REPORT OF THE
VIRGINIA'S CENTER FOR INNOVATIVE TECHNOLOGY ON

THE STATUS OF THE COMMONWEALTH'S TECHNOLOGY ASSETS

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

SENATE DOCUMENT NO. 19

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PREFACE

Senate Joint Resolution 37, passed during the 1998 Session of the Virginia General Assembly, follows up on a similar study requested the previous year. The study requested Virginia's Center for Innovative Technology (CIT) to report on the status of the development of statewide strategies to maintain and expand certain scientific and technological assets (S&T) located in the Commonwealth and attract new technological and scientific research and development (R&D) assets.

Senate Joint Resolution 226, passed during the 1997 Session of the Virginia General Assembly, requested CIT to report on the status of certain scientific and technological assets (S&T) located in the Commonwealth. That study report is Senate Document 8 (1998). The Resolution states that various emerging S&T assets show promise for commercial potential and that Virginia, through CIT, should monitor, support and capitalize on these assets when appropriate. Specific entities identified in the Resolution for reporting include the following:

- Applied Research Center
- Biotech Informatics Center
- Biotechnology Research Park
- Free Electron Laser
- Langley Full-Scale Wind Tunnel
- Smart Roads Project
- Virginia Institute for Micro-electronics
- Virginia Modeling, Analysis, and Simulation Center
- Virtual Reality Center (CAVE™)
- Virginia Space Flight Center

Structure of this Report

In addition to cataloging and updating the status of certain S&T assets, this report also studied the flow of federal funds for R&D into and out of the Commonwealth. This focus is to identify where Virginia can capture the most benefit from federal expenditures on S&T assets and related R&D resources and leverage those resources to benefit the Commonwealth.

An analysis of the patterns of financial support for research and technology development (R&D) is provided, since R&D is at the center of much of the Commonwealth's technology activities. This analysis includes both data on the flow of funds and an assessment of key opportunities and vulnerabilities of that flow.

As used in this report, 'fiscal year' refers to the federal fiscal year beginning October 1 of the prior calendar year. As a result, annual data presented in this report may differ somewhat from annual data reported elsewhere on a Commonwealth fiscal year basis, which begins on July 1 of the prior calendar year.

In addition, an agent for CIT requested each of the assets named above to provide the following information:

- description and mission of their organization or center;
- staffing and funding levels;
- planned or existing economic impact of the organization or center; and
- existing and future needs.

This information is provided within this report where available. Where no new information was provided, the information from the prior report is retained.

This report provides the Joint Commission on Technology and Science an understanding of how Virginia can capitalize on federal funding, as well as how the assets identified initially in Senate Document 8 (1998) are faring. Finally, recommendations are made to maintain and support these resources, as well as science and technology infrastructure within Virginia as a whole, by demonstrating their value to the Commonwealth's commercial sector.

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***Dr. Eileen D. Heveron,** who formerly served as Senior Director, Technology Industry Development & Director of Intellectual Resources at CIT, assisted in shaping the scope of this study.

Dr. Christopher T. Hill, Vice Provost for Research and Professor of Public Policy and Technology at George Mason University (GMU), provided much of the information about federal research spending in Virginia and compiled the updates to the particular list of science and technology assets in Virginia. Others at GMU who assisted in reporting these data and findings include **Dr. Franco Furger,** Research Associate Professor, and **Mr. Jonathan Tucker and Danilo Pelletiere,** doctoral students in public policy.

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EXECUTIVE SUMMARY

This report places key Virginia technology and science assets into a context of federal technology R&D funding. Among other findings, the report notes that:

- Virginia's science and technology assets as a whole and those specifically mentioned in this legislative resolution are key to supporting both existing and emerging technology-based industries in the state as they compete in the global economy. Most of these assets rely heavily on federal funding.

- Virginia's industrial performers are substantially more dependent on federal funds than are industrial R&D in other states.

- Virginia receives a disproportionate share of its federal R&D funds from the Department of Defense (DoD) and NASA, two agencies whose budgets are shrinking or remaining flat.

- Existing science and technology assets must be nurtured over time, as they do take a significant period of time to develop prior to having a significant economic impact. They are, however, key to making Virginia a technology state.

- New opportunities to match Virginia's emerging technology assets with emerging industry sectors appear regularly. The State must be in a position to support the attraction and establishment of new resources.

Recommendations: The Commonwealth should continue to capitalize on all potential research, development, and commercialization opportunities.

- First, Virginia should have a statewide strategy for the attraction and ongoing support of federal research and development assets and funding. This strategy should be developed by the Office of the Secretary of Technology for Virginia with the support of CIT and input from the Commonwealth's universities and the private sector. In addition, the strategy should include tactics to leverage the federal support and assets for the benefit of the Commonwealth.

- Second, Virginia should invest state research and development dollars consciously to be complimentary to federal investment and to improve the Commonwealth's ability to obtain federal research and development funding and assets.

- Third, Virginia should seek greater participation for its small businesses in the federally funded research and development programs.

- Fourth, Virginia should continue to try to document R&D investment flows through its industrial sector, as well as document the economic interactions of the existing and emerging technology sectors in order to better prioritize the investment strategy.

R&D FOR NEW TECHNOLOGY IN VIRGINIA: THREATS AND OPPORTUNITIES

Overview

Virginia is rapidly emerging as a leader among the states in developing a technology-based economy. New industries based on information technology, biotechnology, and space applications are joining more established technology-based industries such as advanced shipbuilding, federal systems integration, and manufacturing in generating new wealth, jobs and opportunities for the citizens of the Commonwealth.

Increasingly, new technology-based industries are established on a foundation of strong research and development. Virginia is blessed with a diverse R&D and technology development infrastructure, including technology-based industrial organizations, research universities, federal laboratories, and a host of major federal agencies that support R&D such as the National Science Foundation (NSF), Office of Naval Research (ONR), Advanced Research Projects Agency (ARPA), and the intelligence agencies.

On the other hand, Virginia faces a number of challenges ahead as it seeks to strengthen and maintain its burgeoning technology-based industries. These include:

- much of the information technology industry is based on applications of new technology rather than on the development of that technology itself;
- Virginia's industrial performers are substantially more dependent on federal funds than are industrial R&D organizations in most competing states;
- Virginia receives a disproportionate share of these federal funds from DoD and NASA, two agencies whose R&D funding has not been growing as compared with funding from, say, NIH and NSF.
- The regional fragmentation that continues to divide the state into competing sectors, while easing, continues to inhibit the development and implementation of a strong state technology strategy.
- Finally, there is reason to think that the statistical foundations of data on Virginia R&D spending are weak, and without good data it is not possible to have a clear picture of Virginia's circumstances.

These matters are addressed in the following sections.

Conduct of R&D in Virginia

In 1995, NSF reports that $3.9 billion was spent on R&D in Virginia.[1] This was equivalent to somewhat more than two percent of all the R&D done in the United States, and it placed Virginia 14th among all the states in the value of R&D performed in the state. (By comparison, Virginia ranks 12th among all the states in total population and 13th in gross state product.)

NSF also reports that industry performed about $1.6 billion of this amount (ranking 19th among all the states) and academia performed about $447 million of it (ranking 15th among the states).

Not accounting for R&D performed by other non-profit organizations (which is typically small as a proportion of all R&D), we estimate that governments in Virginia performed about $1.9 billion in R&D (3.9 - 1.6 - 0.4 = 1.9). This estimated government performance is for the most part in federal laboratories in the state, including those owned by the government but operated by private contractors under long-term contract such as the Thomas Jefferson Accelerator Facility (Jefferson Labs) and the Institute for Defense Analysis, as well as those owned and operated by the federal government such as NASA Langley Research Center.

State-supported R&D

A recent report completed for NSF by Battelle and the State Science and Technology Institute (SSTI) reported that state-supported R&D in FY95 totaled $52 million.[2] In this ranking, Virginia ranked 14th overall, but its per capita spending on R&D funded by state dollars ranked only 30th. Interestingly, Virginia's state funded R&D spending is latter stage than the average.

Stage of Spending	Average for All States	Virginia
Basic	56%	31%
Applied	32%	54%
Development	8%	11%
Commercialization	4%	5%

[1]Unless otherwise noted, all the R&D data presented in this report come from the U.S. National Science Foundation's Division of Science Resources Studies. 1995 is the most recent year for which more complete R&D data are available at the state level. The Commonwealth does not collect R&D data from supporters or performers. The NSF data are based both on surveys of R&D performers (companies, universities, federal laboratories, and nonprofit organizations) and on information provided by R&D supporters, particularly federal agencies. The NSF data at the state level are not without limitations--companies, for example, report their R&D spending to NSF annually for the company as a whole, not for expenditures by state. Similarly, federal agencies supporting R&D may report sending R&D funds to firms located in Virginia, but there is no assurance that the R&D is actually conducted here--a particular issue with large defense R&D contractors. Also, a significant amount of the "R&D" funds reported as spent in Virginia actually support those same government contract firms in conducting systems studies and systems integration tasks that differ substantially from what is commonly thought of as the search for, and application of, new scientific and technical knowledge. Finally, an unknown portion of the reported Virginia "R&D" spending may actually support classified activities in the intelligence agencies, which may or may not be for the conduct of R&D. Taken together, these limitations suggest that the statistical foundations for policy analysis and policymaking on Virginia R&D are weak at best. CIT is currently supporting preliminary studies to attempt to improve the state's understanding of spending on R&D in the Commonwealth.

[2] Survey of State Research and Development Expenditures, FY95, prepared for NSF by Battelle and State Science and Technology Institute, September 1998. This data was compiled by polling all Virginia state agencies and all but one academic institution.

Also worth noting is the distribution of the spending. Seventy-seven percent is spend on Food, Fiber and Agriculture Products.

Functional Area	$ Millions Spent
Community Development, Housing	2.1
Economic Development	8.5
Education	4.1
Energy	0.142
Environment	7.8
Food, Fiber & Agriculture	20.3
Health	4.8
Natural Resources	5.8
Science and Technology Base	8.0
Other	2.6

Virginia R&D is Unusually Dependent on the Federal Government

R&D in Virginia are highly dependent on the federal government for financial support. No direct data are available from standard sources to substantiate this assertion, but an inference can be drawn by comparing reported total R&D federal obligations for R&D in Virginia ($3.60 billion in 1995) with reported total R&D performance in Virginia ($3.90 billion in 1995.) This suggests that the federal government supports about 92 percent of all the R&D done in Virginia. The equivalent numbers for the nation as a whole are federal obligations of $67.1 billion out of total R&D performance of $177.2 billion, or only 38 percent from federal sources. Even allowing for technical problems of interpretation of the Virginia data, this suggests a remarkably high dependence of R&D in Virginia on the federal government. Conversely, this analysis suggests that industry provides very little of its own funds to support the R&D it does in Virginia. Taken at face value, the data suggest that if industry provides all the other funds to support R&D in Virginia, it spends only about eight percent of the total, or about $300 million dollars annually.[3]

By comparison, in Pennsylvania the federal government provides about 35 percent, and in North Carolina about 26 percent of total R&D support. In Maryland, another state rich in federal R&D facilities and agencies, the NSF data suggest that the federal government supports 108 percent (!) of the total R&D performed.

The data for the four states suggest that a reasonable interpretation of the R&D statistics at state level includes the likelihood that a great deal of the funds reported as sent to Virginia (and to

[3]As a check on this estimate, CIT has contracted with George Mason University to survey leading Virginia firms regarding their spending on R&D. In their survey, the team was able to identify only about $140 million of private firm R&D spending of own funds in the state. Christopher T. Hill, Jonathan Tucker and Franco Furger, unpublished data, 1998.

Maryland, for that matter) for the support of R&D actually leave the state and support R&D in other states.[4] To the extent that this happens, federal support to R&D in Virginia is overstated, and private spending is underestimated. A substantial effort is needed to improve our understanding of the accuracy and interpretation of R&D spending in the Commonwealth.

Nevertheless, technical limitations notwithstanding, R&D in Virginia remains very heavily federally supported. This reflects the long history of Virginia as a privileged location for federal R&D activities, particularly those associated with the Department of Defense. The state has benefited enormously from this privileged position as spin-offs from DoD programs led quite directly to the Internet and, thus, to the burgeoning private information services sector in northern Virginia. However, as the role of the federal government in supporting R&D in the nation as a whole has declined (the federal government supported about 60 percent of national R&D in 1970 but only 30 percent in 1997), Virginia industry has not kept up with this transition and industry spending of its own funds on R&D remains low relative to that in competitive states. Few, if any, of Virginia's largest corporate R&D laboratories are on the scale of facilities commonly seen in such states as New Jersey, Massachusetts, or California.

Virginia Dependence on Slow-growth Federal R&D Agencies

The dependence of Virginia on federal R&D funds is even more significant when viewed in the context of the specific sources of those funds among the various federal government agencies.

Most prominent as a federal R&D supporter is the Department of Defense, which supplied more than 70 percent of the entire federal funds for R&D in Virginia. Next most important is NASA, which accounted for about 16 percent. These two agencies alone account for about 85 percent of all federal funds for R&D in Virginia and, thus, following the estimates above, nearly 80 percent of all the R&D done in the Commonwealth. By comparison, these two agencies account for about 60 percent of federally supported R&D nationwide.

On the other hand, the National Institutes of Health (NIH) accounts for less than four percent of federally-supported R&D in Virginia, as compared with nearly 20 percent nationwide, a percentage that is growing rapidly owing to congressional action on the federal R&D budget.

One way to look at Virginia's heavy dependence on DoD and NASA for federal R&D funds, and indeed for all R&D funds, is to focus on Virginia's special strength in conducting R&D for the defense and space establishments. Virginia is a "preferred provider" for these agencies--in fact, Virginia ranks fourth nationwide among states in receiving federal funds from both DoD and NASA.

[4]CIT is supporting a study of the flow of federal R&D grant and contract funds into and out of Virginia by the GMU team. They are using the contract with to use the "RaDiUS" database of the RAND Science and Technology Policy Institute to extract information on federal R&D obligations to the Commonwealth along with surveys of recipients of those funds to ascertain the proportions of funds that subsequently flow to out-of-state R&D performers. Technical problems with the RAND data have delayed the GMU survey.

However, both DoD and NASA have lost ground in real terms in supporting R&D over the past five years.[5] On the other hand, NIH has seen its federal funding grow by 28 percent in the same period, and NSF has enjoyed a growth of 11 percent in real terms. Thus, Virginia is very heavily dependent for R&D funding on federal agencies whose R&D budgets are stagnant or declining, while it is well below the leading states in its success in raising funds from NIH and NSF, the two agencies growing the most rapidly. Combined with the comparatively low level of funding from the private sector's own resources for R&D, the Commonwealth faces a significant challenge in years to come if current trends prevail.

Challenges to Major Virginia Research and Development Facilities

Yet another perspective on Virginia's research and technology development resources can be gained by examining potential challenges to existing major R&D facilities in the Commonwealth.

On the other hand, some major facilities are at least theoretically challenged. For example, NASA Langley Research Center (NASA Langley), which focuses on aerodynamics research, faces budget pressures caused by the ever-tightening squeeze between shrinking NASA budgets and the growing cost of the space station project. Some have projected that if NASA must close a major facility to meet its budget constraints, NASA Langley could be high on the list of laboratories to be considered, with its budget in excess of $500 million annually.

Similarly, some believe that Jefferson Labs in Newport News, which only recently opened with great success, may have difficulty in obtaining the financial support it needs to remain healthy from the Department of Energy as that agency also faces declining R&D budgets. (DoE funding is down 7 percent in real terms over the past 5 years according to AAAS.)

Virginia's universities are reasonable successful at obtaining funds to support R&D from external sources, both industry and government, and some have moved up rapidly in the ranks of such institutions nationwide. Nevertheless, more can be done to strengthen the capabilities of the universities to conduct major R&D projects, especially in cooperation with the many major federal contractors in the state, other industrial groups, and the federal laboratories located here. In 1995, R&D expenditures by colleges and universities totaled $445 million, up from $331 million in 1990, for an average annual rate of growth of about six percent. They grew further to $448 million in 1996, but this represented a growth rate of less than one percent, a disturbing sign in comparison with the 3.5 percent growth in total national R&D expenditures at colleges and universities in the same period.

In 1996, no Virginia college or university ranked in the national top 50 in R&D spending. Highest ranking were Virginia Tech and the University of Virginia at 51st and 56th respectively.

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[5]Between FY94 and 99, DoD R&D was cut by about 2 percent in real terms, and NASA R&D was cut by about 7 percent. Source: "Congressional Action on Research and Development in the FY 1999 Budget," American Association for the Advancement of Science, 1998, p. 13.

Virginia Commonwealth University was in the top 100, at 97th. Considering only expenditures of federal funds, UVA and VT ranked 53rd and 54th, respectively, and VCU ranked 90th.

Hampton University ranked 15th nationally in total R&D expenditures in FY96 among historically black colleges and universities, but only 243rd among all colleges and universities.[6] However, Hampton University ranked 8th nationally among all the historically black universities with $11 million in federal support for science and engineering research and development, more than the College of William and Mary, George Mason or Old Dominion University.[7]

Federal R&D Funds to Small Business

Another element of the federal R&D mix in Virginia is federal R&D funds to small business. The Federal Government has three R&D programs of particular interest to small business, two which are set-asides for small business and one which is open to any business in the US. These are the Small Business Innovation Research (SBIR), Small Technology Transfer Research (STTR) and Advanced Technology Program (ATP). The Small Business Administration recently looked at the state's performance in these programs since their inception. Their conclusions are instructional:

> "Analysis of SBIR awards by state show that the number of SBIR awards is correlated to:
>
> - The number and location of small high technology firms
> - The R&D resources (expenditures) in each state
> - The venture capital investments in each state.
>
> All of these factors showed a similar distribution and appear to play an important role in the geographic distribution of SBIR awards.....Technology-focused universities, state SBIR programs and individual leaders also can be important and do make a difference. ...Virginia and Maryland rank third and fourth in both SBIR dollars and awards. Both benefit from their proximity to Washington, D.C. and the Federal agencies there. Hundreds of small high tech firms in both states have long experience in conducting R&D for the Federal government, particularly for the Defense Department, the NIH and NASA, the three largest R&D agencies."[8]

According to SBA, Virginia has won 2248 SBIR awards in 1983-1996, equaling to $348 million. Except for 1990 when Virginia was 5th, Virginia has been 3rd or 4th since the program began. In the last two years, Virginia has been third. California has always been first and Massachusetts has always been second. Virginia ranks fourteenth nationally in the number of small high-tech firms according to the SBA.[9]

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[6] All data presented in this section is from "Academic Research and Development Expenditures: Fiscal Year 1996," National Science Foundation, NSF98304, 1998.

[7] Federal Science and Engineering Support to Universities, Colleges and Nonprofit Institutions, Fiscal Year 1996, NSF 98-331, National Science Foundation.

[8] U.S. Small Business Administration, Office of Advocacy, An Analysis of the Distribution of SBIR Awards by States, 1983-1996, January 1998.

[9] Ibid.

Virginia ranks high in terms of SBIR grants whether measured in terms of the number of grants or the number of grants per 1000 firms. It also scores highest among all of the Southern states regardless of whether the absolute or relative measure is used.

In the competition for the Advanced Technology Program (ATP) awards, Virginia firms have not been among the leaders. Since the program began to make awards in 1990, only five Virginia companies have won awards out of the 64 awarded in the general competition. Virginia's share of the $192 million awarded has been approximately $12 million.[10]

Implications

- To continue to benefit from the high level of federal R&D spending in the Commonwealth, there is a need to both diversify our sources to include agencies whose R&D budgets are increasing as well as to protect the important federal assets which currently exist in the state.

- The low level of state support for research and development needs to be re-examined to reveal whether there are opportunities to leverage state dollars to obtain additional federal support.

- It is striking that the universities seem to be losing ground and more research is needed to identify the contributing factors.

- While the SBIR numbers appear comforting on the surface, it is important to see what the economic implications are. Are these firms actually commercializing the technology and growing larger or are they in the business of winning SBIRs? The ATP program is quite attractive and needs to be promoted and matching funds identified to improve Virginia's ability to capture its share.

- While not discussed here in depth, the concerns over the amount of federal R&D dollars going to industrial organizations and whether it "sticks" in Virginia bear further study. The Council on Competitiveness states that in Information Technology, "government funding has traditionally provided the impetus for fundamental advances,...either through direct funding of R&D at universities and federal laboratories or through the technology pull of the procurement budgets."[11] If this is true, and if many of our IT companies are pushing their R&D dollars out of state, then our lead in IT could be challenged.

[10] Ibid.
[11] Council on Competitiveness, "Going Global: The New Shape of American Innovation," September 1998, page 69.

THE STATUS OF SELECTED TECHNOLOGY RESOURCES IN THE COMMONWEALTH

In 1997, in response to Senate Joint Resolution 226, CIT submitted a report[12] on the status of the Commonwealth's technology assets that included a description of each of 10 key scientific and technological assets identified in the resolution. This report provides an updated status report on each of those assets. Each named laboratory or program was contacted and offered the opportunity to update the information provided in last year's report. Their replies are the basis for this section. Also provided in Appendix 1 is an updated summary giving highlights of the missions, funding types, strategic needs, and funding needs of each of the ten named assets as they have identified them.

It should be noted that, in addition to these important activities, the Commonwealth has many other important technology assets in the private firms, universities, and federal government laboratories and agencies located in the state. In addition, there are the tens of thousands of trained scientists and engineers and hundreds of thousands of other skilled employees who work with them. Thus, this set of specific assets should be viewed as illustrative, rather than as a summary of the state's assets as a whole. Some other resources are mentioned which have marked particular successes in 1998.

The ten key assets named in the Joint Resolution are discussed in the following sections. In some cases, the names of the specific assets have been updated to reflect more recent information.

Applied Research Center, Newport News

The Applied Research Center (ARC) is an $18.4 million, 7 story, 122,000 square foot facility built by the City of Newport News and the Newport News Economic Development Authority. The ARC is the flagship research facility in a new 200-acre research park adjacent to the Thomas Jefferson National Accelerator Facility and the Jefferson Center for Research and Technology. The ARC building contains 27 state-of-art laboratories including office space, classrooms, advanced computer facilities and a technical library--all designed to concentrate the region's multi-disciplinary materials processing resources and to become a combination high-technology business incubator, multi-capability university research laboratory, and technology transfer center.

The ARC is a unique collaboration between the Commonwealth of Virginia, the City of Newport News, the Newport News Economic Development Authority, the U.S. Department of Energy, Jefferson Labs and Christopher Newport University, the College of William and Mary, Norfolk State University, and Old Dominion University. The partner universities have developed, with the support of funding from the Commonwealth, a comprehensive research program addressing

[12] "Report on the Status of the Commonwealth's Technology Assets," prepared by Virginia's Center for Innovative Technology for the Joint Commission on Technology and Science (SJR 226: 1997). Senate Document No. 8 (1998).

several related application areas of significant importance to industry. On August 11th Virginia's Center for Innovative Technology (CIT) selected ARC as the home of a new technology innovation center—The Center for Plasma and Photon Processing which will advance the use of intelligent processes to control energy to create materials, structures and devices. These methods are critical for high-value added manufacturing of computer and communication equipment, physical and chemical sensors, and biomedical instruments. The innovation center will make these methods available to small and large business along with a full-complement of advanced processing tools for materials and will be a major provider of applications for the free electron laser at neighboring Jefferson Labs. The innovation center is expected to receive $2 million over 5 years.

ARC brings together a large cadre of faculty, researchers, graduate, and undergraduate students with specific skills in the fields of engineering, materials processing and computational science from four universities and a federal lab in a single building in a new research park. Most of the researchers have experience in both academic and industrial environments. The ARC is also home to high-tech business start-ups, a venture capital firm, and high-tech business support services including Virginia's Center for Innovative Technology, the Hampton Roads Technology Council, and the Virginia Philpott Manufacturing Extension Partnership.

The Applied Research Center will not only be an asset for attracting new companies to the region, but will also play a key role in growing the region's own companies. ARC is already home to Dilon Technologies, a start-up firm building breast cancer detection equipment based on particle detection technology licensed from Jefferson Labs.

***Biotech Informatics Center*, George Mason University**

The Institute for Biosciences, Bioinformatics and Biotechnology (IB3) at George Mason University is an entrepreneurial center in pursuit of academic excellence. The Institute represents a model for integrating basic and applied research in the setting of a modern university. IB3 is a unique consortium of George Mason University; the Commonwealth of Virginia; Prince William County, and the American Type Culture Collection (ATCC, the world's largest collection of living biological cultures).

In addition to the ATCC, new strategic alliances have been forged between IB3 and Silicon Graphics (SGI), the FBI Laboratory, and the Forensic Science Service (FSS) of England and Wales. The SGI agreement has resulted in establishment of a Training and Research Center in Bioinformatics. This will facilitate development of new tools for the analysis of genomic and molecular biological data. The initiatives with FBI and FSS represent an international focus on the forensic arts and sciences, with strong emphasis given to integration of DNA-based biotechnology and computational Bioinformatics. Another major area of IB3 programmatic development is genomic diversity, with particular emphasis on microbes of industrial, biomedical and environmental interest. These external partnerships will provide opportunities for student internships and externships. The result will be not only enrichment of training and educational programs, but will foster contacts and networks crucial for the high tech careers of IB3 graduates.

The over 88,000 square foot Academic Building II (PW2) opened on the Prince William campus September 10, 1998. This shared research and education facility contains a 90-seat auditorium, offices and multipurpose rooms, and numerous modern laboratories. IB3 is a key organization in the advancement of the bioscience-based industry through scientific collaborations; offering of expertise and technical service to the scientific community; and in contributing to Virginia's economic strength through educational programs at the undergraduate, graduate, postgraduate, and professional levels.

***Free Electron Laser*, Newport News**

The Free Electron Laser (FEL), a key component developed from research used to create the Continuous Electron Beam Accelerator at Jefferson Labs, is the first laser of its kind to generate "tunable" infrared (and later, ultraviolet) light at high average power. The FEL is a powerful, versatile new kind of industrial laser that could improve or revolutionize manufacturing and materials-processing capabilities for a multi-billion-dollar range of potential markets. In summer 1998, with record-breaking 'first light' achieved in the first FEL, corporate product developers and university applied researchers are preparing initial laser application studies.

The FEL utilizes Jefferson Labs scientists' superconducting radiofrequency knowledge and expertise to build and operate the free electron laser for basic and applied research in materials science. The research strengths of this asset fall into three categories: accelerator technologies such as medical imaging, detector technologies, cryogenics, and real-time process control software; supply side technologies such as optics and laser manufacturing; and demand side, such as polymers, micromachining, nondestructive evaluation, thin films, and electronics materials.

Of high interest to industry in manufacturing products for all applications, the FEL will be used in a variety of industrial projects from micromachining to modification of a wide range of materials used in everyday life to improving adhesion of polymers and metals to nondestructive evaluation of products. Next-generation light sources, environmental monitoring and cleanup, and computer component manufacturing are still other areas ready for commercial application of the FEL technology. Firms such as DuPont, IBM, 3M, Lucent Technologies, Northrop Grumman, Virginia Power, and a host of others are collaborating on the $34 million FEL project.

***Langley Full-Scale Wind Tunnel*, Hampton**

The Langley Full-Scale Wind Tunnel (LFST) is a large low-speed wind tunnel located within Langley Air Force Base in Hampton. It is the second largest wind tunnel in the U.S. (the largest currently operational, one of the four largest wind tunnels in the world, and the largest university-operated wind tunnel in the world; in 1996, Old Dominion University took over operations of the LFST). The LFST provides much-needed aerodynamic testing capability to the automotive and aerospace community and supports research and educational programs. A longer-term goal is to provide world class test capability for ground transportation vehicles. A

truly unique facility, the LFST includes capabilities beyond testing such as engineering and testing support services, design, educational programs, and fabrication engineering services.

***Smart Roads Project*, Virginia Tech**

The Virginia Department of Transportation, in cooperation with the Center for Transportation Research (CTR) at Virginia Tech, is creating The Smart Road. This represents the first highway in the United States to be built from the ground for intelligent transportation system (ITS) and it fills the void between a controlled laboratory environment and on-site real world deployment. The Smart Highway is a 6-mile, 4-lane limited access highway, built in stages. Besides ITS related exploration, the highway will be used for controlled testing and evaluation of vehicle dynamics human factors and "smart" engineering research. The Smart Road that will eventually add to the highway network of the greater Blacksburg area, serves as a testbed and test track for ITS research, testing, training and demonstration, and is a cornerstone in regional development of a transportation technology-based industry.

***The University of Virginia's Institute for Microelectronics (UVIM)*, Charlottesville**

The University of Virginia's Institute for Microelectronics (UVIM) was established in 1996 and reorganized in 1998 to create a more effective organization, responsive to the needs of the University's faculty and the State's industry. UVIM acts as a focal point for microelectronics communications, based primarily on faculty volunteers who seek to maximize the impact of their activities upon the multibillion-dollar microelectronics industry.

The restructured UVIM has begun to develop strong state industry/university relationships as evidenced by the formation of the University of Virginia/Dominion Semiconductor Corporation Collaborative Center during the fall of 1998. The University/Dominion Semiconductor Center seeks to have a positive impact upon Dominion Semiconductor's competitiveness and financial success by focusing faculty and student research attention upon problems of significant industrial relevance. The Center also hopes to energize the employees of Dominion Semiconductor by offering them pathways for intellectual stimulation and growth. UVIM's plans to develop this Center further and to create other similar partnerships with companies in the state (e.g., White Oak Semiconductor, Lockheed-Martin, Ericsson, and ITT-Roanoke) can be significantly enhanced through state financial support.

UVIM is also working with the University of Virginia's School of Engineering and Applied Science to prepare a pre-proposal submission to the National Science Foundation for an Engineering Research Center (ERC) in the area of vapor deposition technology. The ERC program, which can bring in $60 to $70 million research over a 10 year period, requires both state and industry matching support. Such support is often a "tie-breaker" which determines who wins these highly competitive awards. NSF has increased the expectations for matching state support by raising its level of annual funding to awardees, from $2 million to $4 million. While UVIM and UVA have been highly successful in again obtaining strong industry matching funds for their upcoming submission (June 30, 1999), there are presently no identified state matching funds (estimated need = $3 – 4 million) to demonstrate the Commonwealth's support.

Virginia Biotechnology Research Park, Richmond

The Virginia Biotechnology Research Park (Park), created in 1992 in Richmond, is an incubator facility catering to start up entrepreneurial research-oriented biomedical and biotechnology companies. Provided within the Park are such amenities as administrative offices, laboratories, fiber optic telecommunications, library, conference rooms, and networking activities. Within the next 10 to 15 years, all 34 acres of the Park will be fully developed, increasing its value as an economic development tool. Based on its initial operations of about 20 months, the economic impact expected of the center as a function of investment is potentially 60 new jobs with a $2.5 million investment, 120 new jobs with a $5 million investment, and 200 new jobs with a $10 million investment. One-half of the growth of the Park is expected to come from its close affiliation with Virginia Commonwealth University and the potential for start-up companies from researchers and scientists. Average state support of research parks in the Southeast U.S. is estimated by the Park to be approximately 30% of annual operations; currently the Virginia Biotechnology Research Park receives only 6% of its annual operating budget from the state.

Virginia Modeling, Analysis and Simulation Center (VMASC), Suffolk

In developing another valuable resource in the Commonwealth, the federal government has partnered with Old Dominion University, the City of Suffolk, the Hampton Roads Partnership, and the state, to capitalize on and leverage work done at the United States Atlantic Command's Joint Training, Analysis, and Simulation Center in Portsmouth, Virginia. Through this partnership, the Virginia Modeling, Analysis and Simulation Center (VMASC) was created in 1996. VMASC will stimulate economic development in Virginia, specifically in greater Hampton Roads area, through the attraction or start-up of companies around the area of simulation. VMASC will conduct research that develops and promotes the application of simulation technologies, facilitate education of simulation professionals, and serve as a source of world class expertise in this important field.

A planning study conducted by Booz-Allen in early 1996 estimated that the potential economic development value of VMASC exceeded $175 million, not only through the start-up or location of simulation-related companies in the area, but also through actual sale of marketable software packages designed for specific applications such as urban development, port movement, etc. However, the planning study made assumptions of two-year operating funds of close to $4 million, half of which was expected from the Commonwealth. Actual state funds for two years are only $1 million. Additional funding to meet economic development potential for the state would be an additional $1 million.

Virtual Reality Competence Center, Virginia Tech

The Virtual Reality Competence Center at Virginia Tech is a multidisciplinary computer graphic visualization research and educational facility that will become part of the new Advanced Communications and Information Technology Center. The Virtual Reality CAVE™ (Computer Automated Virtual Environment) resides at this Center in Blacksburg, which is a business

partnership between Virginia Tech Intellectual Properties, Inc., and Prosolvia, Inc., an international pioneer in virtual reality (VR) software and simulation applications. The National Science Foundation-Academic Research Infrastructure (NSF-ARI) CAVE™ was funded in September 1996, and in a subsequent proposal to NSF, Virginia Tech became a partner with the NCSA Partnership for an Advanced Computational Infrastructure (PACI). This leveraging of both resources and partnership is a model within the Commonwealth.

The mission of the CAVE™ is to enhance the economic and educational strengths of industry and academic partners through the effective use of interactive virtual environments in core business activities. A virtual environment is a system that "creates an artificial three-dimensional world where communication is interactive with immediate response..." Industrial and governmental activities of the Center are directed at how currently available technology can be used to improve business and technology applications in new areas. For example, in manufacturing, prototypes can be built as virtual worlds rather than building real mock-ups. This leads to significant cost savings, shorter lead times to market, and other competitive advantages. The R&D activities of the Center are directed at how VR technology can be improved and made easier for new and existing companies to make use of it. A large portion of that activity currently involves training and education for Center partners and clients.

The capital requirement of $2 million for virtual reality equipment and support facilities is approximately 75% in hand, and the Center has developed a growth plan to ensure that its operations will be fully supported within three years. The biggest constraints to growth for the Center are a lack of trained staff to develop virtual reality projects, and developing an understanding among the business community as to the value of using virtual reality. Additional funding of between $250,000 and $500,000 would assist in stepping up growth of the center, solving the problems noted above and leading to an excellent international reputation.

***Virginia Space Flight Center,* Wallops Island**

The Virginia Space Flight Center (VSFC) is an initiative of the Virginia Commercial Space Flight Authority, developed in partnership with Old Dominion University, CIT, NASA, and industry. Co-resident with the NASA Wallops Flight Facility on Virginia's Eastern Shore, the VSFC engages in launch services, enhanced payload processing and integration, storage, radar, and telemetry services. The mission of the Center is to foster the development of a robust aerospace enterprise that serves to promote economic development, provides for education and research, and enhances the competitiveness of the U.S. in the aerospace sector. Through the Center, business finds a space launch infrastructure that is safe, capable, efficient and low cost known to few other states, access to state and federal technology, education, and research resources, and assistance in increasing competitiveness by retaining jobs that were to be lost and growing new ones.

The commercial spaceport launch pad at Wallops is currently under construction. As such, it is only the third facility of its kind in the United States. The launch pad will support a wide variety of Expendable Launch Vehicles (ELV) such as Lockheed Martin's "Athena" series, Orbital

Sciences' "Taurus" series and the US Air Forces' "Orbital/Suborbital Minute Man." Completion of the entire project is expected by the year 2000.

SCIENCE AND TECHNOLOGY INFRASTRUCTURE DEVELOPMENT IN VIRGINIA—An Update

New Science and Technology Assets Added to Virginia in 1998

Notable events in 1998 have occurred to strengthen the S&T infrastructure in Virginia.

NSF ERC at Virginia Tech, The Virginia Power Electronics Center

Following a $1.5-million pledge of assistance from Virginia's Governor James Gilmore and the acknowledged support of more than 100 industrial allies, the National Science Foundation has given its endorsement to create an Engineering Research Center (ERC) in power electronics, centered at Virginia Tech, with an initial funding of $12.35 million.

Virginia Tech's 16-year old Virginia Power Electronics Center (VPEC), directed by Electrical and Computer Engineering (ECpE) Professor Fred Lee, submitted the proposal on behalf of a consortium of five universities. The successful proposal provides the state with its first ERC. VPEC has been a CIT Technology Development Center for ten years.

The Center's strategy will be to focus its efforts on the higher-volume power electronics for domestic and industrial applications, such as packaged drives for heating, ventilation, air-conditioning, and refrigeration; hybrid electric vehicles, and high-performance adjustable-speed drives for industrial automation, distributed power-supply systems for computer and telecommunication equipment; as well as ultra-low voltage and high-speed Very Large Scale Integrated (VLSI) circuits, and future generations of processors.

Some of VPEC's more widely known accomplishments include its role in developing the power-electronics building blocks (PEBB's), an approach to standardizing power-electronics components that include semi-conductor materials, circuits, controls, sensors and actuators, aiming at a significant cost and energy savings for the U.S. Navy and the nation's power-electronics industry. The Navy wants to use PEBB's in the high-power range to reduce the size, weight and expense of shipboard power systems. Virginia Tech leads a consortium of three universities conducting this work. VPEC has also contributed to the design of the satellite power system for NASA's Mission to Planet Earth. This system monitors ozone depletion and carbon dioxide. And, they were asked to perform an independent assessment of the design and stability analysis of the power system for the Space Station Freedom.

In the ERC consortium, Virginia Tech is the lead school. Other members are the University of Wisconsin--Madison, Rensselaer Polytechnic Institute, North Carolina A&T State University, and the University of Puerto Rico at Mayaguez.

In general, NSF envisions that all of its ERC's will produce advances in a complex, next-generation engineered system, as well as educate the new generation of engineers to the depth

and breadth needed for leadership throughout their careers in a global economy. NSF's strategy is to integrate research and education using the ERC.
The NSF commitment to the power-electronics consortium is for five years with a renewal possible for another five years. NSF expects the ERC to be self-sufficient through industrial support after a decade.

Technology Growth Fund Program (new in July 1998)—Recommendation of the Joint Commission on Technology & Science in '98 Session.

The creation of a CIT-managed Technology Growth Fund (TGF) program will leverage state resources to attract R&D facilities and organizations, technology infrastructure, and contracts from federal government and the private sector. CIT plans to identify and track federal and commercial technology initiatives and coordinate the Commonwealth's response to compete for federal and private sector R&D resources. Funds are to be assigned to draw significant federal and private funds into the Commonwealth to develop, nurture and expand technology research having economic potential for the state. In addition this growth program would be used to leverage resources in nurturing technology commercialization from the state's technology assets. CIT will initiate a coordinated effort with Virginia's research universities, federal laboratories, and commercial research labs to attract and develop such R&D and technology resources in the Commonwealth. The CIT Board of Directors reviewed guidelines for this program on October 21, 1998.

In the past, CIT had used its reserve funds to help attract such research and development organizations such as the American Type Culture Collection, the research division of Whitehall-Robins and the National Electronics Manufacturing Initiative (NEMI) to the Commonwealth. Similarly, because of these reserve funds, CIT could also serve to pledge to seed or match funds to attract federal funding of technology infrastructure such as the Virginia Space Flight Center and the Free Electron Laser project of the Thomas Jefferson National Accelerator Facility. These reserve funds are now completely exhausted and CIT's participation in the attraction of technology infrastructure to Virginia depends upon this newly established TGF program. CIT has funded this program at about $300,000 in each year of the 1998-2000 biennium.

Technology Innovation Centers and Manufacturing Innovation Center—Recommendation of Joint Commission on Technology & Science in '98 Session.

It had been five years since CIT had funding enabling it to establish new centers. However, in 1998, CIT received funding to begin creating a new generation of these centers--Technology Innovation Centers, whose goals include not only technology development, but also application, commercialization, and a rapid response to meet the needs of businesses.

CIT has partially funded three announced centers: Internet Technology Innovation Center (ITIC), Center for Plasma and Photon Processing (CPPP), 21st Century Manufacturing Center (21CMC). These centers are designed to be an umbrella or virtual organization providing development, application, commercialization, and rapid response efforts to Virginia businesses; focused on existing and emerging technologies; of great importance to the growth of Virginia's technology

businesses; builds S&T infrastructure leading to world class excellence. Below is a brief description of each new innovation center.

1. Internet Technology Innovation Center (ITIC)
   - Four universities: UVA, VA Tech, CNU, & GMU
   - Internet and information technology industry sector infrastructure development
   - Also shorter-term economic impact expected
   - Accelerates creation and deployment of network-based information technology
   - Electronic Commerce, multimedia collaborative tools, information storage and retrieval, virtual environments, human-computer interface, mobile network access

2. Center for Plasma and Photon Processing (CPPP)
   - Four universities: W&M, ODU, NSU, and CNU
   - Federal facility: FEL of Thomas Jefferson National Accelerator Facility (Jefferson Labs)
   - Advanced Materials industry sector; long-term infrastructure development
   - Specific applications to semi-conductor thin films, photovoltaics, sensors, and other industry segments
   - Materials characterization and processing research and development of semiconductor devices, modeling and measurement, etc.
   - Expertise includes plasma source and diagnostic development, novel sources for next generation

3. 21st Century Manufacturing Center
   - Highly collaborative
   - University: JMU
   - Community Colleges: PVCC, DSLCC, BRCC
   - Manufacturing Partner: Virginia Philpott Manufacturing Extension Partnership
   - New generation manufacturing infrastructure support
   - Short-term immediate JCC assistance for small to medium-sized manufacturing organizations across all industry sectors
   - Development and deployment of new 'high-tech' manufacturing methods, processes, and operations

Hampton Roads Technology Incubator

In July 1998, Virginia's Center for Innovative Technology, in collaboration with the Hampton Roads Technology Council, the Hampton Roads Partnership, the SBDC of Hampton Roads, Mentech Advisors, Inc., and the five universities in the Hampton Roads region, won an $800,000 grant from NASA to establish an incubator. The incubator, called the Hampton Roads Technology Incubator, is located at the gates of NASA Langley Research Center, and will be active in identifying NASA-related technologies with commercial potential and incubating companies seeking to commercialize those technologies. The NASA grant was matched with

funds from the Virginia Small Business Incubator Program, CIT and the Hampton Roads Partnership. Only three incubator grants were awarded nationally this year by NASA.

RECOMMENDATIONS:
The Future of Our Scientific and Technological Resources

Virginia's intellectual resources must be supported consistently over the long term if they are expected to yield significant economic benefit to the Commonwealth. To give these assets the boost they need requires a state commitment well beyond current levels of support. Not only must Virginia support the needs of its current resources; a mechanism like the newly-established Technology Growth Fund Program at CIT is needed to nurture new resources. The state must facilitate the discovery of new and improved technologies made within its intellectual assets and support their full commercialization, capturing the wealth and value of existing and emerging technologies and the latent capabilities of the Commonwealth.

Virginia must maintain its leadership as a top technology state. It has competitive advantage in a number of critical areas where, if the state committed to growing these assets, it could realize its potential to attract industry and federal funding, which combined with the state's commitment would lead to Virginia's emergence as a world class technology state.

Recommendations:

The Commonwealth should continue to capitalize on all potential research, development, and commercialization opportunities.

- First, Virginia should have a statewide strategy for the attraction and ongoing support of federal research and development assets and funding. This strategy should be developed by the Office of the Secretary of Technology with the support of CIT and input from the Commonwealth's universities and the private sector. In addition, the strategy should include tactics to leverage the federal support and assets for the benefit of the Commonwealth.

- Second, Virginia should invest state research and development dollars consciously to be complimentary to federal investment and to improve the Commonwealth's ability to obtain federal research and development funding and assets.

- Third, Virginia should seek greater participation for its small business in federally funded research and development programs.

- Fourth, Virginia should continue to try to document R&D investment flows through its industrial sector, as well as document the economic interactions of the existing and emerging technology sectors in order to better prioritize the federal investment strategy.

Appendix 1
List of Selected S&T Assets

Entity	Mission	Funding Type	Strategic Need	Funding Needed
Virginia Biotechnology Research Park	Develop biotech/ biomedical industries	Combination of federal, state, city, university and private	Financial – land acquisition and annual operating funds.	Land ($20M) Operations ($.75M)*
Langley Full-Scale Wind Tunnel	Provide test capability to transportation industry	Combination of state, private, with long-term lease of federal asset	Financial – facility improvements Marketing	$100,000 to $5 million needed to complete facility
Virginia Modeling, Analysis and Simulation Center	R&D and application of simulation technol-ogies for industries	Combination of city, state, and federal	Financial – annual Marketing	$500,000*
UVA's Institute for Microelectronics	Facilitate micro-electronics research, education, and industrial collaboration	University overhead	Visibility—recognition Financial Communication—develop partnerships	$450,000* for staffing, industrial collaboration centers, and workforce education. $3M-$4M for ERC state match/over 5 years
Virtual Reality CAVE™	Enhance strength of industry partners in use of interactive virtual environments	Combination of federal and private	Financial – start-up Marketing	$250,000-$500,000*
Applied Research Center	Provide R&D facilities to academic and industry scientists using FEL technology	Combination of city and state, followed by private	Financial -	$500,000 for infrastructure upgrade and operations

Entity	Mission	Funding Type	Strategic Need	Funding Needed
Free Electron Laser	Build a unique capability for basic & applied materials research	Combination of state, private, and federal	Financial – through partnerships	$1.5M* through university requests + existing $800,000* for state FEL support
Smart Road Project	Test bed/track for intelligent transportation R&D	Combination of federal, state, and private	Financial – research instrumentation	Not available at time of publication
Virginia Space Flight Center, Wallops Island	Provide space launch & services to govt. and commercial customers	Combination of federal and state	Financial – Facility completion	Start up –$.6M* Annual--$5M*
Biotech Informatics Center (IB3)	Workforce training, education, basic/ applied research, distribution of innovative biotechnology.	Combined state, local, private	Financial -Annual	$300,000*

* = State support needed annually

Appendix 2
SENATE JOINT RESOLUTION NO. 37

Requesting the Center for Innovative Technology to develop statewide strategies regarding certain technological and scientific research and development assets.

Agreed to by the Senate, March 5, 1998
Agreed to by the House of Delegates, March 3, 1998

WHEREAS, the Center for Innovative Technology (the "CIT"), Virginia Chamber of Commerce, and Virginia Technology Council jointly sponsored the report, "Building a CommonWealth of Technology: A Blueprint for Technology-Based Economic Growth in Virginia" (the "Blueprint"), which was published in August 1997; and

WHEREAS, the Blueprint is the product of two statewide technology summits (held in Norfolk in January 1997 and Richmond in May 1997) involving the efforts of hundreds of business leaders from six regions of Virginia (Greater Charlottesville, Greater Richmond, Hampton Roads, New Century Region, Northern Virginia, and Virginia's Region 2000) and seven technology industry sectors (aerospace technologies, biotechnology/biomedical applications, energy technology, environmental technology, high-performance manufacturing, information technology and telecommunications, and transportation technologies); and

WHEREAS, the Blueprint is based on the belief that currently, Virginia is in a second tier of technology states, but has the potential to become a global leader in certain technology areas; and

WHEREAS, to seize global leadership, the Blueprint proposes a series of two-year, three-year, and five-year and long-term goals; and

WHEREAS, to help achieve the goals proposed by the Blueprint and emerge as a world-class technology leader, Virginia must capitalize on all potential research, development, and commercialization opportunities; and

WHEREAS, Virginia's ability to capitalize on such opportunities was enhanced by the publication of Senate Document No. 8 (1998), a report by the CIT entitled, "The Status of the Commonwealth's Technology Assets," wherein the CIT indicates that as a whole, Virginia's technology and science assets are key to supporting existing and emerging technology-based industries as they compete in a global economy; and

WHEREAS, the existing technology assets specifically discussed in the report are the Applied Research Center, Biotechnology Research Park, Bioinformatics Center, Free Electron Laser, Langley Full-Scale Wind Tunnel, Smart Roads Project, Virginia Institute for Microelectronics, Virginia Modeling, Analysis, and Simulation Center, Virtual Reality Center, and Wallops Island Space Flight Facility; and

WHEREAS, now that the Commonwealth's existing technology assets have been identified and studied, there exists a great need to develop statewide strategies to maintain and expand these assets and attract new technological and scientific research and development assets; now, therefore, be it

RESOLVED by the Senate, the House of Delegates concurring, that the Center for Innovative Technology be requested to develop statewide strategies which maintain and expand the Commonwealth's existing technology assets identified in Senate Document No. 8 (1998) and attract new technological and scientific research and development assets. The Virginia Economic Development Partnership shall provide assistance to the study.

All agencies of the Commonwealth shall provide assistance to the CIT for this study, upon request.

The Center for Innovative Technology shall provide a report on the status of its development of such strategies to the Joint Commission on Technology and Science on or before October 15, 1998, and shall complete its work in time to submit its findings and recommendations to the Governor and the 1999 Session of the General Assembly as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents.