REPORT OF THE JOINT LEGISLATIVE TASK FORCE ON

SCIENCE AND TECHNOLOGY IN VIRGINIA

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

HOUSE DOCUMENT NO. 46

COMMONWEALTH OF VIRGINIA
RICHMOND
1996

Science and Technology Task Force

January 29, 1996

The Honorable George Allen, Governor of Virginia
and
Members of the Virginia General Assembly:

We are pleased to submit for your review and consideration the Report of the Joint Legislative Task Force on Science and Technology. This Report was prepared in response to the 1993 House Joint Resolution 390 and 1995 House Joint Resolutions 447 and 714.

Respectfully Submitted,

Hunter B. Andrews
Chairman

W. W. Ted Bennett, Jr.
Vice Chairman

DEDICATION

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The members of the Science and Technology Task Force wish to dedicate this Report to The Honorable Hunter B. Andrews, Senator from Hampton and Chairman of this Task Force, and to The Honorable Robert B. Ball, Sr., Delegate from Richmond, who served as the initial Chairman of this Task Force. The Commonwealth is forever indebted to these two gentlemen. In particular, Mr. Andrews insights and institutional knowledge of the Commonwealth were invaluable resources, as well as instructive to the members of this Task Force in their preparation of this Report. Both Mr. Andrews' and Mr. Ball's leadership, vision, and service to the Commonwealth are shining examples of stellar public service.

PREFACE

Authority and Scope of Work

The Task Force on Science and Technology was established originally for a period of two years by the 1993 Session of the Virginia General Assembly with the passage of House Joint Resolution 390. The 1995 Session continued the Task Force for another year with the adoption of House Joint Resolution 447. The original mission of the Task Force was threefold:

1. To report on the status of the recommendations of the 1983 Governor's Task Force on Science and Technology.
2. To coordinate the development of a statewide strategic plan for science and technology.
3. To examine whether a permanent council on science and technology should be created.

The continuing resolution in 1995 asked the Task Force to consider also recent and ongoing initiatives, as well as recommendations, of various organizations and other task forces that were focusing on science and technology issues in the Commonwealth. The Task Force was asked to report its findings and recommendations to the Governor and the 1996 Session of the Virginia General Assembly.

In addition, House Joint Resolution 714 (1995) asked the Task Force to study opportunities and incentives for information and communications technology for the purpose of meeting public needs.

Members

The Task Force was comprised of 23 members representing the Virginia General Assembly and state and local government, research, university and business leaders in the fields of technology and science. The Speaker of the House appointed the 6 House members; the Senate Privileges and Elections Committee appointed the 3 Senate members, and the Governor appointed the 14 citizen members.

Work Plan

The Task Force identified four major study areas: Education, Infrastructure, Competitive Position, and Finance. Subsequently two Subcommittees were appointed; each dealt with two topics. Each member of the Task Force was assigned to a subcommittee and a chairman for each was appointed by the Task Force Chairman. The subcommittees met a number of times in various locations, met with various agencies of the state, and met with business and education leaders. In one instance, one subcommittee met jointly with another legislative subcommittee studying a relevant topic (telecommunications). In another instance, a subcommittee heard testimony from another legislative study committee's draft report which dealt with a similar topic (capital financing) under study by this Task Force.

Prior to the meetings of the subcommittees, the full Task Force received reports from various groups, including the Secretary of Commerce and Trade who reported about the "Opportunity Virginia" initiative, a strategic plan for the state's economic development. Also, the president of Virginia's Center for Innovative Technology (CIT) presented CIT's three-year strategic plan. In addition, a review of the 1983 Report on Science and Technology was presented by staff with a current status update on the major recommendations of that report.

Each subcommittee formulated its own findings and recommendations independently of each other. The full Task Force received the two reports on January 5, 1996, and unanimously adopted recommendations therefrom. The Task Force directed the staff to coordinate the final report from the two subcommittee reports and adopted recommendations, which also includes discussions and recommendations of the full Task Force.

Over the course of the work of the Task Force, it became clear that different groups were dealing with various issues related to the work of the Task Force. "Opportunity Virginia" placed a high priority on technology issues for economic growth in its 1994 Report. Concurrently, the Virginia Technology Council was established to strengthen the technology business sector and position Virginia as a leader in technology vital to economic growth. Regional technology councils began to emerge during this period also. CIT began to emerge in a leadership role coordinating many of these efforts and creating technology jobs and companies. Higher education in Virginia began placing a greater focus on its relationship to economic development.

Indeed, issues related to science and technology and the economy were rising to the top in many agendas. Carving out the focus for this Report was challenging, and in the end became the decision of the subcommittees. The scope of the Task Force effort should not be regarded as exhaustive. However, the Report does address many of the pressing issues facing Virginia today, and proposes recommendations for action to place Virginia in a competitive position for dealing with the future in a global economy.

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EXECUTIVE SUMMARY

In Virginia, as in the rest of the nation, the use of new technology is increasingly the basis of productivity and economic growth. Many traditional heavy industries are declining, and the lost jobs are being replaced by jobs requiring more highly trained workers comfortable with automation and modern information and communications technology. To make the most of these opportunities, and to attract more high-technology businesses, Virginia needs technologically literate workers and managers, a solid base of research and development, and active links among the various public and private institutions that carry out research and put it to work in new as well as existing products and services. Investments in these areas, more and more, are what make one state competitive with others in attracting new businesses and raising the quality of life. Every citizen of the Commonwealth, every teacher, every businessperson and entrepreneur, every parent, every citizen, has something to contribute, for all will benefit.

The Commonwealth has great strengths in its research universities, technology-based industry, federal and nonprofit laboratories, and state-sponsored technology programs. It has raised standards of elementary and secondary education statewide in the past decade. Its 23 community colleges at 38 campuses offer a wealth of training opportunities for industry, and have launched an ambitious program to improve both the content and the accessibility of their offerings. Its Virginia's Center for Innovative Technology, established in 1984 to help build science and technology capability in Virginia, ranks among the most successful state technology programs in the South by many measures, and has recently implemented a regional organization, to better tailor its aid to industry. The 1983 Report of the Governor's Task Force on Science and Technology offers citizens a yardstick for measuring progress.

Yet there is far to go before Virginia can be confident of a place in the first rank nationally. School and colleges need better access to computers and communications technology. State support of public universities is at an all-time low (and tuition at an all-time high). Virginia has not attracted as much venture capital as it needs to finance young entrepreneurial companies. Too little reliable and up-to-date data in science and technology in Virginia is available. In general, the various components of the Commonwealth's education and technology base are not well enough understood to be effectively coordinated with one another. These and other deficiencies can be remedied by the measures recommended in this report.

The Virginia General Assembly recognized many of these problems in 1993, when it established the Task Force on Science and Technology. It continued the Task Force for an additional year in the 1995 Session. The Task Force has 23 members, representing the Virginia General Assembly, state and local government, research, universities, and business. The Task Force was initially instructed to:

1. Report on the status of the recommendations of the 1983 Governor's Task Force on Science and Technology.

2. Coordinate the development of a statewide strategic plan for science and technology.

3. Examine whether a permanent council on science and technology should be created.

The 1995 continuing resolution requested the Task Force to consider also recent and ongoing initiatives by various organizations working the related fields. Another 1995 legislative resolution asked the Task Force to study opportunities and incentives for information and communications technology to meet public needs.

The Task Force believes that the following principles should govern Virginia's support of science and technology:

1. The Commonwealth should capitalize on Virginia as a technology leader.

2. The Commonwealth should have a workforce second to none.

3. The Commonwealth should acknowledge that science and technology initiatives and a strong education system are integral parts of Virginia's economic policy.

4. The Commonwealth should make necessary investments in science and technology initiatives.

5. The Commonwealth should make vital investments in education.

With those principles as a foundation, the Task Force commends the following recommendations to the Governor, the General Assembly, and the citizens of Virginia:

Continued Oversight

1. A Joint Commission for Technology and Education, with special emphasis on the implementation of the technology infrastructure, should be established for a period of two years.

2. The Science and Technology Task Force should be continued for the purpose of reviewing the technology dispersion and public policy of science and technology in the Commonwealth.

3. Virginia's Center for Innovative Technology should be considered the Commonwealth's lead Science and Technology mechanism for the purpose of planning and representing the Commonwealth in matters dealing with science and technology and its role in economic development of the Commonwealth.

Education for a New Knowledge-based Economy and World

4. The focus of Virginia's public school system should be examined and modified to reflect the change from an instructional process that is overwhelmingly memory-based, e.g. rote

memorization of facts, to one which balances memory with an equal focus upon the acquisition and use of facts and figures to analyze and synthesize novel approaches to real world problems and situations. Instruction must also balance individual orientation with group skills, including leadership, civility, and other knowledge and skills for an information age.

5. Each high school graduate should be required to document minimal competency to function as a worker in a knowledge-based economy. The expectation is that employers need men and women with the ability to read with understanding; the ability to communicate clearly both by the written and spoken word; the ability to think through a problem or situation; the ability to calculate with at least a rudimentary understanding of algebra, geometry, and elementary statistics; and the ability to analyze.

6. The Commonwealth should support the *Virginia Works* initiative proposed by the Virginia Community College System (VCCS) in order to foster a stronger economy for Virginia. Funding is needed to support training and retraining efforts of the VCCS in order to ensure a highly skilled workforce and a globally competitive business community.

7. The Commonwealth should continue to support undergraduate and graduate programs, especially in high-technology disciplines, which encourage part-time continuing education and participation by industry employees across the state. These programs must remain responsive to industry's needs throughout the state.

8. Virginia higher education is closely linked with the economic growth of the Commonwealth. Statewide efforts such as Virginia's Center for Innovative Technology, Graduate Engineering, and Old Dominion University's TELETECHNET must be encouraged and supported. Specialized programs, such as those related to the decisions by the American Type Culture Center, Motorola, and IBM/Toshiba to locate in Virginia, should draw on the existing resources of all institutions and be adequately funded.

Planning for the Future

9. The Commonwealth should continue to expand and exploit the capabilities of the state's major research universities in partnership with industry and the CIT. A balanced focus on short- and long-term research and development goals is necessary to keep the Commonwealth competitive in a rapidly changing global economy.

10. The Commonwealth should strengthen support for existing research and technology development capabilities where commercialization potential is very strong in the near term by funding the creation of a new generation of CIT technology centers and fund the creation of new research and technology development centers in emerging technology areas with long-term commercial potential where Virginia has the potential to be globally competitive. The CIT, in cooperation with the research universities, other research facilities, and technology organizations, such as the Virginia Technology Council, should be responsible for identifying these emergent areas and administering funding.

11. The Commonwealth should fund a new technology development center in Health Telematics that will involve the considerable talents of all three medical schools and the public and private health care providers in all regions of the state.

12. In addition to the CIT Technology Development Centers, the state should fund a new generation of Commonwealth Centers to be selected by the State Council of Higher Education for Virginia (SCHEV).

13. The Commonwealth should not attempt to develop an independent telecommunications infrastructure for the state but should take advantage of the commercial infrastructure already in place.

14. The Virtual Campus project should be funded for implementation in 1996-98 with expansion to include additional institutions and organizations.

Necessary Resources, Both Human and Capital

15. The Board of Education and SCHEV should review, and adjust as necessary, the requirements for re-certification to ensure that all teachers re-certified after 2000 possess and maintain the necessary technical skills and knowledge to effectively use existing and future communication and multimedia educational systems in the classroom. All recertification, after 2000, should meet the same requirements.

16. Virginia should study the feasibility of creating the Virginia Educational Technology Fund to assist schools and parents to acquire and maintain computer and telecommunications equipment necessary to transform the learning environment in all schools. To increase commercial and banking participation in the funding of technology by students and parents, the concept of technology bonds and a "loan-loss reserve" should be examined further.

17. Adequate funding should be provided to public and private institutions to maintain and enhance the quality of instructional programs. Higher education in Virginia cannot be sustained at an acceptable level of quality without additional state support.

18. Funding should be provided to restore average salaries to the 60th percentile of benchmark groups over four years, and funding for the Eminent Scholars Program should be increased to fully match endowment earnings. It is vital that the perception of Virginia's colleges and universities reflects the quality of their faculty.

19. Funding for the Higher Education Equipment Trust Fund should be increased to provide for the replacement of obsolete educational and research equipment and the acquisition of new technology. The program should be expanded, with incremental funding, to include essential telecommunications equipment for campus and statewide networking.

Appropriate Beginnings

20. The Virginia Institute for School Leadership should be created and funded to provide training for school principals on how to plan for, implement, and administer the computer and telecommunications technology that will be critical to the future of our schools and students. In conjunction with the Virginia Institute for School Leadership, Virginia should create an Institute for Teacher Training for Technology Utilization. The institute should be structured similar to a federal research laboratory and Virginia should seek federal, foundation, and corporate funding and participation to establish it as a national source of information and resources for K-12 education through technology.

21. Pilot Projects should be funded to examine how information technology can be most effectively and efficiently used in inner-city schools and to share the results with all school districts. Information technology disparities may be more harmful than fiscal differences to students seeking employment in a knowledge-based economy.

22. Curricular revision and in-service training for faculty should be funded through a competitive grant program administered by SCHEV to maximize the effectiveness of the Commonwealth's investment in infrastructure and technology resources.

23. As the statewide infrastructure network is implemented, the VCCS should plan on functioning as regional nodes for access and services for schools, individuals and organizations unable to access the network directly.

Cost Reduction and Improved Customer Service

24. Our colleges and universities must continue to make substantial changes to their programs and operations as they restructure to meet the evolving needs of the Commonwealth and its citizens. Restructuring is a long-term process that requires constant attention and measurement to gauge changes and results.

25. The Commonwealth should make any necessary regulatory changes to establish competitive pricing for wideband networking access for educational users in all regions of the state.

26. The Commonwealth should make the necessary regulatory changes to allow the state to take advantage of the rapidly changing telecommunications marketplace.

27. Policies on intellectual property rights should be examined periodically by the CIT in cooperation with SCHEV and the research universities. Emerging technologies will require rapid implementation of new products. Revised operating agreements between universities and corporate partners may be necessary to provide this flexibility and efficiency for such projects to succeed.

28. The Commonwealth should foster the development of instructional technologies to improve the quality of instruction and extend the outreach of our colleges and universities. The VCCS Information Technology Infrastructure Plan and its related instructional technology initiatives should be funded and implemented in partnership with Virginia Tech and Old Dominion University in order to develop a broadband, wide area network that will extend across the Commonwealth for use by all institutions as well as local schools.

Competitive Position & Finance

29. CIT should be encouraged in its efforts and the Commonwealth should expand its support so that CIT can further deploy resources to help technology companies be competitive.

30. CIT should continue its practice of identifying emerging technologies and making investments thereto, such as the Technology Development Centers program already in place.

31. A network of entrepreneurship centers should be established across the Commonwealth to spur the technology innovations into the marketplace.

32. The Congress of the United States should be encouraged to sustain federal research and development support.

33. The Commonwealth should market more aggressively present and potential federal R&D facilities located in Virginia (e.g., The National Aeronautics and Space Administration (NASA) Langley Research Center and Continuous Electron Beam Accelerator Facility (CEBAF)) as critical Virginia assets.

34. The Commission on State & Local Responsibility & Taxing Authority, chaired by Lt. Governor Beyer, should examine carefully the benefits of removing business, professional, and occupational license (BPOL) tax from venture capital companies;

35. Virginia's Center for Innovative Technology (CIT) should confer with the Virginia Retirement System (VRS) to consider investment in venture capital firms that will invest in Virginia technology companies.

36. The Virginia General Assembly should study tax credits to encourage private investors to do venture capital business in Virginia.

37. The Virginia General Assembly should make funds available and allocated to CIT to establish a seed-stage capital fund for a public-private debt or equity fund for technology start-up companies.

I. INTRODUCTION

To be a recognized leader requires vision. Virginia has the essential technology assets for national leadership, but it must act quickly and with commitment if it is to realize the current and future rewards of these opportunities. Five principles should guide the state's plan to develop its science and technology assets for economic and social development:

1. The Commonwealth should capitalize on Virginia as a technology leader.

2. The Commonwealth should have a workforce second to none.

3. The Commonwealth should acknowledge that science and technology initiatives and a strong education system are integral parts of Virginia's economic policy.

4. The Commonwealth should make necessary investments in science and technology initiatives.

5. The Commonwealth should make vital investments in education.

II. WHERE VIRGINIA STANDS WITH REGARD TO THE 1983 REPORT ON SCIENCE AND TECHNOLOGY

The 1983 Report of the Governor's Task Force on Science and Technology is an appropriate place to begin the present Task Force's assessment. That earlier report offers a clear baseline for measuring progress since that Task Force had a dual mission: to recommend ways in which Virginia could (1) effectively retain and attract high-technology enterprise, and (2) assist its citizens, communities, and institutions in preparing for societal changes resulting from the technological revolution. (1983, p. 3).

In retrospect, the 1983 Report was one of the most influential documents in the development of its educational system and its economic development. It set the agenda for both K-12 and higher education for over a decade and established the priorities for the state's economic development program, including the development and funding of Virginia's Center for Innovative Technology (CIT). A complete review of the major recommendations is included in the appendices to this report.

The 1983 Report defined high-technology industry as characteristically including electronic development and miniaturization, computer related or oriented enterprises, robotics, biotechnology, information processing, media for communication of data and information. Such industries typically depend on a more highly trained or highly skilled workforce than was traditionally the case, research and development play a larger than traditional role, and planning and management personnel must bring to their tasks a sophisticated level of understanding of theoretical and applied science and engineering. Some might define high technology to exclude an industry which exists primarily to mass produce previously developed components or instruments of technology, but such industries rarely stand alone apart from their developmental cousins. And

one of the desirable results of high technology is its multiplier effect in producing jobs in affiliated mass production manufacturing. (Ibid.)

K-12 Public Education

In elementary and secondary education, the 1983 Task Force had four recommendations that influenced state and local programs. It recommended increasing the requirements for graduation to ensure a reasonable balance of rigorous courses in the sciences and the humanities, stressing both technological and communication literacy. New graduation requirements were established in 1985 and are being discussed today. Concerns about adequate breadth of curriculum and utilization of technology continue to be expressed by the business community.

The task force recommended changes to the science curricula to assure that high school graduates have a balanced program in the physical and biological sciences, that students have knowledge of the major concepts of a particular science course, and that students are required to engage in a laboratory experience, including field work. The 1992 revisions to the Standards of Accreditation established a four-unit science requirement for the 23-unit diploma. During their testimony to this committee industrial representatives have raised questions about the adequacy of the experiences of students not enrolled in the 23-unit diploma and the need for more common science and computational requirements for both the college preparatory and workforce preparation diplomas.

Pilot schools of science were recommended in the 1983 Report to raise public awareness and to serve as models for local development initiatives. There are now five Governor's Schools for Science and Technology--Lynchburg, Roanoke, Fairfax, Hampton Roads, and Southside. Another initiative was to emphasize the development of science programs for elementary students and strengthening the background of teachers in science and mathematics. Through the federal V-Quest program, over 800 K-8 teachers have received extensive training as lead science teachers since 1991.

In response to the 1983 Report recommendation, emphasis on the effective use of newer technologies and microcomputers has become a major focus of legislative and local school initiatives. The General Assembly has provided funding for the Satellite Education Network that delivers advanced courses to all school districts. Satellite dishes and distribution networks have been installed on all public high schools but implementation at middle and elementary schools has been delayed. Special funding has been provided for the purchase of microcomputers across the state and in-service training programs. Library automation and continued implementation of the Virginia Public Education Network (VAPen) are providing interchange among schools and Internet access.

Community Colleges and Vocational Training

The role of the community colleges in the delivery of vocational training and preparing workers for careers rather than a single job was one of the major recommendations of the 1983 Report. Organizational issues were identified as inhibiting the coordination of the broad spectrum of

training and education programs offered by the colleges and other agencies. Many of these problems were addressed in the "State Plan for Vocational Education," which is updated annually. The latest response to the need for a coordinated plan for job preparation is found in the *Virginia Works* program from the Virginia Community College System (VCCS), initiated in 1995.

Economic development and technology transfer were areas identified for emphasis and development. All community colleges have economic development offices; many have small business centers. The VCCS and CIT have cooperated in technology transfer and technical assistance activities at a number of campuses. Industry surveys are used to identify training and technology needs in each region and industry sector. The VCCS has accepted primary responsibility for meeting the training needs of existing and emerging businesses. The VCCS has reviewed its technical curriculum and made adjustments to incorporate current technology and application systems.

Funding for technology and revised curriculum content has been provided by the General Assembly over the last decade. Approximately $46 million has been provided to school districts for equipment and infrastructure projects since 1988 and an additional $47 million was authorized for 1994-96. The Higher Education Equipment Trust Fund has provided approximately $38 million to the VCCS for instructional equipment since 1986. The VCCS is developing a statewide television system to extend offerings to all campuses and is an active partner with Old Dominion University in providing the third and fourth year of bachelors degree programs at 16 institutions through the TELETECHNET program, which was established in 1993.

Colleges and Universities

CIT was identified as a means of linking the education and research capacities of the geographically dispersed institutions and to provide a means for mutually beneficial partnerships on research and development programs. Approximately $15-17 million have been available each biennium for cooperative research projects and to leverage state funds with federal and corporate research funding since CIT's inception in 1984. A recent Battelle Memorial Institute[1] report indicated a positive return to the Commonwealth for its investments through CIT of seven dollars returned to the economy for every dollar spent.

The 1983 Report encouraged the establishment of a fund dedicated to research and development in the universities with initial funding from private industry to be matched by the state. The fund was envisioned as a foundation or coordinated through CIT. Through the actions of the General Assembly, CIT was able to fund a number of Technology Development Centers at Virginia's research institutions of higher education. The State Council of Higher Education for Virginia (SCHEV) selected a number of Commonwealth Centers that were funded by the General Assembly. Both selection procedures were competitive and involved national panels to select centers that were already, or had the potential to become, the best in the nation in a specific discipline or specialty. Centers were expected to become self-sufficient over five years. CIT continues to fund its centers that focus on technology with high potential for commercial success.

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[1] Batelle Memorial Institute, *Virginia's Center for Innovative Technology: An Economic Impact Assessment.* (Dec. 1995)

However, because of budget restraints, no new centers have been created by CIT since 1993. Likewise, funding for the Commonwealth Centers has been removed, except for three centers (Oceanography at ODU, Brain Injury at VCU, and Wood Science at VA TECH).

Access to graduate programs in high-technology disciplines was identified as a critical need in various regions of the state. Programs were needed to allow students to continue their full-time work, minimizing residency requirements for graduate degrees, and providing course delivery systems which bring the programs to the student. The 1983 Report strongly endorsed the Richmond Graduate Engineering Instructional Television program as a model for potential expansion into other geographical areas and subjects. The goal was to establish graduate education delivery systems responsive to industry's needs throughout the state. In 1995-96, the Commonwealth Graduate Engineering Program enters its 13th year of offering televised courses in programs leading to a master's degree in engineering and the second year of televised courses leading to a doctoral degree in engineering. These courses originate at Old Dominion University, the University of Virginia, Virginia Commonwealth University, and Virginia Tech, and are broadcast by satellite to sites located throughout Virginia and several other states. Over 750 engineers have received master's degrees through this program and approximately 3,500 students are enrolled each year.

The 1983 Report recommended the support of the National Electron Accelerator Laboratory, now known as the Continuous Electron Beam Accelerator Facility (CEBAF), as a unique resource for graduate education, research, and economic development. The proposal to design and build a new concept accelerator was accepted by the federal government and the CEBAF is nearing completion. Affiliated research positions have been funded at several Virginia universities. This world-class facility is attracting international attention and funding for research projects and industrial utilization of CEBAF resources and findings. Continued attention to the evolution of the CEBAF and expansion of the economic development opportunities will be necessary to realize the potential of this project.

The continued development of engineering and science curricula and research was linked with the availability of up-to-date scientific and technical equipment for the colleges and universities, including cooperative arrangements with industry or private citizens to fund acquisitions. The Higher Education Equipment Trust Fund was established by the General Assembly in 1986 to provide funding for instructional and research equipment. Through this hallmark program, approximately $165 million in equipment has been acquired, with a heavy emphasis on engineering, computer science, physical and biological science, and health laboratory equipment. The scope of the Equipment Trust Fund should be expanded to include campus networking equipment and related infrastructure. As computing strategies reflect greater emphasis on distributed resources and integrated networks, the type of equipment needed will change.

The 1983 Task Force encouraged the recruitment and retention of talented faculty in engineering and high technology disciplines, expansion of the resources available to them, and the increased role of graduate students in teaching and research. Funding for faculty salary increases, matching funds for the Eminent Scholars Program, expansion of engineering and research facilities, and targeted research projects was provided through various executive and legislative initiatives.

III. THE INCREASING IMPORTANCE OF TECHNOLOGY TO THE ECONOMY[2]

Several trends at the global, national and state levels are and will continue to influence economic trends in Virginia. At the national and global levels it is important to note the unfolding of a new core technology (computer and information technology). This has dramatically changed the way things are done and the way we organize to do them. Not only production, but product design, marketing, retailing, wholesaling, finance, real estate, and government are conducted in a more decentralized, yet more networked and cooperative way. Managing more organizations with more information and more autonomy while maintaining order and efficiency has meant that proximity to suppliers and business partners has become considerably more important. The importance of proximity in reducing transaction costs has led to a rise in the importance of regions. As a consequence, it is important to think of Virginia's economy as a set of quasi independent, yet interrelated regional economies.

At the same time it is important to recognize and emphasize that information technology enables the development of other areas of critical technology. Many of the most dynamic and emergent technology developments are at the interface of information technology and other well recognized areas such as materials, biotechnology, aerospace, robotics, transportation, systems design and integration, and advanced manufacturing processes.

The two most significant dynamics facing the Virginia economy are: 1) the changing nature of the federal budget and its impact on the Tidewater and Northern Virginia regions where federal dependency is heaviest, and 2) the pressure on businesses, especially manufacturing to adjust to a flattened learning capability organizational form to maintain or gain competitiveness.

Economic Trends

Total employment in Virginia in 1993 was 2,862,701, an increase of 5.57 percent from 1988. During the same period, U.S. employment gained 4.89 percent. This gain at the state level mirrors the on-going dynamics affecting its economic growth, a shift from goods-producing industries to industries producing services. At the state level, the aggregate shift in employment that resulted from goods-producing sectors which lost 63,173 jobs while the services-producing sectors added 216,135, was a net gain of 152,962 jobs and a percentage decrease from 25.4 to 21.8 for the goods-producing industries. At the national level, goods-producing industries accounted for 22.1 percent in 1993, down from 24.4 percent in 1988.

The most notable employment changes in the state economy were the gain of 165,029 jobs (19.05%) in the services sector and the loss of 27,641 jobs (6.2%) in the manufacturing sector. These changes reflect the impact of restructuring forces on the state's economy. The loss of 37,625 jobs (18.4%) in the construction sector, a far greater decline than experienced by the

[2] This section draws heavily from work in progress prepared for CIT. *Technology Infrastructure Assessment in Virginia*, Stough, R.R. et al (The Institute of Public Policy at George Mason University) prepared for CIT. NOTE: This section reports select regional data: not all regions of the state are included in this discussion.

manufacturing sector during this period, was largely a consequence of the recession and the over-production of commercial office and other built space in the eighties (contributing to an unsupportable and surplus construction work force that peaked in 1988). So, while the loss of construction jobs has had a significant impact on the health of the state's economy, these changes do not reflect economic restructuring that will influence the long-term development pattern of the economy as have the changes in the manufacturing and services sectors. At the sub-state regional level it is important to note that sizeable employment losses were recorded in construction and manufacturing in all regions studied (Northern Virginia, Richmond, Roanoke, Lynchburg, and the Tidewater). Significant (double digit percentage increase) employment growth in the services occurred in all regions but Richmond where the percentage growth was only 3.5 percent.

Large and Growing Sectors

Large industries that have grown rapidly are disproportionally important sources of employment. While this group includes several utilities and goods-producing industries, most are services. These service industries break into two groups: local serving, such as health and credit unions, and export related, such as computer systems design.[3]

It is significant that there is a cluster of computer and information technology related industries in Virginia with large, fast growing and concentrated component industries that promise to link to the manufacturing sector via the recent announcements of new semiconductor facilities: Motorola in central Virginia; and IBM-Toshiba in Northern Virginia. These computer-related industries represent a vertical range of services: systems design, programming, data processing, related services, and leasing. Strength in management services and business consulting is consistent and interdependent with these computer services. This reinforcement and the strength of these industries separately show the state to be well positioned for future economic growth; that is, it is specialized in industries that are growing rapidly nationally. To date this cluster of advanced computer related services has been concentrated primarily in Northern Virginia. The planned Motorola semiconductor facility in central Virginia may lead to greater computer related services developing in the Richmond region.

Large and Declining Sectors

Virginia's economic restructuring has its down side with many large goods producing industries experiencing substantial contraction. Some examples include: coal, highway construction, masonry stonework, ship building, wood household furniture, clothing, cigarettes, organic fibers, cotton mills, paperboard mills, aluminum sheet foil, explosives, mining machinery, hardwood mills, farm-product raw material, operative builders, and plastic foam products. Not all of these large, declining industries are characteristic of the state's historic industrial base. Some are service industries suffering from downsizing and consolidation at the national level, e.g., banking, and others may have been caught in the downsizing of industries they support such as government and construction.

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[3] These categories do not preclude non-local support of predominantly local-serving industries or local consumption of predominantly export-oriented services.

Several patterns are apparent. These large and declining industries are major employers that are significantly concentrated within the state relative to the nation but have experienced substantial contraction during the 1988-1993 period and, as a result, have become somewhat less important. Even though these industries have a major presence in the state economy, their decline is not a function of local economic or market conditions becoming unfavorable in comparison to some other state but rather they are declining due to national and global conditions as outlined above.

IV. VIRGINIA'S SCIENCE AND TECHNOLOGY ASSETS[4]

The present scientific and technical resources in the state are inventoried and assessed below. The data presented should be considered indicative of the state's capacity to develop and use new technology. Following the assessment of these resources, strengths, and weaknesses of the Virginia context historically and at present are also examined. Historical and evolutionary context has much to do with a region's or a state's future potential in the area of technology.

Science and Technology Infrastructure

Research and Development (R&D) Performance in Virginia[5]

R&D is performed in Virginia by an array of firms, academic institutions, federal laboratories, and other nonprofit bodies. In 1991, the NSF reports that $2.771 billion of R&D was performed in Virginia, or about 1.9 percent of all the R&D conducted in the United States. Virginia ranked 13th in the nation in R&D performance, which is consistent with the state's rank of 12th in gross state product. Virginia ranked 22nd among the states in the ratio of R&D performance to gross state product, or 1.9 percent. In comparison, Maryland devoted 5.5 percent of gross state product to R&D, Pennsylvania 3.1 percent, and North Carolina 1.4 percent. The nation as a whole devotes about 2.6 percent of gross domestic product to R&D.

In 1992, Virginia received $3.23 billion in federal obligations[6] for R&D. The state ranked third among all the states on this measure, behind only California and Maryland and just ahead of Massachusetts and New York. Virginia received about 5 percent of all federal R&D obligations.

Federal obligations to Virginia for R&D performed in industry amounted to $1.61 billion, fifth in the nation. Federal intramural laboratories and FFRDCs received a total of $1.36 billion, while universities and colleges received $193 million, 16th in the nation. Other nonprofits received $59 million, 12th in the nation.

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[4] This section draws heavily from work in progress prepared for CIT. *Technology Infrastructure Assessment in Virginia*, by Stough, R.R. et al (The Institute of Public Policy at George Mason University).

[5] All R&D data from the National Science Foundation unless otherwise noted.

[6] NSF reports that R&D obligations can differ substantially from R&D performance, owing to differences in the reporting practices of the funders and performers of R&D, to time lags between award of federal funds and their actual expenditure by performers, and to transfers of federal funds by recipients from one state to another for
the actual performance of the R&D. At this writing, it is not clear why the difference between 1991 performance and 1992 obligations data is as large as it is, although it is likely that the large presence of prime contractor firms in the state may be associated with funds being formally obligated to entities in Virginia but being spent for R&D performed in other states.

Typical of the larger laboratories are the Lynchburg Research Center of McDermott, Inc., with a staff of 120; the Fibers Technical Center of Allied-Signal, Inc., in Petersburg, with a staff of 223; and the USA Research Center of Philip Morris in Richmond with a staff of 328. Many major corporations have moderately large laboratories in the state with staffs of 15 to 30 or so.

It should be noted that the Virginia economy is becoming unusually strong in high-technology fields that are in the information services sectors, rather than in manufacturing, the usual focus of industrial R&D.[7] Firms in information sectors are often highly sophisticated technically and employ large proportions of persons with advanced scientific and engineering degrees. However, they may do little or no organized "R&D" at all. They depend on other firms to invent and develop the components and elements that they integrate into large scale systems to meet customer needs. They are rich in applications engineering, and "poor" in organized R&D. To the extent that such firms represent the cutting edge of technology applications in the world economy, the traditional R&D statistics may fail to capture the full capability and potential of economies such as that of Virginia.

Virginia is host to a number of major federal laboratories, including six FFRDCs (Federally Funded R&D Centers). It also is the home base of a number of the nation's major federal departments and agencies that fund and/or procure R&D activities from other performers. According to NSF data, "intramural" federal laboratories performed $1.11 billion in R&D in Virginia in 1991. Obligations were very similar, or $1.18 billion in 1991.

Six FFRDCs are located in whole or in part in Virginia. FFRDCs are typically long-term contracts with private entities (firms, academic institutions, consortia) to operate laboratories or study and analysis centers in close association with federal sponsoring agencies. The employees of FFRDCs work not for the government, but for the sponsoring agency. This is typically intended to enable the FFRDC to operate with greater flexibility than a federal intramural laboratory is able to do. FFRDC contracts are sometimes controversial in the professional services industry, some of whose members believe that FFRDCs get unfair preferential access to government contracts. On the other hand, FFRDCs are barred from competing with other entities for other competitive R&D contracts offered by their sponsoring agencies.

The six FFRDCs and their sponsoring agencies are[8]:

- C^3I Federally Funded Research and Development Center (MITRE Corporation), McLean: Department of Defense;
- Center for Advanced Aviation System Development (MITRE Corporation), McLean: Department of Transportation;
- Center for Naval Analyses, Alexandria: Navy;

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[7] See, for example, Stough, R.R., Popino, J., Campbell, H., *Technology in the Greater Washington Region*, Greater Washington Board of Trade, May 1995.

[8] Annotated List of FFRDCs, NSF, 1995.

- Continuous Electron Beam Accelerator Facility - CEBAF (Southeastern Universities Research Association), Newport News: Department of Energy;

- Logistics Management Institute, McLean: Department of Defense; and

- Institute for Defense Analyses, Alexandria: Department of Defense.

Each of them is enabled by changes in federal law over the past fifteen years to stimulate spin-offs of new technologies to the private sector and to work with the private sector to develop and transfer technology for commercial purposes.

To a lesser extent, the same can be said for the large federal scientific and technical agencies that have located major administrative agencies within the state. They also bring new, highly trained people to the state, on both permanent and temporary bases. They cause many technical and professional societies to locate in and near the state and they are often associated with major meetings and conferences on technical matters. To some extent, their presence is exaggerated by their budgets and staffing levels, since many of their professional staff are no longer active researchers. And, some of the intelligence agencies have an understandably circumscribed role in influencing the commercial economy of the region. These agencies include:

- Department of Defense: ARPA, Arlington; ONR, Arlington;

- Central Intelligence Agency, McLean;

- National Science Foundation, Arlington;

- Geological Survey, Reston;

- Defense Mapping Center, Reston; and

- National Technical Information Service, Department of Commerce, Springfield.

Nonprofit Research and Development Activities in Virginia[9]

In addition to the usual academic, industrial and government R&D sectors, there is an important fourth sector of private, nonprofit, independent organizations engaged in R&D. In 1991, such institutions in Virginia spent $182 million on R&D. Federal government obligations to such institutions in Virginia totaled $49.5 million, or roughly one-quarter of the total. Other than

[9]Data on this sector are not very reliable. They were last surveyed systematically by NSF nearly 15 years ago, and a new survey is about to be launched. There is a good chance that the data presented here are inaccurate. Furthermore, they may represent double counting of some activities, for example, some of these carried out in FFRDCs operated by nonprofit entities. Not all such FFRDC work is so included however, as in total they spend more than is reported here for all nonprofits.

federal funds, such organizations typically receive funds from state sources and private philanthropy.

Only one Virginia institution appears in the NSF list of top 100 US independent nonprofit recipients of federal R&D funds -- "Analytic Services, Inc.," which received a reported $34.8 million from DOD in 1992. The second largest such entity, the Corporation for National Research Initiatives, received $2.8 million from NSF, placing it well below the entities at the bottom of the top 100 list, which received about $5 million each.

State-Supported Research and Development Programs

Many of Virginia's technology programs are administered through Virginia's Center of Innovative Technology (CIT), a nonprofit corporation created by the Virginia legislature in 1984. With a specific goal of promoting state economic development, CIT sponsors various programs and services by funding university/industry research projects, supporting technology-related activities, assisting in commercializing research outcomes, and then aiding in the creation and the growth of technology companies.

In the past, CIT has focused most of its effort on the upper end of the R&D pipeline, i.e., pure and high end applied research. This meant that university based centers of excellence and linking university researchers to private companies for developing a new technology or innovative process dominated the Center's work. During the past year the Center has undergone a major transformation with a significant restructuring of its priorities. This process has resulted in focusing much of the Center's activity on applied and to some extent commercialization parts of the R&D pipeline. This refocusing toward a more technology transfer oriented set of programs was motivated by a goal to better help companies acquire technology, convert technology into products and services, and to get technology-based products and services to the market.

To help bring the services of CIT closer to businesses, the Center was reorganized from a central program oriented organizational structure to a regional services delivery oriented form. Instead of accessing programs and services through program managers located centrally in Herndon, businesses now have access through a new set of CIT regional offices. These regional offices are linked to an evolving set of regional economic development and technology councils illustrating a second part of the reorganization: building partnerships with the business and technology communities in the state. The regional focus was motivated by the understanding that the state economy is composed of different semi-autonomous regional economic systems. Because of the semi-autonomous or unique character of these systems it is important to link CIT programs directly to them to ensure appropriate targeting and maximum impact. In addition, there is a concentrated focus on five industry sectors: biotechnology; information technology and telecommunication; energy and environment; aerospace and transportation; and advanced manufacturing and electronics.

It is important to observe that 49 states in the U.S. have science and technology oriented development centers like the CIT. Consequently, it is important to consider the relative

performance of this agency. A recent set of studies[10] by the Southern Technology Council sponsored by the NSF benchmarked university-industry technology transfer programs (CIT is the major organization responsible for such programs in Virginia) in the South. Several different performance measures utilized in these benchmarking studies showed CIT's efforts to be superior to other efforts in the South. Virginia had decidedly more patents issued to universities and nonprofits than the median value for the South; at the same time its national ranking on this factor improved from 28th to 6th between 1987-1993. Further, while the median percentage of licenses granted to in-state companies from patents developed in Southern states was 28 percent, the comparable percentage in Virginia was 81 percent. Licensing to in-state start up companies was 11 percent for all Southern states; 67 percent of CIT's licenses go to in-state start-ups indicating that Virginia is retaining higher than average amounts of the benefits from its innovation within the state. CIT reports that 75 percent of it six-figure royalty revenue flow come from in-state licenses; the comparable figure for the Southern states is 0.3 percent with 16 of the 33 institutions that participated in the study reporting that 0 percent of royalties were from companies within their state.

In summary, it appears that CIT is a remarkably strong asset among Virginia's institutional technology infrastructure when compared with peer institutions in other Southern states. The recent reorganization should make it even more effective in leading technology development and transfer in the future.

Other Research and Development Infrastructure Elements

In addition to the wide variety of federal research laboratories and FFRDCs described above there are other significant advanced infrastructure facilities in the state, including the ones below which already are doing some partnering with the state through CIT:

- NASA Goddard Wallops Flight Facility - (Wallops Island, Virginia).
- NASA Langley Research Center (Hampton, VA).

Proximity to the Nation's Capital: A Unique Asset

One of the most important attributes for Virginia's technology development and infrastructure is that it is located adjacent to the National Capital Region, the physical location of the federal government of the U.S. Proximate location has made Virginia and other nearby states, e.g., Maryland, beneficiaries of federal technology policies and programs. The federal government has been the largest single purchaser of technology. Thus, proximate location means ready access to market. The rapid growth of the technology service sector in Northern Virginia over the past two decades (today there are nearly 1300 technology firms operating in the region) was stimulated and supported (even today) by demand for technological solutions to defense and other domestic problems. With the defense buildup in the 1980's and the adoption of a general outsourcing

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[10] Southern Technology Council/Southern Growth Policies Board, *Benchmarking Best Practices for University-Industry Technology Transfer: Working with Start-Up Companies* and *Benchmarking University-Industry Technology Transfer in the South: 1993-1994 Data.* (1995)

policy (to the private sector), locations in Northern Virginia and Suburban Maryland became attractive. Security and ready communication between procuring agencies and contractors made direct access among the parties critical and thus, proximate location essential. Consequently, one of the largest concentrations of advanced technology service businesses arose in the Northern Virginia region. Despite changing federal policies that includes a continuing trend of defense downbuilding, demand for technology services remains high and in fact has continued to increase..

V. EDUCATION AND INFRASTRUCTURE

This section summarizes the deliberations, observations, conclusions and recommendations of the Education and Infrastructure Committee of the Science and Technology Task Force. The committee received reports from various groups, including the representatives of industry sectors involved in the development of the Governor's "Opportunity Virginia" Report and presentations made by representatives of schools, universities, the community college system, state agencies, and industry.

The charge to the Science and Technology Task Force and its Education and Infrastructure Committee evolved over the last two years. The initial charge was established in HJR 390 during the 1993 session of the General Assembly as "reporting on the status of the 1983 task force recommendations and to coordinate the development of a statewide strategic plan for science and technology, including the creation of a permanent council on science and technology and its role in the strategic planning process for the economic development of the Commonwealth."

A number of executive and legislative reports and projects were underway that overlapped the responsibility of the task force. As these projects began to evolve, it became obvious that the role of the task force should be modified to react to these activities rather than duplicate their efforts. The 1995 session of the General Assembly extended the task force and modified its charge (HJR 447). HJR 714 asked the task force to take into consideration that:

- "Virginia's future economic competitiveness depends upon the quality of its information and communications technology, infrastructure and services.

- "A comprehensive and uniform information and telecommunications strategy for Virginia's government, businesses, and educational institutions is needed to secure a place for the Commonwealth in future national and global economies.

- "Virginia may lack the comprehensive telecommunications and information infrastructure required to compete successfully in this new era.

- "It is in the interest of the people of the Commonwealth to encourage cooperation and innovation among public and private sector information technology and telecommunications service providers and users, and to create and use infrastructure that will allow our businesses, citizens, and educational and public sector institutions to respond to and be competitive in the information age.

- "The task force shall (i) determine the means by which state resources may be wisely expended to encourage and complement citizen, business, and state agency access to state-of-the-art, competitively priced communications and information services; (ii) recommend legislation, policies, and procedures that will result in increased citizen access to the "global Internet" in order to provide advantages to Virginia businesses, encourage new business opportunities, and contribute to the emergence of a competitive market for communications services; and (iii) develop recommendations aimed at placing the Commonwealth at the forefront of communications and information technology for all citizens."

The task force was encouraged to seek the cooperation and support of private sector business and industry, including information technology enterprises, cable and telecommunications providers, and others as appropriate.

Future Visions

"Opportunity Virginia: A Strategic Plan for Jobs and Prosperity"[11] was produced during the life of this task force. Because of the broad participation, it represents some general consensus positions that might provide guidance to the committee and the task force. The central focus of the plan is on fostering competitive industries and firms, as well as good, broad-based job and investment opportunities throughout Virginia. The plan recognizes that the Commonwealth must give attention to its existing base of industries and encourage job growth through both existing business expansion and new business recruitment. The plan also recognizes that development is essentially a private sector phenomenon; to compete in a global economy and generate rising real wages and profits, firms and employees alike will have to steadily boost productivity and the quality of their products. Virginia is well-positioned to be a leader in the United States in the emerging global economy. To be a recognized leader, however, will require vision and a renewed commitment to creating opportunity for all Virginians. Virginia has prospered because of its location, quality of life, and the character of its people. These natural assets, while critical to our economic future, will not alone be enough to seize the opportunities presented by the knowledge-based economy of the 21st century. (June 1995, p.3)

The Task Force accepts the vision developed by the information technology and telecommunications sector as presented in the plan.

> Virginia will become the acknowledged world capital for applied and emerging information and telecommunications technologies and the leading exporter of related products and services by aligning government policies, the educational system, and financial resources and services.

The goals and objectives of the other industrial sectors are equally important to the concerns of this Task Force and have been incorporated where appropriate.

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[11] Commonwealth of Virginia *Opportunity Virginia: A Strategic Plan for Jobs and Prosperity.* (1994)

The Virginia First Policy Partners, a statewide group of recognized business leaders promoting economic development for Virginia, identified a number of conditions that are necessary for the well-being of the people of Virginia who depend on the quality and accessibility of basic public and private services:

- "An educational system from pre-school to high school to doctoral programs which prepares our citizens for the intellectual and societal demands of the next century.

- "A transportation system that moves people and goods in ways that enhance our economic prosperity and supports our goals in land development and the protection of our environment.

- "A policy for economic competitiveness that assures the state's ability to attract and retain jobs and to provide a health sustaining economic environment for its citizens.

- "A capital formation structure that meets the needs of Virginia's growing businesses, particularly those which will be the base of the economy of the future: telecommunications, information products, and intellectual services.

- "A statewide innovative technology policy that will ensure Virginia's leadership in technology development and application."

This vision is multi-faceted and varies depending upon the region and industry referenced but it has common expectations for the education and technical capacities of its citizens and organizations. The state's role is that of coordinator and enabler rather than provider. This must be a joint effort between government and industry with citizens assuming responsibility for individual preparation and participation.

Another vision for education in Virginia was established by the Council on Information Management, in its concept of the Electronic Academy. It's report, "Vision for the Electronic Academy or Virtual Campus," calls for an "Electronic Academy," a comprehensive environment that eliminates dependency upon fixed location facilities and provides a completely connected and interactive learning and working capacity for the students, faculty, and staff of all public education units, public and private higher education units, public libraries (including participating private libraries), public museums, and an adequate information access and retrieval capacity for all citizens, state and local government agencies, and private industry. The Academy will be defined by the services provided and the applications of information and communications rather than physical systems or networks. The distinction between computer, television, radio, telephone, paper documents, and networks will have disappeared. The only issues concerning a participant in the Academy are access and accountability.

- "Networks and delivery medium shall become unnecessary distinctions. Satellite, microwave, physical lines, and other forms of electronic storage and transmission will

be controlled through virtual networks provided and maintained by commercial vendors at low and semi-variable cost to participants and users.

- "Access stations shall be available for all students, faculty, and staff away from their normal workstation, home, or while away. These workstations shall provide high definition display, audio input and output, adequate local storage, and adequate bandwidth access to accommodate all forms of video, audio, and data applications. Location of information or applications shall be transparent to the user but there shall be adequate controls to protect the information and systems without burdening the user.

- "Faculty and teachers' roles shall evolve into tutors and guides for students' intellectual investigations. The transfer of knowledge will depend more heavily on the use of multi-media presentations and interactive use of information resources unbounded by location or ownership.

- "Distinctions between higher education and K-12 will be blurred after the development of basic competencies originally defined in the World Class Education Plan. Distinctions between community colleges and senior institutions will be equally blurred with the emergence of cooperative electronic courses that are used interchangeably by all institutions. Emphasis is on documented learning outcomes rather than individual course units and where they were taken.

- "Cost/performance gains will continue to reduce the cost of technology, and end user autonomy will increase. Faculty, students, and citizens will determine what resources and information will be used and when it will be used. Procurement procedures will support this change.

- "Budget procedures and implementations shall provide for the planned replacement of all technology resources on a realistic life-cycle approach with mandatory reallocation to other users when feasible. All sectors of education will have equal access to resources and information.

- "Because of the balance between employed teachers and faculty and new appointments, emphasis shall be given to extensive in-service training rather than focus on pre-service training programs. Pre-training programs for teachers and faculty will be modified to incorporate the appropriate utilization of technology for each discipline rather than through Schools of Education. In-service training for staff responsible for the operation and implementation of technology shall be given a co-equal priority for funding.

- "Administrative systems that provide direct service to students and citizens will have been developed and implemented during 1996-2000. New network models will support electronic applications for admission, distribution of transcript information electronically, financial aid processing, and coordination of direct student loan

processing and collections. Duplicate submission and distribution of information will have been eliminated or reduced." (CIM, 1993)

Education Issues

This section reflects the Task Force's observation that there must be a change in the focus of education from one which is overwhelmingly memory-based, e.g. rote memorization of facts which will increasingly be available in computer-based materials, to one which balances memory with an equal focus upon the acquisition and use of facts and figures to analyze and synthesize novel approaches to real world issues. The focus needs to also balance individual orientation with group skills, including leadership, civility, and other knowledge and skills for an information age. In a complex world, no one stands alone.

The central issue is how formal school education will be at all relevant to the times. If computer and telecommunication technology is not ubiquitous in our schools and colleges, then those with computers will be getting much of their basic and ongoing education outside of our so-called "educational institutions." Either a state (or nation) will be information driven, or it will be driven by those states and nations who have made the commitment and investment.

The introduction to the education section of the 1983 Report was insightful and still applicable today with only minor adjustments.

> "Virginians are justifiably proud of the state's long heritage of quality education. This heritage is now challenged by changes being wrought through a major technological revolution which is dramatically altering the responsibilities of the state's educational institutions. To meet this challenge, our schools and colleges must adapt to the changing needs of our citizens and of modern industry.
>
> "Thirty-five (versus twenty-three in 1983) years have passed since the invention of the silicon chip touched off an electronics revolution which continues with almost unlimited possibilities. Society's increasing use of the products of this revolution has synergistically accelerated the revolution; there is no turning back.
>
> "Important changes are necessary in our elementary and secondary schools, in our colleges and universities, and in our training and retraining programs as society increases its activities in research and development and shifts to industries based on KNOWLEDGE (versus computer) related technologies involving the production, processing, and distribution of knowledge and goods.
> "Educators attuned to the needs of the businesses and industries which fuel growth are required to contribute to the state's economic development. They have an equally important obligation to serve the personal and professional needs of the citizenry.
>
> "For citizens pursuing technical careers, educational institutions have a responsibility to provide sound programs in mathematics, the sciences, and other technical subjects. Early educational experiences in these subjects are necessary as integral parts of

elementary and high school curricula. Colleges must establish admission standards which support and reinforce high school curricular improvements and requirements and these standards must be effectively communicated to students early in their high school years.

"The quality of teaching is a vitally important factor in assuring positive early experiences in mathematics and the sciences. Nationally severe declines have occurred in the number of teachers trained in these subject areas and in the skills attained by those who complete preparation programs, especially in the appropriate and effective use of technology. Additional resources will be needed to recruit new teachers and to continue the training of present teachers.

"At the college level, students entering technical fields need full opportunity to explore their specialty in depth through enriched offerings, through new programs which cross tradition disciplinary boundaries, and apply information access tools in self-directed learning and research.

"Technical training, however, should not mean that a liberal education is to be neglected. State policies emphasize education in the liberal arts even for students in technical programs, this emphasis should be continually re-examined to include new understanding necessary for integrating general and technical knowledge. The business world is acutely aware of the importance of communication skills and the capacity for disciplined reasoning.

"For citizens pursuing nontechnical careers, an education must be provided which prepares students to live in a technology and knowledge-based society. Most employment will continue to be fields outside the core industries of knowledge production and transfer (versus high technology). However, employability will be increasingly dependent upon at least a general knowledge of mathematics and science, and persons familiar with the concepts of these disciplines will be most adaptable to the changes which technology brings.

"A better educated citizenry is needed not only to supply a sophisticated work force but also to ensure intelligent involvement in political decisions and personal satisfaction in a world greatly influenced by technology.

"For persons entering the workforce and for those displaced by technological or economic changes in industry, the state has a particular responsibility to overcome the disruptive effects of social change. The employment prospects of many disadvantaged or handicapped workers may be eroded. Training and re-training must be for the jobs of the future. Those who succeed will be those who have learned how to learn, not those trained for a specific job which may become obsolete." (1983, p.5, with changes highlighted)

As we turn to the identification of educational issues, it is important to establish a conceptual framework within to determine the necessary education and training levels needed to be a successful participant in the World of Knowledge, today and in the future. It is obvious that there must be a minimal capacity to read, write, and compute that will reflect the level and nature of the employment setting. Business representatives told the committee that the functional capacity of high school and college graduates did not meet their requirements. The message is clear. Our economy cannot absorb new workers prepared for semi-skilled laboring positions when there will be few, if any, jobs at that level. The minimum capacity must provide each citizen with the flexibility to adapt to multiple careers of increasing sophistication and competition with other possible labor markets or production systems.

Different Standards for a New Economy

The concept of adequate education must reflect the environment of a "knowledge economy" and the need for "smart workers." Clearly, the minimum expectations must be raised but not just in terms of facts memorized. Functional literacy takes on a new meaning in the knowledge-based, global market place. The description of a "smart worker" should reflect four general characteristics that will vary from job to job and over time but may be used as a measuring rod to challenge current standards and achievement reports.

- The ability to communicate with customers and others in the workplace and be communicated with in an effective and efficient way. The critical measure is comprehension.

- The ability to logically use data and incorporate information into decision-making. The critical measures are self-reliance and productivity.

- The ability to function with facility in the world of today and tomorrow by using the appropriate tools for a technology and knowledge driven world. The critical measure is adaptability.

- The ability to apply new concepts and information in an evolving workplace and to influence the changes rather than just react to them.

This is challenging because there is no "one size fits all" solution and the educational and industrial community must respond to the individual differences that workers bring to the table. Incentives must be matched with personal interests and capacities. Effective programs will respond to both the needs of corporate goals and citizen value systems and situations.

Workforce Implications of Trends and Future Vision

Changes in demographics, family home economics, technology, and worldwide competition are all changing the workforce. Because of technology, jobs and careers evolve, change and even disappear more quickly than ever before. The composition of the workforce, the ways in which

individuals prepare themselves to enter the workforce, and the need for continuous training and retraining are all evolving as well.

The "Virginia Plan for Strengthening the Commonwealth's 21st Century Workforce" (1991) indicated the following.

- "92% of Virginia's workforce for the year 2000 is already working. Many entered the labor market at a time when skill requirements were far less demanding than they are now, or will be in the future. As a consequence, there will be a tremendous need to provide training and retraining for the existing workforce.

- "The new jobs which will be created in the coming decade will require much higher levels of skill than the average job of today--13.5 years of education compared to the current 12.8 years," and 52% of the new jobs will require one or more years of college beyond high school compared to 42% of current jobs.

- "The majority will require education beyond the high school level with solid preparation in communication, science and mathematics."

These 1991 data were substantiated by a recent statewide survey of 6000 businesses in Virginia that was conducted by the Virginia Community College System. Results of that survey indicated the importance of keeping skills current in that 83% of the responding employers provide some type of continuing training and education for their employees, with computer literacy and training as the highest priority training need. Further, the importance of education was further emphasized by responses to the question regarding the degree to which employees with different backgrounds exceeded or met the expectations of their employers on the job:

- Employees with less than a high school, only 73% of the time;
- Employees with a high school degree, 87% of the time;
- Employees with a community college degree, 92% of the time; and
- Employees with a four-year college degree, 93% of the time.

When asked about the difficulty of recruiting individuals in different types of occupations, businesses indicated they had the highest level of difficulty in recruiting professional, paraprofessional and technical employees. The least amount of difficulty was found in recruiting clerical and administrative support staff.

Elementary and Secondary Education

The Virginia First Report outlined general principles and objectives for K-12 education as:

> "The economic and social welfare of the Commonwealth demands a strong, fairly funded education system. Such a system is necessary to ensure the competitiveness of Virginia's businesses and economy in a global marketplace based upon information technology and to ensure access to employment for all of the state's people. Not only

must the educational institutions create conducive to the creation and growth of knowledge-based businesses but they must also provide the process whereby the Commonwealth's residents can become and remain a skilled and flexible labor force.

"To the extent that the Commonwealth is able to provide additional assistance to the state's public K-12 systems, that funding must reflect the prospect of enhanced attainment within those groups of students who are not currently achieving their potential. New funds cannot be used to reduce existing local effort.

"In order to prepare out citizens for the demands of the new economy, we must provide an educational system that provides job skills and learning capacity in the context of a knowledge-based economy on a current and continuing basis. The system must reduce and ultimately eliminate education disparity across groups and geographically by addressing disparity of attainment, opportunity and access to K-12 education and reduce disparity in accessibility and affordability in higher education funding.

"The system must increase the quality and quantity of job related skills with special attention given to technical preparation of students at the post-secondary and secondary levels, while at the same time providing and/or enhancing the intellectual climate and the cultural life in the state." (July 14, 1995)

The Virginia Department of Education, in its Six-Year Educational Technology Plan for Virginia, outlines the environment secondary schools in the Commonwealth must respond to:

- Educators in Virginia today must face the challenge of preparing students to lead productive lives in the 21st Century. Confronting the challenges means dealing with some very fundamental societal conditions. The class of 2006 will graduate from high school into a society where technology expands and redefines how they will live, learn, work, and play. Electronic villages, where homes connect to each other, to businesses, to schools, and to libraries will be commonplace.

- Citizens will be active participants in the democratic process using modems, fax machines, and cellular telephones. Access to the various communication media will create a more global lifestyle.

- Solutions to the 21st Century problems need to be bold and innovative with realistic expectations. In order to meet the technological needs in education, additions to state and local funding through alternative funding strategies and sources need to be identified. Business and industry partnerships and grants are two solutions to secure funding for technology programs. (August 1995)

More important is the vision or goal that was adopted by the Virginia State Board of Education in 1994. "Through technology, Virginia schools will provide all K-12 students opportunities to learn skills essential to be productive, creative citizens of the 21st Century. Students and educators will

have access to a variety of information sources to utilize national and international networks. Students will be empowered to use technology for continued learning."

Leadership

Leadership within school systems and schools will be the critical factor in the success or failure to use technology to improve the learning environment and capacity of future graduates. Without enlightened principals and superintendents, capital expenditures for computers and telecommunications will not yield the desired results because the necessary curricular changes, teacher in-service training, and assessment will not take place. The influence of the principal in determining the success, or failure, of academic restructuring has been well documented.

The Commonwealth should place a high priority on training of administrators for the technological environment that must exist within, and among, our schools. This training must be different from the traditional "school administration" that our colleges of education have been providing. It must reflect the new practices of private industry in new product development and customer service. The emphasis must be on results rather than process.

This leadership problem is so critical that it should be addressed similar to the development of national laboratories by the federal government. The Federally Funded Research and Development Centers have been very successful and are viewed as "honest brokers" of new technology and information. A Virginia Institute for School Leadership that focus on the effective and efficient use of technology in schools should serve all regions of the Commonwealth and should combine the best thinking and resources of the local, state, and federal government with those of industrial partners. This program should be developed and implemented during the 1996-98 biennium.

Technology Certification

Equally important is the development and maintenance of technological competency in the teachers in all of our schools. New teachers must be required to have adequate technological skills to use current and future information resources in their teaching and course development. Since 85 percent of the teachers who will be teaching in 2000 are already employed by our schools, an aggressive program of in-service training must be implemented if Virginia is to transform its schools and its educational outcomes. Something must be done to enable current and future teachers and to monitor the results of their efforts.

Technology Fund

Equipment must be provided and kept current. Goals that refer to numbers of pupils per computer must be expressed in terms current technology. Information presented to the committee documented that the current ratio of computers to students in Fairfax County of 1:9 would fall to 1:30 if obsolete computers were eliminated from the calculation.

It is unlikely that individual school districts will be able to reallocate sufficient funds to acquire the necessary technology or to replace technology out of annual operating funds. The Commonwealth

has created several innovative funding vehicles for technology over the last ten to 15 years. More needs to be done. A combination of local and state bonding should be investigated.

Alternative approach would be to establish a "technology fund" that would be matched by local governments and industry. This fund would be used as a loan-lose reserve for commercial debt that could be made available to parents and school systems for the acquisition of technology equipment.

The Commonwealth should explore the creation of a statewide foundation based on the model developed in Fairfax County to combine the talent and resources of corporations, citizens, and agencies to stimulate and facilitate changes in how schools acquire and use technology. Virginia is blessed with a large concentration of the knowledge industry and it should leverage its dollars through cooperative projects.

Restructuring

Technology is not yet viewed as a resource to extend the capacity of instructional and administrative personnel of our schools. The Board of Education and local school districts should cooperate with the professional associations on ways to extend the capacity of our teachers through the use of technology and to challenge the current assumptions about pupil/teacher ratios. Individual school districts should be encouraged to enter into regional cooperatives for administrative services with other districts, colleges, municipalities, and industries.

Additional resources from the current operating budgets can be freed through such restructuring efforts. These resources should be reallocated to the instructional programs and to maintain technology assets.

Disparity

In recent years, there has been considerable attention given to differences in funding per pupil. The General Assembly has taken steps to address this issue by funding reductions in the class size for early ages, where research documents the greatest payback, and to authorize an additional $47 million for technology initiatives in the 1994-96 budget. The increasing importance of technology in improving the quality of instruction and the self-sufficiency of pupils raises similar questions about the need to consider innovative approaches to the use of technology in urban and rural schools.

In many school districts, assumptions about the availability of computers to students outside of school hours must be examined carefully. While some aspects of this issue are fiscal in nature, others are curricular and social. The approaches that work well in Fairfax, Chesterfield or Virginia Beach might not work as well in Richmond, Norfolk, Petersburg, or Alexandria.

The resources of our colleges and schools should be combined and targeted on this issue. An institute or pilot project should be developed and implemented to determine what approaches work in inner city schools and how to share the results with other school districts across the state.

Community Colleges and Training

The mission of the Virginia Community College System (VCCS) is to assure that all individuals in the Commonwealth are given a continuing opportunity for the development and extension of their skills and knowledge. Restated, that mission is to train and retrain the existing workforce, assist business and industry in becoming increasingly competitive, and to train the workforce of the future.

A recent survey of 6,000 businesses in Virginia that was conducted by the VCCS indicated the importance of continuing education and training to business and industry in that 83% of the responding employers provide some type of training and education for their employees. While half (35.9%) of the employers conduct their own training, 47.4% of the respondents indicated they needed outside training assistance, with the VCCS as the primary provider to whom they turn for assistance. Of those employers that needed outside assistance, 66% contacted the community colleges, followed by 55% that contacted four-year colleges, 40 percent that contacted a high school vocational program, with lesser responses for other types of training providers.

Responses to other questions are a good indicator of why the community colleges are the provider of choice.

The top six types of training and services identified by business and industry as needed now and in the future include (in order of need):

1. Computer literacy and training.
2. Supervisory/management training.
3. Human relations skills.
4. Licensure/certification courses.
5. Quality (quality management, statistical process control, etc.).
6. Job-specific technical/contract training.

The top incentives for business and industry to use training and education services to meet their needs include:

1. Training programs and facilities related to specific industry needs.
2. Training provided at the business site.
3. Tax credit or other public funding to offset training costs.
4. Access to electronic information and networking opportunities.

The Virginia Community College System offers business and industry a statewide system of education and training that is flexible, focused and responsive to these types of needs. It offers both credit and non-credit instructional programs that lead to employment opportunities, as well as open enrollment programs offered to individuals and businesses, many of which are often custom-designed for business and industry. In addition, as the VCCS begins implementation of its

statewide technology infrastructure plan, access to education and training should be improved for business and industry both in terms of content as well as location and accessibility. The VCCS, in partnership with Virginia Tech and Old Dominion University have initiated planning efforts to develop a broadband, wide area network that will extend across the Commonwealth for use by all institutions as well as local schools. Using the 38-campus structure of the VCCS as the backbone of the network, the long-term goal is to provide a robust telecommunications infrastructure throughout the state, the ultimate goal being the extension of network-based courses to serve substantially more students at lower costs.

The centerpiece of the VCCS efforts to support economic development in the Commonwealth is *Virginia Works*. Recognizing that to simply extend the present programs and delivery systems of the community colleges will not be sufficient to position the Commonwealth for the year 2000, the VCCS is moving forward with an initiative to challenge, restructure and strengthen the existing framework for workforce training, services and funding. Based on creating community alliances, the initiative has five strategies to improve the quality of life for citizens of Virginia by increasing the availability of high-skill, high-wage jobs. With the VCCS providing a high-skills workforce now and in the future, and by strengthening the quality and availability of workforce services to business and industry, Virginia will be positioned to attract employers with high-wage jobs, and to improve the productivity, competitiveness, and profitability of existing business and industry.

The VCCS will continue to work with business and industry by addressing specific concerns and needs identified in the recent survey, by continuing to implement the five strategies of *Virginia Works*, and by continued implementation of the VCCS statewide Information Technology Infrastructure Plan. The VCCS' colleges and campuses are located close to most citizens. They could provide the locus for a broad 'Telecommuting Service" and "Internet Access Point" to citizens, local government, and industry.

The VCCS has authority to reallocate funds among its colleges and does so to respond to changes in enrollments and budget needs. To the extent possible, the VCCS should allocate adequate resources to the colleges directly serving technology industries and regions of the state where such firms are concentrated. The VCCS is a critical component of our economic development plan but must position its resources for maximum response and results.

Undergraduate and Graduate Education

Again the 1983 report is relevant today. "The policies and programs of Virginia's colleges and universities have a significant effect on the state's ability to attract and retain high technology industry. High technology firms typically require relatively large proportions of employees with bachelor's and higher degrees in engineering, science, mathematics, and computer science. While the market for such employees is national or even international, the attractiveness of a Virginia location is affected to some degree by the numbers and quality of graduates in the relevant disciplines from Virginia institutions. Moreover, strong programs in engineering, science, and mathematics are needed for Virginia to meet its responsibilities to offer education that will fits its youth for the economy of the future." Since 1983 the blending of the traditional disciplines has

accelerated and today combinations of engineering and information sciences, or telecommunications and computer science, are in demand by students and employers.

Recent decisions to choose Virginia as a business location by the American Type Culture Collection, Motorola, and IBM/Toshiba documented the importance of Virginia's educational institutions notably the desire for proximity to cutting-edge research. There must continue to be a balance of emphasis on undergraduate and graduate instruction and research programs since industry is interested in more than just a secure source of talented employees. Knowledge production is critical to the continued evolution of firms, industries, institutions, and regions of the state.

In 1983 the task force concluded that the higher education picture in Virginia was mixed. Today it is less positive. In his Chairman's Prologue to the report of the Commission on the Future of Higher Education, Senator Chichester said: "For the last six years our colleges and universities have gone through an unprecedented period of upheaval and financial insecurity. Six years ago it would have seem inconceivable to predict that in fiscal year 1996:

- state support is at an all-time low.
- tuition is at an all-time high.
- in this fiscal environment, our colleges and universities must absorb 60,000 more students by the year 2004.

To prepare for this large influx of students, we are asking our colleges and universities to 'restructure' themselves -- to find ways to teach more students with fewer resources, to streamline administrative operations, and to decide which activities should stay, and which should go ... A common thread throughout the report is the paramount importance of the institutions of higher education to the economic development and the economic well-being of the Commonwealth. Through research, occupational-technical training, key programs such as engineering and biotechnology, and in so many other ways, our institutions are a major economic asset of the Commonwealth -- an asset that needs to be nurtured and supported." (1995, p. 4-5)

The Task Force endorses the observations and recommendations of the Commission, especially those relating to efficiency and effectiveness, adequate funding, and accountability. This report will not duplicate the efforts of the Commission but has incorporated some of the recommendations to give added support for their adoption. However, a few issues will be highlighted.

Balance between teaching and research. Teaching and research are important responsibilities and services of our colleges and universities. The balance between these complementary missions is important. We agree with the commission that this balance should differ across institutions.

> "Research is important to industry and the concerns expressed in 1983 are still relevant.

"University research generates much of the knowledge which underlies our technologically oriented society and economy. It educates by revealing its new knowledge to all. It trains future intellectual explorers. It trains the professionals who translate these new revelations into goods and services to benefit our economy and citizens, It educates those who will in turn educate others.

"Alliances between research universities and industry have become an increasingly vital part of society's fabric in the past several decades. These alliances encompass programs to train corporate personnel, faculty consultation, research grants and major contracts, university consortia, industrial parks, and many other relationships. Problems arise from such matters as proprietary rights and conflicts of interest, but means of resolving these problems are being and can be found.

"The extent to which Virginia institutions engage in effective alliances with industry bears directly on the attractiveness of the state as a home for high technology enterprise. Virginia has strong research components at several of its universities and has in existence many examples of effective alliances between research universities and industry." (1983)

The role of Virginia's Center for Innovative Technology in coordinating and financially assisting these partnerships is critical and will be discussed in greater detail in a later section of the report. Industry representatives indicated in testimony to the committee that policies regarding intellectual property rights continue to restrict cooperative research projects at some institutions and the cost of services may not be competitive with other universities or private firms. Both of these issues deserve further attention, especially in the highly competitive markets of biotechnology and medical clinical studies.

Changing Learning through Technology

The Chichester Commission Report[12] is instructive and represents a number of consensus observations on the importance of and potential benefits of greater investment in technology in higher education:

"By now it has become commonplace to write about how our lives are changing under the influence of advanced electronic technology. It's here to stay and it has become a major influence on colleges and universities everywhere. They teach its use, they use it to teach and do research, and they use it to provide the administrative support services that keep the institutions open for business.

"Advanced communications and computing technology, in short, is a major part of both the form and content of higher education as we know it today. For succeeding generations it will be the same, only more so. Technology has transformed the higher education experience. We need to encourage and support new applications to even

[12] Commission on the Future of Higher Education. (1995)

further transform higher education. "Restructuring," as viewed by this commission, means rethinking and re-evaluating every facet of the academic experience. Restructuring is not simply a means to cut costs and teach more students, but a way to radically rethink how we go about providing higher education in Virginia. Nowhere do we see more opportunities to depart from the old ways and attempt new approaches than in the area of technology.

"We cannot ignore that we need to teach teachers how to use the technology and how they can incorporate it into the curriculum. A recently released report on technology in the classroom cautions that technology cannot just be "dumped" into schools -- teachers must learn new ways to teach and assess students' progress. "Otherwise," the report's author suggests, "you'll have teachers using 21st-century technology for an 18th-century learning system."

"New instructional technologies which "extend the reach of the faculty" should be promoted as a means to increasing productivity, and providing educational opportunities to time- and place-bound students. A key factor in improving access will be a communications infrastructure that can link each college and university, community college, and, ideally, public schools and business. The Commonwealth should encourage the development of a network to support the concept of a statewide "VIRTUAL CAMPUS" (emphasis added) that can deliver instruction to individuals or organizations free from the constraints of distance and time."

The Task Force strongly endorses the concept of the Virtual Campus.

A final concern is the allocation of resources among the senior institutions of higher education. Institutions serving knowledge-based industries and the regions where such firms are concentrated need resources to respond quickly and adequately. The Commonwealth should examine its allocation policies and make adjustments as necessary. Sufficient funding of existing sources of knowledge production is as important as developing new strengths. A balanced plan that addresses both short- and long-term development issues is need.

It is in this dynamic environment that the Task Force approached its expectations of the higher education system.

Research

CIT was created by the General Assembly in 1984 as a private, nonprofit corporation to enhance the research and development capability of the state's major research universities in partnership with industry. During the period 1984-1994, CIT implemented this original legislative intent by bringing Virginia businesses and institutions of higher education into relationships that promoted a climate of collaboration and technological innovation:

- CIT co-funded 836 research projects at Virginia public universities, involving 786 companies and attracted over $155 million in private and other funds.

- CIT established 13 technology development centers at Virginia's research universities, 11 of which presently exist, increasing R&D capabilities in the following fields:

  Advanced Ceramics Materials (VA Tech).
  Bioprocess/Product Development (UVA).
  Drug Design, Delivery & Clinical Applications (VCU).
  Command, Control, Communications & Intelligence (GMU).
  Magnetic Bearings (UVA).
  Semicustom Integrated Systems (UVA).
  Wireless Telecommunications (VA Tech).
  Coal and Minerals Technology (VA Tech).
  Electrochemical Science and Applications (UVA).
  Fiber & Electro-Optics Research (VA Tech).
  Power Electronics (VA Tech).

- CIT's Technology Application Center at Old Dominion University and its technology assistance and transfer program based primarily at Virginia community colleges completed over 1,900 industry projects, often with the assistance of college and university faculty.

- CIT was instrumental in raising Virginia's ranking among the states from 28th to 6th in the number of patents issued to universities and nonprofit institutions from 1987-1993.

Toward the end of this period, frequent calls from the technology business community, as well as from legislative study groups, recommended that CIT shift its focus from funding university infrastructure and R&D to near-term and commercially relevant activities that demonstrated tangible economic results. Consequently, funding of university-based centers began declining in 1988 and in 1990, the last of the technology development centers was initiated.

In 1993, the General Assembly amended CIT's mission by broadening its scope and emphasizing near-term economic development activities in addition to university-based research. In 1994, Governor Allen appointed a new Board of Directors to oversee the restructuring of CIT, and a new strategic plan was approved by the Board. The new plan identified several strategic goals to guide CIT's activities:

- assist in creating or retaining 6,000 jobs and be instrumental in starting, retaining, or converting 150 companies by the end of 1997. During this same period, 1,500 companies will be assisted in improving their competitiveness and these companies will report an economic impact of $100 million during the first year after receiving these services.

- increase industry competitiveness by supporting the application of innovative technologies that improve productivity and efficiency.

- mobilize support for high technology industries to commercialize new products and processes, include organizing assistance for small business and supporting select industry sectors and regional high technology efforts.

- promote economic development in Virginia by attracting and retaining high technology jobs and businesses.

- enhance and expand the R&D capabilities of Virginia's colleges and universities, including transferring technological advances to the private sector.

- capitalize upon the presence of federal labs and the technology resources within the Commonwealth.

Traditionally co-funded university research grants were replaced with "technology awards" to universities where companies were expected to pay back CIT investments when they were commercially successful. Entrepreneurship centers and business development support expanded with concomitant declines in funding for university-based research and development. By late 1995, independent studies conducted by the Battelle Memorial Institute and the Institute of Public Policy at George Mason University reported CIT's successes in economic development, documenting over 3,500 technology-based jobs and 27 companies have been attracted, created, or retained in Virginia in fiscal year 1995 as a result of CIT-sponsored activities.

CIT's success at aiding Virginia's short-term economic development is becoming increasingly evident. However, currently there are no new long-term initiatives being taken or planned to help strengthen Virginia's existing science and technology infrastructure. No new long-term capacity is being developed around emerging technologies where Virginia may have a longer term potential of becoming competitive.

There are a number of technology capabilities in Virginia which are or have the potential of being strategic economic importance to the Commonwealth over the next five to ten years including:

- laser and light source technology -- developing the capabilities of the Continuous Electron Beam Accelerator Facility, including the Free Electron Laser.

- microelectronics -- developing the emerging capabilities in the next generation of semiconductor research and development.

- aerospace/aeronautics -- developing the capabilities of orbital and suborbital commercial space launches from Wallops Island.

- information technologies -- developing information technologies, systems, products and services in areas such as software development, systems integration, electronic commerce, bio- and medical informatics, wireless telecommunications; and fiber and electro-optics.

These capabilities need to be supported and developed further, perhaps through mechanism like a second generation of technology development centers, inter-institutionally arranged, having an R&D focus but with a greater emphasis upon Virginia's economic development than their predecessor organizations. In addition, efforts should be made to identify and support research and technology development in emerging technology areas with commercial potential where Virginia has the potential to be globally competitive over the next decade in areas such as genetic research, "super materials," high density energy sources, "smart" manufacturing systems, and medical diagnostic and treatment tools and procedures.

Health Telematics: Telemedicine and the Computer-Based Patient Record

Telematics is a new term used to describe both telecommunications efforts related to medicine (Telemedicine) as well as medical or health informatics. Health informatics is a new discipline centered around use of computers and information sciences for health care delivery, education, and research. Over the next twenty years, a few sites around the globe will attain the stature of "neurons" in the development of a global intelligence as foreshadowed by Orson Welles in the 1930s. Virginia can clearly be one of those "hot spots" if it acts now and intelligently to exploit this window of opportunity. A number of states are already seeking this stature and are ahead of us in a number of ways. As a result of geography and past investment, however, Virginia should not be counted out, particularly if it moves to this agenda in the coming biennium.

The Commonwealth of Virginia is very well positioned to experience benefits in economic development and health status if it can facilitate a broadband infrastructure to allow a bonding between telecommunications and computing. The health applications will come in three forms.

Direct Health Care. First, those citizens (patients and physicians) living in rural settings will have direct contact with regional health facilities as well as tertiary care institutions, especially for advise on specific acute health problems which otherwise would trigger emergency transportation. Experience elsewhere has shown that Telemedicine's savings are particularly notable in avoiding unnecessary transfers of patients for care when local expertise can have the benefit of specialty consultation on a real-time basis. Extrapolated in terms of worker productivity (family members who must accompany or transport the patient), costs of air transportation, and repeated medical testing all result in savings. Further, it is becoming apparent that with teleradiology services otherwise unavailable, more isolated areas can have the benefit of quick, expert opinion and reduce the number of radiologists needed within communities. This is a very real savings since radiologists earn substantial salaries.

Education. During the next five years, the availability of a broadband network across the Commonwealth would allow the educational institutions, health professional groups, and related organizations to develop statewide efforts particularly focused upon health professionals. This has real implications for continuing education as well as entry level education. The opportunity to tie UVA, VCU/MCV, and MCHR more closely for economies of scale is real.

In the next decade, there is every likelihood to expect that programs focused upon citizens with chronic illnesses requiring periodic checkups could be monitored from their homes, thereby reducing substantial costs of time and travel for visits which are typically health maintenance rather than direct treatment. It has been shown that preventive checkups of this type can save later admissions to hospitals requiring substantial costs for treatment. For example, patients with hypertension can experience loss of blood pressure control with strokes developing or heart attacks. Diabetics who may require hospital admission for treatment of diabetic coma can avoid such admissions through better management of their insulin and blood sugar levels. These strategies in some instances involve home health visits and in other instances, direct communication with patients in their own homes. With a rising elderly population and associated chronic disease, this capability offers real opportunities to dramatically reduce costs which otherwise will begin to further escalate with the graying of the population.

Research. The growth of Telemedicine, computer-based patient records, managed care, the call for greater public accountability of public expenditures, and the growth of the global information infrastructure all offer the Commonwealth a unique opportunity to become a national and international leader. Our current circumstances offer us a very bright future in this regard if state seed moneys are invested in a collaborative partnership with industry. An example, is the grants offered by Virginia's Center for Innovative Technology to the University of Virginia and George Mason University to develop new programs to broker the development of the Information Age within the Mid-Atlantic Region.

Infrastructure Issues

The committee's investigation of infrastructure issues can be divided into two categories: those pertaining to the state, region, or national networking, including access to information and services through the Internet, and the wide- and local-area communications requirements within institutions, schools, libraries, and agencies. Without a coordinated approach at both levels, the desired benefits of a statewide information infrastructure will not be realized.

Statewide Information Infrastructure

The central focus of the plan developed in Opportunity Virginia is "the availability and accessibility of technology, the related skills of the workforce, and our ability to capitalize on existing technology strengths will be critical determinants of Virginia's economic future. These are important both to the base of 'traditional businesses and industries and the Commonwealth's ability to become a leader in technology-based sectors." (Opportunity Virginia, 1994)

The Education and Infrastructure Committee reviewed the observations and recommendations made in "Opportunity Virginia and RoadMap to the Future"[13] and agrees in general with the two reports and specifically with the goal of advancing the key economic objectives of the Commonwealth by accelerating the implementation, deployment, and use of a statewide information infrastructure. The report proposes four strategies for achieving this goal:

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[13] Council on Information Management, *RoadMap to the Future: A Strategic Plan for Virginia Information Technology Infrastructure.* (June 1995)

1. Facilitate, support and promote the deployment of a private statewide information infrastructure to support broadband communications services with applications to economic development, public safety, education, health, nonprofit and government sectors.

2. Remove unnecessary regulatory, policy or organizational barriers that inhibit development and usage of such an infrastructure.

3. Ensure universal and equal access to all its services, at an affordable cost, to all its citizens.

4. Encourage integration within the information infrastructure of existing and developing educational, regional and community networks.

The report indicated that "to maximize the private investment and utilization of infrastructure that currently exists, Virginia must be certain to have laws and regulatory policies to allow private sector investment to keep Virginia on the leading edge of telecommunications." The RoadMap report indicated that "improvements in technology, broadly defined, are integral to improving efficiency in both the public and private sectors. This is critical because the information and communications revolution will perhaps be the single most important technology-related spur to economic growth over the next ten years. The key now is to facilitate the connectivity of regionally based systems and encourage the development of the applications that will drive expanded utilization by both the public and private sectors."

Higher Education Needs

> "We now live in a world in which local and regional competitiveness is determined by critical masses of knowledgeable people, rather than capital and natural resources. By linking the Commonwealth's institutions of higher education, Virginia's citizens will benefit from effective modes of teaching and learning. They will also be able to leverage emerging economies of scope in acquiring and producing new knowledge. Students will be able to have access to faculty, traditional classes, degree and non-degree program, and other learning resources -- from or to any participating campus." (Virginia Tech, "Technology Infrastructure Vision")

The Virginia Tech Report focuses both within the campuses of the higher education system but also among them and other available resources in a digital format. The concept of the "Virtual Campus" is developed here and in the Chichester Commission report. A few comments are included to highlight the concept.

> "Needed is a state-of-the-art, wide area, educational network (WAN). In addition to traditional local area network (LAN) interconnection and information transmissions, this network will support development and ultimate realization of a statewide "virtual campus." The virtual campus will permit the delivery of instruction to organizations

and individuals relatively free from the constraints of distance and time and will permit common access across institutional boundaries to information resources which are scarce or unique.

"The concept of virtual campuses encompasses emulation of ordinary classrooms, art studios, libraries, faculty offices, student centers, media centers, science labs, and administrative offices using a variety of media for an on-line and off-line format. Technology will be used to extend these education and information resources to groups or individuals exclusive of geographic and, in some cases, of time constraints. The infrastructure must be capable of supporting a spectrum of needs ranging from simple electronic mail to fully interactive, multimedia classroom emulation extended to many, separate locations simultaneously. The network fabric in the form of local area network (LAN) interconnection will be supported. Ideally, Internet access in variable bandwidth for individual sites should be inherent within the fabric of the overall WAN. The emerging interactive, multimedia applications which will support the development of educational programs will not operate using traditional communications infrastructures. These applications demonstrate an exponentially voracious hunger for network bandwidth and the ability to interconnect various platforms and transport technologies."

This approach is a beginning effort to foster the needed cooperation. Virginia Tech, Old Dominion University, and the Virginia Community College System in association with Virginia Commonwealth University, Radford University, the Virginia Department of Information Technology, and the Council on Information Management have joined to build a pilot network. A request for proposals was issued in the summer of 1995. Hopefully, this pilot network will help pave the way for a statewide infrastructure fully capable of supporting the objectives of the Virtual Campus.

The Chichester Commission recommends that "as Virginia moves to link higher education, the Commonwealth should adopt a policy of 'buy, rather than build' when it comes to technology infrastructure. Changes in technology, coupled with changes in the telecommunications regulatory environment, have spawned an array of private-sector firms ready to provide the products and networks to higher education. While the Commonwealth could conceivably save funds in the short term by constructing its own telecommunications infrastructure (as some states have done), these savings may be lost by investing in a technology that could soon be obsolete. Therefore, Virginia's colleges and universities should be encouraged to buy telecommunications services, rather than to build the infrastructure themselves." (1995, p. 37)

The vision for the Virginia infrastructure is for a network of networks which places great emphasis on how individuals, institutions, schools, and organizations actually access the linked networks. Businesses and individuals cannot fully realize the significant benefits of an advanced telecommunications network unless it is readily available to them. The physical link between communication services and agencies, institutions of higher education, schools, businesses and households is identified as the "last mile connection" and represents the most difficult issue to solve and to fund.

There is an additional issue that applies to both the statewide and institutional infrastructures and it relates to the strategy of ensuring universal and equal access to all services, at an affordable cost, to all citizens. The problem of "haves and have-nots" has various dimensions -- geographic, economic, and personal preference. It may not be possible to eliminate differences in real access but such disparities should not be the result of public policy, regulation, or regional economics. Within our schools and colleges, we must take steps to make sure that adequate resources and training are available to all students, teachers, and faculty.

Institution or School Infrastructure

In addition to the "last mile" issues of the level of service and cost to the school or institution for access to adequate bandwidth, the major problem facing most schools, school districts, institutions, and libraries is how to make the telecommunications services available throughout the buildings, campus, or locations to all students and faculty. While higher education institutions have made greater investments in local networks than K-12 schools, the availability of network access and services varies greatly among the public and private institutions.

In 1993 only 31 percent of Virginia schools reported having local area networks serving an entire building. A survey done this year indicates that limited progress has been made with only 33 percent of schools reporting building-wide LAN service. In many areas, telephone lines into schools are limited and internal-building delivery systems to deliver voice, video, and data service to individual classrooms and offices does not exist.

Bringing powerful tools to the front door of an ill-equipped school or adding free-standing microcomputers, may not provide the anticipated impact for the expenditure. The allocation of the responsibility for establishing and paying for the necessary local infrastructure between institutions, schools, the state and telecommunications provider is a difficult but critical policy decision.

VI. COMPETITIVE POSITION AND FINANCE

The Competitive Position and Finance Subcommittee drew its charge from the following definitions:

- Competitive Position. To focus on the programmatic resources as they affect the competitive position for Virginia industry sectors--emerging, existing and targeted. This subcommittee is to consider issues with regard to such in the following areas: R&D deployment, commercialization, business assistance, and research and regional centers or councils, to include S&T services and policy organizations.

- Finance. To focus on the business, tax, and regulatory issues affecting the promotion of S&T in Virginia as it relates to financial issues. This subcommittee is to consider issues with regard to such in the following areas: venture capital, capital formation, and taxes on S&T businesses.

Science and Technology Assets in Virginia

Selected comments about Virginia and its science and technology assets include:

- Of federal spending for R&D in Virginia, Virginia is under-invested (only 2%) in computer sciences relative to reported industry strengths.

- Agriculture has a high R&D federal investment, but little industry (market) strength.

- Systems integration should be married with other sectors of economic activity (medical, banking, aluminum, wood, shipbuilding, semiconductors).

- Biotechnology, though small in relative numbers, is fast growing in Virginia as an industry sector.

- Although there are excellent economic data on regions available, not much information is known or available about S&T--with as much precision. This reality makes it more difficult to assess S&T issues from a research perspective.

- Data about S&T are also confounded by the fact that Information Technology sector does not perform R&D per se, but is a major source of S&T employment in Virginia.

Cooperative Technology Programs in Virginia and Other States

Cooperative Technology Programs are defined as initiatives involving government and industry, and often involve universities for the purpose of sponsoring the development and use of technology and to improve practices, and whose primary goal is economic growth.

Cooperative Technology Programs exist in 49 states; Nevada is in the process of setting up one. There exists a great diversity in programs across the states, but major purposes of these Cooperative Technology Programs are:

- Technology development research and applications for products and processes.
- Industrial Problem Solving identifying and resolving company needs through technology and best practice applications.
- Technology Financing public capital or help in gaining access to private capital.
- Start-Up Assistance aid to new small technology-based businesses.
- Teaming help in forming strategic partnerships.

These cooperative technology programs began in the 1960's with the investment in the Research Triangle in North Carolina and with the creation of industrial extension programs in Georgia and Pennsylvania. During the late 1970's and 1980's with the recession devastating the Rust Belt, multi-faceted programs were initiated in Pennsylvania, Ohio, and New York. The focus then was

on tapping into university expertise. As such, Virginia's Center for Innovative Technology (CIT) was initially created in 1984 as Virginia's cooperative technology program with the express purpose of enhancing the research and development capability of the state's major research universities in partnership with industry.

By the early 1990's, there was a widespread acceptance of these programs, including increased federal involvement in some programs, and a greater focus on technology extension. But by the mid-1990's, there exists a potential for decreased federal activity, yet continued state growth.

Spending on these programs is on the rise. In Fiscal Year 1994, the states spent a total of $385 million to sponsor cooperative technology programs nationwide. Population of states strongly influences the size of the programs. The average annual program budget for the largest ten states was about $20.5 million in FY94. For the next ten largest states, the average program budget is about $7.6 million in FY94. CIT's budget was about $10.4 million, of which $8.2 million was the General Fund Appropriation. Using the $10.4 million figure, Virginia ranks 13th of states in spending on cooperative technology programs, which is about $1.63 per person in FY94 and ranks 19th of states in spending per capita. Virginia is 12th in population.

By contrast, the spending for cooperative technology programs in Virginia's border states is higher: North Carolina's per capita spending was $5.48, and in Maryland, per capita spending was $ 2.58.

Virginia has one of the more comprehensive programs, coordinating most functions of cooperative technology programs nationwide. Of the above-listed functions, Virginia through the CIT provides these activities that compare to programs in other states:

- University-industry technology centers.
- University-industry research partnerships.
- Technology extension/deployment.
- State-sponsored federal outreach.
- Incubators.

Potential areas of activity for Virginia include:

- Equipment and facility access programs.
- Implementation grants.
- Company financing.

Much of the success of incubators has to do with the quality of management and the advisory boards. A low cost investment (average is about $200,000) produces high results: normally about 80% small companies fail; 80% small companies in incubators survive.

Capital Needs of Technology-Based Businesses

Deliberations of the Joint Subcommittee Studying Capital Access and Business Financing in the Commonwealth were presented to the Subcommittee. Findings and recommendations that particularly affect technology-based companies include:

- Removing the BPOL tax on seed and venture capital firms to make attracting new firms to Virginia easier.
- Establishing a seed and early stage equity fund.
- Promoting Virginia as a technology state.
- Supporting venture capital networks.
- Establishing a venture capital roundtable.
- Enlisting VRS leadership in recruiting venture capital firms.
- Establishing a statewide network of angel investors.
- Establishing a market feasibility program in conjunction with MBA programs to assist businesses develop financing plans.

An overview of the working paper prepared by Virginia's Center for Innovative Technology about Capital Access for Technology-Based Firms was presented to the subcommittee and highlights are presented below.

Two primary points about technology businesses in the Virginia economy:

- Their economic impact in terms of jobs and earnings far exceeds the norm.
- Their needs are different, particularly with respect to capital access.

There exist five gaps in capital requirements of technology-based companies compared to existing programs:

- Inefficient angel networks.
- No way to fund early market feasibility studies.
- Little seed-stage equity funding.
- Little seed-stage debt funding.
- Few private sector venture capital firms.

The working paper suggested recommendations that would begin to eliminate these gaps:

- Initiate a statewide private investor network similar to a program begun by the Hampton Roads SBDC that would match angel investors with entrepreneurial technology-based companies.

- Initiate in conjunction with MBA programs a Market Feasibility Program to assist entrepreneur inventors with assessing the market feasibility of a technical idea before extensive technical work is performed.

- Initiate a public fund or tax credits to provide seed-stage equity funds to technology start-up companies.

- Initiate a public fund or tax credits to provide seed-stage debt funds to technology start-up companies.

- Initiate an aggressive plan to recruit Venture Capital companies to Virginia that may include VRS investments in Virginia funds.

VII. TASK FORCE RECOMMENDATIONS

The Task Force recommendations are stated below. The final recommendations of the full Task Force differ from some items recommended in the subcommittee reports. The first three recommendations were considered and adopted by the full Task Force, but were not presented in either subcommittee report. The other recommendations were forwarded to the full Task Force from the subcommittees.

The Science and Technology Task Force recommends that:

Continued Oversight

1. A Joint Commission for Technology and Education, with special emphasis on the implementation of the technology infrastructure, should be established for a period of two years.

2. The Science and Technology Task Force should be continued for the purpose of reviewing the technology dispersion and public policy of science and technology in the Commonwealth.

3. Virginia's Center for Innovative Technology should be considered the Commonwealth's lead Science and Technology mechanism for the purpose of planning and representing the Commonwealth in matters dealing with science and technology and its role in economic development of the Commonwealth.

Education for a New Knowledge-Based Economy and World

4. The focus of Virginia's public school system should be examined and modified to reflect the change from an instructional process that is overwhelmingly memory-based, e.g. rote memorization of facts, to one which balances memory with an equal focus upon the acquisition and use of facts and figures to analyze and synthesize novel approaches to real world problems and situations. Instruction must also balance individual orientation with group skills, including leadership, civility, and other knowledge and skills for an information age.

5. Each high school graduate should be required to document minimal competency to function as a worker in a knowledge-based economy. The expectation is that employers need men and women with the ability to read with understanding; the ability to communicate clearly both by the written and spoken word; the ability to think through a problem or situation; the ability to calculate with at least a rudimentary understanding of algebra, geometry, and elementary statistics; and the ability to analyze.

6. The Commonwealth should support the *Virginia Works* initiative proposed by the Virginia Community College System (VCCS) in order to foster a stronger economy for Virginia. Funding is needed to support training and retraining efforts of the VCCS in order to ensure a highly skilled workforce and a globally competitive business community.

7. The Commonwealth should continue to support undergraduate and graduate programs, especially in high-technology disciplines, which encourage part-time continuing education and participation by industry employees across the state. These programs must remain responsive to industry's needs throughout the state.

8. Virginia higher education is closely linked with the economic growth of the Commonwealth. Statewide efforts such as Virginia's Center for Innovative Technology, Graduate Engineering, and Old Dominion University's TELETECHNET must be encouraged and supported. Specialized programs, such as those related to the decisions by the American Type Culture Center, Motorola, and IBM/Toshiba to locate in Virginia, should draw on the existing resources of all institutions and be adequately funded.

Planning for the Future

9. The Commonwealth should continue to expand and exploit the capabilities of the state's major research universities in partnership with industry and the CIT. A balanced focus on short- and long-term research and development goals is necessary to keep the Commonwealth competitive in a rapidly changing global economy.

10. The Commonwealth should strengthen support for existing research and technology development capabilities where commercialization potential is very strong in the near term by funding the creation of a new generation of CIT technology centers and fund the creation of new research and technology development centers in emerging technology areas with long-term commercial potential where Virginia has the potential to be globally competitive. The CIT, in cooperation with the research universities, other research facilities, and technology organizations, such as the Virginia Technology Council, should be responsible for identifying these emergent areas and administering funding.

11. The Commonwealth should fund a new technology development center in Health Telematics that will involve the considerable talents of all three medical schools and the public and private health care providers in all regions of the state.

12. In addition to the CIT Technology Development Centers, the state should fund a new generation of Commonwealth Centers to be selected by SCHEV.

13. The Commonwealth should not attempt to develop an independent telecommunications infrastructure for the state but should take advantage of the commercial infrastructure already in place.

14. The Virtual Campus project should be funded for implementation in 1996-98 with expansion to include additional institutions and organizations.

Necessary Resources, Both Human and Capital

15. The Board of Education and SCHEV should review, and adjust as necessary, the requirements for re-certification to ensure that all teachers re-certified after 2000 possess and maintain the necessary technical skills and knowledge to effectively use existing and future communication and multimedia educational systems in the classroom. All recertification, after 2000, should meet the same requirements.

16. Virginia should study the feasibility of creating the Virginia Educational Technology Fund to assist schools and parents to acquire and maintain computer and telecommunications equipment necessary to transform the learning environment in all schools. To increase commercial and banking participation in the funding of technology by students and parents, the concept of technology bonds and a "loan-loss reserve" should be examined further.

17. Adequate funding should be provided to public and private institutions to maintain and enhance the quality of instructional programs. Higher education in Virginia cannot be sustained at an acceptable level of quality without additional state support.

18. Funding should be provided to restore average salaries to the 60th percentile of benchmark groups over four years, and funding for the Eminent Scholars Program should be increased to fully match endowment earnings. It is vital that the perception of Virginia's colleges and universities reflects the quality of their faculty.

19. Funding for the Higher Education Equipment Trust Fund should be increased to provide for the replacement of obsolete educational and research equipment and the acquisition of new technology. The program should be expanded, with incremental funding, to include essential telecommunications equipment for campus and statewide networking.

Appropriate Beginnings

20. The Virginia Institute for School Leadership should be created and funded to provide training for school principals on how to plan for, implement, and administer the computer and telecommunications technology that will be critical to the future of our schools and students. In conjunction with the Virginia Institute for School Leadership, Virginia should create an Institute for Teacher Training for Technology Utilization. The institute should be

structured similar to a federal research laboratory and Virginia should seek federal, foundation, and corporate funding and participation to establish it as a national source of information and resources for K-12 education through technology.

21. Pilot Projects should be funded to examine how information technology can be most effectively and efficiently used in inner-city schools and to share the results with all school districts. Information technology disparities may be more harmful than fiscal differences to students seeking employment in a knowledge-based economy.

22. Curricular revision and in-service training for faculty should be funded through a competitive grant program administered by SCHEV to maximize the effectiveness of the Commonwealth's investment in infrastructure and technology resources.

23. As the statewide infrastructure network is implemented, the VCCS should plan on functioning as regional nodes for access and services for schools, individuals and organizations unable to access the network directly.

Cost Reduction and Improved Customer Service

24. Our colleges and universities must continue to make substantial changes to their programs and operations as they restructure to meet the evolving needs of the Commonwealth and its citizens. Restructuring is a long-term process that requires constant attention and measurement to gauge changes and results.

25. The Commonwealth should make any necessary regulatory changes to establish competitive pricing for wideband networking access for educational users in all regions of the state.

26. The Commonwealth should make the necessary regulatory changes to allow the state to take advantage of the rapidly changing telecommunications marketplace.

27. Policies on intellectual property rights should be examined periodically by the CIT in cooperation with SCHEV and the research universities. Emerging technologies will require rapid implementation of new products. Revised operating agreements between universities and corporate partners may be necessary to provide this flexibility and efficiency for such projects to succeed.

28. The Commonwealth should foster the development of instructional technologies to improve the quality of instruction and extend the outreach of our colleges and universities. The VCCS Information Technology Infrastructure Plan and its related instructional technology initiatives should be funded and implemented in partnership with Virginia Tech and Old Dominion University in order to develop a broadband, wide area network that will extend across the Commonwealth for use by all institutions as well as local schools.

Competitive Position and Finance

29. CIT should be encouraged in its efforts and the Commonwealth should expand its support so that CIT can further deploy resources to help technology companies be competitive.

30. CIT should continue its practice of identifying emerging technologies and making investments thereto, such as the Technology Development Centers program already in place.

31. A network of entrepreneurship centers should be established across the Commonwealth to spur the technology innovations into the marketplace.

32. The Congress of the United States should be encouraged to sustain federal research and development support.

33. The Commonwealth should market more aggressively present and potential federal R&D facilities located in Virginia (e.g., The National Aeronautics and Space Administration (NASA) Langley Research Center and Continuous Electron Beam Accelerator Facility (CEBAF)) as critical Virginia assets.

34. The Commission on State & Local Responsibility & Taxing Authority, chaired by Lt. Governor Beyer, should examine carefully the benefits of removing business, professional, and occupational license (BPOL) tax from venture capital companies;

35. Virginia's Center for Innovative Technology (CIT) should confer with the Virginia Retirement System (VRS) to consider investment in venture capital firms that will invest in Virginia technology companies.

36. The Virginia General Assembly should study tax credits to encourage private investors to do venture capital business in Virginia.

37. The Virginia General Assembly should make funds available and allocated to CIT to establish a seed-stage capital fund for a public-private debt or equity fund for technology start-up companies.

APPENDICES

APPENDIX A

GENERAL ASSEMBLY OF VIRGINIA--1993 SESSION

HOUSE JOINT RESOLUTION NO. 390

Establishing a science and technology task force to coordinate the development of a statewide strategic plan for science and technology.

Agreed to by the House of Delegates, February 25, 1993
Agreed to by the Senate, February 23, 1993

WHEREAS, the Commonwealth desires to promote economic growth by attracting high technology industries to Virginia, creating high wage jobs and expanding the tax base; and

WHEREAS, in an era of growing international competition, the future vitality of the Commonwealth's industrial base depends in part on the successful development and exploitation of scientific and technological advances; and

WHEREAS, the Commonwealth has invested in a wide array of science and technology resources; and

WHEREAS, the last comprehensive action plan for science and technology in the Commonwealth was developed in 1983 by a task force appointed by the Governor; and

WHEREAS, the special Review Committee mandated by Item 267 of the 1992 Appropriation Act concluded that current strategic plans for science and technology are insufficient; and

WHEREAS, the Southern Growth Policies Board and the 1992 Carnegie Commission on Science, Technology and Government recommended that every state establish a permanent science and technology advisory body; and

WHEREAS, science and technology should be an integral part of the overall economic development strategy for the Commonwealth; and

WHEREAS, the Review Committee concluded that the Center for Innovative Technology should be an integral part of the overall economic development strategy of the Commonwealth; now, therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That a science and technology task force be established to report on the status of the 1983 task force recommendations and to coordinate the development of a statewide strategic plan for science and technology. The task force shall be composed of twenty-three members representing the Virginia General Assembly and state and local government, research, university and business leaders in the fields of technology and science. The members shall be selected as follows: six members of the House of Delegates to be appointed by the Speaker; three members of the Senate to be appointed by the Senate Committee on Privileges and Elections; and fourteen citizens to be appointed by the Governor who shall have knowledge and expertise in science and technology.

Among the issues to be examined shall be the creation of a permanent council on science and technology and its role in the strategic planning process for the economic development of the Commonwealth. The Center for Innovative Technology, the Department of Economic Development, and the State Council of Higher Education shall provide staff and such technical assistance as the task force deems appropriate.

All agencies of the Commonwealth shall provide assistance upon request to the task force.

Direct costs of this study shall not exceed $8,100.

The task force shall submit a preliminary report of its findings and recommendations to the Governor and the 1994 Session of the General Assembly. A final report shall be prepared for consideration by the Governor and the 1995 Session of the General Assembly. Both reports shall be submitted in accordance with the procedures of the Division of Legislative Automated Systems for the processing of legislative documents.

APPENDIX B

HOUSE JOINT RESOLUTION NO. 447

Continuing the Science and Technology Task Force.

Agreed to by the House of Delegates, February 23, 1995
Agreed to by the Senate, February 21, 1995

WHEREAS, the coordination of science, technology, higher education, work force training, and industrial development strategies is essential to the promotion of economic growth in Virginia; and

WHEREAS, recognizing that "science and technology should be an integral part of the overall economic development strategy of the Commonwealth," the 1993 Session of the General Assembly established a 23-member science and technology task force to review the recommendations of previous governmental task forces and to "coordinate the development of a statewide strategic plan" for science and technology; and

WHEREAS, to delve more deeply into specific issues, the task force established subcommittees to examine education and the preparation of human resources in Virginia for the industrial and government sectors; infrastructure, including telecommunications, transportation, and research parks, centers, and laboratories; finance and business, tax, and regulatory issues; and competitive position, including research and development deployment and business assistance efforts; and

WHEREAS, the role of science and technology in economic development continues to be of critical concern to the Commonwealth, as evidenced by the establishment of the Virginia Technology Council to assist in the development and implementation of a statewide technology blueprint and to "strengthen the technology business sector and position Virginia as a leader in this industry so vital to economic growth" as well as by the recommendations of "Opportunity Virginia," a report by the Secretary of Commerce and Trade; and

WHEREAS, continuing review of recent and ongoing initiatives and the work of organizations addressing science and technology, such as the Virginia Technology Council, the Governor's Telework/Telecommuting Advisory Task Force (House Joint Resolution No. 68, 1994), "Opportunity Virginia," the State Library Board, and the Department of Information Technology (House Joint Resolution No. 76, 1994), will promote increased coordination among these efforts and will help ensure the implementation of those science and technology initiatives essential to the future growth and prosperity of the Commonwealth; now, therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That the Science and Technology Task Force be continued. The task force shall consider, among other things, the recommendations of various organizations focusing on science and technology issues, including, but not limited to, the Governor's Telework/Telecommuting Advisory Task Force (HJR No. 68, 1994), "Opportunity Virginia," the State Library Board, the Department of Information Technology (HJR No. 76, 1994), the Center for Innovative Technology, the strategic planning process for the economic development of Virginia; and other related issues as it deems appropriate.

The current membership of the task force shall continue to serve as appointed pursuant to House Joint Resolution No. 390 (1993); any vacancies shall be filled in the manner consistent with the original resolution.

The Center for Innovative Technology, the Department of Economic Development, and the State Council of Higher Education for Virginia shall provide such technical assistance as the task force deems appropriate. All agencies of the Commonwealth shall provide assistance to the task force, upon request.

The task force shall be continued for one year only and shall complete its work in time to submit its final findings and recommendations to the Governor and the 1996 Session of the General Assembly as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents.

APPENDIX C

GENERAL ASSEMBLY OF VIRGINIA -- 1995 SESSION

HOUSE JOINT RESOLUTION NO. 714

Requesting the Science and Technology Task Force to study advanced information and communications technologies.

Agreed to by the House of Delegates, February 22, 1995
Agreed to by the Senate, February 24, 1995

WHEREAS, Virginia's future economic competitiveness depends upon the quality of its information and communications technology, infrastructure and services; and

WHEREAS, a comprehensive and uniform information and telecommunications strategy for Virginia's government, businesses, and educational institutions is needed to secure a place for the Commonwealth in future national and global economies; and

WHEREAS, Virginia may lack the comprehensive telecommunications and information infrastructure required to compete successfully in this new era; and

WHEREAS, it is in the interest of the people of the Commonwealth to encourage cooperation and innovation among public and private sector information technology and telecommunications service providers and users, and to create and use infrastructure that will allow our businesses, citizens, and educational and public sector institutions to respond to and be competitive in the information age; now, therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That the Science and Technology Task Force be requested to study advanced information and communication technologies. The task force shall study opportunities and incentives for, as well as barriers to, the deployment of information and communications technology for the purpose of meeting public needs in such areas as economic development, education, health care, crime control and prevention, public administration, and such other areas of public concern as it may identify. The task force shall (i) determine the means by which state resources may be wisely expended to encourage and complement citizen, business, and state agency access to state-of-the-art, competitively priced communications and information services; (ii) recommend legislation, policies and procedures that will result in increased citizen access to the "global internet" in order to provide advantages to Virginia businesses, encourage new business opportunities, and contribute to the emergence of a competitive market for communications services; and (iii) develop recommendations aimed at placing the Commonwealth at the forefront of communications and information technology for all citizens.

All agencies of the Commonwealth shall provide assistance to the task force, upon request. The task force shall also seek the cooperation and support of private sector business and industry, including information technology enterprises, cable and telecommunications providers, and others as appropriate.

The task force shall complete its work in time to submit its findings and recommendations to the Governor and the 1996 Session of the General Assembly as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents.

APPENDIX D

SCIENCE AND TECHNOLOGY TASK FORCE SUBCOMMITTEE ASSIGNMENTS

Education and Infrastructure: Stanley E. Harrison, Chairman

The Honorable Raymond R. "Andy" Guest, Jr.
The Honorable Kenneth R. Plum
The Honorable James M. Scott
Julia Abrahams, Ph.D.
Shirley Scales Craig, Ph.D.
Don E. Detmer, M.D.
Beverly K. Hartline, Ph.D.
Daniel G. LeBlanc
Robert G. Templin, Jr., Ed.D.

The Honorable Hunter B. Andrews, Ex-Officio

Finance and Competitive Position: The Honorable Alan A. Diamonstein, Chairman

The Honorable Robert B. Ball, Sr.
The Honorable J. Brandon Bell
The Honorable W. W. "Ted" Bennett, Jr.
The Honorable Robert L. Calhoun
Harry S. Bass, Jr., Ph.D.
Richard T. Cheng, Ph.D.
Edward L. Hamm, Jr.
John W. MacIlroy
Gregory Vincent Selby, Ph.D.
Shaukat M. Siddiqi, Ph.D.
Hayes E. Willis, M.D.

The Honorable Hunter B. Andrews, Ex-Officio

APPENDIX E

STATUS REPORT ON THE 1983 SCIENCE AND TECHNOLOGY TASK FORCE MAJOR RECOMMENDATIONS

ELEMENTARY AND SECONDARY EDUCATION

Recommendation

1. Adopt requirements for high school curricula which ensure a reasonable balance of rigorous courses in the sciences and the humanities, stressing both technological and communication literacy.

    a. Require of all high school graduates at least two years of science and two years of mathematics between grades 9-12.

    b. Require of all college-bound graduates one additional year of science and one additional year of mathematics.

    The Task Force prefers the more extensive requirements recommended by the National Commission on Excellence in Education but believes that full immediate adoption of those recommendations may be too large a step to take immediately.

    Status Update

    a. Complete - the graduation requirements established in 1985 meet this requirement for both math and science and require an additional credit in one or the other for a 21-unit diploma.

    b. Complete - the graduation requirements established in 1985 for the 23-unit diploma require three math and three laboratory science courses.

    In 1995, the Board of Education "adopted" new Standards of Learning in all four areas. The new standards are intended to be more rigorous and measurable.

    There should be periodic reviews of general education and technological competency requirements.

VOCATIONAL TRAINING AND COMMUNITY COLLEGES

Recommendation

1. Establish a comprehensive training policy in recognition that training and retraining of the work force is a long-term educational effort; assign priorities and delegate responsibilities to appropriate agencies.

Status Update - Ongoing

State Plan for Vocational Education in Virginia.

Preparation of the plan has been an ongoing activity with an updated plan each year and a new five-year plan for each new funding period. The plans have identified vocational education an needs and strategies for meeting those needs. The plans have also identified and funded activities in other agencies such as the Virginia Employment Commission, Virginia Community College System, state universities, the Tayloe Murphy Institute, Department of Rehabilitative Services, Department of Correctional Education, etc.

Efforts to address the needs have included the coordination of a system of articulation between public schools and community colleges which involved every school division and community college in the Commonwealth. The natural progression of this effort included the development of two plus two programs, and the Tech Prep programs to provide a higher level of preparation to meet the technological needs of business and industry.

The VCCS has completed the development of a comprehensive training policy that reflects the number of different providers of such training as part of WORKFORCE 2000, SCHOOL TO WORK, and VIRGINIA WORKS projects.

The apprenticeship-related instruction component of the Apprenticeship Program was transferred July 1, 1995 to the VCCS. Budget reductions prior to the move have necessitated cutting the funds to the localities with these programs. Funding back to the 1994-95 appropriated level is essential to continue this important function.

The VCCS has made a commitment to training and retraining the workforce through its VIRGINIA WORKS program, funding six community college projects from the 1995-96 appropriation for this program, but further resources are required for further implementation and adequate responsiveness to Virginia businesses and industries.

COLLEGES AND UNIVERSITIES

Recommendation

1. Expand and exploit the capabilities of the state's major research universities in partnership with industry. The Task Force endorses the concept of the "Center for Innovative Technology" as embodied in the proposal which was developed jointly by and submitted by the University of Virginia, Virginia Commonwealth University, and Virginia Polytechnic Institute and State University. The Task Force recommends, however, a major expansion of the proposed approach to include functions at the central location beyond the proposed administrative and leadership function, i.e., on-site research by industry and the participating universities, and on-site graduate education. Further we recommend that the central location be in Northern Virginia, because of the large concentration of high technology industry in that section of the state. Nevertheless, UVA, VCU, and VPI&SU

must be principal participants as outlined in the proposal and because of its proximity, George Mason University should be a participant. The Task Force recommendation will require resources greater than those contained in the proposal. Though it would be possible to initiate this concept gradually, the Task Force favors an aggressive and immediate beginning. The Governor may wish to consider the appointment of an implementation committee in the near future.

Status Update - Ongoing/Significant Accomplishments

The Innovative Technology Authority (Authority) and Virginia's Center for Innovative Technology (CIT) were created in response to the study and are well established in the economic development plans of the Commonwealth. The CIT was recently reviewed by the Governor and General Assembly and has modified its mission and program emphasis. In 1994, the Authority was shifted to the Commerce and Trade secretariat. Approximately $17 million are appropriated to the Authority for programs in 1994-96.

CIT is located in Northern Virginia, but has Institutes and Centers throughout the state. A separate report on the CIT will be presented in a separate agenda item.

Recommendation

2. Establish and enhance graduate programs in high-technology disciplines which encourage part-time continuing education and participation by industry employees. These programs should address the need for such students to continue their full-time work, minimizing residency requirements for graduate degrees, and providing, where possible, course delivery systems which bring the programs to the student. The committee strongly endorses the Richmond Graduate Engineering instructional Television project as a model for potential expansion into other geographical areas and subjects. The goal must be to establish graduate education delivery systems responsive to industry's needs throughout the state.

Status Update - Ongoing/Significant Accomplishments

In 1995-96, the Commonwealth Graduate Engineering Program enters its 13th year of offering televised courses in programs leading to a master's degree in engineering and the second year of televised courses leading to a doctoral degree in engineering. These courses originate at Old Dominion University, the University of Virginia, Virginia Commonwealth University, and Virginia Tech, and are broadcast by satellite to sites located throughout Virginia and in several other states. Additional doctoral courses are taught by The College of William and Mary live at the Peninsula Graduate Center in Hampton, George Mason University has requested authorization to offer several of its engineering courses at federal and corporate locations in other states. Although enrollment in televised courses has dropped recently, the program continues to receive national recognition. Over 75 engineers have received master's degrees from the participating institutions.

Costs of instruction for the program are comparable to on-campus instructional costs since enrollments average about 60 students per class. Student performance in

televised courses is equal to that of on-campus students. Economic conditions and industrial downsizing have changed the role of the program. The institutions with industrial partners are conducting a review of the program and will present a strategic plan for the 1996-1998 biennium.

Recommendation

3. Establish a fund dedicated to research and development in the universities with initial funding from private industry to be matched by the state. The fund should be in the nature of a foundation and its administration might well be coordinated with or become a part of the proposed Center in the first recommendation above.

Status Update - Completed/Significant Achievement

Through the actions of the General Assembly, the CIT selected and funded a number of Technology Centers and SCHEV selected the centers and the General Assembly funded a number of Commonwealth Centers. Both selection procedures were competitive and involved national panels to select centers that were already, or had the potential to become, the best in the action in a specific discipline or specialty. Centers were expected to become self-sufficient over five years. State funds were used to match federal and industrial grants to leverage limited resources.

Funding has been withdrawn from the original Commonwealth Centers. Some state funding remains for three Commonwealth Centers (Oceanography at ODU, Brain Injury at VCU, and Wood Science at Va Tech). New institutions have been funded to reflect the strengths of the participating institutions. Refer to the CIT report for further information on recent investments in research capacity building projects.

Recommendation

4. Continue planning and support for the National Electron Accelerator Laboratory in Virginia as a unique resource for graduate education and research.

Status Update - Completed/Significant Achievement

The proposal to design and build a new concept of electron beam accelerator was accepted by the federal government and the Continuous Electron Beam Accelerator Facility is nearing completion. Affiliated research faculty positions have been funded at several Virginia universities. This world-class facility is attracting international attention and funding for research projects and industrial utilization of CEBAF resources and findings.

ENVIRONMENT

Recommendation

1. Establish an orderly and economically sound legal basis for the transfer of water between jurisdictions and watersheds. The most practical means of meeting this need is probably the establishment of a state administrative procedure to consider and approve interbasin water transfers which make water available to high value uses and are in the public interest.

Status Update

Transfer of Water Between Jurisdictions and Watersheds

The lead state effort to address water supply issues up to and since the Science and Technology Task Force made this recommendation was the Water Study Commission, established by the General Assembly. One new initiative impacting the use of water in Virginia was new legislation creating the Authority with the State Water Control Board (SWCB) to create and manage surface water management areas. The design of this initiative tends to be more oriented towards regulating the use or transfer of surface water, rather than providing access by a locality in one water basin to water in another water basin. The intent of this initiative is more to protect water resources from depletion, degradation or over-use, rather than to reallocate water from water-rich basins to water-needy areas.

Another factor impacting interbasin transfers in Virginia is federal regulatory authority including jurisdiction over related activities. One example would be approvals required for water withdrawals from navigable waterways. In order to locate a permanent structure to withdraw water from a lake, river or stream, approval in the form of a 401 Certificate must be acquired from the state. Also, a 404 Permit is required from the U.S. Army Corps of Engineers after the project receives approval from the state. The permitting and appeals processes at the federal level vary substantially from those at the state level.

Recommendation

2. Begin planning promptly for the wastewater facilities needed to provide for future development of high technology industry and other needs. The Division of Industrial Development and the State Water Board should develop a program to assure that areas identified as suitable for high technology development have or will get wastewater treatment capacity that will permit such development. Information developed in this program should be used in establishing priorities for the allocation of state assistance for facility development. A precondition for this effort is a statewide inventory of unallocated capacity of streams, existing treatment capacity and utilization and projected needs. In recognition of the inability of local governments to meet fully wastewater treatment needs, the state should provide a financing mechanism to assist in meeting these needs.

Status Update

Wastewater Treatment Capacities

The Clean Water Act goals for water quality are supported by requirements for the state to inventory stream segments by water quality and to limit discharges in areas where water quality is inadequate to a total maximum daily load of pollutant discharges. The statewide inventory of water quality is conducted biennially under the provisions of Section 304B of the Clean Water Act and identifies stream segments that do not meet the water quality standards.

Virginia operates a revolving loan fund for localities to assist with financing improvements in publicly-owned treatment works. Initial capital for the fund is allocated to the SWCB from EPA and the loan fund is administered by the Virginia Resources Authority. The revolving loan fund provides access to capital for Virginia localities' wastewater treatment expansion and improvement projects. The clear priority in allocations from this fund is for all publicly-owned treatment works to meet water quality standards.

The capacity of wastewater treatment works in Virginia is permitted by the SWCB for a period of five years. The utilization of these facilities, as indicated by the flow of discharges from the facilities, is reported monthly to DEQ.

Recommendation

3. Develop an environmental model of the state and its environs at an appropriate state university. Although this tool for strategic decision making in the economic/environmental area will consist of separate submodels for air, surface water, and subsurface water, one single group should have responsibility for the development and use of the overall system. A broadly-based board with access to the Governor at the cabinet level should be formed to oversee the development and use of the model. The model can be used to identify the regions of the state most suitable for development from an environmental perspective and to determine state policies.

Status Report

An Environmental Model of Virginia

Environmental modeling in Virginia has focused on the performance of individual natural resources, such as air and water, with respect to specific environmental quality objectives. Another major focus of environmental modeling has been permitting specific activities, including the impacts a project or development may have on an area's environmental quality. Neither the assignment or the funding of an environmental model of Virginia was made.

TRANSPORTATION

Recommendation

1. To improve air service:

(a) strengthen the Division of Air Service Development and integrate its activities with those of the Division of Industrial Development;

(b) at the local and state levels, encourage better relations with the airlines and pursue more aggressive and imaginative promotional strategies to attract and enhance service to Virginia's airports;

(c) where necessary to attract needed service, develop capital facilities and provide other incentives;

(d) vigorously seek more landing and departure "slots" for service between National Airport and other Virginia locations; support the proposed shift of general aviation from National to Davison Airfield at Fort Belvoir;

(e) with Federal officials and with the airlines, promote Dulles International Airport as an important hub and access point to other Virginia markets; seek special funding for improved surface transportation to Dulles.

Status Update

High technology firms considering Virginia locations require good air service, especially those engaged in international operations.

Though Virginia has seen dynamic growth in international and transcontinental services, there continues to be a need to increase air service. In the mid-1980's, control of Washington Dulles International Airport (Dulles) changed from the Federal Aviation Administration to a regional authority, which has allowed for growth of international service. In fact, Dulles' European operations are ranked fifth for the entire U.S. and third on the East Coast.

The construction program now in progress at Dulles will greatly increase the capacity for international air service. When comparing potential growth along the East Coast, Dulles becomes the one airport where increased capacity can easily be achieved.

The open-skies agreement with Canada has greatly increased direct service between Canadian airports and both Washington National Airport and Dulles. However, there is still a need to expand direct service from Japan. Direct service should also be developed from locations in the Pacific Rim and developing areas in Eastern Europe and Africa. South and Central American doors have been opened up, but the emphasis has been on cooperative airline programs and not Virginia destinations.

Since industrial development and tourism play such an important role in the establishment of air routes, a continued partnership between the Departments of Economic Development (DED) and Aviation is required to leverage world-class air service for the Commonwealth. In the present competitive environment, the ability of the Commonwealth to offer world-class air service as a major ingredient to industrial prospects, especially those involved in high technology, is a major asset.

Paralleling the need for world-class air service to and from the Commonwealth also requires airport related surface transportation capabilities, both in highway and intermodal services, to meet traveler needs. Traveling to and from the airports requires efficient and fast modes from major centers. These services need to operate effectively even during congested periods. The traveler who finds that it takes more time to get to or from an airport than the length of the flight will not be prone to recommend locating or expanding business in the area.

MARKETING

8881. In the Division of Industrial Development:

Recommendation

(a) establish a strong market research capability;

Status Update

Marketing research activities were not reduced during the budget cutbacks of the early 1990's. Current plans call for strengthening research by adding three additional positions. A major new initiative is the development of target industry studies, including several which focus on high technology industries (e.g. semiconductors, biotechnology, computers, information technology).

Recommendation

(b) increase the advertising budget;

Status Update

In 1983 the advertising budget was $300,000 to $400,000. This sum gradually increased to $1.5 million by the late 1980's. With the cutbacks of the early 1990's, funding for advertising was eliminated for two years. It has since been restored and is now at a record high of $2 million.

Recommendation

(c) direct additional marketing efforts at attracting small business and identifying geographic concentrations of businesses likely to be attracted to Virginia;

Status Update

Recognizing that small businesses have unique needs, a network of fifteen Small Business Development Centers with twenty-one locations around the state was established. In addition, a Small Business Section was established within the Department of Economic Development (DED) to provide ombudsman services to small businesses, and the Small Business Financing Authority was created to provide financing services.

Recommendation

(d) review the effectiveness and the scope of the contact visits program;

Status Update

At the time of the last Science and Technology Task Force, two DED employees were committed to calling on existing Virginia industry. The purpose of this effort is to gather leads on expansions, explain state services available to businesses, and offer assistance where applicable. Since that time, the program has been expanded and now consists of a staff of five full-time and five part-time employees.

Recommendation

(e) develop an aggressive export development program;

Status Update

In 1987 the Department of World Trade was created to focus exclusively on export promotion. In 1991, the Department of World Trade was folded into DED. DED's export promotion staff consists of five export promotion managers and a position in Europe to foster export growth. In addition, the Small Business Financing Authority offers export finance assistance.

Recommendation

(f) promote effective use of foreign trade zones in the Tidewater and Dulles areas;

Status Update

Foreign Trade Zones are routinely marketed to foreign and domestic projects. Virginia now has five Free Trade Zones: Dulles, Culpeper, Suffolk, Tri-City Regional Airport, and Richmond.

Recommendation

(g) evaluate the European and Japanese marketing operations;

Status Update

These operations have been reviewed internally on several occasions since 1983. They were also studied by JLARC during its overall review of DED operations. DED is currently in the process of opening a new office in Frankfurt, Germany and is adding to its Tokyo staff. Currently 570 foreign affiliated establishments are in Virginia. They employ over 59,000 Virginia workers and have total capital investment of $6 billion.

Recommendation

(h) devote adequate resources to the retention and expansion of existing Virginia industries and to achieving greater familiarity with high technology enterprise in the state;

Status Update

See (d).

Recommendation

(i) develop regional offices of the Division of Industrial Development;

Status Update

DED opened regional offices in the mid-1980's in Abingdon, Staunton, and South Boston to provide community development and preparedness services. These objectives were successfully achieved. Since then, the Staunton and South Boston offices have been closed. The Abingdon office now focuses on existing industry and tourism.

Recommendation

(j) modify the criteria for evaluation of the development program to encompass service sector activity;

Status Update

In 1981 the scope of DED's annual announcement list of new and expanding facilities was broadened to include a summary of new and expanding basic service sector companies. The 1983 annual report was further expanded to include a detailed listing of each basic service sector company by name comparable to the existing list of new and expanding manufacturing establishments. In the latest year-end report for 1994 there were 58 basic service sector companies (34% of the total) planning to employ 6,858 people (40% of the total) and to make a total capital investment of $381 million (20%).

Basic service sector projects include corporate headquarters, back office operations, telemarketing, and warehousing and distribution facilities. Examples of firms DED has assisted in locating in Virginia include Lillian Vernon, Orvis, J. Crew, Time-Life Books, and USAA. At any time 1/3 of DED's project activity is basic service sector.

Recommendation

(k) enlist business executives to assist in calling on active prospects for relocation in Virginia.

Status Update

DED has continued to use the business community in its relocation efforts. Furthermore, the last session of the Virginia General Assembly created the Virginia Economic Development Partnership to be run by a board consisting of private sector business people.

ORGANIZATION

Recommendation

1. Create a policy advisory group of leaders from high technology industry and education:

   (a) to monitor performance of state agencies in carrying out Task Force recommendations;

   (b) to provide guidance to the Governor and state agencies on the growth of high technology;

   (c) to assist in mobilization of effort on the Federal level;

   (d) to serve as ambassadors to high technology industry considering a Virginia location;

   (e) to review plans and performance of the Division of Industrial Development in high technology matters.

This group should be active in policy formulation, must have high visibility in state government, and should have specific identification with science and technology. The Governor should be closely involved, perhaps as Chairman.

Status Update

Not until the current Science and Technology Task Force has there been any official forum for monitoring progress made on the 1983 Report. However, some of the actions reported below indicate that some efforts have been made in addressing high technology industry and education issues from a policy or organizational perspective as were recommended in the 1983 Report.

Though no Governor has officially appointed a Science and Technology Advisor to the Governor, some cases of a designation have been utilized, sometimes on a volunteer basis. Governor Robb designated the President of CIT to fill this role, who was then Dr. Ronald E. Carrier. Governor Baliles designated Dennis Barnes as the Space Business Advocate. In more recent years, no similar designation has been made.

In 1994, the Virginia Technology Council was established to be an advocate for technology policy at all levels of government in Virginia. In addition, in December 1994, the Board of Directors for Virginia's Center for Innovative Technology adopted a strategic plan which calls for CIT to provide collaborative leadership for the improvement of the competitive stature of Virginia technology companies.

These activities require the tracking of the growth of technology in Virginia. In addition, the Department of Information Technology (DIT) and Council for

Information Management (CIM) monitor the needs of state agencies, institutions of higher education, local schools, and local government with regard to information technology and telecommunication needs. SCHEV also monitors the information technology needs of the colleges and universities.

During the Baliles Administration, a person was designated to work on ensuring that Federal procurement dollars were spent in Virginia. In 1993, CIT's enabling statute was modified to include assistance with attracting Federal programs to aid Virginia technology companies. Other designations have been made on special assignments or circumstances, e.g., defense conversion and Air & Space Museum Annex.

Since its inception, CIT has worked in conjunction with DED in efforts to attract and retain technology industries in Virginia. Notable recent examples of this cooperative effort include Motorola and American Type Culture Collection.

Recommendation

2. Create a high level position within the Governor's Cabinet structure to expedite and coordinate regulatory procedures associated with new or expanding business enterprises and to provide staff leadership for the group referred to in the first recommendation, above.

Status Update

Since the 1983 Report, no Cabinet-level position has been created that specifically expedites and coordinates regulation procedures associated with new or expanding business enterprises. In fact, the former Secretariat (Commerce & Natural Resources) which coordinated both business affairs and regulatory affairs was separated, and since the late 1980's these activities are now under the supervision of two separate Cabinet officials. However, since the early 1990's continuing efforts have been made to streamline and expedite regulatory procedures.

Recommendations	Status
Elementary and Secondary Education	
1. Adopt requirements for high school curricula which ensure a reasonable balance of rigorous courses in the sciences and the humanities, stressing both technological and communication literacy. a) Require of all high school graduates at least two years of science and two years of mathematics between grades 9-12. b) Require of all college-bound graduates one additional year of science and one additional year of mathematics. The Task Force prefers the more extensive requirements recommended by the National Commission on Excellence in Education but believes that full immediate adoption of those recommendations may be too large a step to take immediately.	Completed a) The graduation requirements established in 1985 meet this requirement for both math and science and require an additional credit in one or the other for a 21-unit diploma. b) The graduation requirements established in 1985 for the 23-unit diploma require three math and three laboratory science courses. In 1995, the Board of Education "adopted" new Standards of Learning in all four areas. The new standards are intended to be more rigorous and measurable. There should be periodic reviews of general education and technological competency requirements.
2. Within the science curricula assure that high school graduates have a balanced program in the physical and biological sciences, that they have knowledge of the major concepts of a particular science course and that they have engaged in laboratory and field work.	Completed The 1992 revisions to the Standards of Accreditation require that for the 23-unit diploma, courses in three of the four sciences be taken.
3. Establish pilot schools of science to raise the level of awareness and to serve as models. Where possible, expand the Governor's School for the Gifted, especially in mathematics and science. The Task Force is aware of a proposal from the Secretary of Education to establish an exemplary high school. While we have had no opportunity to consider the details of this proposal, it appears to be an initiative consistent with the Task Force findings and recommendations.	Completed There are now five Governor's Schools for Science and Technology (Lynchburg, Roanoke, Fairfax, and Newport News/Tidewater - New Horizons and Southside) which operate full-time academic-year programs as well as summer programs.
4. To improve teaching at the high school level and to alleviate teacher shortages a) provide competitive salaries in areas of critical shortage, a mechanism for additional compensation such as extended contracts and the master teacher concept. b) provide summer and in-service institutes for improvement and where needed for retraining of teachers provide incentives to encourage teachers to retrain for areas of shortage, emphasizing the development of inquiry and problem solving methods in mathematics and sciences c) provide loans, repayable by teaching to students preparing to enter areas of shortage d) encourage joint teacher opportunities with business-industry.	Continuing a) Local initiatives are the most common response. b) Ongoing, through programs administered by the state with federal funds Title II Eisenhower Program - focuses on teacher training in math and science V-Quest - in collaboration with IHEs and local divisions, working to restructure teacher pre and in-service training c) Teacher Loan program - transferred to SCHEV d) Local initiatives Project SOAR was conducted to provide in-service training and technical skills development related to special education. A large number of teachers participated in the program. The new SOL recommends additional staff development programs and activities to improve teacher preparation and performance.
5. At the elementary level, emphasize the development of science programs and the strengthening of teacher backgrounds in science and mathematics.	Ongoing Through V-Quest, over 800 K-8 teachers have received extensive training as lead teachers for mathematics and science since 1991.

6. At high school and elementary levels, emphasize effective use of newer technologies such as microcomputers and the video disc, and train teachers for such use. Budgets and administrative guidelines should encourage the incorporation of new technologies into existing programs.	Ongoing Through General Assembly initiatives, V-Quest, the Board of Education's Six-Year Technology Plans, and technical assistance from DOE, the following have been achieved. 1. Satellite dishes on every high school in the state 2. Creation of Virginia's Public Education Network 3. Creation of Virginia Satellite Education Network Public 4. Public television partnership for teacher in-service training 5. Library media center upgrades in all schools across the state 6. Networking grants to schools 7. Train-the-trainer workshops across all technologies for teachers

Vocational Training and Community College	Status
1. Establish a comprehensive training policy in recognition that training and retraining of the work force is a long-term educational effort; assign priorities and delegate responsibilities to appropriate agencies.	Ongoing <u>State Plan for Vocational Education in Virginia.</u> Preparation of the plan has been an ongoing activity with an updated plan each year and a new five-year plan for each new funding period. The plans have identified vocational education needs and strategies for meeting those needs. The plans have also identified and funded activities in other agencies such as the Virginia Employment Commission, Virginia Community College System, state universities, the Tayloe Murphy Institute, Department of Rehabilitative Services, Department of Correctional Education, etc. Efforts to address the needs have included the coordination of a system of articulation between public schools and community colleges which involved every school division and community college in the Commonwealth. The natural progression of this effort included the development of 2 plus 2 programs, and then Tech Prep programs to provide a higher level of preparation to meet the technological needs of business and industry. The VCCS has completed the development of a comprehensive training policy that reflects the number of different providers of such training as part of WORKFORCE 2000, SCHOOL TO WORK, and VIRGINIA WORKS projects. The apprenticeship-related instruction component of the Apprenticeship Program was transferred July 1, 1995 to the VCCS. Budget reductions prior to the move have necessitated cutting the funds to the localities with these programs. Funding back to the 1994-95 appropriated level is essential to continue this important function. The VCCS has made a commitment to training and retraining the workforce through its VIRGINIA WORDS program, funding six community college projects from the 1995-96 appropriation for this program, but further resources are required for further implementation and adequate responsiveness to Virginia businesses and industries.
2. Re-examine current training programs, eliminate duplication and fragmentation, and assign research responsibilities as to trends, needs, and critical skills. Designate a coordinating authority to respond to new training needs as they arise.	Partially Completed. An economic development office has been established in the VCCS a statewide training coordinating committee comprised of representatives from the community colleges has been established. A statewide survey was conducted in concert with the Department of Economic Development to ascertain training needs. There is ongoing work on the development of common workforce training certification and curriculum development. Continued work in this areas is recommended.
3. Give attention to the impact of high technology on low and medium technology careers, identify and train workers with adaptable skills for prospective new jobs and coordinate programs with business recruitment efforts of the Division of Industrial Development.	Completed This assignment has been accomplished but will require continued attention from the VCCS to adjust training curricula to rapid changes in technology, especially in telecommunications and implementation of control processors into medium and low-tech products. The VCCS has curricular review and advisory committee structures in place to respond to needs identified by the Department of Economic Development. Necessary equipment has been purchased through the Equipment Trust Fund, but resources do not always keep pace with such needs. The VCCS will conduct a study of equipment needs this fall.

4. Expand the role of the Industrial Training Division in training for new and existing industry. Clarify its relationship to the Community College System and to the Division of Industrial Development assigning it firmly to one or the other.	No Change Although recommendations from several reports suggested moving the Workforce Division from DED to the VCCS, this was not done. However, Workforce Services often contracts with Community Colleges to provide the training to new and expanding businesses. Training and retraining for existing business remains with the individual community colleges in each region.
5. In the community colleges, accept as a principal responsibility addressing the needs of existing and emerging business. Update and evaluate programs to determine their continued usefulness. Give special attention to the unique needs of small businesses.	Partially Completed The VCCS continues to monitor the changing needs of current and emerging firms in cooperation with the CIT and DED. Small business centers have been established in each region of the state, with some located on community college campuses. The lack of state funding for training and retraining for business and industry continues to hinder the ability of the VCCS to address these needs, especially for small and medium-sized businesses. These companies often lack sufficient funds to pay the direct and indirect cost of these non-credit training programs.
6. Provide fundamental competencies to students in vocational programs. The minimum preparation should include basic verbal and computational skills which promote job mobility by training for careers rather than merely the first job.	Ongoing The Department of Education works with specialists from general and vocational education to identify the basic skills needed by every student for success in the classroom, in continuing education, and on the job. Efforts in this area have included the development of Competency Based Education for all vocational programs and Standards of Learning for other education areas. This has been an ongoing process with Standards of Learning having been reviewed by the Board of Education as recently as July, 1995. The VCCS has conducted several reviews of vocational and college-preparatory programs since 1983. The VCCS has established system policies on remediation and general education requirements for associate, certificate, and diploma programs. In July, the VCCS modified its policies on program requirements to reduce the required number of hours to 60 to 64 for associate degree programs. This should reduce the time needed to complete training programs and for students to enter the workforce.
7. Give attention to staffing and equipment problems in vocational schools and community colleges. The use of portable equipment and the resources of industry should be fully explored.	Ongoing Since 1983, there has been continuous attention given to the staffing and equipment needs for vocational education. Teacher education programs have been revised and changes have been made to provide more rigorous preparation for vocational education teachers. The General Assembly has provided special funding for equipment in Virginia's high schools. Approximately $46 million has been appropriated for equipment and technology infrastructure projects since 1988. In an attempt to assist school divisions, the Department of Education provides a list of appropriate equipment for all vocational programs. This is updated on a regular basis. The higher education Equipment Trust Fund has provided approximately $38 million for instructional equipment in the VCCS since its implementation. The VCCS is developing a distance learning program that will allow greater access to specialized equipment and faculty across the system. The VCCS is implementing a new telecommunications system that will provide for greater access to computational and information resources at all colleges and to citizens and industrial partners in each community college district.

8. Give attention to the training and placement needs of displaced workers. Establish model training programs, studying the pilot program planned for September, 1983 in the Petersburg-Hopewell area.	Completed Joint programs and planning activities are ongoing between the VCCS and the Virginia Employment Commission. Dual purpose facilities are being investigated and may result in improved services to displaced workers and others seeking employment.
9. Give attention to the special problems brought about by the high technology revolution as it affects disadvantaged and handicapped workers.	Ongoing The federal vocational education act has provided set aside funding to programs for the disadvantaged and handicapped since 1983. There have been special programs, staff development, and equipment provided to the state and schools for this purpose. There has been an effort to continually revise all programs to keep up with new technology that has been introduced into the workplace since 1983. However, the current workplace, the technology requirements of all jobs, and the way people are moving from one occupation to another was not envisioned by futurists in 1983. Reforms that reflect the reality of the workplace have been slow to be implemented--educators and parents have had a difficult time comprehending what is actually happening in the workplace. One attempt to provide the disadvantaged and handicapped with the skills they need has been an effort that has included work by the Department of Rehabilitative Services and special educators. The TRAC (Trade Related Academic Competencies) initiative has identified the academic skills that are related to many occupational clusters. Materials have been used with great success with the disadvantaged and handicapped in their occupational preparation programs. Since the passage of the Perkins II Vocational Education Act, funds have been targeted to assisting the disadvantaged. There is also an accountability component that requires schools using the funds to use a system of Core Standards and Measures that look at the progress made by students who benefit from funded programs and non-funded programs in the locality. These standards and measures look at such things as occupational competency, academic achievement, and transition from school to work.
10. Expand the use of non-commercial television for training as well as other business purposes.	Completed The VCCS, K-12, and other higher educational institutions have been active participants in the use of broadcast and satellite delivery of instructional materials and courses. The delivery systems include direct broadcast from the public television stations, local cable systems, low-power television systems (ITFS) satellite delivery, and land-line technologies. The VCCS is implementing a compressed video system that will be integrated into their telecommunications system and the state's network. Analog satellite service has been used extensively since the mid-1980s with the cooperation of the public television stations and the Department of Information Technology. Most of the higher education programming will be converted to a digital format during the 1995-96 academic year. A long-term solution to the system capacity necessary to deliver distance learning and other instructional services by integrating the resource needs of K-12, higher education, and state government is needed and progress should be measured each biennium as a condition for continued, or increased, funding.

Colleges and Universities	Status
1. Expand and exploit the capabilities of the State's major research universities in partnership with industry. The Task Force endorses the concept of the "Center for Innovative Technology" as embodies in the proposal which was developed jointly by and submitted by the University of Virginia, Virginia Commonwealth University, and Virginia Polytechnic Institute and State University. The task Force recommends, however, a major expansion of the proposed approach to include functions at the central location beyond the proposed administrative and leadership function; *i.e.*, on-site research by industry and the participating universities, and on-site graduate education. Further, we recommend that the central location be in Northern Virginia, because of the large concentration of high technology industry in that section of the State. Nevertheless, UVA, VCU, and VPI&SU must be the principal participants as outlined in the proposal and, because of its proximity, George Mason University should be a participant. The Task Force favors an aggressive and immediate beginning. The Governor may wish to consider the appointment of an implementation committee in the near future.	Ongoing/Significant Accomplishments The Innovative Technology Authority and the Center for Innovative Technology were created in response to the study and are well established in the economic development plans of the Commonwealth. The CIT was recently reviewed by the Governor and General Assembly and has modified its mission and program emphasis. In 1994, the Authority was shifted to the Commerce and Trade secretariat. Approximately $17 million are appropriated to the Authority for programs in 1994-96. The Center for Innovative Technology is located in Northern Virginia but has Institutes and Centers throughout the state. A separate report on the CIT will be presented in a separate agenda item.
2. Establish and enhance graduate programs in high-technology disciplines which encourage part-time continuing education and participation by industry employees. These programs should address the need for such students to continue their full-time work, minimizing residency requirements for graduate degrees, and providing, where possible, course delivery systems which bring the programs to the student. The committee strongly endorses the Richmond Graduate Engineering Instructional Television project as a model for potential expansion into other geographical areas and subjects. The goal must be to establish graduate education delivery systems responsive to industry's needs throughout the State.	Ongoing/Significant Accomplishments In 1995-096, the Commonwealth Graduate Engineering Program enters its 13th year of offering televised courses in programs leading to a master's degree in engineering and the second year of televised courses leading to a doctoral degree in engineering. These courses originate at Old Dominion University, the University of Virginia, Virginia Commonwealth University, and Virginia Tech, and are broadcast by satellite to sites located throughout Virginia and in several other states. Additional doctoral courses are taught by the College of William and Mary live at the Peninsula Graduate Center in Hampton. George Mason University has requested authorization to offer several of its engineering courses at federal and corporate locations in other states. Although enrollment in televised courses has dropped recently, the program continues to receive national recognition. Over 750 engineers have received master's degrees from the participating institutions. Costs of instruction for the program are comparable to on-campus instructional costs since enrollments average about 60 students per class. Student performance in televised courses is equal to that of on-campus students. Economic conditions and industrial downsizing have changed the role of the program. The institutions with industrial partners are conducting a review of the program and will present a strategic plan for the 1996-98 biennium.
3. Establish a fund dedicated to research and development in the universities with initial funding from private industry to be matched by the State. The fund should be in the nature of a foundation and its administration might well be coordinated with or become a part of the proposed Center in the first recommendation above.	Completed/Significant Achievement Through the actions of the General Assembly, the CIT selected and funded a number of Technology Centers and SCHEV selected the centers and the General Assembly funded a number of Commonwealth Centers. Both selection procedures were competitive and involved national panels to select centers that were already, or had the potential to become, the best in the action in a specific discipline or specialty. Centers were expected to become self-sufficient over five years. State funds were used to match federal and industrial grants to leverage limited resources. Funding has been withdrawn from the original Commonwealth Centers. Some state funding remains for three Commonwealth Centers (Oceanography at ODU, Brain Injury at VCU, and Wood Science at VA TECH). New institutions have been funded to reflect the strengths of the participating institutions. Refer to the CIT report for further information on recent investments in research capacity building projects.

4. Continue planning and support for the National Electron Accelerator Laboratory in Virginia as a unique resource for graduate education and research.	Completed/Significant Achievement The proposal to design and build a new concept of electron beam accelerator was accepted by the federal government and the Continuous Electron Beam Accelerator Facility is nearing completion. Affiliated research faculty positions have been funded at several Virginia universities. This world-class facility is attracting international attention and funding for research projects and industrial utilization of CEBAF resources and findings. Continued attention to the evolution of the CEBAF and expansion of the economic development opportunities will be necessary to realize the potential of this project.
5. Expand the resource base for engineering schools to permit additional faculty, teaching assistants, support staff, laboratory and research equipment, and space. Increased financial support for faculty salaries in high technology disciplines should be pursued.	Ongoing/Significant Reversal of Gains prior to 1990 Funding for faculty salary increases, equipment acquisition, expansion of engineering and research facilities, and targeted research projects was provided through various executive and legislative initiatives, including the General Obligation Bond issue. With the budget reductions over the last five years, much of the gains have been lost, especially in faculty salaries and operating budgets. The approval of the new engineering school at Virginia Commonwealth University is identified as a factor in the decision by Motorola to develop a manufacturing facility in Richmond. Biotechnology initiatives have been approved in recent years reflecting the shift in national and regional research and economic development priorities. In 1995, the state committed funds to support a building for the American Type Culture Collection, a major biotechnology corporation, on the Prince William campus of George Mason University.
6. Formally establish business-industry-higher education liaisons at all appropriate colleges and universities. Advisory committees should be initiated to address issues of program planning and policy development, continuing education responsive to industry needs, the use of instructional technology, equipment needs, and research for economic development. The Task Force applauds the efforts of George Mason University and the Norther Virginia industries in establishing strong relationships through the George Mason institute and urges other universities to examine this model of cooperation for application to their situation.	Ongoing Most institutions have established some form of advisory committee to assist with curriculum development, research affiliations, and focusing of school or institution mission or priorities. Industrial advisory committees were established to assist the implementation of the Graduate Televised Engineering Program and continue to participate in the evaluation of the program and targeting future course offerings. Every four-year college and the VCCS have identified a person to serve as economic development directors.
7. Make special efforts to recruit qualified women and minority students into high-technology fields. This effort should include cooperative work with the secondary schools to design strategies for ensuring that women and minority students are attracted to high technology fields and take the appropriate preparatory coursework. The effort should continue throughout undergraduate education, and it should include improved admissions and recruitment programs, support services, and financial incentives.	Ongoing There are a number of programs designed to increase the number of women and minority students interested in and qualified to enroll in high-technology disciplines and programs. Cooperative programs between the K-12 schools and public colleges are focused on middle school students. Better Information Programs are designed to inform both students and parents on the importance of course decisions and opportunities for preparation for technological careers. Community based programs have been developed in urban areas and are providing advising and financial assistance to students interested in engineering and health programs. Colleges and universities have expanded their efforts to expand the pool of qualified applicants for high technology programs and with the cooperation of industrial partners have expanded the financial aid resources for needy students.

8. Use scholarships, fellowships, and other incentives to recruit qualified graduate students into high-technology disciplines and to promote production of graduates from doctoral programs in these fields. Special attention should be given to recruiting doctoral students in engineering and computer science.	Ongoing In addition to the programs administered by the state and individual institutions, the Commonwealth participates in a Southern Regional Education Board program intended to increase the pool of minority students eligible for academic careers. These programs should be reviewed to determine the extent they are achieving the goal of increasing the number of qualified graduate students in engineering and related high-tech disciplines.
9. Engage in a long-term program of increased support for securing up-to-date scientific and technical equipment for colleges and universities, including cooperative arrangements with industry or private citizens to fund equipment for higher education.	Completed/Additional Attention Needed The Higher Education Equipment Trust Fund was established by the General Assembly in 1986 to provide funding to up-grade equipment needed for instruction and research. Approximately $166 million in equipment has been acquired for the colleges and universities, with a heavy emphasis on engineering, computer science, and physical and biological science laboratory equipment. Equipment deficiencies were greatly reduced between 1986 and 1990. The continuation of the trust fund has helped offset the budget reductions and permitted the implementation of new approaches to teaching and knowledge acquisition by students. Institutions are facing accelerated obsolescence rates for equipment, especially computational devices, and limited resources to allocate to new acquisitions. The average age of equipment is increasing and maintenance is being delayed. Increased allocations for laboratory equipment are important and should be considered for 1996-98, as well as, the expansion of the equipment program to include campus networking equipment and related infrastructure. As computing strategies reflect greater emphasis on distributed resources and integrated networks, the type of equipment needed will change. The location of the equipment will become less important but at the price of greater dependance on robust networks connected to external resources.
10. Strive to increase the participation of all undergraduate students in mathematics and science by requiring more general education courses in these fields and by encouraging students to pursue advanced coursework.	Partially completed The public colleges and universities are engaged in restructuring their academic programs at the direction of the General Assembly, SCHEV, and the Secretary of Education. Initial results are impressive and appear to be freeing resources for curricular changes and new approaches to teaching. Many institutions are reducing the number of hours required for undergraduate degrees and rethinking general education requirements. Under the general guidelines established by SCHEV, the senior institutions have been working with the VCCS on transfer issues, including agreement on the components of a core set of general education experiences and statewide articulation agreements. There should be periodic reviews of minimum mathematical, computational, and scientific competencies of graduates and entering students to determine if further adjustments in curriculum are needed to meet employment and productivity requirements. Student assessment programs will be helpful in providing the information needed to monitor program and student performance. Industry participation in identifications of technical competency requirements will be an essential component of the reviews.