonmembers the availability of the support mechanisms.

6. The nonengineering support organizations are felt to be much less effective in meeting the needs of the engineering community, largely due to a lack of comprehension of what constitutes engineering, an adverse perception of how engineering has served or is serving the public, or a failure to understand the needs that exist in the engineering community.
7. Magnifying the problem of inadequate nontechnical support is the fact that the engineering profession is highly influenced by the public sector in the manner and extent to which it contributes to society. Legislative, financial, regulatory, and administrative constraints of the society at large are present for every sector, and the degree to which they affect the optimum use of engineering skills and knowledge is of major concern to the profession.
8. Engineers and engineering have not received media coverage reflecting the quantity and quality of their contributions to society, principally because of the current lack of access by journalists to credible sources of information.
9. Similarly, the educational institutions are playing an active and effective role in meeting the needs of the engineering community. However, individual organizations often have geographical or other constraints on the breadth of the population they can serve. Furthermore, in continuing education a dichotomy exists between academic emphasis on degree programs and the practicing engineer's need for training by means of short courses, seminars, etc., which are generally nondegree programs.
10. Trade associations are particularly supportive in the industrial sector and most frequently affect the activities of the profession as opposed to the individual engineer.

RECOMMENDATIONS

1. Effective, long-range contributions to society by the individual engineer and the engineering profession are highly dependent upon improved support from society at large. New and innovative approaches must be developed for this long-recognized but inadequately addressed need. The technical/professional societies, the National Academy of Engineering, and other organizations in the engi

neering community should give particular emphasis to this area in establishing their priorities and programs.

2. The engineering community should take immediate steps to develop a national network that would provide journalists with access to information about engineers and engineering. The National Academy of Engineering appears to be a strong candidate for the leadership role in establishing such a network.
3. Although in most cases there does not appear to be a need to form new types of support organizations, many of the existing organizations and the accompanying mechanisms critically affect the ability of engineers to contribute to society. These organizations should continually reexamine their programs for adequacy in terms of the changing needs of the engineering profession. They should also look beyond their current constituencies, seeking ways to broaden their availability and service to the engineering community as a whole.
4. The issue of the technology explosion as it affects the ability of the engineering profession to optimize its contributions to society should be considered an item of major concern. Existing organizations should reevaluate methods for providing better access to their support for the individual engineer; they should also provide for communication and discussion of the implications of such an explosion to society at large.

1

The Academic Sector

The Academic Sector Task Force focused its efforts on two issues: identifying those needs of engineers that relate to academia and identifying and evaluating the support organizations/mechanisms it felt were most important for individuals within the academic community and the academic community as a whole. This chapter presents the findings of the task force, which are summarized in the sections below. Each section discusses a need (or needs) identified by the task force, existing support organizations/mechanisms relating to that need, and recommendations for improving the support currently being provided.

THE NEED TO INFORM PRECOLLEGE STUDENTS ABOUT ENGINEERING

Most precollege students have a limited understanding of engineering as a profession, in part because most precollege faculty and counselors do not have enough information on the subject to advise their students effectively. As a result, many students are ill-prepared to enter engineering curricula. Both of these problems must be addressed if the profession is to develop a solid reservoir of highly qualified students who consider engineering to be a desirable college curriculum choice.

A number of support organizations and mechanisms currently exist for tackling these problems:

Organizations	*Mechanisms*
Administrators/teachers/ counselors	Television and radio
Engineering institutions	Motion pictures
Professional societies	Industrial interaction
Media	Newspapers and periodicals
	University interaction

From the studies of the task force, however, it appears that the support organizations do not use the available mechanisms to introduce information on careers in engineering that is needed at the primary and secondary school levels. At best, college/university catalogs are sent to counselors' offices and to local professional society members. Practicing engineers or university faculty may make presentations to interested students in advanced mathematics or physics classes or on such occasions as National Engineers Week. But there is no structured program to disseminate information about or promote interest in engineering at earlier stages of schooling.

The task force recommends that a concerted effort be mounted to inform precollege educators about engineering as a profession and to stress the importance of developing a middle school/high school curriculum that will prepare students for a college engineering curriculum as well as stimulate their interest in engineering as a career choice. To achieve this objective, school districts may wish to designate an administrator who could assume the responsibility for these curriculum matters.

The task force further recommends that a leading role in these efforts be taken by the professional societies. Programs should be developed at the national level for distribution through the media or for presentation by local professional society members. And the societies should increase their preparation and distribution of engineering career guidance brochures to describe the responsibilities and activities of engineers who are members of that society.

The American Association of Engineering Societies (AAES) should consider assuming a major role in the development of curricular information for use in precollege schools. If this information is presented effectively in an engaging format, it may be sought by precollege educators and counselors. On a regional or local basis, engineering institutions could also assist in the delivery and explanation of the material.

Finally, practicing engineers should make an effort to describe and define to local precollege educators the role of an engineer in the "real world." Such information transfer might be carried out most effectively during informal events like open houses. Currently, these events are usually held for students, but they are often less useful than they might be because they do not focus on any specific profession.

ESTABLISHMENT OF PRE-ENGINEERING PROGRAM STRUCTURE AND STANDARDS

Increasing numbers of engineering students are choosing to begin their formal college education by spending the first two years of their undergraduate program at a local junior, community, or other college. Students cite several reasons for this choice: insufficient funds to attend an out-of-town engineering school for four years, lack of maturity or self-confidence when faced with the demands of a university environment, indecision about making the commitment to a career in engineering, or inability to gain admission directly to an engineering program because of deficient secondary school preparation or performance. Yet many students following this path ultimately wish to earn a bachelor's degree in engineering. To achieve this objective, the pre-engineering programs in which they are enrolled must prepare them in such a way that they will be accepted for transfer and can continue with the advanced phases of a full four-year engineering program.

This need can be best served by those organizations that are currently responsible for and involved in engineering education on both local and national levels, as well as by state bodies that exist or could be created to coordinate and promote interinstitutional cooperation. Such organizations and the mechanisms that might be employed for these activities include:

Organizations	*Mechanisms*
Legislatures/lay bodies	University interaction
Professional societies	Uniform transfer policies
Engineering institution administrations	Model curricula
Program standards	Professional society guidelines
Industrial interaction	

If students choose to begin their educational career in a pre-engineering program, their success in transferring to and pursuing the advanced portion of the curriculum at an engineering school will depend on how well they have been prepared to make this transition by the junior, community, or other college first attended. At present there appear to be two major impediments to a successful transition. First, existing support organizations have paid little attention to this pool of students, obviously considering them unimportant. As a result these organizations have been relatively uninvolved in programs for these students. Second, those individuals responsible for structuring and offering pre-engineering programs are frequently unaware of the range of instruction/curricula needed to prepare for more advanced studies.

The task force believes that existing support organizations must take the lead in solving these problems. They must assume the responsibility of generating and making available the information needed to improve the quality of pre-engineering programs. (To accomplish this task, a new support organization similar to ABET may be required.) Also, the efforts of these organizations should include the development of new programs and the provision of whatever educational assistance may be necessary to improve the level of preparation of students transferring from such programs. In addition, the development of guidelines, standards, and model curricula necessary to upgrade the quality of pre-engineering programs should address such factors as library, computational, and laboratory facilities; faculty qualifications; support staff needs; counseling requirements; and required levels of performance.

Another important aspect of such work should be the development of statewide college transfer committees or boards to establish standards that provide uniform transfer capabilities from pre-engineering programs to engineering schools. The task force does not suggest, however, that engineering institutions should abandon their responsibility to evaluate the quality of transfer credit.

FINANCIAL RESOURCES FOR ENGINEERING STUDENTS

The financial needs of engineering students are but one part of the broader category of the financial needs of all college students. For engineering students, however, these needs are perhaps exacerbated by the rigor and duration of most engineering degree programs. These characteristics make "working one's way through college" while enrolled in an engineering curriculum relatively more difficult than in other fields.

In general, engineering students derive financial support from one or more of the following:

Organizations	
Their families	Their employers
Federal government	State government
Private foundations	Engineering institutions
Industry	

Mechanisms	
Summer/part-time jobs	Co-op/internships
Programs	Teaching/research
Grants/contracts	Grants or scholarships
Fellowships and tuition loans	Sponsored research

As a goal, the task force suggests that candidates who are qualified to pursue an engineering education and who demonstrate financial need should not be denied that education because of such a need. (This concept is more widely accepted today at the graduate level than at the undergraduate level.) And professional engineering societies should actively promote the implementation of this concept among the appropriate support organizations, although major financial contributions will be required also from government, industry, and private agencies. Additional support from the federal government could come in the form of tax relief to full-time engineering students for that share of their income derived from co-op employment, internships, assistantships, etc.

IMPROVED ENGINEERING CURRICULA

At both the undergraduate and graduate levels, the utility and value of engineering degree recipients, and their potential for successful practice and contribution to the profession, are strongly dependent on the quality of their formal education. Unfortunately, as engineering enrollments have increased nationwide, excessive loads have been placed on underfunded program efforts.* As a result, the quality of engineering education has deteriorated. Because of the importance of engineering to the nation's economic well-being and stability, the growing interest in engineering as a career choice, and the increasing quality of the students seeking admission to engineering institutions, it is imperative that this trend be reversed.

A wide range of support organizations operating through a multitude of mechanisms influences the educational curricula of engineering students. Illustrative of some of the more important are the following:

* See *Engineering Education and Practice in the United States: Foundations of Our Techno-Economic Future* (Washington, D.C.: National Academy Press, 1985).

Organizations

Legislatures/lay boards	Administration
Faculty	Government
Industry	Professional societies
ABET	

Mechanisms

Program funding	Resource allocation
Curriculum development	Research and student support
Cooperative interactions	Technical meetings and periodicals
Accreditation standards	

The importance of the highest-quality curricula is not in dispute. The real issue is how to bring together the efforts of the appropriate support organizations to make the goal a reality. As a first step, each organization must reevaluate both its specific role in the total process and its relationship to all the other support organizations. Coupled with this should be an establishment of priorities for engineering education as it relates to the other responsibilities of the organization.

Two key factors must be recognized by the funding organizations: (1) first-rate engineering education is expensive; and (2) existing laboratory and computational facilities, faculty and support staff, salaries and benefits, operating funds, research and project support, and maintenance budgets are in most cases inadequate; yet they are essential to a high quality engineering curriculum.

Of equal importance is the responsibility of those directly involved in the delivery of the program to ensure professional competence and state-of-the-art curricula. Particular emphasis must be placed on the ever-expanding data base with which students must interact as the computer becomes an inseparable part of the engineering work environment. And special attention must be directed to the introduction, in both the classroom and the laboratory, of the latest technologies in theory, application, and practice.

Also significant are the contributions to be made by those organizations, such as industry and the professional/technical societies, that have indirect contact with the educational process. The efforts of these organizations are vital and may include such activities as evaluating the product (the graduate), reporting on the latest developments and applications of new technologies, and identifying trends that may influence curricula orientation.

For the most part, these roles appear to be reasonably well recog nized. If fundamental engineering curricula needs are to be met, however, it is essential that the participating support organizations work more closely and cooperatively with one another.

IMPROVED FINANCIAL COMPENSATION PACKAGES FOR ENGINEERING FACULTY

Engineering faculty must be provided with a compensation package that is commensurate with their particular talents, education, and experience, based on the current market value for engineers. Inappropriate compensation should never be the sole reason that qualified engineering faculty decline a teaching position or leave an institution. Fortunately, more and more colleges and universities are finally recognizing the necessity for increasing the compensation of engineering faculty to those levels found on the open market; but some remain unable to do so, however, because of such factors as economics, politics, and negotiated contracts. These institutions find it increasingly difficult to attract the quality of engineering faculty required to ensure first-rate programs.

It is the opinion of the task force that this situation will become increasingly critical. With the rapid technological advancements that are occurring in many areas of the economy, industry must look for more highly qualified engineers. As a result, industry leaders may turn more to colleges of engineering to recruit faculty who can provide the expertise required in some of the more advanced areas of engineering.

The following support organizations and mechanisms are available:

Organizations	*Mechanisms*
State legislatures/ lay boards	Higher education appropriations
Federal government	Grants and subsidies
University and college administrations	Adequate resource allocation
Industry	Faculty involvement
Professional societies	

These support organizations must recognize the negative long-term impact on the quality of engineering faculty of compensation that is not commensurate with market rates. Engineering faculty should be given the same consideration as that given to the medical, dental, and law faculties in the development of compensation packages. Formulas for funding and resource allocation decisions within the educational institutions must be based on this premise. The role of the professional societies may be the key in this politically oriented issue in effecting changes outside of the institution.

PROVISION OF ADEQUATE SUPPORT RESOURCES FOR FACULTY

Faculty instructional needs that must be met if optimal engineering education is to be achieved include reasonable and adequate teaching loads/class sizes; facilities (classroom, laboratory, and computational); library; assistants (laboratory, computational, and teaching); and technicians (laboratory and computational). The presence or absence of these elements plays a major role in the recruitment and retention of top-flight faculty, to whom the working environment is typically as important as financial security.

Support organizations and mechanisms that operate in this area include those listed below:

Organizations	*Mechanisms*
Legislatures	Higher education appropriations
Industry	Gifts, endowments, and grants
Professional societies/ABET	Equipment, grants, and subsidies
Lay boards and university administrations	Resource allocation and faculty involvement
Federal government	Minimum standards

The support organizations responsible for resources currently are not providing adequate funds to support high-quality engineering instruction. This is evident in the declining number of engineering programs receiving the maximum accreditation by ABET. Fortunately, the severity and significance of this need have been recognized, and certain industrial and federal government mechanisms are being implemented or increased. But all support organizations must be committed to a policy of promoting strong engineering education, and such a commitment requires a concerted effort in both the political and academic arenas. Only then will the necessary increased resources be available to accomplish the goal of high-quality engineering education. (A possible short-term solution may be to increase engineering tuition/fees above those of other professional colleges, thereby providing higher support for engineering education.)

Support resources can be sought also in other sectors. Many industries are involved in major training programs for their technical employees, and they have spent millions of dollars for state-of-the-art laboratories or training facilities. These facilities could be used to great benefit by local engineering institutions. Alternatively, with appropriate support from engineering institutions such laboratories or training centers could be set up on campus for joint use by the engineering college and the contributing industry.

RESEARCH SUPPORT FOR FACULTY

Research support for engineering faculty must include modern facilities (laboratory and computational); assistants (laboratory, computational, and research); technicians (laboratory and computational); and provisions for post-doctorates/visiting professors. Without this level of support, meaningful basic and applied research cannot be conducted. Moreover, as with salary and instructional needs, research-oriented faculty can find this support in government and industry and may choose to seek employment in these sectors rather than in teaching.

The following are sources of research support for engineering faculty:

Organizations	
Legislatures	Lay boards and administrations
Industry	Federal and state governments
Professional societies	
Mechanisms	
Appropriations	Research grants, facility and personnel budgets; faculty involvement
Gifts and research grants	Political and moral assistance
Fellowships	
Equipment and subsidies	

Certain federal agencies are recognizing the need to implement or expand some of these mechanisms. In general, however, support of university research by federal and state governments and by industry, when compared to both the gross national product and the consumer price index, has declined in recent years. Similarly, institutional support has been less than adequate.

To ameliorate this situation, support organizations must work toward recognition of the negative long-term effects of limited research activities by the engineering educational institutions. Each organization (governmental bodies, professional societies, institutions, and industry) must assume a leadership role in expanding and increasing the interest and level of effort necessary to support adequate engineering research.

FACULTY DEVELOPMENT AND RECOGNITION

For maximum professional productivity, engineering faculty must be assured of support for continued technical competence, professional development, recognition, advancement, and stability. (In particular, a lack of sufficient funds to maintain professional competence is viewed as a major engineering institution weakness.) If these needs are not met, the result will be outdated, unproductive, insecure faculty who cannot provide the solid core of engineering expertise required for a vigorous engineering educational program.

These organizations/mechanisms are sources of the necessary support:

Organizations	
University administrations	Industry
Professional societies	Federal government
Mechanisms	
Awards	Chairs
Consistent promotion and tenure	Long-range planning
Technical meetings and short courses	Policies
Scholar/scientist awards	Sabbaticals and consultantships
National Academy of Engineering	Grants
	Travel

The task force recommends that funds provided by support organizations for these existing mechanisms be expanded. To help achieve this goal, the professional societies can play an important role by informing those organizations responsible for resource allocations of the importance and benefit of professional development for engineering faculty.

ADMINISTRATIVE SUPPORT FOR ENGINEERING INSTITUTIONS

The need for administrative support for engineering institutions has been presented dramatically in an article entitled "The Crisis,"* which deals with engineering education. The piece documents a critical shortage of both faculty and laboratory equipment. This crisis has occurred even while the nation is engaged in intense economic and military competition in areas related to the technical products of engineering. With an expanded, more sophisticated engineering educational process, critical needs have developed in the area of institutional operations, particularly from administrative and organizational standpoints. And these needs have been exacerbated by the increased level of reporting required by both governmental and nongovernmental agencies.

Administrative support organizations and mechanisms for engineering institutions include the following:

Organizations	*Mechanisms*
Legislatures/lay boards	Allocation of nonhuman resources
University administrations	Institutional studies/statistical information
ABET	Institutional budgets
Professional societies	Allocation of professional and staff positions

It is incumbent upon the support organizations to recognize and promote effective administrative support for engineering institutions. This can be accomplished at a number of levels, both internal and external to the institutions. One approach may be to organize engineering colleges as professional schools of engineering, similar to medical, dental, and law schools. (This concept was proposed several years ago by the National Society of Professional Engineers but did not receive widespread endorsement by engineering deans. The reason for their lack of interest was not clearly stated, but it appeared to be related to the lack of adequate resources for existing programs, let alone expanded ones.)

LONG-RANGE PLANNING FOR ENGINEERING INSTITUTIONS

As in any complex organization, engineering colleges, and the universities of which they are components, must conduct long-range planning. They must strive to define missions and purposes, forecast future demands and expected performance, assess the resources required to accomplish their missions and purposes over that planning period, and set about to provide and properly use the resources available.

There is currently a significant lack of long-range planning by engineering educational institutions, even though such planning is absolutely essential if changing technology is to be adequately addressed in

* "The Crisis," *Engineering Education* (November 1982).

a timely fashion. For the most part, universities are unable to respond to these changes quickly enough to adjust their curricula, facilities, or faculty needs. The result is inadequately prepared students.

Meanwhile, industry is currently spending millions of dollars on training programs designed to close the technological gap between the United States and its foreign competitors. Participating in these training programs are engineering graduates who are being brought "up to speed" in technical areas. The cost of this training adds to the cost of the product, thus making that industry less competitive in the marketplace. The task force believes that these costs could be reduced if engineering institutions can anticipate more effectively the technical needs of their graduates entering the labor force.

For the purposes of this report, the term "long range" implies 5 to 10 years. Although planning should be continuous, the formalized plan for each institution should be published no less than every 2 years, so that faculty, administration at all levels, and other support organizations can be apprised of the institution's stated goals and can work together to achieve them. The support organizations and mechanisms available to implement this process:

Organizations	*Mechanisms*
State boards/regents	College staff
College administrations	Industry interaction
Faculty	Formalized planning documents
University administrations	Government interaction
Advisory committees	

Most major corporations have full-time departments devoted to corporate strategy planning. Their mission is to ensure that the company's products will be manufactured in a manner that is the most cost effective, that produces goods of the highest quality possible, and that meets the competitive demands of the marketplace. Engineering institutions must address similar needs, because many of the same factors that govern industry will affect the requirements of engineering education. Consequently, it is essential that administrations and faculties recognize the importance of strategic planning to ensure that the quality of their product (degree recipients) meets the requirements of the labor market.

To fill this role the task force suggests that a strategic planning section be established within the engineering colleges of the universities. Staffing requirements would be minimal as most of the necessary information will be available through the university data base, as well as through interaction with industry, government, and other employers.

2

The Government Sector

The Government Sector Task Force was composed of members of the President's Government Advisory Group of the National Society of Professional Engineers. (This group is composed of federal, state, and local government engineers who have been addressing, on a continuing basis, issues similar to those raised in this study.) As a component of the Panel on Support Organizations in the Engineering Community, the task force was charged with examining the primary needs of engineers working in the government sector and the support mechanisms to fulfill such needs—both for the individual engineer and for the entire engineering profession. In establishing these needs, the various levels of government—federal, state, and local—were recognized, and those needs pertinent and common to all were given priority. The sections that follow describe and discuss those needs and support organizations selected by the task force as the most critical.

ACQUISITION OF REQUISITE MANAGEMENT SKILLS

During their formal professional education, engineers primarily pursue a technical curriculum with little, if any, management training. And considering the limited time available to the student, such an approach probably makes sense in that it focuses on the education needed by young engineers during their early years of employment. As their careers progress, however, engineers increasingly assume positions that demand some form of management skills (this is particularly true in those positions involving public administration). Because they have seldom had the opportunity to acquire these skills, many engineers find it difficult to adapt.

This training deficiency must be overcome, and the most likely time for such education is probably during the postgraduate period (it is doubtful whether current undergraduate curricula can be sufficiently broadened to include management training). But for those engineers already in the field, a number of organizations and mechanisms exist for meeting this need, a partial list of which includes the following:

Organizations	Mechanisms
Educational institutions (engineering and nonengineering)	Academic curriculum
Professional societies	Continuing education courses
Employing governmental organizations	Developmental training
	Conferences and seminars
	Correspondence courses
	Sabbatical leave

These support organizations are in place and the mechanisms listed are being used by some engine ers. Nevertheless, a problem exists in that government employers do not always use an organized, well-defined method to review their organizational needs for management personnel and identify individuals with the potential for management positions. Most governmental entities are constrained from preselecting individuals for positions of advancement. This constraint in turn precludes management from directing its training effort toward a limited number of individuals with excellent management potential and forces it to provide generalized training to a broader group instead. As individuals progress, government organizations are sometimes faced with selecting individuals for management positions who have not developed the requisite skills nor demonstrated the potential for management. If at all possible, educational institutions should incorporate into their undergraduate curricula courses that acquaint the individual with management problems that may be encountered in the "real world." Of equal importance is the need for modifying government regulations to permit the objective preselection of candidates for management training.

DEVELOPMENT OF COMMUNICATION SKILLS

In general, college engineering curricula require that students take a number of courses involving or stressing written and oral communica tion. Such courses, however, do not usually cover "selling one's position." Additionally, most engineering students and practitioners react with characteristic apprehension when faced with any type of communication other than technical. The end result of this situation is often a deficiency in the necessary skills needed by the engineer to discharge his or her duties effectively. This deficiency is magnified in the government sector where much of an engineer's essential communication is with a public untrained in engineering matters. Government engineers need added skills in communication, therefore, to enhance their effectiveness, carry the necessary message to the public, and develop self-confidence.

The task force believes this need can be best served by existing organizations at various levels. But, convincing engineers that such skills are needed throughout their careers is a more difficult problem. Organizations and mechanisms that might be used in this effort include the following:

Organizations	Mechanisms
Educational institutions (engineering and nonengineering)	Academic curricula
Service clubs	Self-improvement courses
Employing governmental organizations	Public involvement
	Continuing education courses
	Public speaking opportunities

These necessary support organizations and mechanisms already exist. The problem lies in persuading more engineers to take advantage of the training opportunities they offer during college and early in their career. In the latter case, encouragement and/or reimbursement from the employing organization would be beneficial, although this is often difficult in government organizations where expenditures are closely regulated by legislation. It is vital that practicing engineers and educators stress the importance of communication skills to students. Educators could serve this purpose by requiring documented demonstration of verbal and written communication skills as a prerequisite to graduation.

MAINTENANCE AND ENHANCEMENT OF TECHNICAL ENGINEERING SKILLS

This need was addressed previously in the discussion of concerns common to all sectors of the engineering profession. But, engineers in government face several unique problems: (1) a lack of incentive for the individual to extend himself; (2) indifference to the need for such train ing on the part of management, which in government is primarily nontechnical, and (3) imposed financial constraints, primarily on time.

Maintaining and enhancing technical engineering skills can be accomplished best by existing organizations at varying levels, including the following:

Organizations	Mechanisms
Educational institutions	Academic curricula
Private training institutes	Specially developed courses
Technical societies	Hands-on experience
State registration boards	Continuing education courses
	Shared experiences
	Computer training

That the necessary support mechanisms already exist does not change the fact that engineers in the governmental sector are not taking, or are not allowed to take, full advantage of these opportunities. The extent to which engineers, and more important, their employing governments, recognize that continuing education and training are essential may be an additional concern outside the scope of this report. What is evident is that the support organizations should make a greater effort to "sell" their programs to both the government employer and the government employee.

INCREASED EMPHASIS ON PROFESSIONAL DEVELOPMENT

As discussed previously, engineers must not only possess the requisite technical skills but also must concern themselves with professional development, establishing a position of trust with respect to relating technical skills to the needs of the profession and to society at large. This is particularly important for engineers in the government sector. Engineering decisions there are exposed to public view, and they must be rendered in a manner that generates public confidence. Engineers in government and their managers must place more emphasis on professional development. And government engineers need more opportunities to attend professional meetings and seminars. They need opportunities to gain an appreciation of how their fellow engineers operate within their constituencies, to participate in the development of standards of practice, and to enhance their stature in the eyes of fellow professionals in the private sector.

This need can best be met by various professional organizations, at the national and state levels, that promulgate codes of ethics. It can also be met by requiring registration for all those practicing engineering that involves public health and safety. Existing organizations and available mechanisms include those listed below:

Organizations	Mechanisms
Professional organizations	Professional meetings
Employing governmental organizations	Enforced ethical practices
State registration boards	Registration display boards
	Official policy statements
	Conferences and seminars
	Professional registration
	Employment practices

For engineers to take full advantage of these support mechanisms, governmental organizations must allot the necessary time and reimburse expenses for those attending activities related to professional development. In addition, efforts must be made to overcome the perception on the part of governmental officials and entities that "professional organizations" are dedicated to advancing a particular profession as opposed to improving individuals within that profession.

RECOGNITION OF ENGINEERING CONTRIBUTIONS

Engineers as a whole, but government engineers in particular, do not enjoy the same prestige in the community as do other professionals known for their contributions to society. Apparently the public is unaware of the professional approach employed by the engineer who works to protect the health and welfare of the citizenry by developing public works facilities. The problem is accentuated for government engineers because their contributions are usually hidden by the political process.

If qualified young people are to be encouraged to select government service as an entrance to the engineering profession, the reputation of the profession must be enhanced and recognition must be given to engineers in the government sector for their very real contributions. Public pronouncements disparaging the government employee (bureaucrat) have been damaging, as have negative statements from individuals in the private sector who often consider themselves in competition with engineers in government.

There are a number of organizations and mechanisms that could assist in improving this situation:

Organizations	Mechanisms
Employing governmental organizations	Public acknowledgments
Community institutions	Employer publicity
Media	Awards
Professional societies	Public appearances and speeches
Educational institutions	Public service projects
	Dedication ceremonies
	Display boards

For government engineers to receive appropriate recognition for their contributions to society, much effort will be required, particularly since the engineering portion of a public works project is generally carried out by more than one individual. Governmental organizations should be encouraged to acknowledge the individual contributions of their engineers in bringing a public works project to successful culmination. In addition, organizations and societies should strive to make more use of awards, to publicize contributions, and to foster public service projects.

IN-HOUSE TECHNICAL ENGINEERING OPPORTUNITIES

Pressures are increasing to accomplish a great deal or even all necessary governmental engineering work using engineering resources from the private sector. Although it is certainly valid, and even desirable, that much of this work be performed by the private sector, it is also essential that governmental entities retain a certain portion of the work to provide hands-on engineering experience for its own forces. Total reliance on the private sector will eventually lead to a decline of the existing engineering talent in government, to the point that recruitment will suffer, review capability will be obliterated with the attendant ability to protect the public's interest, engineering decisions rightfully belonging to the government will be abrogated, and the country's technological development will suffer. The private sector has a right to expect that it will perform a certain portion of the government's engineering efforts for which it is qualified; the government engineering sector also can expect to perform a certain portion to ensure sufficient maintenance of its technical capability to discharge its responsibilities. The appropriate proportion will depend on a number of variables, including the size and distribution of organizations, the functional nature of the work load, and the mission assignment.

This need can only be met if the employing governmental organiza tion and the private engineering industry reach an understanding of the value of each entity performing an appropriate portion of the work. The necessary support organizations and mechanisms already appear to exist. But both sides of the equation must come together to resolve the issue in a manner that will serve the common good at all levels of government. Existing organizations and mechanisms that might serve this purpose include those listed below:

Organizations	Mechanisms
Employing governmental organizations	Maintaining dialogue
Professional organizations	Statements of principle
Trade associations	Shared interface

IMPROVED WORKING CLIMATE

In many cases, personnel regulations, salary restrictions, and administrative attitudes toward government employees tend to undermine the morale of the work force and discourage the recruitment of topflight engineering graduates. Existing problems include low salaries at both entry and upper levels, classification standards that favor managerial rather than technical abilities, excessive administrative personnel procedures that require a disproportionate amount of time for nonengineering matters, and, all too frequently, a demeaning attitude toward government employees.

This need can be best served by the respective personnel organizations and by the responsible political entity, aided by professional organizations that can foster support for the government engineer. Available organizations and mechanisms include the following:

Organizations	Mechanisms
Professional societies	Improved salary schedule
Legislative bodies	Streamlined regulations
Media	Public support
Employing governmental organizations	Dual-ladder salary schedule
	Acknowledgment

Because of existing regulations, depressed salaries, and unfavorable publicity about government employees at all levels, the quality of the engineering force in government appears to be diminishing. To turn this situation around totally is beyond the capabilities of the engineering profession. But, it must continue to work with the appropriate political entities and attempt to convince these authorities of the adverse effects that will result from these conditions, effects that may well compromise the quality of public works being developed.

DEVELOPMENT OF SKILLS FOR SERVING THE PUBLIC INTEREST

Because engineers tend to view their jobs as purely technical, many are not prepared to consider the broader aspects surrounding a decision affecting the public interest. In the broadest sense, both the public and private sectors must be considered, and this consideration must include their interconnection and how their combined decisions will affect the future. Many government engineers have limited experience in this area, yet their roles in administering technical regulations can have a significant and lasting impact on society. Engineers frequently lack education in the basic concepts of the humanities, sociology, economics, and politics, a deficiency that makes decision-making more difficult and that can result in decisions made without considering all facets of an issue.

There are a limited number of organizations and mechanisms that can support efforts to meet this need. Some of these might include the groups and methods listed below:

Organizations	Mechanisms
Educational institutions	Undergraduate curricula
Trade organizations	Progressive experience
Professional societies	Interfacing with nonengineers
Employing governmental organizations	Postgraduate specialization
	Training courses

Government organizations should make a special effort to broaden the education of their engineers along nontechnical lines, such as public involvement issues. As previously mentioned, engineers need a better appreciation of the humanities, social factors, politics, and economics. If engineers are to serve the public, then they must understand its nature in order to provide the best service. Furthermore, engineers should be encouraged and permitted to gain this added education and experience during their early or middle career stages. This ensures that the needed skills are not lacking when the stage of policy setting and program making is reached. Making the possession of these skills a recognized requirement for promotion to certain positions will also ensure that employees acquire them.

DEVELOPMENT AND MAINTENANCE OF PROFESSIONAL STANDARDS

To enhance the professional stature of the government engineer in the eyes of the public and to provide a common base from which to measure performance and set compensation, it is necessary that governmental organizations establish and rigorously maintain professional and educational standards. These should include requirements for registration; usable, understandable job descriptions; and measurable performance standards. Rigorous enforcement of such professional standards would greatly improve the image of the government engineer, in turn making government employment a more attractive alternative for engineers.

Organizations and mechanisms that are directly concerned with these issues can best meet this need:

Organizations	Mechanisms
Employing governmental organizations	Registration laws
State registration boards	Job descriptions
Professional societies	Standards of conduct
	Codes of ethics
	Work standards

Generally, it has been the professional societies that have fostered professional standards. But such work requires additional support. Employing governmental organizations must become more active, recognizing that complying with such standards will enhance the stature of government engineers in the eyes of the public and in the eyes of professional associates in the private sector. It will also ensure that engineering needs in the government sector are satisfied in a manner consistent with expected levels of quality.

INDUSTRY-COMPETITIVE COMPENSATION BASE

Salaries of government engineers have lagged behind those of engineers in the private sector. This has adversely affected the morale of current employees, causing excessive turnover and making recruitment difficult. Compensation of government engineers should be comparable to that of engineers in the private sector, yet the nonsupportive public perception of the government engineer and a general lack of understanding of engineering work make this a difficult condition to achieve.

While some existing professional organizations may promote an appropriate level of compensation for government engineers, its actual accomplishment falls to those organizations having direct salary control:

Organizations	Mechanisms
Employing governmental organizations	Salary comparison studies
Professional societies	Training allowances
Legislative bodies	Salary adjustments
	Meeting allowances

Professional societies and the managements of employing governmental organizations are the only groups that can convince legislative bodies that a proper level of compensation is necessary to attract and retain quality engineers in the government sector.

EXPANDED PRIVATE/GOVERNMENT SECTOR CONTACT

In a way, the private engineering sector may view government engineers as a competitive force that enjoys certain privileges not accruing to their private counterparts. In truth, each has an important function to perform and it is essential that these mutually supportive functions be understood and appreciated. Moreover, high levels of quality in the government engineering sector result in an improved relationship between the private engineer and the government.

This need will be best served by those organizations most directly involved:

Organizations	Mechanisms
Employing governmental organizations	Joint meetings
Professional society segment representing the private sector	Continuing education
Private practice employers	
Professional society segment representing the government	

Although government organizations and private organizations can maintain a dialogue, it will not be as effective as an organizational approach to the problem, i.e., the respective professional societies fostering and promoting better understanding. At the same time, government organizations must allow for such interaction by encouraging and permitting attendance at meetings and by publishing papers that support effective interrelationships.

3

The Industrial Sector

Because of the diversity and magnitude of the industry segment of the engineering community, the Industrial Sector Task Force used questionnaires to obtain a consensus regarding the needs of the engineer in industry. Five specific industry groups were included in the survey: (1) aerospace, (2) aluminum (metal processing), (3) chemical/petroleum, (4) electric power generation, and (5) electronics/computing.

An attempt was made to include the automotive and steel industries, but their particular circumstances during the time frame in which the survey was conducted precluded their participation. In addition, representatives of the construction industry were provided with the results of the survey and expressed concurrence with the conclusions.

A basic study questionnaire was developed by the task force and distributed through key individuals within each industry group. The purpose of the questionnaire was as follows:

1. To identify those needs perceived as important and unimportant to the individual engineer, as well as to determine which needs are important or unimportant to an engineer's particular industry as a whole.
2. To identify the perceived level of satisfaction of engineering needs for the individual and his/her respective industry.
3. To obtain judgments concerning the percentage of needs currently being met by supporting organizations.

4. To identify those support organizations that satisfy these needs and the estimated percentage of their contribution.

Approximately 75 companies responded to the questionnaire by surveying the various levels of engineering—from practicing engineers to engineering management—and a variety of functions, including design, manufacturing, and research and development. The results were analyzed to determine which needs were perceived as most important, as well as to identify the key support organizations. Several of the needs that were expressed by the respondents matched those identified by other sectors, including technical training, increased emphasis on professional standards, and professional development. The needs unique to the industrial sector are presented below.

CAREER ASSESSMENT/DEVELOPMENT

The career development needs of the individual engineer can be easily submerged in the operational concerns of a major industry. Yet these same individuals must continue to experience job satisfaction and be motivated and productive if they are to make positive contributions toward achieving the company's goals. Assisting employees in evaluating alternative career opportunities and establishing personal objectives benefits both the employee and the employer. There is a mutual need, therefore, for industry and the engineers employed in industry to participate in an ongoing program of career assessment and development.

Although the primary responsibility for career assessment and development lies with the employer, other support organizations can assist in meeting this need:

Organizations	Mechanisms
Employing organizations	Counseling
Technical societies	Seminars
Professional societies	Guidance programs
	Workshops

COMMUNICATION AND DATA EXCHANGE BETWEEN COMPANIES

There is an ongoing need for information transfer both among individual engineers and in the industrial sector. As a whole industry stands to benefit significantly from the discussion and exchange of data within companies, between company components, within corporations, and between corporations. Advancement of technology, exchange of concepts and ideas, and minimization of duplication are some of the major benefits. In a competitive environment, however, a maximum level of open communication, a level that is not exceeded, must also be established. This clearly applies to the transfer of data between corporations and between countries.

A number of support organizations exist to answer this need.

Organizations	Mechanisms
Employing organizations	Corporate communication process
Governmental agencies	Technology transfer
Technical societies	Technical publications
	Technical conferences

RESEARCH AND DEVELOPMENT PROJECT CAPITAL

Industry must maintain a balance between profitability and the dedication of resources to develop new business. The development of new technology opportunities for a high payoff must be balanced against possible failure, which may jeopardize the financial stability of the company. As a result, many potential projects based upon new engineering technology are not pursued until success becomes more obvious.

In the face of increasing foreign competition (subsidized by their governments) the U.S. position of engineering dominance will continue to erode unless innovation and creativity are encouraged and supported financially. If industry in the United States is to remain competitive, venture capital must be made available for the advancement of technology.

In addition, to meet this need, investment groups, financial institutions, and venture capital companies must be better informed about the benefits and risks accompanying engineering innovation. Moreover, the concept of pilot studies needs to be expanded so that capital expenditures can be minimized until the potential for success can be more accurately evaluated.

Support organizations capable of providing research and development capital do exist, but the mechanisms are not functioning at the level of effectiveness necessary to address the problem. Industry is somewhat reluctant to look to government for the financial support of engineering research and development projects, but it recognizes the desirability of a broad support base. The existing support organizations and mechanisms are perceived to be as follows:

Organizations	Mechanisms
Financial groups	Grants
Venture capital companies	Investment stocks
Investment groups	Loans
Government	Tax incentives

OPPORTUNITIES FOR POSITIVE VISIBILITY AND APPRECIATION

This need manifests itself both for the individual engineer in industry and for the industrial engineering sector as a whole. Among companies with large numbers of engineers, individual recognition is the greatest unsatisfied need. The benefits of a sound policy for recognizing the achievements of engineers include motivation, productivity, job satisfaction, stability, and innovation. Rewards in the form of recognition enhance and help to make technical careers more attractive.

Industry as a whole also has a significant need for the positive recognition of engineering achievement. There has been some adverse publicity in recent years regarding the negative environmental or sociological impact of industry's development of new technology; yet scant attention has been paid by the media to the benefits of those technological advances developed through research by major industrial corporations. Industry has the responsibility to inform the public of the benefits of its technological achievements; however, a better informed and more objective media base also needs to be developed.

The support organizations that have the potential to address this need include the following:

Organizations	Mechanisms
Employing organizations	Achievement awards
Professional societies	Documentaries
Government	Industry appreciation programs
Technical societies	Press releases
Media	Employee recognition programs
Service organizations	

RECRUITMENT OPPORTUNITIES

The key to any successful industry is people, and acquisition of well-qualified engineers is essential for growth and technical leadership. Moreover, matching the right person with the right job is necessary to ensure quality work and to retain quality employees.

Most of the nation's major engineering education institutions have formalized recruiting procedures for their graduating seniors or graduate students. Such programs should be carefully structured and well coordinated to minimize the expenditure of dollars and time by interviewers and students alike.

Communication between industry employers and engineers employed in industry is more difficult than recruiting on campus. There is a need to make contact with engineers in industry who desire to make a career change and have the specific expertise and personal attributes sought by another company. Because of the highly technical and diversified nature of engineering work, employment agencies frequently lack the full understanding of what type of individual an organization needs or what employment opportunities match the skills of a particular engineer.

A number of support organizations exist to meet the need for better recruitment opportunities, but the available mechanisms need to be strengthened and expanded:

Organizations	Mechanisms
Educational institutions	Recruitment programs
Trade publications	Employment opportunity listings
Technical societies	Employment referral services
Employment agencies	Newsletters
Professional societies	Workshops

4

The Private Sector

The Private Sector Task Force was composed of both consulting engineers and key staff representatives of two professional organizations, the American Consulting Engineers Council and the National Society of Professional Engineers. Together they reached a consensus regarding the identification of primary needs of the private practice sector of engineering, needs that result both from concerns common to all sectors and those unique to this group. The task force also examined the wide diversity of private practice engineering services and the manner in which they are furnished. Consulting engineers, as private practice engineers are generally known, may function as large corporations, as small business entrepreneurs, or as highly specialized experts on call from academia or industry for special consultation and/or legal testimony. The needs identified by the task force and the support organizations/mechanisms available to the private practice engineer are detailed in the sections that follow.

DEVELOPMENT OF MANAGEMENT SKILLS FOR PROFITABLE OPERATIONS

Most private practice engineering firms are small businesses. A 1982 census of firms conducted by *Consulting Engineer* showed that 82.5 percent have fewer than 26 employees, and another 13.0 percent have 26 to 100 employees. In these firms the principals/owners are usually both the technical experts and the business managers. They must possess a high degree of both technical and managerial skill if the firm is to remain a profitable operation.

Unfortunately, undergraduate engineering education is not structured to provide a strong background in management. Typically, engineers have had to develop these skills on the job, with various degrees of success.

Better training is needed to respond to the changes in the profession, especially in the following areas.

- *Company Financial Management*. Development of a reliable company financial management reporting process is necessary to provide the data essential for proper management. Engineers in private practice must develop the skills necessary to structure a system and to analyze the data being generated.
- *Job Cost Accounting*. This process provides the project cost information necessary for budgeting a project accurately and for monitoring that project in progress.
- *Engineering Team Organization*. Most projects require attention from engineers and technicians representing various disciplines, and the formulation of a team of the appropriate personnel provides the mechanism for these efforts. However, most engineers are not adept at organizing and managing a team, or even participating as a team member.
- *Computerization*. Computers are an essential tool both for the accounting functions and the technical work of an engineering firm. The typical individual engineer currently responsible for the management of a private practice did not use computers to any great degree during his/her college training; these individuals must now develop competence and knowledge regarding computer applications and equipment on their own. These engineers need assistance in acquiring these skills, as well as assistance in staff organization, to utilize computers successfully.

Engineers in private practice who are not principals also need management skills because those who demonstrate exceptional technical skills usually advance into positions with management responsibilities. The lack of management training makes it difficult for them to assume these responsibilities. If they are to function effectively, it is essential that instruction in the principles of good management be made available to these individuals.

Support organizations exist to help meet this need, as follows:

Organizations	Mechanisms
Educational institutions	Academic curricula
Technical societies	Home study courses
Professional societies	Seminars/short courses

EDUCATION AND TRAINING IN COMPETITIVE TECHNIQUES AND STRATEGIES

The 1980s have been difficult for engineers in private practice. Federal budgets have been cut. Major public works programs have been reduced or, in a few cases, eliminated. New kinds of competitors—research and development firms, equipment manufacturers, educational institutions, and utilities—are among the new entities moving into traditional consulting engineering markets. Internationally, the growing strength of the American dollar has dampened overseas clients' interest in "high cost" U.S. engineering services. Foreign firms, in fact, are purchasing or creating U.S.-based engineering subsidiaries to compete head to head with consulting engineers for domestic work.

The tightened national economy has forced engineering consulting firms to reduce their staffs, with many former employees choosing to open their own consulting firms, thus adding to the competition. New technologies like computer-aided drafting and design (CADD) have left some firms behind in the "productivity race." A growing demand by clients for price-competitive procurement without adequate specification of the scope and level of services required has caused many inappropriate and inequitable contract awards. Moreover, some firms feel that price competition is unethical and decline to participate. When proposals are requested setting forth qualifications and excluding price considerations, the number of private practice engineers responding (even on relatively small jobs) is four or five times greater than the number that would have responded as recently as 5 years ago.

Because the consulting engineering field has become such a highly competitive one, salesmanship is a major factor in the success or failure of a firm. Many firms are finding, for the first time, that it is necessary to increase the percentage of their resources dedicated to business development. Moreover, today's consulting engineer must be increasingly alert to the potential for new markets as the nation's engineering needs shift and change.

And, because the opportunities for creating new markets are generally limited in any one time frame, the majority of a consulting engineering firm's business development efforts is generally directed toward increasing its share of the market in competition with other firms.

All of this means that there is more to finding new work than merely assigning a staff member to the job. It means the initiation of a conscious, logical marketing program. But engineers are not educated to be salespeople and in fact are typically not adept at touting their own skills. Consequently, engineers in private practice need improved com petence in both written and verbal communication, marketing techniques, and interpersonal skills.

A number of existing organizations and mechanisms that are related to the marketing of engineering business development provide information on the philosophies and techniques of effective business development. They include the following:

Organizations	
Professional societies	Technical societies
Trade associations	Publications
Educational institutions	Private marketing consultants
Mechanisms	
Manuals	Seminars
Workshops	Cassettes
Association advertising	Programs
Referral services	Peer information exchange
Technical literature	Business leads
Engineering business reports	Short courses/seminars

DEVELOPMENT OF ADEQUATE RISK MANAGEMENT TOOLS

The number of claims against private practice firms or engineering consultants has climbed steadily for the past 20 years, increasing in severity as well as frequency. That frequency now exceeds 40 claims for each 100 insured firms, with the average severity of each claim surpassing $20,000. Although engineers mount a successful defense in approximately 75 percent of the cases, "success" means only that the insurance carrier did not pay any damages on behalf of the engineer. The private practice engineer still encountered substantial defense costs, in time as well as money, and may have had to agree to a settlement within the deductible.

An important aspect of the solution to this problem is a strong program of quality control. Such a program is essential to an engineering consulting firm if it is to maintain a record of high-quality service and integrity to minimize its liability losses. The techniques of a good quality control program are not taught as part of the college engineering curricula and are frequently learned only after a firm has suffered embarrassment, the loss of a client, or even a claim demonstrating negligence. Consequently, there is an ongoing need by private practice engineers to learn the fundamentals of a formalized quality control program.

A second essential risk management tool for engineering consulting firms is professional liability insurance. This type of insurance is not new to the engineer in private practice. The largest and oldest program of professional liability insurance has been in existence for over 25 years. However, the crisis in professional liability and associated litigation is a relatively recent phenomenon. Professional liability insurance rates have climbed steadily for the past 20 years because they are directly tied to the number and severity of claims.

The need in professional liability insurance involves resolving issues that are related to improved practice and, more importantly, addressing those issues affecting the practice from other sources. All too often consulting engineers are sued indiscriminately as part of an overall claim against any parties either directly or indirectly involved in the circumstances leading to the damage suit.

In summary, private practice engineers face a significant need for risk management tools that will permit them to render high-quality, state-of-the-art service to their clients with the minimum exposure to potential litigation. Private practice engineers must certainly stay abreast of current legal trends, defense strategies, and new areas of litigation involving engineering firms. They must be familiar with techniques for resolving conflicts, amending errors, and documenting problems, all part of a strong risk management program. Service to the client should not be allowed to deteriorate by permitting adversarial relationships to develop whenever problems arise.

A number of existing organizations and mechanisms provide support to the engineer in private practice in the application of risk management tools:

Organizations	Mechanisms
Professional societies	Workshops
Technical societies	Newsletters
Liability insurance carriers	Model contract documents
Law firms	Seminars
	Home study courses

ACHIEVING VERSATILITY AND PROFITABILITY WHILE MAINTAINING PROFESSIONAL INTEGRITY AND OBJECTIVITY

The private practice sector of the engineering profession is currently grappling with major changes in business practice, changes related to nontraditional roles that are available and potentially beneficial to consulting engineers. Whereas private practice engineers have, in the past, generally procured work based on the presentation of their qualifications without price consideration, such firms today are more and more being invited to bid on design services in much the same manner as construction contractors. In addition, consulting engineering firms are finding increasingly that their role in a project is that of a team member in a design-build effort. Finally, the private practice engineer is also facing shortages of capital for public works projects, private development, and industrial expansion—shortages that have drastically reduced both public and private demand for design services. To deal with this situation, engineers in private practice are beginning to offer a new type of service: the development and testing of new and creative methods for financing clients' projects.

The pros and cons of these changes and trends are debated widely among private practice engineers. Regardless of the final consensus, however, the changes exist and their impacts must be acknowledged and dealt with. Typically, the private practice engineering firm is not confortable with the competitive bidding process as it applies to the procurement of design services. Nor is it generally adept at providing services as part of a design-build team, particularly in dealing with questions related to conflicts of interest and potential liability. There is, therefore, an increasing need among private practice engineers for opportunities to acquire the requisite skills and take the precautions necessary to respond to and deal with these new demands successfully. Furthermore, it is becoming important for consulting engineers to become as conversant with funding alternatives as they now are with design, equipment, and material alternatives for a specific project.

A number of support organizations currently exist that attempt to respond to this need:

Organizations

Professional societies	Technical societies
Educational institutions	Insurance companies
Investment bankers	Industry
Legislative bodies	

Mechanisms

Seminars	Workshops
Short courses	Postgraduate courses
Publications	Standardized contract documents
Procurement procedures	

5

Society at Large

The peoples' science is where science eventually becomes technology and engineering. There, it serves people materially, just as in its primary form science enhances understanding. But serving materially gets complicated by economics and emotions. So journalists and media makers, with their time and space pressures, find it hard to dig in and get at the underlying discovery.

William O. Baker Media Resource Service 1984

(New York: Scientists' Institute for Public Information)

OVERVIEW

American society depends on innovation for its prosperity and growth, and innovation, in turn, depends on the ingenuity of engineers. Yet most Americans have little idea of what engineers are or what they do. Moreover, as critical social policy discussions increasingly involve technology and engineering (e.g., toxic waste disposal and reprocessing, nuclear safety, military weapons systems, space program options, robotics, recombinant DNA applications), this public ignorance begins to have ominous societal implications. It seems reasonable to conclude that the public needs more information and a better understanding of the role of engineering in today's technologically complex world.

Because the general public depends on the mass media—newspa pers, magazines, radio, and television—for the vast majority of its information, any effort to improve public understanding of engineering must focus on improving media coverage. The mass media constitute the major bridge between what C.P. Snow called the "two cultures": the technological community and the general public.

Yet considering the critical role engineers play in today's society, media coverage of engineering has been scanty and confused. Journalists often consider the roles of engineers and scientists to be interchangeable, frequently attributing the successes of the U.S. space program, for example, to "NASA scientists." In addition, a survey conducted among 1,000 journalists in the preparation of this report indicated a widely held stereotype of engineers as inarticulate. Perhaps most significantly the survey also shows that journalists generally have difficulty finding engineers who are willing to talk with the press.

The first step in improving the public's understanding of the engineer is to identify the needs not only of the engineering community but of the media and the general public for more and better information about engineering. The engineering community wants recognition for its contributions to society; the media want "stories"; and the public wants information that will be useful in everyday life. At first glance, it may seem that these needs are totally distinct or even conflicting. However, a closer look reveals that these needs have a common component: the public's desire for accurate, credible information about what William O. Baker describes as " the peoples' science."

It is only by addressing the needs of the media and the general public, as well as its own needs, that the engineering community can succeed in improving its media coverage. Conventional public relations approaches will not work with today's science-and-technology journalists who are already flooded with press releases and phone calls "pitching" products, processes, and programs by the thousands. The single most important step the engineering community can take to help improve media coverage—and at the same time, to help overcome the barriers of misunderstanding and mistrust between the engineering community and the media—is to provide journalists with ready access to reliable, credible sources of information.

In May 1984 the Twentieth Century Fund Task Force on the Communication of Scientific Risk, headed by Harrison E. Schmitt, recommended "the establishment of organizations to provide journalists with abroad range of scientific and technical information-especially during crisis situations when there is little time to dig up background material—and to make specialized knowledge of scientists available to them." Some mechanisms for implementing this suggestion have already been established, and the framework for a media resource network is for the most part in place (see Appendix A.). Most of the larger engineering societies and the National Academy of Engineering (NAE) maintain membership listings and a committee structure that would make it relatively easy to identify engineers qualified to comment on specific topics. Public information offices at leading technological institutes often have similar listings of their faculty members. In addition, the Twentieth Century Fund Task Force cites as "one useful model" the Media Resource Service of the Scientists' Institute for Public Information.

To succeed in improving its image, however, the engineering community must overcome certain lingering isolationist attitudes, including elitism ("the public doesn't need to know what I'm doing and can't understand it anyway"), blaming the media for the lack of public support, and fear of discussing problems or controversies.

The opportunity for increasing the quantity and the quality of media coverage of engineering has never been better. A new computer-age generation of readers and viewers has begun to make its presence felt among media managers. One recent reflection of this is the proliferation of science/technology sections in daily newspapers around the country, most of which include a regular column on computers. The interconnectedness of engineering and the public's workaday world has never been more apparent. But before this interconnectedness can be exploited to improve the public's perceptions of engineering, the needs of all the parties involved must be defined and examined.

WHAT ENGINEERS NEED

Traditionally, engineers have had little success in communicating to the public the problems and promise of the technological enterprise. While few engineers conform to the stereotype of the inarticulate clod, many are cool to media queries, suspecting that reporters are simply looking for sensationalism and are incapable of understanding complexities.

In recent years, more and more engineers have become aware that their reticence has contributed to several serious problems: reduced financial support for academic research, a proliferation of state and federal regulatory legislation, an increasing burden of paperwork and administrative details, and, most important, a growth of public suspicion and mistrust.

A particular problem faced by the engineering community is the widespread stereotype of engineers as "wooden." In preparing this report, the task force surveyed 1, 118 journalists (569 science writers and 549 generalists); 74 percent of the respondents said they felt this stereotype was either "true" or "somewhat true" (see Appendix B).

In the days when technology was generally viewed as the goose that lays the golden egg of progress, this was not a serious problem. But today, the eggs are not all golden and the technological problems of the modern age (Three Mile Island, DC-10s, toxic wastes) have fostered a growing public reaction against modernity. Engineers can no longer afford the attitude that the public " can't understand" or "doesn't need to know" about technology.

WHAT THE MEDIA NEED

The press has been accused of committing a great many sins in its handling of such technological controversies as Three Mile Island. But regardless of the bias (and, to be sure, bias exists) of the particular newspaper or television network, the press depends for its information on professional, expert authorities. With a small number of notable exceptions, media people have little or no training in science and technology and no time or money to acquire it. All too often the media are forced to grab what they can "on the run." (This is especially true for television.)

Despite the increased attention paid to science and technology by many media outlets, it is no secret that the media in general remain either underinformed or misinformed in these areas. Although they may have the best of intentions, journalists find it virtually impossible to manage the volume of information that is required to remain abreast of technological developments.

The single biggest problem in overcoming this information gap is the media's lack of easily accessible sources, responsible experts who are able and willing to answer, articulately and factually, media questions on the fast-breaking developments in this increasingly technological society.

At three recent science/technology workshops for general assignment reporters in Pennsylvania, Sharon Friedman, journalism professor at Lehigh University and organizer of the workshops, reported that most of the participants cited a lack of background and information sources as their chief problem in covering these topics. The survey conducted by the task force (see Appendix B) also indicated that the paucity of engineers as sources was a particular problem for the media. Journalists were asked: In stories dealing with health, science, or technology, what percentage of the time do you call upon any of the follow ing types of experts? Engineers averaged 10 percent as compared to 40 percent for physicians and 35 percent for scientists.

Increasingly, news organizations are hiring or assigning one staff person as a science specialist. However, no one specialist can possibly cover the growing number of scientific and technical disciplines that have become intertwined with our social policy decisions. As Howard Simons of the *Washington Post* has pointed out, science writing is a specialty that is many specialties. Even when an outlet decides to hire an articulate scientist, how will it decide which one to hire: the biochemist who knows recombinant DNA research but gets lost in geology, or the geologist who understands oil and gas reserves but knows nothing of aerospace? Moreover, because most of today's "science" stories actually involve applications of technology, even a good general knowledge of science may not equip a science writer with the background or contacts needed to provide responsible coverage of breaking events.

A strong case can still be made for having a general assignment reporter rather than a specialist cover science/technology stories—someone who reflects the feelings and questions of the general public. But the issue is not so much who does the reporting as who answers the reporters' questions. Whether the media executive chooses a specialist or a general assignment reporter or both, any and all of these individuals must have access to the widest possible list of expert resources.

WHAT THE PUBLIC NEEDS

The most compelling reason for improving communication between engineers and journalists is the public's need for responsible information. And it is a critical need because the public's perception of technology has become a major factor in national decision making (e.g., Three Mile Island).

The social implications of this situation extend far beyond such immediate issues as nuclear power or toxic chemicals, or the short-term interests of engineers. Responsible public participation in the decision-making process requires a public that is well informed about science and technology. Without such information, the public is forced to act (or more often react) out of fear of the unknown or simply to leave decison making to the so-called experts. Either alternative can be devastating to the democratic system. To quote Walter Cronkite: "We are living in a truly revolutionary age—in one generation we have entered three new eras: the Space Age, the Atomic Age, and the Computer Age. Understanding any one of these requires more information than any one of us can possibly have. We are in a crisis because of this—how do we inform the electorate?—because a democracy cannot survive without an informed electorate."*

The current wave of popular and media interest in science and technology provides an unprecedented opportunity to meet this need.

BREAKING THE SILENCE

In this country, when a company wants more or better public exposure for a product or a program, it usually hires an advertising agency or a public relations firm. While this practice (i.e., salesmanship) may work for selling new and used cars, it will not work for the engineering enterprise as a whole. Indeed, it may only aggravate existing misunderstanding and mistrust between journalists and engineers.

In recent years, journalists, and especially science writers, have been besieged by press releases and phone calls from public relations people trying to "sell" technology to the press. Two years ago, the National Association of Science Writers devoted an entire issue of its newsletter to a series of angry complaints from leading science journalists around the country, expressing resentment of what they call science hype. But the question remains: If a PR campaign won't work, what will?

As already noted, the primary need felt by journalists covering science and technology is for increased and more reliable sources of information. Despite the current fashion of blaming media coverage for the public's misconceptions, the recent report by the previously mentioned Task Force of the Twentieth Centry Fund declared: "If news organizations exaggerate the health risks of new diseases, nuclear power accidents or toxic waste spills, the fault is probably in their sources of information, not their way of operating."

The single most important step the engineering community can take to improve media coverage of engineering is to make its expertise accessible upon request from journalists. By responding to journalists' queries, engineers will be providing information when it is needed, thus avoiding the sales-pitch type of pressure that only serves to alienate listeners. Once an engineering resource network is set up, however, another important step will be an energetic outreach effort to inform journalists around the country of its availability. This media information campaign needs to be viewed as an ongoing program, conducted

* *Media Resource Service 1984* (New York: Scientists' Institute for Public Information), p. 1.

primarily through the mail, but also enlisting the cooperation of media-society publications and forums to announce the new network.

The journalist-engineer relationships established through this interaction can be instrumental in overcoming the stereotypes and mistrust that currently characterize each community's attitudes toward the other. If the experience of the Media Resource Service is any indication, journalists will soon discover that most engineers are not inarticulate, and engineers will learn that most journalists are not merely sensation-seekers. Indeed, many journalists are intimidated by technology (even as many engineers are intimidated by the media), and the increased person-to-person contact can help to overcome that intimidation. Although it is understood that not every telephone conversation will bring ideal results, the effect of thousands of such conversations over several years will be improved mutual understanding—and, not insignificantly, improved media coverage.

To succeed in this approach, the engineering community must overcome certain attitudes that have served to reinforce its isolation from the public at large:

- A narrow, short-term view that seeks recognition only for engineering achievements selected by professional societies and institutions and refuses to discuss anything else.
- A lingering elitism that argues that the general public has no need to know what engineers are doing ("and anyway, our work is too complicated for the average person to understand").
- Fears on the part of some engineers, especially in the private sector, that talking to the press will inevitably result in the violation of some company policy.
- Antimedia bias (often based on experience with inaccurate reporting) that blames journalists for the public's fear of certain technologies and sometimes extends to an informal boycott of the press by those engineers holding this view.
- A reluctance on the part of some engineers and engineering leaders to discuss controversial social policy issues such as toxic waste disposal, nuclear power or the impact of robotics on employment.

These attitudes may reflect some legitimate concerns, but their net effect is to reinforce the barriers of mistrust and misunderstanding that already exist between the media and the engineering community. Whatever real or imagined problems engineers see in the process of reaching out to the media, these problems can be overcome through discussion and planning within engineering societies, corporate research divisions, and other technology institutions. The primary req uisite is a commitment on the part of these organizations and the entire engineering community to improve public understanding.

Mechanisms for such an improvement are for the most part already in place and need only be strengthened and expanded. In addition to public information offices of engineering societies, the National Academy of Engineering, and technical institutes, such mechanisms include the Media Resource Service of the Scientists' Institute for Public information (SIPI); the Mass Media Science and Engineering Fellowship program of the American Association for the Advancement of Science (AAAS); the Vannevar Bush Fellowships in Public Understanding of Technology and Science at the Massachusetts Institute of Technology (MIT); media seminars sponsored by the Council for the Advancement of Science Writing; and the Media Roundtable program cosponsored by SIPI, AAAS, and the Association of American Universities.

Engineers can provide invaluable information and understanding to the media and, through the media, to the public. With the help of existing mechanisms and in cooperation with engineering societies and institutions, the silence can be broken.

OPPORTUNITIES FOR EXPANSION

Opportunities to increase the quantity and the quality of media coverage of engineering have never been more plentiful. Science and technology coverage has expanded dramatically in recent years, particularly in the print media. At least seven major new science and technology magazines were launched between 1979 and 1982 to satisfy to what publishers perceived as a growing popular interest. Although some of these magazines have recently folded, the survivors appear to be thriving. In addition, a plethora of computer and specialized high-technology magazines has appeared, and bookstores report these publications are among their most popular items.

Even more significantly, no fewer than 14 large and mid-sized newspapers across the country have launched weekly science/technology sections during the past 2 years, and more are on the way. Numerous others have begun weekly science pages. With the *N. Y. Times*' Tuesday "Science Times," which started the trend in 1979, and the *Miami Herald's* section, which was begun in 1980, the number of such sections is now 16.

Although the quality of science and technology coverage varies from newspaper to newspaper, these sections all share the goal of making technologically sophisticated subjects accessible to and understood by the general public. The extra space for large, colorful, and detailed illustrations is a further attempt to provide more comprehensible explanations of complex scientific and technological concepts. These sections represent a major departure from previous publications that were aimed at audiences already attentive to science and technology.

The new science sections are directed at what media executives see as a new computer-age generation of readers. Although the ever-popular medical and health topics take up 25 percent or more of the columns in these sections, just as much if not more space is now devoted to high technology subjects and computers. This emphasis is reflected in the names of some of the new sections: "Science/Computers," "Tomorrow," "Sci/Tech," "Future Currents." Many also carry a regular computer column by a local expert.

David Lawrence is the executive editor of the *Detroit Free Press*, whose science section has just expanded by 50 percent and changed its name from "Science" to "Science/High Tech." Lawrence explains: "Our expansion is based on market research, sure, but it's no more than what you can see with your own eyes. It's all those people with computers in their basements. It's my seven-year-old's second-grade computer class."

Network television has not yet matched this coverage, but the increase in radio, television, and cable news broadcasts offers greatly expanded opportunities for reports on developments in the engineering community. Nearly 30 percent of the calls received by SIPI's Media Resource Service come from radio and television journalists. An analysis of these inquiries indicates that the overwhelming majority deal with the promises, applications, and consequences of technology in the world rather than with the development and testing of theories in the laboratory. Here, the engineer, rather than the scientist, becomes the critical expert with whom journalists must speak.

CONCLUSIONS

The conclusions reached by the task force are enumerated below:

1. An understanding of the engineering community by society at large, which is vital to the health of the engineering enterprise, depends on the ability of engineers to communicate with the public through the mass media.
2. The current explosion in the use of home and office computers and other high-technology products has created an unprecedented opportunity for increased public awareness of the work of the engineer

ing community. This opportunity is illustrated by the growth of popular media coverage of science and technology, including a recent proliferation of weekly science/technology sections in daily newspapers.

3. Engineers and engineering have not received media coverage that reflects either the quantity or quality of their contributions to today's "high-tech society."
4. The principal problem journalists face in covering the engineering enterprise is a lack of access to responsible, credible sources of information and understanding. Until now, the engineering community has done little to remedy this situation.

RECOMMENDATIONS

In addition to strengthening and expanding existing support mechanisms (see Appendix A), the engineering community should take immediate steps to develop a national network to provide journalists with access to information about engineers and engineering, thereby improving public awareness and understanding. There are several possible approaches that are not mutually exclusive:

- Within the major organizations in the engineering community (engineering societies, technical institutes, the National Academy of Engineering, and the Industrial Research Institute), establish lists of available experts, cross-referenced by specialization and geographical location. Such lists would be set up through the public information offices of the various organizations, and consultation and cooperation among the groups would be maintained on an informal basis.
- Develop more formal, centralized coordination of these available sources of technological information by a leading organization such as the National Academy of Engineering or a division of the National Science Foundation.
- Use SIPI's Media Resource Service as the centerpiece of the network to coordinate referrals to appropriate professional societies, the National Academy of Engineering, technical institutes, the Industrial Research Institute, and corporate public relations offices.

Any or all of these approaches require the development of a roster of available resource personnel by major organizations within the engineering community and a plan for communication and coordination among these groups. On controversial issues, the network must be prepared to provide access to responsible sources representing a diversity of opinion.

Once the network is in place, a coordinated media outreach effort should be launched to advise journalists of its existence and to identify emerging areas of engineering achievement and policy issues on which experts are available to comment. Journalists may need to be reminded frequently of the availability of engineers as resources, especially during the initial months of the new network. Indeed, engineering resources already available to the media, through public information offices at engineering institutes and professional societies, would almost certainly be called upon more often if journalists were reminded more frequently of their existence. The new network should plan to conduct such an informational campaign using mailings to journalists and also enlisting the cooperation of media-society publications and meetings.

The network should also provide expert engineering resources for existing and future mechanisms that offer seminars and classes in science and technology for journalists. These mechanisms include the Science Media Fellowship Program of the AAAS; the Vannevar Bush Fellowships in Public Understanding of Technology and Science at MIT; the media seminars of the Council for the Advancement of Science Writing; and the Media Roundtable program cosponsored by AAAS, the Scientists' Institute for Public Information, and the Association of American Universities. The National Academy of Engineering and other leading groups within the engineering community should seek to set up similar seminars and other educational programs for journalists.

Funding for the network should come from four sources: government, through the National Science Foundation; media organizations; engineering societies; and the corporate community. This four-part funding is essential to the public credibility that the network must maintain if it is to succeed.

Appendix A

Public Information and Media Outreach Activities

Several types of efforts to foster media and thus public understanding of engineering and technology are already being made. These range from the standard public relations operations of most companies and professional societies to a small number of more innovative projects.

The Media Resource Service (MRS) was established in 1980 by the Scientists' Institute for Public Information as a free referral service available to all members of the media seeking reliable sources with scientific and technological expertise. MRS maintains a data base of more than 15,000 experts from academia, government, and private research/consulting organizations who have agreed to answer media questions in their areas of specialization.

When a journalist calls with a question, the MRS staff searches the program's data base to find the appropriate specialists, examining such criteria as field(s) of expertise, geographical location (where applicable), and position on controversial issues (representatives of two or more sides are always given).

In almost all cases, the staff then calls each expert to determine availability and to alert him or her that the journalist will be calling. This serves simultaneously to clear the way for the journalist and to allow the expert an opportunity to prepare for the journalist's question.

The American Institute of Chemical Engineers (AIChE) devotes its principal outreach efforts to promoting coverage of its national meetings and conferences and its brochures and fact sheets on specific issues. The AIChE has done some limited videotape distribution profil ing the role of the chemical engineer (five 30-second and one 60-second public service announcements and one 60-second radio spot). The institute's Public Relations Committee is being reorganized to create better opportunities to provide technically accurate information to the press.

The American Society of Civil Engineers (ASCE) has prepared information kits on infrastructure issues and on the water crisis for distribution to its sections and branches. These kits, including slides, booklets, and press releases, provide background technical information. Sections and branches are encouraged to arrange for media use of these materials. The ASCE has also produced two movies, one entitled "America in Ruins," the other on civil engineering education. In addition, the society has put together a four-color booklet on the role of the civil engineer (largely as a career guidance aid) in conjunction with a 20-second public service announcement (PSA) television spot.

The American Society of Mechanical Engineers (ASME) arranges for media coverage of technical conferences and publishes articles in ASME publications. It also produces films, including one on its Historic Mechanical Landmarks Program featuring technologically significant devices. Films are distributed to sections, schools, and civic groups. Occasional TV spot announcements are also produced.

The Institute of Electrical and Electronics Engineers (IEEE) has compiled a technical resources directory for distribution to the media. It lists dozens of experts (including names, addresses and phone numbers) in approximately 100 areas of technology. IEEE held a media technology briefing on robotics and as part of its recent annual meeting held five sessions with 16 engineers and 38 editors on supercomputers, defense electronics, communications, technology for the handicapped, and electric power transmission. It has produced two PSAs (one 60-second spot, one 30-second) that have also been adapted to print. A 28-minute film oriented to a nontechnical audience describes the role of the electrical engineer. Finally, IEEE has fostered extensive media coverage of its activities (e.g., centennial) and publications (e.g., special issues of *Spectrum* on space technology and supercomputers).

The National Society of Professional Engineers (NSPE) is preparing an engineering experts directory for direct distribution to the media and for distribution through the society's chapters. NSPE conducts public relations seminars for its members to encourage them to work with the media and has prepared a public relations handbook for engineers. It has fostered media coverage of its activities and routinely arranges interviews for the president of the society when he travels. NSPE also tries to inform the media about the profession through sponsorship of the Outstanding Engineering Achievement Awards and National Engineers Week. The society reaches into hundreds of communities through an extensive scholarship program and MATHCOUNTS. NSPE also sponsors awards programs for both print and broadcast journalism.

Beyond the efforts of engineering societies, centers of engineering excellence have also worked to improve media understanding of technology. Several corporations (e.g., Westinghouse) have provided time and training for engineers to make media appearances discussing technology. Most engineering colleges have at least one public information staff person who can serve as a conduit for the press to expert faculty.

The Massachusetts Institute of Technology (MIT) conducts the Vannevar Bush Fellowships in the Public Understanding of Technology and Science. The program is designed for eight experienced technology and science journalists per year. Its aims are to recognize individual achievement and to provide journalists with the opportunity to expand their contacts and conduct a lengthy research project. The host MIT also benefits from the development of new pathways by which to describe developing technologies and their implications to the public.

Another program bringing experts and media together is the New Horizons series of meetings held annually by the Council for the Advancement of Science Writing (CASW) in cooperation with a host university. In these 4-day sessions, engineers and scientists make presentations on new research findings. Nightly social gatherings bring experts and journalists together to foster the development of personal contacts. The CASW has also held four regional sessions on issues relating to public health and the environment as well as occasional 1-day meetings in Washington, D.C., on science policy issues.

The American Association for the Advancement of Science (AAAS) has since 1975 conducted its Mass Media Science and Engineering Fellows Program. (Engineering was added to the title in 1982.) The program aims to strengthen the relationship between scientists and engineers and the media by allowing advanced students in science/engineering to work for a summer on newspapers and magazines and at TV and radio stations. About 150 students have participated in the program, with several continuing on in subsequent media jobs.

Finally, a joint media outreach effort dealing with university research is being developed by AAAS, the Association of American Universities, and the Scientists' Institute for Public Information. This 18-month program will bring scientists and engineers who are experts on university research together with a small number (from 8 to 15) of journalists for free-wheeling discussions of such issues as the transfer of strategic technology to the Soviets.

This survey of media outreach efforts is not intended to be exhaustive. Its aim has been simply to touch upon the activities of some major engineering organizations as well as some of the more interesting activities of other organizations.

Appendix B

Survey of Journalists' Perceptions of Engineers, Physicians, and Scientists

As part of this report, a survey was taken of journalists in the print and electronic media regarding their perceptions of technical experts, specifically, engineers, physicians, and scientists. The survey was an attempt to determine the answers to these questions:

1. How often, relatively speaking, do journalists solicit the three types of experts for comment?
2. How do journalists perceive these experts?
3. Where are journalists most apt to look for these experts?

The eight-question survey was mailed to 1,118 journalists, including 569 science journalists (from the mailing list of the National Association of Science-Writers) and 549 generalists. A discrete body of engineering/technology writers was not readily identifiable.

A total of 202 journalists responded, which was a response rate of 18 percent. Of the 549 generalists, 54 (10 percent) returned the questionnaire, with 148 (26 percent) of the science writers responding. Given this much higher response rate, answers for each of the following questions were controlled for the type of journalist responding.

Overall, the results of the survey showed that journalists have substantially less contact with engineers than with either physicians or scientists. Journalists turned to engineers on only 11 percent of their stories on health, science, or technology, with little distinction between science writers (10 percent) and nonscience writers (13 percent). On the other hand, journalists turned to physicians 41 percent of the time with little difference between the type of journalist and to scientists 35 percent of the time (science writers, 39 percent; generalists, 23 percent). (See Table B-1.) Only 23 journalists (11 percent of the total 202 respondents) turned to engineers before physicians or scientists.

Respondents were also asked to describe, on the average, how many engineers, physicians, and scientists they spoke with each week. Overall, respondents spoke with 4 times as many physicians or scientists as engineers. There were differences, however, between science journalists and nonscience journalists. Nonscience journalists contacted only 1.5 to 2.5 times as many physicians or scientists; science reporters approached 4.5 times as many scientists or physicians.

When journalists were asked whether they thought a description of the engineer, physician, or scientist as "wooden" was true, somewhat true, or not true, about three out of four (74 percent) said that it is true or somewhat true for engineers. Only 55 percent thought that the assessment was true or somewhat true for physicians, compared to 50 percent for scientists.

Responding journalists also were surveyed about where they were most likely to seek each of the three types of experts. On a scale of one (most likely) to seven (least likely), reporters were asked to rate the following sources of contacts: academia, government, industry, professional society, public interest, trade association, and other.

Reporters were most likely to turn to industry while seeking engineers, with academia, government, and professional societies as next choices (see Table B-2). When controlling for type of reporter, however, nonspecialists were more likely to look first to academia and then to industry, professional societies, and government.

Table B-1 Use by Respondent Journalists of Three Types of Experts (percent)

	Journalists		
Experts	Nonscience	Science	Total
Engineers	12.8	10.0	11.0
Physicians	42.1	41.4	41.5
Scientists	22.6	39.4	34.9

Table B-2 Journalists' Preferred Use of Institutions in Seeking Experts

Types of Institutions	Engineers	Physicians	Scientists
Academic	2	1	1
Government	3	3	2
Industry	1	4	3
Professional society	4	2	4
Public information	6	5	5
Trade association	5	7	6
Other	7	6	7