REPORT OF THE
JOINT SUBCOMMITTEE STUDYING

HOW VIRGINIA CAN BEST MAINTAIN HIGH QUALITY ENGINEERING PROGRAMS IN ITS PUBLIC INSTITUTIONS OF HIGHER EDUCATION

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

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Administrative and Clerical

Office of Clerk, Senate of Virginia

Report of the

Joint Subcommittee Studying How Virginia Can Best Maintain High Quality Engineering Programs In Its Public Institutions of Higher Education

To

The Governor and the General Assembly of Virginia
Richmond, Virginia
December 29, 1983

TO: The Honorable Charles S. Robb, Governor of Virginia

and

The General Assembly of Virginia

Origin of the Study

The Joint Subcommittee Studying How Virginia Can Best Maintain High Quality Engineering Programs in its Public Institutions of Higher Education was authorized to conduct its study by Senate Joint Resolution No. 5, which was agreed to during the 1983 Session of the General Assembly. The resolution may be found in the appendices of this report.

Senate Joint Resolution No. 5, 1983, requested that a joint subcommittee of the Senate Education and Health and Finance Committees, and the House Education and Appropriations Committees be established to study how Virginia can best maintain the high quality engineering programs in its public institutions of higher education.

Appointed to serve on the joint subcommittee were Senators Willard J. Moody of Portsmouth, Chairman, Frank W. Nolen of New Hope, and Stanley C. Walker of Norfolk; and Delegates V. Earl Dickinson of Mineral, Franklin P. Hall of Richmond, Royston Jester, III, of Lynchburg, Joan H. Munford of Blacksburg, and Mitchell Van Yahres of Charlottesville, Vice-Chairman. Also appointed to the joint subcommittee were John T. Casteen, III, Secretary of Education; Gordon K. Davies, Director of the State Council of Higher Education; and Ray E. Martin, a practicing engineer, of Richmond.

Statement of the Problem

Recently, there has been concern that the quality of engineering programs has declined. In 1982, the Committee on the Quality of Engineering Education of the National Association of State Universities and Land-Grant Colleges' Commission on Education for the Engineering Professions was directed to determine the extent of truth in assertions that quality has declined, and, if it has, to identify the specific nature and causes of the decline together with proposed remedies.

This committee found that the U. S. engineering education system has experienced a serious decline in quality in the last few years. The nation has been spared the full impact of this deterioration because the popularity of engineering has resulted in the admission of only the brightest and most able students. It was determined that the root causes of the quality decline are over enrolled classes, obsolete equipment, equipment shortages, insufficient space, and a persistent shortage of faculty. Many young people choose not to pursue academic careers because of non-competitive salaries and poor working conditions. The committee concluded that should a decline occur in the popularity of engineering as a college option, the nation will require a continuous supply of engineers at a level substantially higher than that of five or ten years ago. The resource base for quality engineering education will continue to be overtaxed by this demand. Thus, strong measures are required to regain and maintain quality.

Activities of the Joint Subcommittee

During the course of the study, the joint subcommittee conferred with the deans of the schools of engineering, staff of the Council of Higher Education, and representatives from business and industry. The joint subcommittee determined that its charge included an examination of the need for increased funding of engineering education programs, maintaining or improving the quality of such programs, updating laboratory equipment and facilities, and increasing the number of engineering graduates.

Information was solicited concerning the proliferation of programs, the perspective of industry regarding the quality of engineering graduates, the number of students who transferred to other in or out-of-state engineering schools and their reasons, the number of engineering students who matriculated over the past few years, the number of those who graduated, the number of those who obtained employment, and the number of those who enrolled in graduate school. The Council was also requested to provide information on the actual cost of educating an engineer and regulations regarding the operation of private engineering schools in the state.

The Status of Engineering Programs in Virginia

Four universities, Old Dominion University, the University of Virginia, Virginia Military Institute, and Virginia Polytechnic Institute and State University have engineering schools; two universities, George Mason and Virginia Commonwealth offer engineering-related programs; and three universities, Norfolk State, Virginia State and Old Dominion, offer engineering technology.

Thirty-three bachelors, twenty-eight masters and twenty doctoral programs in engineering and engineering technology are offered in Virginia. Comparatively, Virginia ranks poorly at the masters and doctoral levels in computer science programs. There are only seven masters and two doctoral programs in computer science in the state. Among private schools, there is almost no engineering activity. Hampton Institute offers a bachelor's degree program in engineering and the Institute of Textile Technology in Charlottesville has a master's degree program in textile engineering.

Institutions operating in Virginia from out-of-state are George Washington University, Catholic University, the University of Maryland and Emory Riddle Aeronautical Institute. George Washington University operates in Tidewater, Lynchburg and in Northern Virginia. It offers an array of masters programs in aeronautical, electrical, acoustic, environmental, and fluid mechanics engineering. The school is heavily involved with NASA on the peninsula and with industry in Northern Virginia. Catholic University offers a masters degree in management in Northern Virginia, and the University of Maryland, with programs in computer sicence, electrical engineering and mechanical engineering, offers a television hook-up between its campus in College Park and IBM - Manassas. In the Tidewater area, Emory Riddle Aeronautical Institute offers a program related to aeronautical engineering. All out-of-state institutions have to be approved to operate in the Commonwealth by the Council of Higher Education. All have to meet minimal standards regarding faculty, library and various student services.

A new venture in graduate engineering studies was begun in Richmond last fall. It is a collaborative effort of the University of Virginia and Virginia Polytechnic Institute and State University to provide graduate engineering programs to practicing engineers in this area. The program is offered at Virginia Commonwealth University as the host and administrative institution. A director was appointed to the program to coordinate the offerings of the universities, to involve the industrial community of Richmond in the program and to coordinate the work of business and industry with that of the universities to take full advantage of the adjunct faculty who might be willing to teach, the use of laboratories and research equipment and the recruitment of qualified students. VCU also contributes to the effort by offering nonengineering courses and courses related to engineering in the sciences, mathematics and physics. It is expected that nearly 200 students will enroll in the program this fall.

The cost of this program for 1983-84 is approximately $560,000 from general funds. Another $4.8 million in general funds has been requested for 1984-86 to transmit the program from Richmond to the east and north. This figure does not include tuition and fees and nongeneral funds that may be associated. Of the request, $1.4 million is designated for the statewide network and telephone costs. This represents 1080 hours in instruction per year; therefore, a budget request for the delivery of the program is expected from the Council of Higher Education in the 1984 Session.

A. Baccalaureate Degree Programs

In the United States today, the total number of freshman and full-time undergraduate enrollment in engineering has reached an all-time high. There are 340,000 students majoring in engineering in the United States. Last year the nation conferred 70,000 engineering degrees at the bachelor's level and Virginia contributed almost 1,600 to this total.

In comparison to other states, Virginia ranks fourteenth in size of population, thirteenth in full-time equivalent enrollment, and twelfth in bachelor's degrees conferred in engineering. The total number of programs at this level is twenty-six, with areas of concentration in electrical, civil and mechanical engineering. Together, VPI & SU and UVA confer 83% of all such degrees.

B. Master's Degree Programs

At the master's degree level, Virginia ranks fourteenth in the nation in the number of degrees conferred, placing the Commonwealth at the same ranking relative to its population. The masters degree, probably the most important level for industry because it is the terminal degree for many engineers working in industry,is where there is a dire need for continuing education. In 1982, there were graduated 371 masters degree holders in engineering in Virginia, an increase of over 70% during the past decade. The areas in which the largest number of masters degrees are conferred are electrical, civil and mechanical engineering.

C. Doctoral Degree Programs

Since 1972, the number of doctoral degrees produced in the Commonwealth has remained relatively stable. It was noted that there are two ways of acquiring a pool of engineers who hold the doctoral degree: (1) to educate them in the State's postsecondary institutions, and (2) to recruit graduates from other states. In this respect, Virginia has succeeded in educating its own engineers at all degree levels. However, this alone does not fill the needs of engineering education in the Commonwealth.

Virginia graduates approximately sixty engineers with doctoral degrees each year. Nationally, about 1000 such graduates are produced each year. Virginia Polytechnic Institute and State University has ten of the twenty doctoral programs and the University of Virginia has nine. Together they produce the largest quantity of doctoral engineers and credit hours in Virginia. Most doctoral degree recipients are civil, electrical, or mechanical engineers or engineering mechanics.

Women and Minorities in Engineering Programs

Of national concern is the number of women and minorities in engineering programs. However, institutions in the Commonwealth rank very well in this regard. Virginia Commonwealth University ranks thirty-ninth in the nation in science and engineering in the number of women and fifteenth in the number of blacks enrolled in such programs.

Virginia Polytechnic Institute and State University ranks seventy-seventh and the University of Virginia ranks eighty-sixth in the nation in the number of women enrolled in their science and engineering programs. Old Dominion University is seventy-ninth in the number of blacks enrolled in these programs.

Research in Engineering

At the institutional level, Virginia has three institutions which rank among the top 100 research institutions in the nation: Virginia Commonwealth University (75th), the University of Virginia (57th) and Virginia Polytechnic Institute and State University (74th).

There is $92,980,000 worth of engineering research in the Commonwealth, funded largely by federal funds. In the competition for research funds, Virginia compares favorably.

The National Aeronautics and Space Administration (NASA) funds twenty-two percent of all engineering research in the Commonwealth. Seventeen percent of engineering research is funded by private industry with the remainder funded by the U.S. Department of Energy and the U.S. Department of Defense.

Though the federal research funding budget is decreasing, it is not decreasing in engineering. The amount of money that is given to academic research and development in any year is approximately $7 billion in this country. About $420 million (6%) of that is spent on equipment. Of this amount, $210 million was spent by twenty institutions, none of them in Virginia.

The recommendation of the Governor's Task Force on Science and Technology that a Center for Innovative Technology be established promises to be a major move in Virginia in the engineering and high technology fields.

The Task Force's report indicates that it believed that the concept of a Center for Science and Technology should include research and that its administrative offices be located at a site in Northern Virginia which is the heart of the burgeoning of high technology industry. The Task Force also recommended that the participants be Virginia Polytechnic Institute and State University, the University of Virginia, Virginia Commonwealth University, George Mason University and Old Dominion University and that there be an immediate and aggressive beginning to the project. The high technology programs which are offered in the Commonwealth are clustered in the southwest, Charlottesville and in Tidewater. Therefore, it is essential that research undertaken anywhere in the Commonwealth involve VCU, UVA and Virginia Tech. Research space totals 475,000 feet at VPI, 386,000 feet at UVA and 340,000 feet at VCU. On the peninsula, Old Dominion University and the College of William and Mary have lesser amounts, but are still significant. Engineering research space in Virginia is worth $94 million.

In analyzing research space in the State, it is extremely important to note the age of the buildings. The average age of an engineering building at VMI is 41 years; at UVA, 33 years; at VPI & SU, 23 years; and at ODU, 15 years. Of all the engineering buildings in this State, 75% were built before 1970 and 31% were built before 1950. Buildings are typically built with life expectancies of 40 to 50 years. This reveals that a major need for capital improvement in engineering is imminent. This is important because the appropriation for capital outlay in Virginia includes all equipment. Consequently, when buildings are very old, by implication, equipment in those buildings is also very old. Virginia is faced with the problem of obsolescence and deterioration of engineering buildings as well as the obsolescence of equipment.

In a study done by the National Science Foundation on university scientific research equipment, it was found that university laboratory equipment was about twice the age of that in industry. Most university laboratories fared poorly when compared to United States industry labs. Even industry labs did not compare well to those in Japan and Western Europe.

In 1975-80, 56% of the engineering programs in the United States were accredited fully and 44% received accreditation with caveats and stipulations. Almost all of the caveats and stipulations addressed equipment modernization problems.

To address this problem, Virginia's engineering institutions received money for equipment enhancements during the last fiscal year. George Mason University received $1 million in general funds, Old Dominion University, $1 million, and the University of Virginia, $1.5 million. This will help, but it is not sufficient.

Recruitment and Retention of Faculty

One of the problems faced by all Virginia institutions and all engineering colleges is the recruitment of faculty. One reason that the recruitment of faculty is difficult is that the salaries are not competitive with industry. The 1982 General Assembly took this fact into account when it established salary averages for institutions by a device called "high cost disciplines". Every institution received 4 1/2% salary increases in 1982-84. Institutions that have "high cost disciplines", which are engineering, physical sciences, computer science and accounting, all received between a 1.1% to 1.7% additional increase because of the high cost disciplines they offer.

Virginia funds engineering at a ratio of faculty to student which is higher than those which are used in general academic instruction. At the graduate level, for example, engineering is funded at a 1:7 ratio, while all other disciplines are funded at a 1:10 or 1:8 ratio. At the junior and senior levels, engineering is funded at 1:11 and all other disciplines at 1:14. This does not mean, however, that the institutions actually staff at these levels due to various pressures exerted upon them to effect salary savings, and sometimes to buy equipment. Inadequate funding and a shortage of qualified doctoral engineers are two factors which prevent institutions from hiring needed faculty.

Perspectives of Business and Industry

The Joint Subcommittee held a public hearing to solicit the views of business and industry. The following summation reflects the points stressed by those industries that were represented.

The healthy and continued growth of existing industries and the attraction of new medium and high technology industries will depend substantially upon the availability of high quality education in industrially important regions of the Commonwealth, ongoing graduate education programs, and engineering courses to aid in the retraining or career development of engineering personnel and to meet industry needs. Other priorities include initiatives to assure the success of masters level engineering programs and appropriately trained engineering technicians.

Meeting these goals will require the state legislature to place a higher priority on engineering education. This will require more money for higher faculty salaries, up-to-date laboratory facilities, state-of-the-art computer systems, and innovative programs to support industry. These priorities presume that engineering students will be taught the communication skills that are essential in transforming technical concepts into reality.

The Governor's Task Force on Science and Technology stressed the importance of science and technological training at all levels of education and found that the emphasis on graduate engineering programs benefited other levels because of the "trickle down" effect. The Task Force also commented extensively on the desirability of providing extension graduate engineering programs as a requirement of high tech industry. The Task Force also acknowledged the highly competitive environment involving engineering faculty as well as the problem of equipment obsolescence. It was noted in the report the strong commitment by business and industry to address these problems in tangible ways, for example, the exchange of faculty and businessmen.

Industry representatives stated that many new employees were recruited from Virginia institutions. They also noted two recommendations by the Accreditation Board for Engineering and Technology. First, that "there is a dire need to enhance university laboratory facilities nationwide," and second, "that each engineering school must demonstrate a computational capability...noncompliance with these recommendations could result in loss of accreditation." Contributions from industry include millions of dollars worth of equipment, grants, and loans of technical professionals as faculty to colleges and unviersities. Many technical professionals often continue their education through a combination of on-the-job training, tuition refund programs, and continuing graduate study leading to an advanced technical degree. Cooperative programs between universities and high technology industry together with the use of interactive instructional delivery systems, such as interactive instructional television (ITV), would benefit all concerned and allow the university to reach more students in the same classroom time.

The "crisis" in engineering is not a new problem, nor is it a problem that can be solved quickly. A solution to the problem will require a concerted effort by state government, industry and academia for years to come due to rapid and dynamic technological changes, domestic and world economic conditions, and the commmon recognition that education is a continuous process. The public and higher education systems must adapt to the diverse and complex socio-economic and technical changes in order to produce a more employable, educated citizenry. Increasingly, there is a need for persons who have cross-disciplinary knowledge in the technical areas, sciences and in the fundamentals of interpersonal communications such as the knowledge of the social sciences, business and the liberal arts. To be technically skilled and literate is a requirement for high technology workers today. As high technology becomes embedded in other industries, it will be a requirement for many more workers in traditional industries.

Effect of the "Crisis" on State Engineering Schools

The effects of the crisis in engineering education has affected Virginia's engineering schools.

Virginia Military Institute noted in testimony to the Joint Subcommittee that the growth in enrollment has caused a need for more faculty, an increase in class size, temporary excessive teaching loads, equipment for additional laboratory stations and reallocation of space. Though the salary level for engineering was augmented by state funds, VMI still has the lowest salary level among the State's engineering schools. Recruitment of qualified faculty is a problem. For example, the recruitment for faculty in the electrical engineering department resulted in only 35 applications. When those applicants with insufficient credentials had been eliminated, the yield was ten qualified applicants. The recruitment problem is further complicated by VMI's requiring commissioning in the Virginia Militia.

The school is still using equipment purchased fifty years ago. Combined state and private funds were used in the last several years to prevent VMI's engineering laboratories from becoming so inadequate as to lose is ABET accreditation. One priority at VMI is the continuation and completion of its rehabilitation of current buildings to address the problem of space and to improve, modernize and rearrange the building's interior to comply with modern standards.

The College of Engineering at Virginia Polytechnic Institute and State University has a long history of producing successful graduates. Included in the roster of baccalaureate alumni are the Chairmen of Exxon, Raytheon, American Electric Power, American Enka, Pittston, Hercules and the past President of Georgia Tech as well as the past Director of the Lyndon B. Johnson Space Center. Doctoral graduates are well placed in research laboratories and are on the faculty of leading colleges of engineering across the country. At the present time the College is graduating approximately 1,000 BS, 250 MS and 40 PhD's each year. The faculty are engaged in research projects funded from external sources in the amount of $10 million annually. Admission pressures are intense and enrollment in the College is selective.

Virginia Tech stated that four specific problem areas must be addressed: space, facilities,, recruitment and retention of faculty, and increased enrollment. The salary differential offered by industry and other schools, and the space/facility constraints which curtail the opportunity for research are factors which make it difficult to compete successfully for qualified faculty. The shortage of faculty, coupled with the lack of classroom space and laboratories, makes it impossible to offer additional sections of courses. Virginia Tech is finding it difficult to further expand its engineering school. Additional space was necessary twelve years ago.

The engineering program at the University of Virginia was established in 1868. The school is relatively small, with 1500 undergraduate students, 500 graduate students and 150 faculty. There are ten divisions offering undergraduate and graduate degree programs. Approximately 300 bachelor degree students are graduated yearly.

The school is in need of additional space, modern laboratory and instructional equipment, and well-trained technicians who can install, operate and maintain highly sophisticated electronic and computing equipment. It is estimated that $400 per student per year for the next five years is required to bring the undergraduate and graduate laboratories up to standard.

The graduate program is less well established than the undergraduate program. The school acknowledges the need to attract high quality graduate students into the doctoral program. Few undergraduates enter the graduate program due to the attraction of high salaries in industry and limited research opportunities in graduate school. There is a need to increase the stipends for fellowship students, research assistants and teaching assistants. The library holdings and facilities need to be upgraded, and the research program and facilities need to be expanded and improved. The University cited as additional needs (1) the recruitment, development and retention of high quality faculty; (2) the encouragement of more undergraduates to enter graduate school; (3) the upgrading of engineers in industry and private practice by offering more off-campus graduate programs; and (4) the appropriation of funds by the legislature to expand the ITV program jointly offered with VPI & SU other parts of the State.

The engineering program at Old Dominion University was begun in 1966. Since that time its departments of civil, electrical and mechanical engineering have graduated nearly 1000 students and added graduate programs in each department. The school has one of the ten most productive engineering research departments in the nation and enjoys a national reputation. More than 71% of ODU's engineering graduates remain in Virginia.

Old Dominion University is the only engineering school in the State located in a populous industrial setting. Because of its location, the school focuses on the special needs of eastern Virginia. However, many of the problems which plague other engineering schools are experienced by ODU as well. The engineering school has experienced an explosive growth in enrollment, while total university enrollment has been either stable or in decline, during a time when the recession has made it impossible for appropriate reallocations to be made to alleviate engineering's problems. It has also become difficult to compete effectively for qualified Ph.D.'s to fill vacancies. Inadequate computer and laboratory support resulted in a poor rating during the 1982 accreditation review.

The most creative engineers are not always found at the top of their class, and the current selection process impedes the identification of such people. In addition, high tech laboratories are needed to retrain practicing engineers in nontraditional areas and to keep them abreast of the latest advances in their fields. Old Dominion University noted in testimony before the Joint Subcommittee that it has been proposed that the school be used as a focal point for beginning an extension service similar to that of the agricultural extension service. Such a service would focus on working together with the school of business, local government and civic groups to identify and match potential products with persons who have a reasonable chance of starting a new industry successfully. Emphasis would be on attracting disadvantaged students to careers in engineering and science.

Engineering-Related and Engineering Technology Programs

The majority of engineering-related and engineering technology programs are based in the Virginia Community College System. These programs are designed for persons who plan to transfer to a four-year institution to complete a baccalaureate degree program in one of the following engineering fields: aerospace, agricultural, architectural, ceramic, chemical, civil, electrical, industrial, mechanical, metallurgical engineering, engineering mechanics, mining, or nuclear engineering. The engineering programs include the courses generally required in the first two years of a baccalaureate engineering curriculum.

A student who wishes to enter the community college's engineering program must have satisfactorily completed high school units or equivalent in English, mathematics (i.e., algebra and plane geometry, advanced mathematics or trigonometry, and solid geometry), laboratory science, and social science. The engineering curriculum includes course requirements in English, humanities, mathematics, science, social science and introductory engineering.

The engineering curriculum is available at eight community colleges. Related engineering technology programs (e.g. broadcast engineering technology, drafting and design) are also offered and are designed to prepare engineering technicians for immediate employment in construction and industry upon graduation.

The community college's transfer associate degree programs in engineering are experiencing an increase in enrollment and graduates. The programs provide an opportunity for students to remain close to home and take the first two years of a four or five-year degree program. The cost per credit hour of instruction is just slightly higher than that for the business administration transfer program. The engineering faculties at the colleges also have expressed a need for new and more technically advanced equipment.

Results of the Survey of State Engineering Schools

During the course of its study, the Joint Subcommittee requested the Council of Higher Education to survey the engineering schools to obtain information on students, facility and equipment needs, faculty, funding, and degree programs. This Council's report, which includes an analysis of the data is appended to this report. Overall, the Council's report indicates that the educational, general and sponsored program budgets for engineering for the years, 1981 through 1983, at many of the schools have remained relatively stable.

The report noted further that there has not been a great change in enrollment over the past four years and that there is no established schedule for the replacement of obsolete equipment.

RECOMMENDATIONS

The Joint Subcommittee recommends that:

1. The Commonwealth initiate efforts to rectify the present serious equipment deficiencies in the engineering programs of state-supported colleges and universities.

Rationale

The engineering disciplines are characterized by rapidly changing technologies. For this reason, the equipment used in instruction must be kept as up-to-date as possible. However, the resources to accomplish this goal on a yearly basis are limited. Traditionally, major equipment upgrading is accomplished during the construction of new facilities. As the number of new engineering buildings at Virginia's public colleges and universities has declined in recent decades, a backlog of equipment needs has developed. In presentations to the Joint Subcommittee, engineering deans estimated these equipment needs to be in excess of $19 million. To the extent possible, this deficiency should be reduced immediately in order to maintain the quality of instruction necessary to educate engineers knowledgeable in the latest technologies in their fields.

2. The State Council of Higher Education develop a formula to fund the acquisition or replacement of equipment for engineering programs separate from capital outlay for buildings and facilities for review by the Senate Finance Committee, the House Appropriations Committee and the General Assembly by the 1985 Session of the General Assembly.

Rationale

In the current budget process, capital outlay for equipment is funded as a corollary for capital outlay for construction. Presently, no separate formula for capital outlay for equipment exists. This has resulted in obsolete equipment remaining in use in old buildings. The average age of an engineering building in this state is 28 years old. Seventy-five percent of the engineering buildings were build before 1970 and thirty-one percent were built before 1950. Therefore, the obsolescence of the equipment used in engineering laboratories in Virginia has in the past, and is now, endangering the accreditation of the schools.

A formula for the replacement of equipment for the State's engineering schools would provide a mechanism for incremental funding for annual updating of institutional equipment without creating a fiscal crisis.

3. The Commonwealth remedy the severe space problems encountered by engineering programs in serving current student enrollments by adding new facilities and rehabilitating existing facilities.

Rationale

Enrollment increases in engineering programs have resulted in shortages of space for classroom and laboratory instruction, faculty offices and research. As a result, the quality of teaching and research in engineering disciplines is threatened. The need for renovating or replacing old facilities is also great. The average age of engineering buildings at VMI is 41 years; at UVA the average age is 33 years; at VPI 23 years; and ODU 10 years. Assuming that the average building is predicted to have a life expectancy of 40 to 50 years, the Subcommittee believes that a schedule for renovation or replacement of these facilities is essential.

4. The interactive television programs be supported in order to provide much needed off-campus engineering programs and to satisfy the need for graduate programs in engineering in the Commonwealth.

Rationale

Because current economic conditions are not conducive to the establishment of additional masters degree engineering programs on the campuses in the state, maximum use of available technological capabilities in telecommunications appears to be the most cost effective means of satisfying the demands of business and high technology industries for continuing engineering education. Collaboration among the institutions will prevent duplication of programs while providing a critical service. Further, business and industry representatives have endorsed these programs as a means of continuing education in engineering because of the lower costs to the company and accessibility to the employee. Television may also be a useful means of providing services to business and industry other than master's degree programs, for example, for short courses or specialized training programs. Such programs should be developed as a service supported by business and industry.

5. The Commonwealth's resources be focused on improving and enhancing the engineering programs already in existence in the Commonwealth's institutions of higher education in order to support and attract industry.

Rationale

In order for Virginia to sustain a rapidly advancing high technological economy, a sound, innovative, and adequately funded higher education system must be in place. Concentrating on improving the quality programs which are already in place would appear to be the most efficacious method of assuring industries of the friendly atmosphere in the Commonwealth.

6. Those institutions having engineering programs cooperate with those institutions expressing a need to establish such programs in the development of intercampus programs or activities such as the interactive television program.

Rationale

Innovative solutions must be sought for the needs for high technology education which are realistic in terms of available funds and faculty. Sharing of faculty and facilities as well as ideas and expertise could only result in improvement of the quality of all of the programs. Such cooperative efforts could utilize the resources of business and industry to the mutual benefit of both.

7. The engineering schools be encouraged to interact with business and industry in maintaining the engineering programs and in obtaining financial and academic support.

Responses to the staff survey of business/industry contributions to the Commonwealth's engineering programs indicated the good working relationships that existed between those companies contributing to engineering programs. It appears evident that these companies believe that they are benefited by this relationship by being able to attract qualified employees and by being able to afford continuing education for their personnel.

The Joint Subcommittee determined that academicians should be urged to aggressively seek funding and other support from the business world. The Joint Subcommittee believes these relationships provide strong stimuli for seeking excellence and frequently have exciting results. In particular, the Joint Subcommittee encourages collaborative research with business and industry, personnel exchanges between the institutions and business and industry, and cooperative arrangements for the use of equipment and donations.

8. The Senate Finance Committee and the House Appropriations Committee continue to support provisions in the Appropriations Act for providing salary differentials for engineering and other high cost faculty in order for schools to compete successfully for staff.

Testimony provided to the Subcommittee by the Deans of the schools of engineering, the Council of Higher Education as well as materials distributed by staff have substantiated the acute shortages of faculty for high technology programs. Highly qualified individuals can easily acquire positions with business and industry which pay better. The Subcommittee believes that the only effective way to attract scarce faculty is to provide higher salaries and better facilities.

9. No additional undergraduate engineering schools be established in the Commonwealth's institutions of higher education until the present engineering programs are receiving funding adequate to assure accreditation and maintenance of educational quality.

The Subcommittee has received overwhelming evidence of serious underfunding of the Commonwealth's schools of engineering. This underfunding has created problems in staffing, maintaining accreditation and in promoting national reputations for having quality programs. The Subcommittee sincerely believes these problems must be alleviated before any new undergraduate programs should be established. The four schools, which represent the foundation of Virginia's engineering education, must be provided the funding to support the high technology structure the Commonwealth desires for the future.

10. The Council of Higher Education study the resource needs and relationships with business and industry of the associate and baccalaureate degree programs in engineering technology at the public colleges and universities.

Rationale

The scope of the Joint Subcommittee's charge was limited to the study of engineering education. The Subcommittee, however, is convinced that the education of engineering technologies is of great importance to the nation and the Commonwealth's efforts to attract new industry and upgrade existing industry. The Governor's Task Force on Science and Technology highlighted the importance of a well-educated technical workforce and expressed its concern for improved relationships between technical training and the needs of business and industry. Recent studies of the current technical workforce and projections for future demands for technologists suggest the need for further training and retraining of workers in traditional industries which are modernizing their technologies, and the education of technologists for new industries. The Joint Subcommittee recommends further study of these programs to ensure their good health and ability to provide the necessary training for the future economy.

11. Institutions examine alternatives to measuring the quality of engineering programs in terms of the amount of resources allocated to the program.

Rationale

Engineering programs at the state-supported colleges and universities face the challenge of sustaining quality during a period of fiscal constraint. In such circumstances, traditional methods of judging education's quality in terms of the resources committed to it are of limited value. The national accrediting bodies have judged quality in this way, but many are now working toward the introduction of assessment based upon results. Historical standards of funding per student or staffing ratios of full time equivalent faculty to students may be difficult or impossible to achieve. Alternative ways of providing education have to be devised. The engineering disciplines, with their emphasis on quantitiative and precise knowledge and skills, may be particularly amenable to evaluations based on educational results. The Subcommittee endorses the exploration of new forms of pedagogy and staffing patterns, and careful assessment of their effects upon educational quality.

Conclusion

Recent reports on the crisis in engineering education all indicate a decline in the quality of such programs. Each has established that the decline is due, in part, to obsolete equipment and facilities, insufficient space, and a shortage of qualified faculty. The study conducted by this Subcommittee substantiates these findings. The results of this study are also compatible with those cited in the report of the Governor's Task Force on Science and Technology regarding engineering education. The Governor's Task Force concluded that "continuing education is an integral part in the support of high technology industries throughout the state." It also noted that a limited amount of continuing education programs in high technology disciplines was available in the State and that there were serious deficiencies in the quality of laboratory equipment, faculty shortages and old buildings and facilities. The Joint Subcommittee concurs with these findings.

To succeed in the coming technological age, support present industries and attract new industries, Virginia must have a solid and viable public and higher education system firmly established. Establishing Virginia's prominence as the prime location for industry requires excellence in the delivery of educational programs that serves its citizenry and meets the needs of business and industry. This will require engineering schools and other institutions which offer other "high cost disciplines" (1) to be outstanding in the quality and visibility of their research, (2) to seek exceptional leadership that can effect an improvement in research quality, obtain long-term sources of support, understand national priorities, initiate and establish contacts with industrial and political decision-makers, and (3) to be able to allocate resources.[1] These features are contingent upon adequate facilities, quality of graduate students, state-of-the art equipment and computational capability, and qualified faculty which, in turn, necessitate adequate funding of engineering schools.

The Joint Subcommittee believes that the coordination of engineering technology programs at the community colleges with the engineering programs at the four-year institutions is essential to meeting the growing need for qualified engineers.

In addition, it is imperative that a schedule for funding the rehabilitation of existing facilities and the construction of new facilities be developed. As previously stated in this report, the average age of the engineering buildings in Virginia is 28 years old. Assuming that the average building is built with a life expectancy of 40 to 50 years, the Joint Subcommittee believes that this schedule for rehabilitation and replacement of facilities is crucial to avoiding a crisis which is imminent.

The Joint Subcommittee was apprised that a bond bill for capital outlay for educational institutions will possibly be introduced in the 1984 Session of the General Assembly. The Joint Subcommittee strongly supports such a measure. Though a bond bill will accomplish much to alleviate the need for the rehabilitation and replacement of facilities at the engineering schools, it does not satisfy the need for judicious planning for the perpetual maintenance of these facilities, nor does it provide a mechanism for the acquisition of equipment. Therefore, the Joint Subcommittee wishes to stress that a formula is needed to fund capital outlay for buildings and facilities separate from funding for equipment. Concepts as to how such a formula should be developed, funded and administered were discussed by the Joint Subcommittee but a consensus on the essential features of such a formula was not reached. It was, therefore, determined that the study should be continued (1) to give the Joint Subcommittee the opportunity to put the knowledge it has gained in the last several months to work in benefiting the Commonwealth and its engineering programs, (2) to coordinate the development of the formula with the Council of Higher Education, and (3) to continue to investigate methods of alleviating the problems related to maintaining quality engineering programs. Proposed legislation to this effect is appended to this report.

The Joint Subcommittee thanks the Council of Higher Education, the deans of the schools of engineering, and representatives of business and industry for their assistance.

Respectfully submitted,

Willard J. Moody, Chairman

Mitchell Van Yahres, Vice-Chairman

V. Earl Dickinson

Franklin P. Hall

Royston Jester, III

Joan H. Munford

Frank W. Nolen

Stanley C. Walker

John T. Casteen, III

Gordon K. Davies

Ray E. Martin

Footnotes

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Appendices

A. Proposed Legislation

B. SCHEV Summary Report of the Engineering Education Study

C. Senate Joint Resolution No. 5, 1983

APPENDIX A

Continuing the joint subcommittee of the Senate Committees on Education and Health and Finance and the House Committees on Education and Appropriations studying how Virginia can best maintain the high quality engineering programs in its public institutions of higher education.

WHEREAS, the Joint Subcommittee studying how Virginia can best maintain high quality engineering programs in its public institutions of higher education has examined the many problems related to sustaining the Commonwealth's high quality engineering programs; and

WHEREAS, the Joint Subcommittee has developed eleven recommendations, the implementation of which, in its opinion, will be crucial to the future of Virginia's engineering programs; and

WHEREAS, one of these important recommendations requests the State Council of Higher Education to develop a formula for funding acquisition and replacement of equipment separate from buildings and facilities for review by the Senate Finance Committee and the House Appropriations Committee; and

WHEREAS, the Joint Subcommittee views its work as essential to the well-being of Virginia's engineering programs and, therefore, to the well-being of Virginia's attractiveness to industry; and

WHEREAS, the members of the Joint Subcommittee have developed ideas for the creation and application of a formula to fund equipment; and

WHEREAS, the Joint Subcommittee would like the opportunity to put the knowledge it has gained in the last several months to work in benefiting the Commonwealth and its engineering programs; now, therefore, be it

RESOLVED by the Senate, the House of Delegates concurring, That the Joint Subcommittee of the Senate Committees on Education and Health and Finance and the House Committees on Education and Appropriations studying how Virginia can best maintain the high quality engineering programs in its public institutions of higher education shall be continued to coordinate the development of a formula for funding equipment separate from buildings and facilities and to continue to investigate methods of alleviating the problems related to maintaining Virginia's engineering programs.

The Joint Subcommittee shall complete its work in time to submit its recommendations to the 1985 Session of the General Assembly. The membership of the Joint Subcommittee shall remain the same and shall continue to consist of eleven members as follows: two members from the Senate Committee on Education and Health, one member from the Senate Committee on Finance, three members of the House Committee on Education, two members of the House Committee on Appropriations, two ex officio members–the Secretary of Education and the Director of the State Council of Higher Education–and one citizen member of the Virginia Society of Professional Engineers.

The direct and indirect costs of this study are estimated to be $17,470.

SENATE JOINT RESOLUTION NO. ...

Requesting the State Council of Higher Education to develop a formula to fund the acquisition and replacement of equipment for engineering programs.

WHEREAS, the joint subcommittee studying how Virginia can best maintain high quality engineering programs in its public institutions of higher education found that engineering disciplines are characterized by rapidly changing technologies; and

WHEREAS, the equipment used in instruction must be kept up-to-date in order to maintain the quality of instruction necessary to educate engineers knowledgeable in the latest technologies in their fields; and

WHEREAS, capital outlay for equipment is funded as a corollary of capital outlay for buildings and facilities; and

WHEREAS, the average age of engineering buildings in the Commonwealth is twenty-eight years old and the equipment in these buildings is frequently outdated; and

WHEREAS, it is estimated that these equipment needs are in excess of $19 million; and

WHEREAS, the obsolescence of the equipment used in engineering laboratories has in the past endangered, and is now endangering the accreditation of Virginia's engineering schools; and

WHEREAS, a formula to fund the acquisition and replacement of such equipment would provide a mechanism for incremental funding for annual updating of this equipment without creating a fiscal crisis; now, therefore, be it

RESOLVED by the Senate, the House of Delegates concurring, That the State Council of Higher Education is requested to develop, in cooperation with the joint subcommittee studying the engineering programs, a formula to fund the acquisition and replacement of equipment separate from capital outlay for buildings and facilities for review by the Senate Finance Committee and the House Appropriations Committee by the 1985 Session of the General Assembly.

APPENDIX B

Summary Report of Engineering Education Study

Presented to the Joint Subcommittee on Engineering Education by the State Council of Higher Education November 1983

Report of the
Engineering Education Study

Table I
Educational and General and Sponsored Program Budgets
for Engineering Education, 1980-83

	Educational & General			Sponsored Programs			Total		
Instit	1980-81	1981-82	1982-83	1980-81	1981-82	1982-83	1980-81	1981-82	1982-83
ODU	$1,209,036	$1,229,344	$1,375,006	$1,374,975	$1,356,152	$1,417,762	$2,584,011	$2,585,496	$2,792,768
UVA	4,850,689	5,674,226	6,104,486	7,668,806	7,868,200	8,773,345	12,519,495	13,542,426	14,877,831
VMI	643,322	879,333	1,184,164	----	----	----	643,322	879,333	1,184,164
VPI	12,710,402	13,830,140	16,243,216	9,624,538	10,456,226	11,015,910	22,334,940	24,286,366	27,259,126

Table II
Equipment Expenditures for Engineering Education, 1980-83
and Total Engineering Equipment Inventory Replacement Value

	Equipment Expenditure			Replacement
Institution	1980-81	1981-82	1982-83	Value
ODU	$187,184	$137,275	$100,002	$1,168,000
UVA	691,072	697,037	956,872	12,400,000
VMI	9,377	103,089	145,138	3,446,820
VPI	1,045,795	1,067,796	1,403,038	35,804,000

NOTES: (1) ODU totals include equipment purchased with both educational and general and sponsored program funds.

(2) UVA totals include equipment purchased with funds from educational and general, overhead cost recoveries, sponsored programs, private or corporate gifts, local or university sales and service and endowment funds. Also included are expenditures for rental, lease and lease-purchase agreements for each of the three academic years totaling, respectively: $27,572, $21,737 and $43,509.

(3) 1981-82 expenditures for VMI were all made from private funds; VMI's expenditures for 1982-83 include $38,305 from private funds.

(4) VPI expenditures include equipment purchased with educational and general, sponsored programs, research and extension funds. Also included are expe[illegible]itures for rental, lease and lease-purchase agreement[illegible]or each of the thr[illegible]ademic years totaling, respectively: $45,487, $47,845[illegible]$136,505.

Equipment Replacement Schedules for Engineering Education

ODU: The School of Engineering has no equipment replacement schedule

UVA: The School of Engineering has no equipment replacement schedule; however, individual departments do develop equipment priority lists based on a determination of their needs. Equipment is then purchased on a schedule consistent with the priority listings.

VMI: Each department at the Institute projects new and replacement equipment costs for each of the next three biennia. These projections become the blueprint for equipment acquisition schedule. The schedule has been followed precisely for the past six years.

VPI: The School of Engineering has no formal equipment replacement schedule.

Access To Engineering Equipment Outside Engineering Schools or Departments

ODU: The School of Engineering has access to the university computer and limited access to the facilities of the Langley Research Center, NASA, in Hampton. Professors from ODU conduct some experiments at NASA and the School borrows equipment from the Center valued at less than $20,000.

UVA: The School of Engineering uses the University Academic Computer Center for instruction and research. The School also shares the facilities of other units of the university, including: the Department of Environmental Sciences, the Medical School and the university power plant. Ad hoc agreements are established with organizations outside the university, including with: NASA, Langley's computer facilities; Cray Research Corporation's computer system; Colorado State's computer system; Merke Laboratory; the Federal Highway Department's computers; the Highway Research Council; Bell Laboratories; General Electric's computer graphics system; the National Research and Resource Facility at Cornell University; the National Resource Centers at Arizona State (for High Resolution Electron Microscopy), Berkeley, California (for High Voltage), and Minnesota (for Surface Analysis); the Argonne and Los Alamos Laboratories; the Virginia Electric and Power Company's reactor simulator at Surrey, Virginia; and with corporations with whom research is being done. These arrangements involve no financial terms.

VMI: Engineering departments have access to the university computer. Charges are pro-rated on a percentage basis to departments using the computer and charged against the operating budget of the computer center, with no monetary transfer made against the departments' budgets.

VPI: The School of Engineering has access to the university's computer system, which bills users at the rate of $500 per hour.

Table III

Undergraduate Headcount and Full-Time Equivalent Enrollments in Engineering Education, 1980-83

	Lower Level						Upper Level						Total					
	1980-81		1981-82		1982-83		1980-81		1981-82		1982-83		1980-81		1981-82		1982-83	
Institution	Hdct	FTE	Hdct	FTE	Hdct	FTE	Hdct	FTE	Hdct	FTE	Hdct	FTE	Hdct	FTE	Hdct	FTE	Hdct	FTE
Old Dominion Univ	557	377	550	398	570	396	365	420	449	562	507	618	922	797	999	960	1077	1014
Univ of Virginia	789	651	780	620	732	583	662	630	722	714	771	781	1451	1281	1502	1334	1503	1364
VMI	349	186	357	158	390	206	262	413	262	499	248	384	611	599	619	657	638	590
Virginia Tech	2569	2391	2644	2397	2450	2340	2222	2507	2312	2607	2319	2679	4903	4905	4974	5116	4779	5026

NOTE: Headcount totals are for Fall terms; full-time equivalent totals are annualized. Lower level students are freshmen and sophomores; upper level are juniors and seniors. Totals may include some students who are not classified by level.

Table IV

Number of Transfer Students and Foreign Nationals in Undergraduate Engineering Education, 1980-83

	Transfer Students			Foreign Nationals		
Institution	1980-81	1981-82	1982-83	1980-81	1981-82	1982-83
Old Dominion Univ	381	406	479	55	55	71
Univ of Virginia	47	40	42	8	10	7
VMI	9	10	14	---	15	14
Virginia Tech	229	199	155	148	141	107

Table V
Headcount and Full-time Equivalent Enrollments
in Graduate Engineering Education, 1980-83

	Master's Level						Doctoral Level						Total					
	1980-1		1981-2		1982-3		1980-1		1981-2		1982-3		1980-1		1981-2		1982-3	
Inst	Hdct	FTE	Hdct	FTE	Hdct	FTE	Hdct	FTE	Hdct	FTE	Hdct	FTE	Hdct	FTE	Hdct	FTE	Hdct	FTE
ODU	131	113	113	119	143	114	32	12	23	9	33	16	163	125	136	128	176	130
UVA	351	271	315	244	359	271	114	101	123	103	134	115	465	372	438	347	493	386
VPI	456	308	479	372	506	401	99	111	168	140	196	17[illegible]	558	421	653	516	707	576

NOTE: VPI totals include some unclassified graduate students. Headcount totals are for Fall terms; full-time equivalent totals are annualized.

Table VI
Foreign Nationals Enrolled in Graduate Engineering Education, 1980-83

	Master's Level			Doctoral Level			Total		
Inst	1980-1	1981-2	1982-3	1980-1	1981-2	1982-3	1980-1	1981-2	1982-3
ODU	14	24	27	5	6	18	19	30	45
UVA	26	27	26	30	31	29	56	58	55
VPI	166	164	197	53	94	118	219	258	315
Total	206	215	250	88	131	165	294	346	415

Geographical Distribution of In-State Engineering Education Students

Undergraduate Programs

ODU: The university draws 60 percent of its Virginia-resident engineering undergraduate students from Tidewater area communities, including Virginia Beach and Norfolk (17 percent each); Hampton (10 percent); Chesapeake (6 percent); Newport News (5 percent); Portsmouth (3 percent); and Suffolk (2 percent). Approximately 6 percent of engineering undergraduates come from two northern Virginia communities: Fairfax County (4 percent) and Alexandria (2 percent). An additional 3 percent come from the city of Richmond. In-state students account for 87 percent of the undergraduates in engineering education.

UVA: Undergraduate engineering students at the university come from 109 Virginia cities and counties. The largest proportion (43 percent) come from five northern Virginia communities: Fairfax County (30 percent), Alexandria (5 percent), Prince William County and Fairfax City (3 percent each), and Arlington (2 percent). Nearly 10 percent of the students are from the Richmond metropolitan area, including Richmond City, Henrico and Chesterfield Counties. Newport News and Norfolk contribute 2 percent each to the student total. In-state students represent 77 percent of the undergraduate engineering students at the university.

VMI: Engineering students at the Institute come from 50 Virginia cities and counties. About one-fifth of these students are from the Tidewater communities of Virginia Beach (7 percent of the total), Newport News (6 percent), Norfolk (4 percent), Hampton and York County (2 percent each). An additional 18 percent of the engineering students are from northern Virginia counties (Fairfax-- 11 percent and Prince William-- 4 percent) and the city of Arlington (3 percent). The city of Richmond (6 percent) and the counties of Henrico and Chesterfield (5 percent each) account for 16 percent of the total. Lynchburg (4 percent) and Lexington (3 percent) are also a source of engineering students. In-state students are 55 percent of all engineering students at VMI.

VPI: Undergraduate engineering students at the university come from 49 Virginia cities and counties. More than one-third the undergraduate engineering students at VPI are from the northern Virginia communities of Fairfax County (15 percent of the total), Alexandria (6 percent), Fairfax City

(5 percent), Arlington and Falls Church (3 percent each), Prince William County and Loudoun (2 percent each). An additional 14 percent of the engineering students come from the Tidewater cities and counties of Virginia Beach, (5 percent), Hampton (3 percent), Newport News, Norfolk and Chesapeake (2 percent each). The city of Richmond (7 percent) and the nearby county of Chesterfield (2 percent) are a source of students. Montgomery County and Roanoke City contribute an additional 7 percent of the total. In-state students are 86 percent of all undergraduate engineering students at VPI.

Graduate Programs

ODU: Over three-fourths of the in-state engineering graduate students at the university live in the Tidewater areas of Viriginia Beach (21 percent of the total), Norfolk (16 percent), Hampton (11 percent), Newport News (9 percent), Portsmouth (9 percent), Chesapeake (8 percent) and Suffolk (2 percent). The cities of Danville, Covington, Falls Church and Alexandria each account for 2 percent of the total. In-state students are 66 percent of all engineering graduate students at ODU.

UVA: Graduate engineering students at the university come from 48 Virginia cities and counties. Nearly one-fourth come from the northern Virginia areas of Fairfax County (11 percent of the in-state total), Arlington (7 percent), Fairfax City and Alexandria (3 percent each). One-fifth the students reside in Charlottesville. Lynchburg and Richmond each supply 3 percent of the graduate student total. In-state students constitute 54 percent of all engineering graduate students at the university.

VPI: Residents of 37 Virginia cities and counties are represented among the university's engineering graduate students. The nearby county of Montgomery and the city of Roanoke account for 29 percent of the in-state total. An additional one-fourth of the students come from the northern Virginia communities of Fairfax County (15 percent), Alexandria (7 percent) and Prince William County (3 percent). In-state students are 63 percent of all graduate engineering students.

Out-of-State and Foreign National Students in Engineering Education

Undergraduate Programs

ODU: Out-of-state students in undergraduate engineering programs represent 11 percent of the total enrollment. In addition, these programs enroll 2 percent foreign nationals. Engineering students come from forty-six states, with over one-half the out-of-state total coming from the Middle Atlantic states of New Jersey (18 percent), New York (16 percent), Maryland (12 percent), Pennsylvania (9 percent) and Delaware (2 percent). Other states with more than one percent of the total include Connecticut and Florida (4 percent each), North Carolina (3 percent) and California (2 percent).

UVA: Out-of-state students from 26 states comprise 23 percent of all undergraduate engineering students at the university. Less than one percent of the engineering graduate students are foreign nationals. Over 60 percent of the out-of-state students come from the Middle Atlantic region, including: New Jersey (16 percent of the total), Maryland (15 percent), New York (14 percent), Pennsylvania (13 percent) and the District of Columbia (4 percent). Other states with more than one percent of the total include Ohio (4 percent) and Florida (3 percent).

VMI: Out-of-state students represent 43 percent of engineering students at the Institute. Foreign nationals comprise an additional 2 percent of the total. Students from 37 states other than Virginia are enrolled in engineering, almost one-half from the Middle Atlantic states of Pennsylvania (16 percent), New York (12 percent), Maryland (11 percent) and New Jersey (8 percent). Other states with more than one percent of the total include three southern states (North Carolina, Georgia and Florida --5 percent each), Ohio and California (5 percent each).

VPI: Students from states other than Virginia are 13 percent of all undergraduate engineering students at the university. Foreign nationals account for one percent of the total. Two-thirds of the out-of-state students are from the Middle Atlantic states of Maryland (27 percent), New York (13 percent), New Jersey (12 percent), Pennsylvania (12 percent) and Delaware (3 percent). Other states with more than one percent of the total include West Virginia (5 percent), North Carolina (4 percent), Ohio (3 percent), Florida and Tennesee (2 percent each).

Out-of-State and Foreign National Students, cont.

Graduate Programs

ODU: Out-of-state students are 8 percent and foreign nationals 26 percent of the total engineering graduate students at the university. Of the 40 states represented, 9 account for more than one percent of the total out-of-state enrollment, including: North Carolina (12 percent each), New York and Pennsylvania (10 percent), Washington, California and Florida (6 percent each), Texas (5 percent), Ohio and West Virginia (4 percent each).

UVA: Out-of-state students account for 43 percent of the total graduate engineering enrollment at the university. Foreign nationals represent 3 percent of the total. Students come from 29 states, 10 of which are more than one percent of the total, including: New York (16 percent), Maryland (15 percent), Pennsylvania (14 percent), New Jersey (13 percent), Ohio (7 percent), Connecticut and Florida (5 percent each), California (4 percent), Illinois and Tennessee (3 percent each).

VPI: Students from 35 states other than Virginia represent 16 percent of the total graduate engineering enrollment at the university. Foreign nationals are 21 percent of the total. Nine states contribute more than one percent of the out-of-state enrollment, including: Pennsylvania (14 percent), Maryland (12 percent), New York (9 percent), New Jersey (8 percent), North Carolina (6 percent), Tennessee and West Virginia (5 percent each), Florida and Ohio (4 percent each).

Indicators of the Academic Quality of Students Enrolled in Undergraduate Engineering Education

I. High School Record

Three institutions reported information about students' high school achievements.

VMI: Engineering students rank, on the average, in the top one-quarter of their high school classes; the average rank for all entering cadets is the second quarter of the high school class.

ODU: Engineering students in 1982-83 had an average high-school grade-point average of 2.9 on a 4.0 scale. In 1983-84, the average for engineering students was 3.1. No information is presented comparing engineering and other students.

VPI: The unversity presented a three-year comparison of high school grade-point averages for engineering and other students at the university, as follows:

	High school grade-point average		
Major	1981-82	1982-83	1983-84
Engineer	3.55	3.56	3.62
Other	3.25	3.27	3.26

The university also noted that in 1982-83, 74 percent of entering freshmen in engineering were from the top 10 percent of their high school class; 52 percent had taken calculus, 49 percent had advanced or honors English, 64 percent had three or more years of a foreign language, and 60 percent had computer experience. Only 5 percent had not taken any foreign language in high school.

II. Scholastic Aptitude Test Scores

Inst		Major	1981-82	1982-83	1983-84
			Combined SAT Score		
ODU		Engr	992	1024	1095
		All	950	960	960
UVA		Engr	1209	1210	1241
		All	No Information		
VMI		Engr	1046 for 1980-83		
		All	1040 for 1980-83		
VPI	Engr		1160	1170	1206
	All		1010	1020	1030

NOTE: UVA provided a breakdown of engineering students' SAT scores for both the mathematics and verbal portions of the test. Mathematics scores averaged 653, 652 and 666 for the three years respectively. Verbal scores averaged 556, 558 and 575 respectively. VPI provided a comparison of engineering and all students on the mathematics and verbal portions of the SAT. For engineering students, mathematics scores averaged 630, 630 and 650 for each of the three years respectively; for all students. comparable averages were 530, 540 and 550. For engineering students, verbal scores averaged 530, 540 and 556 for each of the three years respectively; for all students, comparable scores were 480, 480 and 480.

III. Proportion of Applicants Who Are Accepted or Enroll in Undergraduate Education

UVA: The ratios of applicants to acceptances into UVA's engineering school for the three years from 1980-83 were 25, 27 and 20 percent respectively.

VMI: The Institute does not accept students directly into engineering programs. The ratio of those who apply to VMI versus those who actually enroll, for the three academic years from 1980-83, has been 30, 35 and 34 percent respectively.

VPI: Comparing engineering and other students, the ratios of applicants to acceptances for engineering students for the years 1980-83 have been 57, 64 and 46 percent, respectively; for other students the comparable ratios have been 61, 53 and 58 percent. The proportions of those who apply versus those who actually enroll for these same years has been: 35, 39 and 29 percent for engineering students; 37, 31 and 32 percent for other students.

IV. Scholarships

<u>VPI</u>: The university awarded to engineering students 250 of 1100 freshmen scholarships based solely on merit. In a university-wide scholarship competition limited to the top 400 applicants to the university, 275 engineering students typically will be included in the competition. In this competition, 16 scholarships are awarded annually, with about 12 usually being awarded to engineering students. In Fall, 1982, the university had 28 National Merit Scholarship recipients, appproximately 25 of whom were engineering students.

The Academic Quality of Graduate Engineering Students

I. Assistantships, Fellowships and Other Awards

ODU: The university reports no significant number of nationally competitive scholarship recipients. Approximately 80 percent of engineering graduate students are awarded graduate teaching or research assistantships.

VPI: For each of the academic years from 1980-83, graduate teaching or research assistantships were awarded to 62, 62 and 71 percent of engineering graduate students. Comparable totals for other graduate students for each of the three years respectively are 47, 47 and 51 percent.

II. Graduate Record Examinations

ODU: This examination is not required for admission to graduate programs at the university.

UVA: For engineering students pursuing a Master's degree, GRE scores for 1980-83 were:

GRE Test	1980-1	1981-2	1982-3
Verbal:	541	546	539
Math:	671	668	665
Total:	1212	1214	1204

For doctoral students, the comparable totals were:

GRE Test	1980-1	1981-2	1982-3
Verbal:	504	533	521
Math:	680	673	680
Total:	1184	1206	1201

VPI: Comparisons of total GRE scores for engineering and all graduate students for each of the academic years 1980-83 are as follows:

Major	GRE Scores		
	1980-1	1981-2	1982-3
Engineering	1163	1176	1197
All	1158	1156	1172

III. The Ratio of Applicants To Acceptances

UVA: The proportions of applicants to acceptances for Master's degree programs for 1980-83 were 85, 80 and 74 percent respectively. For doctoral programs, the comparable proportions were 72, 65 and 61 percent respectively.

VPI: The ratio of applicants who were accepted into all graduate engineering programs in engineering for 1980-83 were 41, 42 and 40 percent for the respective years. Comparable proportions for all graduate programs other than engineering were 53, 49 and 45 percent.

IV. Undergraduate Grade-point Average

UVA: Students in Master's programs in engineering had high-school grade-point averages of 3.2 on a 4.0 scale for each of the three academic years 1980-83. Students in doctoral engineering programs had high-school grade-point averages of 3.1, 3.3 and 3.2 for the academic years 1980-83.

Retention of First-time Freshmen in Engineering Education, 1980-83
Enrollment in Subsequent Semesters

Inst	Year	Major	Percent Returning Next Fall Term
ODU	1980	Engr	No information
		Other	No information
	1981	Engr	69
		Other	No information
	1982	Engr	91
		Other	No information
UVA	1980	Engr	89
		Other	91
	1981	Engr	89
		Other	91
	1982	Engr	86
		Other	92
VMI	1980	Engr	81
		Other	77
	1981	Engr	86
		Other	79
	1982	Engr	88
		Other	87
VPI	1980	Engr	92
		Other	90
	1981	Engr	90
		Other	88
	1982	Engr	No information
		Other	No information

Four-Year Completion Rates for Baccalaureate Students
in Engineering Education, June 1983

Inst	Major	Percent Completion in Four Years
ODU	Engr	25
	Other	No information
UVA	Engr	59
	Other	72
VMI	Engr	51
	Other	52
VPI	Engr	70
	Other	67

Information on Employment of Engineering Education Graduates

ODU: The university is unable to supply employment information on baccalaureate graduates. For graduates of Master's programs, the university estimates only about 10 percent are employed in fields other than engineering. Most Master's graduates were part-time students already employed in the field and in the geographical area; these former students have remained in the area. Doctoral graduates virtually all remain in engineering fields. NASA Langley is the largest employer of these graduates.

UVA: The university is unable to supply information on the employment of graduate degree recipients. Employment statistics for baccalaureate graduates in 1980-82 are as follows (totals are percentages):

	1980	1981	1982
Employed or Had Job Offer	51	52	42
Further Education	16	16	17
Seeking Employment	5	6	18
Not Seeking Jobs	1	2	3
Unknown	27	24	20

VMI: For 1980-82, 4 percent of VMI engineering graduates went on to graduate school; 65 percent went into military service (30 percent into non-engineering jobs, 35 percent to engineering-related work). An additional 23 percent have taken positions in Virginia industries, while 8 percent entered industries in other states. Officials at the Institute estimate that nearly all engineering graduates who are employed have jobs which are closely related to their engineering training. After five to ten years, about one-half migrate to management, another one-fourth pursue master's degrees, and 6 percent enter doctoral programs.

VPI: The university reports post-graduate plans of engineering graduates for the years 1980-82. At the baccalaureate level, those employed after graduation included 79, 77 and 73 percent for the three years respectively. Each year 13 percent of the graduates enrolled for further education. Those seeking employment upon graduation included 6, 8 and 12 percent of the totals for the three years. At the master's level, those employed upon graduation included 68, 62 and 63 percent of the yearly totals. Those still seeking employment after graduation included 3, 3 and 6 percent of the annual totals respectively. Graduates taking further education after graduation included 20, 21 and 18 percent of the yearly totals. Doctoral graduates included 86, 88 and 93 percent of yearly graduates who were employed upon graduation. In 1980, 5 percent and in 1982 3 percent of graduates were still seeking employment after graduation.

Table VII
Full-Time Equivalent Undergraduate and Graduate Engineering Faculty By Discipline:
Annual Average For Three-Year Period, 1980-83

		Annual Average, 1980-83				
Engineering Discipline	Inst	Full-Time	Part-Time	GTA's	Admin	Total
General	UVA	20.0		1.0		21.0
	VPI	14.7				14.7
Aerospace	UVA	3.7				3.7
	VPI	13.3		0.3		13.6
Applied Mechanics	UVA	1.6				1.6
Biomedical	UVA	6.4				6.4
Chemical	UVA	7.8			0.1	7.9
	VPI	10.3	0.6	0.4		11.3
Civil	ODU	6.7	0.8	0.4	0.8	8.7
	UVA	8.5	0.3		0.2	9.0
	VMI	11.7	0.8			12.5
	VPI	29.0	1.3	1.4		31.7
Comp Science & Applied Math	UVA	22.8		0.5	0.1	23.4
Electrical	ODU	7.9	0.2	0.9	1.0	10.0
	UVA	12.4	0.1			12.5
	VMI	6.7	0.5			7.2
	VPI	34.5	0.7	6.1		41.3
Engineering Mechanics	VPI	34.7	1.1	0.9		36.7
Engineering Physics	UVA	1.0				1.0
Industrial	VPI	19.7	0.2	2.0		21.9
Materials	UVA	5.6				5.6
	VPI	8.7	0.6			9.3

Full-Time Equivalent Faculty By Discipline, continued

Engineering Discipline	Inst	Annual Average, 1980-83 Full-Time	Part-Time	GTA's	Admin	Total
Mechanical	ODU	11.4	0.7	1.1	0.7	13.9
	UVA	12.0			0.1	12.1
	VMI	4.3	0.4			4.7
	VPI	36.0		1.9		37.9
Mining & Minerals	VPI	7.2	0.2	0.6		8.0
Nuclear	UVA	5.4				5.4
Systems Engineering	UVA	5.6			0.1	5.7
Total	ODU	26.0	1.7	2.4	2.5	32.6
	UVA	112.8	0.4	1.5	0.6	115.3
	VMI	22.7	1.7			24.4
	VPI	208.1	4.1	13.6		225.8

Table VIII
Engineering Faculty Salary Averages By Rank, 1980-83,
and a Comparison With Institutional Averages in 1982-83

Faculty Rank	Inst	Engineering Faculty 1980-81 No. Fac	Salary Average	Engineering Faculty 1981-82 No. Fac	Salary Average	Engineering Faculty 1982-83 No. Fac	Salary Average	All Faculty 1982-83 No. Fac	Salary Average	Differential All vs. Engr Faculty 1982-83
Full-time										
Lecturer	UVA	2	$19,300	1	$21,000	1	$23,000	20	$22,300	+3.1
Instructor	ODU	2	20,000	1	20,900	2	25,000	61	17,100	+46.2
	UVA	1	13,400	3	16,700			26	17,100	
	VMI	5	14,600	3	15,100	5	16,900	6	18,750	-9.9
	VPI	34	16,600	33	17,100	23	19,000	142	17,500	+8.6
Assistant Professor	ODU	8	21,500	10	23,900	11	26,400	167	22,300	+18.4
	UVA	35	22,000	34	24,400	33	26,200	269	22,500	+16.4
	VMI	3	19,200	6	21,200	7	24,300	25	22,000	+10.5
	VPI	66	23,000	55	24,900	70	28,200	447	24,100	+17.0
Associate Professor	ODU	15	25,100	14	28,300	14	31,600	201	26,800	+17.9
	UVA	44	29,000	48	31,000	47	32,800	279	30,700	+6.8
	VMI	6	22,300	5	25,000	6	30,100	16	26,400	+14.0
	VPI	70	26,800	76	29,000	70	31,900	432	30,000	+6.3
Professor	ODU	9	33,700	7	36,400	7	38,800	128	36,100	+7.5
	UVA	50	37,000	55	40,200	65	42,400	346	44,500	-4.7
	VMI	9	25,700	8	25,600	8	36,500	45	31,200	+17.0
	VPI	89	38,300	94	41,500	101	43,500	396	41,600	+4.6
All Full-time Ranks	ODU	34	26,300	32	28,500	34	31,000	575	26,200	+19.1
	UVA	132	30,000	141	32,600	146	35,500	949	32,800	+8.2
	VMI	23	21,600	22	22,800	26	28,000	92	27,100	+3.3
	VPI	259	28,400	258	31,202	264	34,200	1,417	29,300	+16.7
Part-time	ODU	8	1,200	10	1,400	20	1,300			
	UVA	8	14,700	10	12,200	11	13,200			
	VMI			1	4,000	1	6,000			
	VPI	47	18,800	30	21,800	26	21,500			
GTA's	ODU	10	6,000	14	6,500	14	6,500			
	UVA	49	4,400	56	5,7000	68	5,600			
	VPI	43	5,800	77	6,300	68	6,600			

Faculty Position Openings and Personnel Actions

ODU: In 1981-82, the engineering school had three position openings. Three full-time faculty were hired to fill the positions. In 1982-83, the school had three positions open, and left all three vacant. In 1983-84, the school had 8.5 positions open. Two were left vacant; full-time faculty were hired to fill the remainder of the openings. Vacancies for 1982-84 occurred in the disciplines of civil (2), electrical (2.5), and mechanical engineering (0.5).

UVA: In 1980-81, the engineering school had 18.3 full-time equivalent faculty positions open. Full-time faculty were hired to staff 6.0 of these positions; part-time faculty filled 5.4 positions. Nearly seven full-time equivalent positions were left vacant. Vacancies occurred in the dean's office, and in the disciplines of chemical (0.9), civil (0.3), mechanical and aerospace (0.4), and systems (0.7) engineering, and in materials science (0.2), engineering physics and nuclear engineering (1.5), and computer science and applied mathematics (1.0). In 1981-82, the school had 14.4 full-time equivalent faculty openings. Full-time faculty were hired to fill 4.8 positions; part-time faculty staffed an additional 1.7 positions. Nearly 8 positions were left vacant, including 1.1 FTE positions in the dean's office and others in the disciplines of chemical (1.25), civil (0.9), mechanical and aerospace (0.2), and systems engineering (0.7), and in materials science (0.1), engineering physics and nuclear engineering (1.9), and computer science and applied mathematics (1.3). In 1982-83, the school had 15.7 full-time equivalent faculty openings. Full-time faculty were hired for 4.4 positions, with the remaining positions left vacant. Vacancies occurred in the dean's office (1.25 positions), and in the disciplines of biomedical (0.5), chemical (1.0), civil (2.1), electrical (0.2), mechanical and aerospace (0.4), and systems engineering (0.3), and in materials science (0.2), engineering physics and nuclear engineering (2.2), and computer science and applied mathematics (2.0).

VMI: In 1981-82, the engineering departments had 5 faculty openings. One full-time and 4 part-time faculty were hired. In 1982-83, 6 positions were open, and all were filled by part-time faculty. In 1983-84, 7 positions were open; again, all were filled by hiring part-time people.

VPI: In 1980-81, the university wanted to hire 24 permanent, full-time, tenure-track faculty. The number actually hired as full-time tenure-track faculty was 16. Positions not filled by this type of faculty appointment were in the departments of Civil Engineering (3), Engineering Science and Mechanics (3), Materials Engineering

(1) and Mining and Minerals Engineering (1). In 1981-82, the university filled 11 of 21 open positions with full-time, tenure-track faculty. Positions not staffed by full-time, tenure-track faculty were in the departments of Civil Engineering (4), Electrical Engineering (1), Engineering Science and Mechanics (2), Materials Engineering (1) and Mining and Minerals Engineering (2). In 1982-83, the university hired 17 full-time, tenure-track faculty for the 26 available openings. Positions filled by other types of appointments were in the departments of Aerospace and Ocean Engineering (1), Civil Engineering (2), Engineering Mechanics (2), Industrial Engineering and Operations Research (1), Materials Science (2) and Mining and Minerals Engineering (1).

Report of

Estimated New Resource Needs

Additional Resource Needs For Engineering Education:
Institutional Estimates

New Positions

	Faculty	Secretaries	Technicians	Teaching Assistants
ODU	5	3	1	1.75 FTEF
UVA			1	8.25 FTEF
VMI	5		2	0.30 FTEF*
VPI	87	17	14	
TOTAL	97	20	18	10.3 FTEF

* Cadets assisting full-time are paid $330. VMI budgeted $8,500 for this purpose. The Council staff calculated this as equivalent to approximately one-third an average faculty salary.

Non-Recurring Costs

	Capital Outlay	Equipment
ODU	$3,653,500	$1,250,000
UVA	$6,738,700	$10,768,124 **
VMI	$1,015,000	$1,036,000
VPI	$8,800,000 *	$6,086,200 ***
TOTALS	$20,207,200	$19,140,324

* Includes $3.8 million already approriated but "frozen"; excludes $2.0 million in uiniversity debt-financing program earmarked for engineering
** Includes $6,694,000 for academic computing and $131,224 to fund library shortfall. Costs are presented for three biennia.
*** Includes $2,086,200 proposed in Governor's Economic Development Program competition

TOTAL NON-RECURRING COSTS: $39,347,524

Recurring Costs

First Year

	Personnel	Other Operating	Total
ODU	$529,000	$210,000	$739,000
UVA	$591,700	$386,000	$977,700
VMI	$328,500	$220,000	$548,500
VPI	$5,460,000	$360,000	$5,820,000
TOTAL	$6,909,200	$1,176,000	$8,085,200

TOTAL RECURRING COSTS: $8,085,200

APPENDIX C

SENATE JOINT RESOLUTION NO. 5

Requesting the Senate Education and Health Committee, the Senate Finance Committee, the House Education Committee, and the House Appropriations Committee to establish a joint subcommittee to study how Virginia can best maintain the high quality engineering programs in its public institutions of higher education.

Agreed to by the Senate, January 25, 1983
Agreed to by the House of Delegates, February 24, 1983

WHEREAS, the Virginia Society of Professional Engineers has identified critical needs of the Commonwealth's colleges of engineering in the areas of laboratory equipment, physical space, and faculty salaries; and

WHEREAS, engineering education in Virginia may be severely hampered by lack of adequate funding to meet the needs of faculty and students in a time when technology is rapidly changing; and

WHEREAS, engineering education will continue to play a vital role in developing the future strength and vitality of this State's economy; and

WHEREAS, Virginia's engineering schools help the Commonwealth maintain its industrial base and are one of the significant factors in attracting new industry to the State; and

WHEREAS, Virginia's engineering schools provide the much-needed talent required by private firms, state agencies, and local governments; and

WHEREAS, Virginia's engineering schools help the State monitor and provide solutions for critical environmental problems; and

WHEREAS, the quality of engineering education must be maintained at Virginia's colleges of engineering; now, therefore, be it

RESOLVED by the Senate, the House of Delegates concurring, That the Senate Education and Health Committee, the Senate Finance Committee, the House Education Committee and the House Appropriations Committee are requested to establish a joint subcommittee to study how Virginia can best maintain the high quality engineering programs in its public institutions of higher education.

The joint subcommittee shall consist of eleven members: the Senate Privileges and Elections Committee shall appoint two members from the Senate Education and Health Committee and one from the Senate Finance Committee. The Speaker of the House of Delegates shall appoint three members from the House Education Committee and two from the House Appropriations Committee. The Secretary of Education and the Director of Higher Education shall serve as ex officio members. A representative from the Virginia Society of Professional Engineers shall be appointed by the Chairman of the Senate Education and Health Committee.

The joint subcommittee is requested to complete its work in time to submit recommendations to the 1984 Session of the General Assembly.

The cost of this study shall not exceed $10,600.