March 2002

Hampton Roads Research Partnership
Technology Commercialization Assessment
Phase 2: Identifying Opportunities

Sponsored by
Hampton Roads Partnership
430 World Trade Center
Norfolk, Virginia 23510

Presented by
RTI
Centers for Technology Applications and International Development
3040 Cornwallis Road
Research Triangle Park, North Carolina 27709

Contents

Executive Summary

The Hampton Roads Research Partnership (HRRP) has engaged RTI to assist them with identifying effective ways to leverage their research and development assets to enhance regional economic development. This report describes the results of an effort to identify opportunities for collaborations between HRRP and industry that would take advantage of their mutual strengths in growth or hot technology areas. This phase 2 engagement addresses three of six recommendations made by RTI at the conclusion of *HRRP Technology Commercialization Assessment, Phase 1, Needs Assessment*.[1] The recommendations addressed in this report are:

- **Find the intersection of hot technologies and HRRP technologies (gap analysis)**
- **Capitalize on the existing strengths**
- **Plan for the long term now, but also seek action on short and intermediate term possibilities**

Having already described the HRRP technology strengths in phase 1, the first task of phase 2 amounted to determining a relevant description of hot technologies and characterizing the technology base in the local industrial base. RTI examined many lists from a variety of sources to derive the hot technologies list for this analysis. Likewise, the prominent technologies in local industry were determined from information obtained from a variety of sources. The study found that there were only a few intersections of near-term interest.

Because of its pervasiveness in the local economy and its broad range of technology needs, the marine transportation industry headed the list of near-term opportunities, or thrust areas. HRRP strengths in areas such as materials technology, propulsion, modeling and simulation, high performance computing, and sensors are needed for maritime transportation, and they are represented in the local industry. The other near-term thrust areas involved aerospace applications, and medical devices.

Longer-term opportunities were identified when R&D strengths matched up with hot technologies, but had weak or no representation in the local economy. These areas included photonics, laser processing, marine research, bioinformatics, composite materials, and nanotechnology.

RTI was also tasked with taking a quick look at potential funding sources that may be relevant to the thrust areas. While RTI cannot be sure that the sources reported were previously unknown to the HRRP, this report does provide a list of representative sources available for monitoring funding organizations that are relevant to the thrust areas. In one case reported to the HRRP in an August 2001 meeting, RTI pointed out that there was substantial available funding for

[1] *Hampton Roads Research Partnership, Technology Commercialization Assessment, Phase 1, Needs Assessment.* Research Triangle Park, NC: Research Triangle Institute, 2001.

historically black colleges and universities that was not yet being pursued by the qualified HRRP schools.

The results of this study led to a series of action items that RTI suggests will be helpful in establishing meaningful collaborations in the thrust areas. Along with supporting data from case studies in three other metropolitan areas, the report recommendations address:

- **Identification of funding opportunities**
- **Support for technology commercialization**
- **Communication, networking, and partnerships**
- **Public relations and marketing**
- **Building a broader technology resource base**

By going forward, the Hampton Roads area may have a full plate. While the opportunities are many, the work is hard. The phase 2 report provides a sense of where the near-term opportunities are, and what steps could be taken to achieve meaningful partnerships that would attract real funding. A concluding thought may be helpful: the action of a few can make a difference for many. During the past decade, other communities have started where Hampton Roads is at today. For many of the successful ones, success was achieved relatively quickly because of effective leadership and commitment to action. Both are apparent in the HRRP and Hampton Roads Partnership.

1. Introduction

The Hampton Roads Research Partnership (HRRP) seeks to leverage the region's existing technology base to create economic development opportunities, especially those that create new jobs and can increase regional per capita income. Economic development has stagnated in the last 10 years, even as the economy of such neighboring regions as Northern Virginia has grown. The HRRP leadership recognized that better job opportunities and per capita income are often linked to technology-related business. Increasing research and development (R&D) and licensing activities within the area is one way to strengthen this link, and attracting new local businesses based on "home grown" technologies is another.

As first steps toward meeting this goal, HRRP engaged RTI to perform the following tasks in a two-phased effort:

- Assess the current capabilities and future opportunities of the HRRP members to transfer technology (Phase 1)
- Identify opportunities for the HRRP to leverage its technology resources in future economic development efforts (Phase 2)

The results of the Phase 1 effort are documented in *Hampton Roads Research Partnership: Technology Commercialization Assessment, Phase 1: Needs Assessment*, submitted in May 2001. RTI also provided a commercialization training course to the HRRP members. The current report, *Hampton Roads Research Partnership: Technology Commercialization Assessment, Phase 2: Identifying Opportunities*, documents the findings of Phase 2.

A concise summary of Phase 1 findings and recommendations and a description of Phase 2 follows.

Summary of Phase 1: Needs Assessment

The ability to commercialize technology effectively is important for leveraging a region's technology base to create and maintain the high-technology industries and programs that support regional economic growth. The technology transfer programs at the HRRP member institutions are agents of commercialization. A strong technology transfer program is a vital link between university and government R&D, and local industry. In Exhibit 1.1, technology transfer is represented by the arrow connecting "university R&D" and "industry." A technology transfer program also serves the following four roles that are necessary for technology-based economic development:

- Facilitate spin-out companies based on university-developed technologies

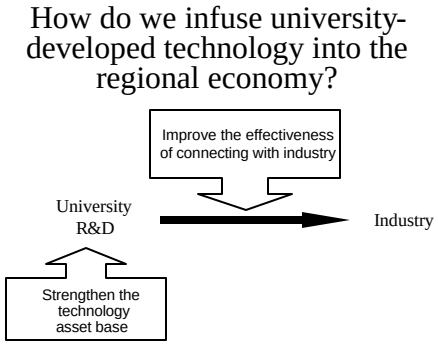
- Generate licensing revenues from intellectual property
- Recruit, retain and reward faculty
- Train the workforce for local technology industries (through R&D activities)

For Phase 1, RTI performed a benchmarking study, including a strengths, weaknesses, opportunities, and threats analysis of the individual HRRP members and an examination of the collective performance of the members.[2]

Two essential findings from the Phase 1 study were the following:

- No individual institution alone has the capability to drive regional economic development.
- Collectively, the technology transfer capability of the eight academic HRRP members working together is more effective than if the institutions worked individually, but lacks sufficient scale and strength to have an extraordinary economic impact.

Exhibit 1.1: The Role of Technology Transfer in Economic Development



RTI presented two recommendations to improve the infusion of university technology into the regional economy.

- **Need 1:** Strengthen the technology asset base
- **Need 2:** Improve the effectiveness of transferring the technologies (connecting with industry)

[2] The institutions examined were the Jefferson National Laboratory and the eight academic institutions that collectively make up HRRP: Christopher Newport University (CNU), Eastern Virginia Medical School (EVMS), Hampton University (HU), Norfolk State University (NSU), Old Dominion University (ODU), Virginia Institute of Marine Sciences (VIMS), Virginia Wesleyan College (VWC), and the College of William and Mary (W&M).

RTI identified six near-term actions to address these needs:

- Improve technology transfer capabilities of member institutions
- Find the intersection of hot technologies and HRRP technologies
- Attract research talent in the technology thrust areas
- Capitalize on existing strengths
- Organize a true collaboration
- Plan for the long term now

Identifying opportunities to achieve three of these actions (the second, fourth and sixth items above) is the purpose of Phase 2, as summarized in this document.

Overview of Phase 2: Identifying Opportunities

The findings of Phase 1 indicated that there was a need to increase the infusion of university-developed technology into the local economy. RTI was asked to provide certain information that could help facilitate this outcome and to determine the direction for cooperative regional efforts to address this need.

It has been noted that the R&D asset base of the Hampton Roads area is smaller than the R&D base typically found in regions that exemplify a vigorous technology transfer climate between universities and industries. Consequently, an important challenge for Hampton Roads will be to maximize the impact of its relatively limited resources. Targeting resources (funding, infrastructure, etc.) to a shared technology area (or thrust area) will improve the impact of the resources. Once the most viable thrust areas are identified, Hampton Roads will benefit especially from seeking funding sources for R&D projects within the thrust areas. Also, as Hampton Roads prepares to strengthen its tech-based regional economic development, it will benefit from the experience of similar areas that have undergone similar transformations. Learning from and adapting components of the strategies of other successful regions should be part of Hampton Roads' strategic plan. RTI was asked to perform three tasks to help implement three of the six near-term actions of Phase 1: develop a gap analysis (find the intersections of hot technologies and HRRP technologies), examine potential funding sources for specific thrust areas (capitalize on existing strengths), and plan near- and long-term actions (plan for the long term now):

- **Develop a gap analysis to determine thrust areas –** The targeted technology areas are referred to as thrust areas, which are specific areas of technology activities within the regional economy in which the potential to build upon existing strengths is most promising. To identify the most logical thrust areas for Hampton Roads, RTI performed a gap analysis. Briefly, a gap analysis includes these steps: identify the technologies that will become economic powerhouses within the next 10 to 20 years; identify the intersection of these "hot" technologies and the existing

HRRP technologies represented by the region's industry and academic R&D; identify attractive near-term and longer-term opportunities based upon the thrust areas identified by these intersections. The gap analysis is described in Section 2.

- **Examine potential funding sources specific to the thrust areas –** To capitalize on existing strengths, the pursuit of funding for research should focus on the thrust areas. A discussion of how Hampton Roads can tap resources centered on the thrust areas is in Section 3.

- **Plan near- and long-term actions that address the thrust areas and include best practices from the case studies of other areas –** In Section 4, Recommendations, specific actions for science-driven regional economic development are given. These recommendations are based upon an examination of three regions that faced similar situations to Hampton Roads, and successfully met the challenge. The recommended actions include some that were key elements contributing to the successes in the three other regions. Case studies of the three other regions (Denver, Albuquerque/Santa Fe or Metro New Mexico, and San Diego) are summarized in Appendix A.

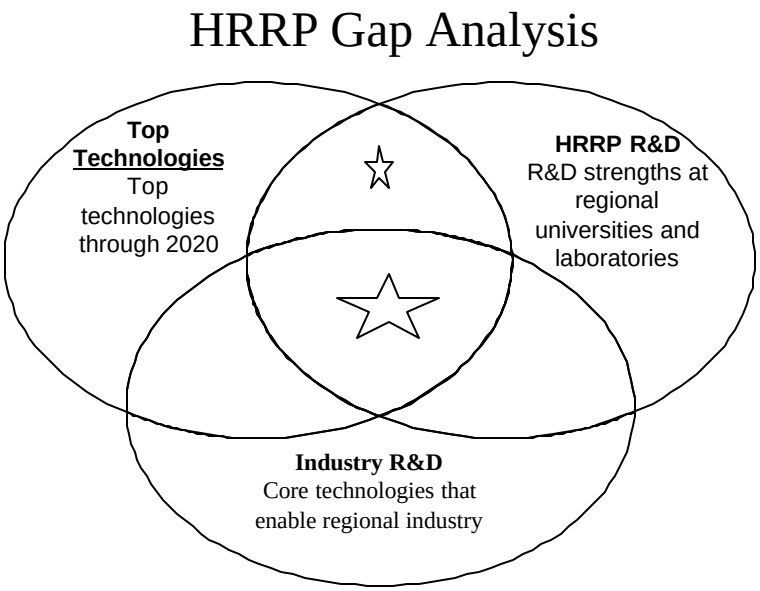
2. Gap Analysis Findings

The purpose of a gap analysis is to identify the key technologies/industries that could serve as thrust areas for driving regional economic growth efforts. To identify these thrust areas, three lists of key information were compiled and analyzed. They were:

- the research strengths existing at the regional universities and research labs, i.e. the HRRP member institutions
- the top technologies that are likely to drive economic growth over the next 10 to 20 years;
- the core technologies that enable current regional technology-based companies.

Exhibit 2.1 illustrates this analysis.

Exhibit 2.1: HRRP Gap Analysis



A comparison of the three lists identified technology areas that were present on all three lists, or a triple – a regional research strength, top technology, and regional industry capability. The triples, represented by the large star in Exhibit 2.1, are technology areas that can potentially serve the role of short-term thrust areas. Once the initial triples were identified, further analysis determined the

relative strength of each. Information from the following sources was used to narrow the list of triples to three short-term thrust areas:

- Company research (company website, listings in corporate databases, such as OneSource Information Services, Inc., CorpTech Division)
- University research plans (from website information and available strategic plans)
- Phone calls to select companies and academic institutions to verify/clarify the information gathered

The short-term thrust areas were defined as those offering opportunities for driving economic growth within one to five years. These opportunities are more viable for the short term because of the region's existing complementary activities, in both university and corporate R&D – in other words, there is an intersection or overlap of the region's university research and corporate R&D strengths against the top growth technologies.

In a similar manner to how the short-term thrust areas were identified, a comparison of the three lists identified the technology areas for which there was a presence on two lists, or double – regional research strength and a top technology (represented by the small star in Exhibit 2.1). The doubles can potentially serve the role of long-term thrust areas. As with the triples, once the list of doubles was identified, it was narrowed based on an analysis of the strength of the individual opportunities.

Long-term thrust areas were defined as having the potential to offer opportunities for significant economic impact in the future, perhaps in five to 10 years. The long-term thrust areas identified in this analysis can be broadly characterized as having significant research being conducted at regional research institutions, but little other activity within the regional economy. Economic impact over the short term would be limited, given that there is no overlap of these university research activities with the core technologies of the regional companies and, therefore, no short-term opportunities for leveraging these research strengths into commercial activities. These long-term areas can, however, provide a focus for attracting additional research funding, and for attracting new companies in related fields to the region.

In the Venn diagram of Exhibit 2.1, the triples (short-term thrust areas) are represented by the star. Additional discussion about the results of the gap analysis is found on page 24.

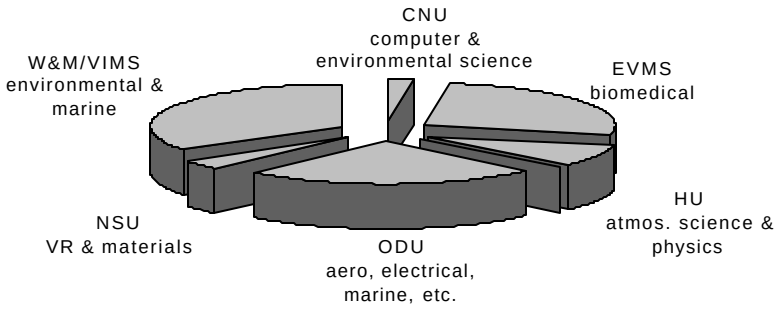
Regional Research and Development

Understanding the research and development efforts taking place in regional universities and government labs is a vital aspect of the gap analysis. As shown in Exhibit 2.2, HRRP university members have a combined R&D annual budget of about $90 million. Exhibit 2.3: Regional Research Strengths, is a list of research facilities and capabilities. The HRRP institutions are identified in both exhibits with the following acronyms:

Christopher Newport University	CNU
Eastern Virginia Medical School	EVMS
Hampton University	HU
Jefferson National Laboratory	JLab
NASA Langley Research Center	LaRC
Norfolk State University	NSU
Old Dominion University	ODU
Virginia Wesleyan College	VWC
Virginia Institute of Marine Sciences	VIMS
College of William & Mary	W&M

For this evaluation, LaRC and JLab were given different treatment than the academic institutions. While the technical facilities, capabilities, and expertise of LaRC and JLab are included in the regional R&D strength listing, the budgets of LaRC and JLab are not included in HRRP's total R&D budget.

Exhibit 2.2: Distribution of R&D Funding among the HRRP Academic Institutions and a sampling of general R&D areas (Total is approximately $90 million a year.[3])



[3] For a full listing of the data, see *Hampton Roads Research Partnership, Technology Commercialization Assessment, Phase 1, Needs Assessment.* Research Triangle Park, NC: Research Triangle Institute, 2001

Regional research can be characterized as consisting of relatively small efforts in a fairly diverse range of topical areas. The HRRP members have annual sponsored R&D funding levels ranging from approximately $2 million at CNU to $24 million at EVMS. And, each member's funding is for various research topics. The funding that supports these research efforts, in aggregate for all of the universities (excluding LaRC and JLab), totals about $90 million annually.[4]

This aggregate total is comparable to what is spent annually at one typical medium-sized research university, such as Tulane, Tufts, or Clemson. The HRRP universities' $90 million of R&D funding is divided among several academic institutions, and further divided among several R&D programs at each academic institution. Therefore, the size of typical research programs at any of the HRRP institutions is relatively small compared to programs at the larger institutions, and it is doubtful that, at current levels, the programs could be national powers in a specific technical area. This disparity presents a challenge in building momentum for commercialization activities. On the other hand, these research efforts at HRRP institutions are likely to be less institutionalized than at larger universities, allowing greater flexibility in shaping the research agenda and its focus. Also, it should be noted that most of the regional research efforts tend to be applied research rather than basic research. This is a positive factor for attracting new funding since most government funding is for applied research. Furthermore, applied research, by definition, is directed at applications, and therefore has a greater probability of resulting in commercialization than does basic research.

Exhibit 2.3 shows representative regional research strengths. The facilities and capabilities were gathered from interviews with key personnel at the academic institutions and from published accounts, including the technical strategic plans for EVMS, ODU, W&M, and HU. Facilities and capabilities are included without ranking for "importance" or size or funding level.

[4] *Hampton Roads Research Partnership, Technology Commercialization Assessment, Phase 1, Needs Assessment.* Research Triangle Park, NC: Research Triangle Institute, 2001

Exhibit 2.3: Regional Research Strengths

Aerospace Engineering	**Facilities**	
	Center for Experimental Aeronautics	ODU, LaRC
	Combined Loads Test Facility	LaRC
	Langley Wind Tunnels	ODU, LaRC
	Virginia Space Flight Center	ODU, LaRC
	Capabilities	
	Aerodynamics Research	LaRC,ODU, HU, NSU, W&M
	Aerospace Engineering Program	ODU,HU,NSU
	Flight Systems	LaRC, ODU
	Materials and Structures	LaRC, ODU, NSU
	Systems Engineering	LaRC, ODU
Biomedicine/Biotechnology	**Facilities**	
	Center for Biotechnology	ODU
	Center for Ocular Pharmacology	EVMS
	Center for Pediatric Research	EVMS
	Glennan Center for Geriatrics and Gerontology	EVMS
	Sleep Disorders Center	EVMS
	Capabilities	
	Biochemistry	EVMS, ODU
	Bioinformatics	EVMS
	Biotechnology and Plasma and Laser Processing	W&M
	Chemistry	W&M, ODU
	Diabetes Research	EVMS
	DNA Analysis	NSU
	Genetic Engineering, Micro and Molecular Biology	HU
	Imaging	W&M
	Microbiology/Immunology	EVMS
	Pathology	EVMS
	Pharmacology	EVMS
	Physiology	EVMS
	Prostate Cancer Treatment Research	EVMS
	Reproductive Medicine and Contraceptives Research	EVMS

Exhibit 2.3: Regional Research Strengths (continued)

Computational Data Analysis	**Facilities**	
	Beowulf Supercomputer	CNU
	Computational Science and Parallel Processing Center	W&M
	Origins 2000 Computer	HU
	Sun Microsystems Supercomputer	ODU
	Ultra High-Speed Data Acquisition System	JLab
	Capabilities	
	Artificial Intelligence and Neural Nets	HU
	Computational Science and Research	NSU
	High Speed Data Acquisition	CNU
	Quantum Chemistry Computation	NSU
Computational Modeling/Simulation	**Facilities**	
	The Virtual Reality Facility	ODU
	Virginia Modeling, Analysis, and Simulation Center	ODU
	Capabilities	
	Computer Engineering	ODU, HU
	Modeling and Simulation	CNU, W&M, HU
	Virtual Reality Training	NSU, ODU
Electrical Engineering	**Facilities**	
	Physical Electronics Research Center	ODU
	Capabilities	
	Digital Signal Processing	CNU
	Electrical Engineering	ODU, HU
	IC Circuit Design	CNU
	Non-Destructive Evaluation	W&M, LaRC

Exhibit 2.3: Regional Research Strengths (continued)

Environmental and Atmospheric Science	**Facilities**	
	Center for Atmospheric Science-Atmospheric Science and Remote Sensing	HU
	Lake Matoaka Environmental Field Laboratory	W&M
	Langley Boeing 757 Research Platform	LaRC
	Virginia Institute of Marine Sciences/W&M School of Marine Science	W&M
	Capabilities	
	Atmospheric Science	LaRC
	Environment and Atmospheric Remote Sensing and Modeling	CNU
	High Temperature Gas Clean-up and Catalysis	HU
	Wastewater Treatment Systems	HU
	Environmental Science	ODU, HU, W&M, CNU, VWC
Internet Tools and Commerce	**Capabilities**	
	Internet Security	NSU
	Virginia Electronic Commerce Technology Center (VECTEC)	CNU
Marine Sciences	**Facilities**	
	Center for Coastal and Physical Oceanography	ODU
	Virginia Institute of Marine Sciences	W&M
	Capabilities	
	Marine and Environmental Sciences	HU, ODU, W&M/VIMS

Exhibit 2.3: Regional Research Strengths (continued)

Maritime Industry, Marine Engineering	**Facilities**	
	Center for Advanced Ship Repair and Maintenance	ODU
	International Maritime, Ports and Logistics Management Institute	ODU
	Capabilities	
	Maritime R&D	ODU, W&M, VIMS
	Naval Science	HU
Materials	**Facilities**	
	Center for Materials Research	NSU
	Center for Plasma and Photon Processing	W&M, ODU, CNU, HU
	Capabilities	
	Materials and Structures	LaRC
	Materials Processing	JLab
	Non Destructive Evaluation	W&M
	Optical Spectroscopy, Electron Microscopy	HU
	Polymer Chemistry	HU, LaRC
	Space Materials and Nanotechnology	NSU, LaRC
	Surface Sciences – Plasma and Laser Processing	W&M

Exhibit 2.3: Regional Research Strengths (continued)

Photonics	**Facilities**	
	Center for Materials Research	NSU
	Center for Photonic Materials Research	NSU
	Center for Plasma and Photon Processing	W&M, ODU, CNU, HU
	Laser and Photonics Lab	CNU
	Research Center for Optical Physics	HU
	Capabilities	
	Optics	NSU, ODU
	Photochemistry	W&M
Physics	**Facilities**	
	Central Electron Beam Accelerator Facility	JLab
	Nuclear High Energy Physics Research Center	HU
	Capabilities	
	Chemical Physics	NSU, HU
	Nuclear Physics	JLab
	Photo Physics	W&M
	Physics	HU, ODU, NSU
Public Policy	**Facilities**	
	CATI Public Policy Survey Lab	ODU
	Social Science Research Center	ODU
	Capabilities	
	Health-related Policy	ODU

Exhibit 2.3: Regional Research Strengths (continued)

Sensors	**Facilities**	
	Advanced Particle Detection Equipment	JLab
	Solid State Sensors Lab	CNU
	Capabilities	
	Cryo systems Research	JLab
	Fiber Optic Sensors	HU
	Sensors Research	LaRC
Technology in Education	**Facilities**	
	Center for Bringing Education and Science Together	NSU
	Center for Learning Technologies	ODU
	Lions Child Study Center	ODU
	Capabilities	
	Science Education Delivery	CNU, LaRC
	Public School Applications	VWC

Top Technologies

The anticipated growth technologies through the next 10 to 20 years provide the backdrop against which the university research strengths and industry-based technologies can be compared. Many technology forecasts are available, but many of them typically focus on certain segments of the economy – such as defense or computers. For the gap analysis, a broad-based forecast was required. Therefore, RTI created an overall forecast based upon a compilation of many other forecasts, including forecasts from the following sources.

- American Association for the Advancement of Science
- Battelle Memorial Institute
- Department of Defense Military Critical Technologies
- George Washington University
- National Science Foundation
- National Academy of Sciences/National Research Council
- New Technology Week
- NIST Advanced Technology Program
- Oregon Business Magazine
- R&D Magazine
- Technology Review
- U.S. Office of Science and Technology Policy
- World Future Society

The RTI composite forecast for top technologies and industries over the next 10 to 20 years is provided in Exhibit 2.4. It includes both manufacturing and service industries. Entries were selected on a qualitative basis. Judgments were made based on frequency of inclusion in the various reference lists, coupled with RTI's experience in technology commercialization. In generating the RTI forecast, a number of observations were noted:

- energy production and better energy efficiency will be important
- the revolution in biological sciences will continue, such as practical applications from the rapidly increasing understanding of genetics
- the evolution of information technologies will continue, including computers, software and communication devices
- the relatively new field of nanotechnology[5] holds great promise for a range of new technologies

[5] Nanotechnology (molecular manufacturing) is a branch of engineering that deals with the design and manufacture of extremely small electronic circuits and mechanical devices built at the molecular level of matter.

Exhibit 2.4: Top U.S. Technologies and Industries through 2020

Industry/Technology Sector	Related Applications	Contributing Technologies
Bioinformatics and Biological Computing	Instrumentation Sequence Analysis Software	Computing Genomics Nanoscale Devices Proteomics
Biomedicine (Molecular Biology and Medicine)	Genetic Engineering for livestock, crops, weed and pest control, nutritional control, and design for different environments Medical devices Pharmaceuticals	Biotech/Biomedicine Genomics Marine Biology MEMS Proteomics Sensors
Communications Equipment/ Infrastructure	Broadband Internet GPS Systems Optical networks Portable Information Appliances Wireless Internet and Communications	Advanced Materials and Materials Processing Digital Rights and Security MEMS Microelectronics Micro/nano Satellites Photonics
Computer, Software, and Data Processing Services	Distance Learning High Performance Computing – Applications in Genetics, Proteomics, Health Care, Modeling, Simulation, and Design Software – Application Specific Software – Embedded Voice/Language Processing	Computer Science Genetic Algorithms Mathematics Neural Networks Photonics Wireless and Satellite Communications
Energy	Batteries Fuel Cells Micro Turbines Portable Power Sources	Advanced Materials and Materials Processing Nano-structured Materials, Sensors, Instruments Nuclear Sensor Technology
Environmental	Clean Coal Precision Farming Remote Sensing and Monitoring Water Treatment	Advance Materials and Materials Processing Biotechnology Chemical processes Communications Sensors/Imaging

Exhibit 2.4: Top U.S. Technologies and Industries through 2020 (continued)

Industry/Technology Sector	Related Applications	Contributing Technologies
Healthcare Services	Genetic-based Diagnostics for Disease Treatment and Prevention Implanted Devices Information Systems Telemedicine – Remote Patient Monitoring and Care	High Performance Computing Sensors, Embedded Sensors Software Smart Systems Wireless and Internet
Microelectronics and Optoelectronics	Flexible Transistors MEM Devices Organic Devices Solid State Lighting	Advanced Materials and Materials Processing Laser Processing MEMS and Nanotechnology
Transportation	Air – New Designs, Materials, and Propulsion Systems Automotive – Hybrid Vehicles, 42V Electrical Systems, Etc. Energy-Power Sources Ships – New designs, materials, and propulsion systems	Advanced Materials, including Nano-composites and Materials Processing Composite Materials Computer Design and Analysis Modeling and Simulation Nano-instrumentation Sensors Smart Systems
Smart Systems	Embedded sensors Heating/Cooling Systems Industrial Processes Manufacturing Systems, Robotics Intelligent Appliances	Advanced Materials Automotive Distributed Control Systems Internet Microelectronics Wireless Communication

Regional Industrial Technologies

The technologies found in regional technology-based companies represent the final key piece of information for identifying potential thrust areas. Technology capabilities currently contributing to the regional economy provide opportunities for leveraging economic growth over the short-term. These technology capabilities are presented in Exhibit 2.5: Regional Industrial Technology Capabilities.

This list of industrial technology capabilities was derived from information provided from a number of organizations and other sources. Major sources included:

- Hampton Roads Economic Development Association
- Hampton Roads Technology Council
- Golden Egg (Center for Innovative Technology)
- Peninsula Alliance for Economic Development.

Other sources included:

- Hampton Roads Partnership
- Hampton Roads Technology Incubator
- Hampton Roads Inc.
- Newport News Economic Development Association
- Hampton Roads Planning District Commission
- Chmura Economics and Analytics
- OneSource Information Services, Inc., CorpTech Division code listings for the area

Companies are organized under technology headings. No attempt was made to order the companies by size, strength, or any other measure. The scope of the company listing is not exhaustive, but is rather a representative list of technology presence. In some of these headings (software for example) there are many more companies active in the region than those listed. However, the list reflects most, if not all, of the important technology capabilities represented within the region.

It is clear that the regional economy is strongly dependent upon U.S. government spending and the shipbuilding and repair industry. The largest companies in the region serve these organizations. Most of the other regional technology companies are relatively small (some might employ on the order of 1,000 people, most are much smaller). Furthermore, these remaining technology-based companies are diverse in their focus.

Exhibit 2.5: Regional Industrial Technology Capabilities

Aerospace

AeroTech Research
Bihrle Applied Research
Honeywell Technology Solutions
Integrated Systems Control, Inc.
Tecnico

Chemicals

Allied Colloids
BASF
C.E. Thurston
Ciba Specialty Chemicals USA
NOVA Chemicals

Communications

ACS Systems and Engineering
ALLTEL Communications
Cable and Wireless
Celtranix Telemetry
Cox Communications
GSTEK, Inc.
Metro Information Services
Milcom Systems Corp.
Texcom, Inc.
Verizon Communications

Computers, Office Equipment and Services

ARS Manufacturing
Canon Virginia
Mitsubishi Chemical America Imaging Division
Planning Research Corp.
ProSoft

Electronic Components, Accessories, Research

Automation Controls
General Dynamics Electronics Systems Division
Maida Development (capacitors, etc.)
TDS, Inc.

Exhibit 2.5: Regional Industrial Technology Capabilities (cont'd)

Energy, Environmental

Allied Colloids
Buchart Horne
CH2M Hill
Evercel
Gannett Fleming
Hilton's Environmental
Malcolm Pirnie
URS Consulting

Engineering, Modeling and Simulation

Anteon Corp.
BMH Assoc.
CACI, Inc.
Dynamic Engineering
Science Applications International Corp.
URS Consultants

IT Systems

Allied Technology Group
CACI, Inc.
Computer Sciences Corp.
Convergent Technologies
ManTech International Corp.
Metro Information Services
Raytheon Technical Services
ZEL Technologies

Manufacturing

Cooper Automotive
Dynamic Engineering – Center for Rapid Prototyping
First Data Resources
Hanmi International Corp.
Howmet Castings
John Deere
MG miniGears
Muhlbauer High Tech International
Newport News Shipbuilding
NGK-Locke Polymer Insulators
Opton, Inc.
Siemens Automotive
Southland Technologies
Stihl
Volvo Penta of the Americas

Exhibit 2.5: Regional Industrial Technology Capabilities (cont'd)

Marine and Naval Engineering

- CDI Marine Company
- J.J. McMullen and Associates
- M. Rosenblatt & Sons
- NNS - Virginia Advanced Shipbuilding and Carrier Integration Center
- Q.E.D. Systems
- VSE Corporation

Medical, Biotechnology

- BIOcompatibles
- BioEnhance
- Bionetics
- Code Laboratories, Gambro Inc.
- Dilon Technologies
- Jones Institute
- LabCorp
- LifeNet

Sensors, Instrumentation

- Controls Corp. of America
- Face International
- Lucas Controls Systems
- Oceana

Shipbuilding, Maintenance

- Earl Industries
- Lyon Shipyard
- Marine Hydraulics International
- Metro Machine Corp.
- Newport News Shipbuilding
- Norfolk Naval Shipyard
- Norfolk Ship Repair and Drydock

Software

- Arrowhead Technologies
- Bionetics
- Choice Information Systems
- Computer Sciences Corp.
- Dendrite International
- ECI Systems and Engineering
- Ferguson Enterprises
- Great Bridge (database management)
- K&R Custom Software
- Monette Information Systems
- Network Dynamics
- Oop
- Pensoft
- S3, Ltd.
- Science Applications International Corp.
- Symantec
- The Moore Group

Results of the Gap Analysis – Thrust Area Opportunities

The gap analysis was conducted by comparing the three compiled lists: the regional research strengths, the top technologies, and the regional industry technology strengths. By analyzing these three lists for gaps and intersections, three short-term and six long-term thrust areas were identified.

As shown in Exhibit 2.1, the gap analysis was conducted by comparing these lists in different combinations: the list of regional research strengths against the list of top technologies, the regional industry technology strengths against the top growth technologies, and the regional research strengths against the regional industry technology strengths. Areas of technology that were present on two or all three lists were identified. After the initial lists of doubles and triples were determined, additional clarification on whether to consider a particular area as a strength was obtained through focused interviews. Depending on the degree of overlap between university research and the presence of industry technologies, these thrust areas were characterized as either short-term (one to five years) or long-term (five to 10-plus years) thrust area opportunities.

The short-term opportunities are top technologies that have complementary activities found in both the research labs and the regional companies (a high degree of intersection or overlap between regional university and corporate R&D strengths and the top growth technologies). Long-term thrust areas, on the other hand, are characterized by a weak overlap between existing research strengths and the regional industrial technology base. For each of the long-term thrust areas, there is evidence of significant research being conducted at regional research institutions, but little evidence of regional industrial strength in the technologies involved. No cases were found where a technology strength existed in the region that was not also represented in an area R&D organization.

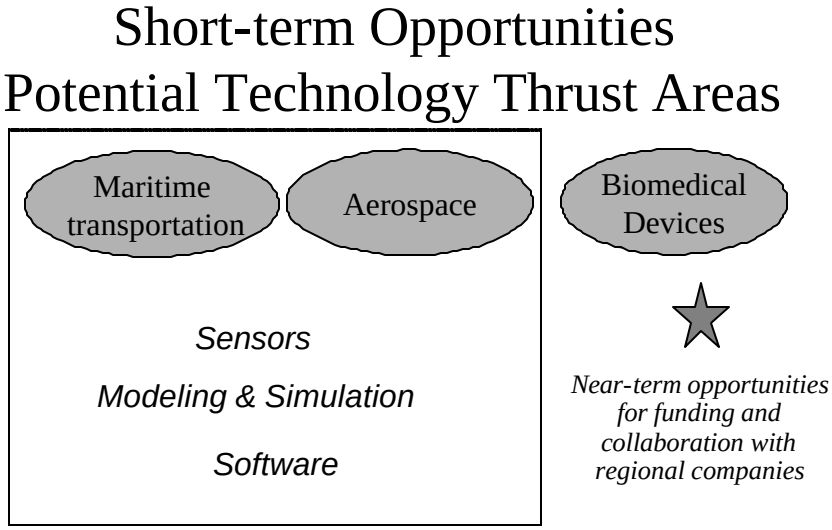
The short-term and long-term thrust areas are presented in the following two sections. Appendix B also provides a listing of these short- and long-term thrust opportunities and their related OneSource Information Services, Inc., CorpTech Division (CorpTech®) industry code listings. CorpTech codes are descriptive of products and services provided by high tech companies. The codes provided in the appendix are representative of the primary industry CorpTech classifications represented by each of the thrust areas.

Short-Term Thrust Areas

Top technology areas with representation from both university research and regional companies were identified as short-term opportunities. These areas provide potential thrust efforts whereby individual efforts can be leveraged upon each other for greater benefit, and can lead to joint programs and strategies for garnering research funding that can lead to commercialization activities and economic growth. It should be noted that one-on-one discussions among regional companies and researchers regarding plans and strategies will be key to capitalize on these opportunities (see Section 4, Recommendations, for specific ways to facilitate discussions).

There are three short-term thrust areas: maritime transportation; aerospace, and biomedical industries (such as medical devices). Exhibit 2.6 shows these three areas, followed by a brief description of each. Three cross-cutting technology areas that support the three thrust areas were identified and are shown beneath the three short-term thrust areas in Exhibit 2.6. A discussion of funding opportunities for the thrust areas follows in Section 3, Opportunities for Funding in Thrust Areas.

Exhibit 2.6: Short-term Thrust Opportunities



Maritime transportation – Maritime transportation includes technologies associated with designing, manufacturing, repairing, and maintaining ships and their systems – both military and commercial. Power and propulsion systems, materials, sensors, software and computing, communications, and navigation and control technologies are crucial to maritime transportation.

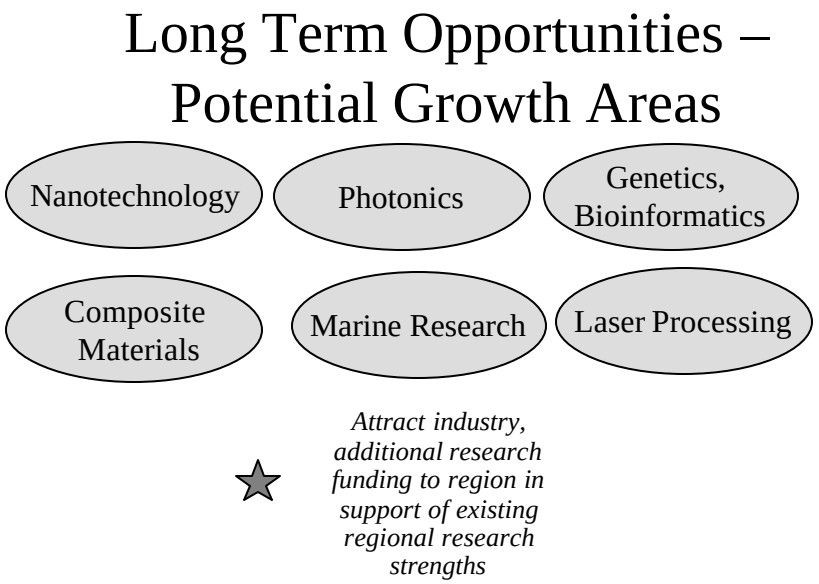
Aerospace – Aerospace includes technologies that support the design, manufacture, and launch of commercial and government-sponsored aircraft, spacecraft, satellites, and related subsystems. New designs, materials, sensors, software, and instrumentation contribute to improvements in propulsion, communications, and controls for safer and more cost-effective vehicles and systems.

Biomedical industries – This area involves biomedical devices, including instrumentation and equipment used for sampling, monitoring, analyzing, or altering the biological condition. The development of biomedical devices requires the marriage of engineering (mechanical, chemical, and electrical, e.g.) with medicine.

Long-Term Thrust Opportunities

Areas of significant university/national lab research strengths that do not have corresponding presence in the regional industry base are viewed as longer term thrust opportunities. Economic impact over the short term would be limited, given that there is little or no overlap of these university research activities with the core technologies of the regional companies, and therefore, no short-term opportunities for leveraging these research strengths into commercial activities. While the lack of the commercial component limits short-term economic opportunities, the institutional R&D strengths can provide new opportunities for attracting research funding to further build these efforts. There is also a significant opportunity for increased collaboration among the regional institutions to strengthen these thrust areas. Furthermore, increased funding and collaborative efforts can create spin-off companies, or attract companies to the region. The long-term thrust opportunity areas are nanotechnology, photonics, laser processing, composite materials, marine research, and medical genetics-bioinformatics. They are shown below in Exhibit 2.7, followed by a brief description of each.

Exhibit 2.7: Long-term Thrust Opportunity Areas



Nanotechnology – This technology is a combination of chemical science and engineering related to molecular manufacturing. *NanoTechnology* magazine describes it as "building things one atom or molecule at a time with programmed nanoscopic robot arms. A nanometer is one billionth of a meter (3-4 atoms wide). Utilizing the well understood chemical properties of atoms and molecules (how they "stick" together), nanotechnology proposes the construction of novel molecular devices possessing extraordinary properties." Representative nanotechnology applications include:

- high performance computing and data storage
- advanced miniaturization of systems
- smart sensors and actuators
- biomedical sensors
- ultra-small probes, nano-spacecraft, and nano-rovers
- nanotubes
- self-assembling molecules
- biomimetic nanostructures
- revolutionary materials (e.g. semiconductors, nanocrystals, nanoclusters, magnet particles)

Photonics – Photonics is a branch of physics that deals with the properties and applications of photons especially as a medium for transmitting information. Photonics includes the fields of optics, lasers, imaging and fiber optics. The science includes light emission, transmission, deflection, amplification and detection by optical components and instruments, lasers and other light sources,

fiber optics, electro-optical instrumentation, etc. The range of applications of photonics extends from energy generation to detection to communications and information processing.

Laser processing – This method of materials processing involves the use of lasers to process materials, including plastics, synthetic fibers, advanced materials, and metals (welding, cladding, cutting, surface transformation hardening, creation of near-net-shape components). It can be used for coatings removal, and remediation of hazardous materials as well as components for electronics, microtechnology, and nanotechnology. Laser processing may be used to produce polymer fabrics, recyclable beverage and food packaging, corrosion-resistant metals with increased toughness; mechanical and optical components with precisely micromachined features; micro circuitry; and electronics for use in harsh conditions. Ultrahigh-density CD-ROM technology and improved micro-optical devices are examples of laser-processed devices.

Composite materials – This industry involves the combination of materials differing in composition or form (fiber reinforced polymers are examples). Composite matrix materials include polymers, metals matrix, and ceramics. Fiber and powder reinforcements can be made of carbon, ceramics, and polymers.

Marine research – The study of the characteristics and properties of marine organisms is the focus of marine research. Example applications include pharmaceuticals based on marine compounds and technologies that clear undesirable organisms from tanker ballast.

Genetics and bioinformatics – This area involves the development, processing, warehousing, and manipulation of complex data sets about biological information, such as genetic codes. One goal of bioinformatics would be the development of a data system that would allow a medical treatment to be tailored to a person's genetic code.

This gap analysis was based on an understanding of the important technologies to the region's academic institutions and companies. There are other economic factors that are important in deciding thrust areas for Hampton Roads. Among the factors that should complement this gap analysis, and were not considered within the scope of this analysis are: the region's overall business climate, its political and business institutions, new business support mechanisms, geography, transportation infrastructure, utility infrastructure, energy costs, and labor availability. It should also be noted that in focusing on technologies for short-term opportunities, the approach taken in this analysis does not consider the business strategies of the regional technology companies. Company surveys were beyond the scope of this study. While all of these factors can be crucial to the successful implementation of growth plans, they are considerations that should be identified and evaluated through an on-going interaction among key business and research institutions throughout the region. The regional leadership's collective knowledge about these factors should always become an intrinsic part of any regional plan, helping to shape goals and expectations accordingly.

3. Opportunities for Funding in Thrust Areas

As previously described, the region has a number of economic sectors with potential for R&D collaboration among HRRP, industries, and organizations composing these sectors. Three promising sectors, or thrust areas, are maritime transportation, aerospace, and biomedical devices.

R&D funds these sectors are available from a variety of sources, including federal agencies, state and local governments, foundations, industry, and private investors. Within these funding sources, federal agencies have historically provided the largest share of R&D funding to both academic institutions and research laboratories. In 2001, for example, federal sources accounted for $17.9 billion of approximately $32 billion (in current dollars) spent on all R&D at U.S. academic institutions. Health and Human Services ($11 billion), the National Science Foundation ($2.8 billion) and the Department of Defense (DOD) ($1.5 billion) are the top three federal sources for academic R&D funding.

Identifying potential sources of funding for specific or proposed projects should be an on-going process, involving HRRP's key leadership, development offices at the universities, and relevant commercial partners. Outside consulting groups, including RTI, are available to help HRRP identify funding sources for specific projects, as well as help prepare proposals or other documentation to pursue funding. However, the key to any successful fund-raising effort is a strong commitment from key people who would be directly involved in a proposal's work – individuals at campuses, organizations, and businesses working together to promote their own ideas for R&D funding.

A few examples of collaborative R&D potential within major thrust areas are given in this section, followed by a selective list of resources that may be helpful in seeking potential funding.

Maritime Transportation

Maritime transportation is the dominant industry within the region. It includes both military and commercial activities, as well as industries or technologies associated with designing, building, and maintaining ships and their systems. Power and propulsion systems are included, as are materials, sensors, computing, communication and navigation technologies. This thrust area includes a number of technologies represented within the region's research and technology base.

The Virginia Advanced Shipbuilding and Carrier Integration Center (VASCIC) is an excellent example of regional R&D synergies emerging within this thrust area.

With state support, the 230,000-square-foot VASCIC in Newport News is expected to house 400 people from Newport News Shipbuilding and other shipbuilders, the U.S. Navy, private industry and area universities who will "develop, evaluate, and insert new cost-effective technologies that enhance capability, flexibility, survivability, and combat effectiveness of Navy vessels" (http://www.vascic.com/).

The U.S. Department of Transportation's Maritime Administration, Office of Shipyard Revitalization, administers a program that offers opportunities for collaborative funding for improving ship design and construction processes in U.S. shipyards. Since its inception in 1994, MARITECH has funded $349 million in projects involving maritime companies and over 20 colleges and universities.

In addition, the National Shipbuilding Research Program (NSRP) is a potential resource for the HRRP. NSRP is composed of 11 U.S. shipyards that collaborate on shipbuilding research and development with government, industry and academia.

R&D related to shipbuilding may include the following:

- nanomaterials and composites, such as polymer or metal matrix composites based on carbon nanotubes and other nanostructures for use in fuel cells, batteries, turbines, and electrical systems
- sensors and actuators for ships, including applications for hydrodynamic surface control
- advanced concepts in hull designs, other structures, and propulsion systems

In addition, examples of on going R&D financed by the DOD help illustrate the potential for funding within the maritime transportation thrust area. These current studies include ship and submarine signature research, development of advanced electric power systems, thermal and electric propulsion (torpedo, mobile mine, and countermeasure applications), fuel tank oxygen sensors for live-fire ballistic testing, and fiber reinforced polymer composites for infrastructure applications.

Aerospace

Aerospace is another vital sector of the regional economy that offers a range of opportunities for academic and commercial R&D partnerships. In addition to commercial aviation, the region is home to Langley Air Force Base and NASA's Langley Research Center. R&D for the aerospace industry include both aviation and space applications. Langley Research Center, for example, supports research with space applications as well as research in aviation safety, hypersonic air travel, and revolutionary aircraft design and manufacturing. The center also seeks ways

to make airplanes quieter, more energy efficient, more environmentally friendly, and cheaper to manufacture, maintain and fly.

As in the maritime transportation thrust area, aerospace R&D involves design, construction, and maintenance as well as a number of supporting technologies. Emerging aerospace technologies include the development of nanomaterials and composites that may have important applications in airframe construction, propulsion systems, sensors, smart materials, and actuators.

Moreover, an example of regional R&D collaboration within this thrust area is the Virginia Small Aircraft Transportation System Laboratory Alliance (SATSLab), in which NASA and the Federal Aviation Administration are partnering with state government and industry to showcase key technologies for vehicles, airports, and other infrastructure. In July 2001, NASA awarded SATSLab $2.5 million for research involving small aircraft. Blacksburg, Danville Regional, Manassas Regional and Newport New s/Williamsburg airports are tentatively designated as venues involved in SATSLab. SATSLab may represent an opportunity for academic R&D participation in the emerging field of personal air transportation.

Among other regional collaborative efforts are:

- laser processing research by Northrop Grumman and the Aerospace Corporation, as well as several universities (member institutions of the Laser Processing Consortium at Jefferson Labs)
- simulation for advanced concepts in aircraft designs and structures for NASA at Old Dominion University

Biomedical Devices

Biomedical research is largely represented by Eastern Virginia Medical School in Norfolk. However, related activities are in place that could be leveraged into biomedical applications. Potential target areas for R&D include sensors, actuators, and devices for patient diagnostics, home care, remote patient monitoring, and drug delivery. This thrust area has the potential of attracting NIH funding.

Other Technology Areas that Support the Thrust Areas

Computer modeling and simulation, software development, and sensor technology are other leading areas with strong representation within the region's universities and commercial communities. While in themselves not notable end-user industries, these three areas are broad cross-cutting capabilities that support the primary thrust areas.

Modeling and simulation could serve as an important component of a larger activity directed at specific areas of the regional economy. Modeling and simulation applications overlap other thrust areas, including maritime transportation and aerospace. The presence of modeling and simulation capabilities within the region could also be used to leverage activity within new technological or industrial sectors.

A few companies and universities within the region are involved in modeling and simulation services, including Dynamic Engineering Inc. (DEI) in Newport News and the Virginia Modeling and Simulation Center (VMASC) at Old Dominion University. DEI provides design, analysis, manufacturing, and test support for aerospace and marine customers. VMASC helps develop new simulation technologies under the sponsorship of Old Dominion University, the DOD, the Commonwealth of Virginia, and the City of Suffolk. The center consists of a consortium of Virginia universities.

The National Computational Science Alliance is a nationwide partnership of more than 50 academic, government and business organizations working together to prototype an advanced computational infrastructure for the new century. Opportunities for involvement in this and similar technology consortia continue to develop.

There are a significant number of regional companies providing software development services and products, and the region's universities are also involved in software activities. Like modeling and simulation, this regional strength could help leverage development of other industries and regional capabilities.

JLab and LaRC have significant sensor technology capability, as do as some of the academic institutions. There are a small number of regional companies involved in sensor technology. Sensor R&D is key to the development of new maritime, aerospace, and biomedical devices.

Potential Growth Areas

In addition to the thrust areas above, the region has six areas of emerging research capabilities – nanotechnology, composite materials, photonics, marine research, laser processing, and specialized medical fields such as genetics and bioinformatics. Nanotechnology is particularly compelling due to substantial increases in funding by many federal agencies and the formation of the National Nanotechnology Initiative. Nanotechnology is an emerging technology with limited commercial markets at this stage of development. Therefore, the absence of commercial activity is not a disadvantage relative to other regions in the country. The number of potential applications for nanotechnology, however, is very broad, and the challenge for HRRP is to identify emerging nanotechnology opportunities that mesh with existing regional strengths and activities.

These potential growth areas offer long-term opportunities to attract business or additional funding to the region. Many of them are closely allied with the major thrust areas (e.g., composite materials with virtually all thrust areas). Because of these close associations, HRRP members should be mindful of opportunities to expand or modify specific proposals to include activities within these six areas.

Selected Funding Resources

Funding for basic and applied research is available from a variety of federal, state, local, and private sources. As previously indicated, the majority of the most promising funding opportunities will be found among a few sources, most of them federal agencies. Successful funding requires an on-going effort to match the region's most appealing opportunities with funding when available, and to do so in a timely way. Regional opportunities are ever changing, as are the opportunities for funding.

Many information sources for funding opportunities have migrated to the World Wide Web. A concise, representative list of Web sites helps illustrate the kinds of funding resources that should be routinely monitored.

The major funding agencies and the requested FY2002 budgets are listed below. These budget figures are comprised primarily of 6.1 (basic research) and 6.2 (applied research) funding. All figures are from the OMB data for R&D for FY 2002, *Budget of the United States*.

Agency	FY 2002 Budget ($ million)
HHS	23,496
NASA	7,033
DOE	6,329
DOD	4,963
NSF	3,017

The following material provides commentary and references for selected funding sources that may be relevant to R&D in the thrust areas. While it is not an exhaustive treatment, the references will lead to ample funding opportunities for specific projects that academic researchers and collaborators may choose to pursue. This listing includes federal government references, private company resources, state government sponsored information, and some topical resources relevant to the thrust areas.

According to the National Science Foundation, federal funding for R&D for all academic institutions has been over $15 billion for the past 3 years. Detailed funding data are notoriously difficult to interpret. Data are plentiful, but the classification and qualification vary quite broadly. The federal funding data cited

below is taken from a consistent set of data provided by the National Science Foundation for total federal funding obligations in fiscal year 2001 for universities and colleges. These data are shown for comparative purposes; therefore, precise current figures are unnecessary for the present discussion.

Health and Human Services

HHS provided about $9.6 billion in R&D funding to universities and colleges in 2001, much of that through the National Institutes of Health ($9.4 billion). NIH funds a wide variety of programs relevant to the HRRP such as bioengineering and bioinformatics. Most of the grant proposals that are submitted to NIH are unsolicited. Information on programs and funding is available at http://www.hhs.gov/agencies/grants.html.

National Aeronautics and Space Administration

NASA's basic and applied research budget is primarily used by its three research centers, Langley (Hampton, VA), Glenn (Cleveland, OH), and Ames (Moffett Field, CA). These centers often work in collaboration with universities and companies in their regions. NSF reported that NASA obligated R&D funds exceeding $740 million for universities and colleges in FY 2001. Research announcements that are available on the Web can be found through http://www.nasa.gov/research.html. Opportunities for collaboration are identified through program offices, commercialization offices, and one-on-one networking. NASA's SBIR and STTR budgets total almost $100 million.

Department of Energy

The DOE budget for R&D includes many components of interest to the HRRP area. High-energy physics represents$706 million (part of which goes to Jefferson Labs), Basic Energy Sciences ($997 million), Biological and Environmental Research ($2,930 million), and Fossil Energy ($296 million) all contain research topics of interest. NSF reported that DOE obligated R&D funds exceeding $620 million for universities and colleges in FY 2001. Partnership information can be found at http://www.energy.gov/business/partners/techpartner.html. DOE has a wealth of other Web sites for obtaining information on their organizations and opportunities. An interesting place to start is http://www.osti.gov/das.html, a site created by DOE's Office of Scientific and Technical Information.

Department of Defense

NSF reported that DOD obligated R&D funds exceeding $1.16 billion for universities and colleges in FY 2001.

The Navy's $455 million basic research budget for FY 2002 is controlled by the Office of Naval Research http://www.onr.navy.mil/onr/. Science and Technology programs are discussed in detail through http://www.onr.navy.mil/sci_tech/default.htm. The Navy provided almost $270 million in R&D funding for universities and colleges in FY 2001. In particular, the Navy is seeking R&D advances in many of the materials, sensors, modeling and simulation, and propulsion technology areas for which this study found R&D and industrial strengths in the Hampton Roads area.

The Army basic research budget of $222 million for FY 2002 includes $69 million for university and industry research centers., a potentially relevant topic for HRRP. Overall, the Army provided about $82 million in R&D funding for universities and colleges in FY 2001. In addition to networking at the various Army research facilities, funding opportunities can be found through the Army Research Office http://www.aro.army.mil/research/index.htm. One of the newer programs for which they are seeking research proposals is the Institute for Soldier Nanotechnologies http://www.aro.army.mil/soldiernano/index.htm. Army research opportunities are also found through the Army Research Laboratory, http://www.arl.army.mil/main/Main/default.cfm.

The Air Force basic research budget for FY 2002 is $221 million. The Air Force Research Lab (AFRL http://www.afrl.af.mil/) is responsible for the research activities in the US. AFRL has ten directorates covering applications from propulsion to sensors to materials and manufacturing. The Air Force Office of Scientific Research, http://afosr.sciencewise.com/index.htm, manages the basic research programs. Information about funding opportunities is available at http://afosr.sciencewise.com/oppts/afrfund.htm#research. NSF reported that the Air Force obligated R&D funds exceeding $106 million for universities and colleges in FY 2001.

Other DOD agencies that offer relevant research grants are the Defense Advanced Research Projects Agency http://www.darpa.mil/ and the Ballistic Missile Defense Organization http://www.acq.osd.mil/bmdo/bmdolink/html/bmdolink.html. NSF reported that DARPA obligated R&D funds exceeding $345 million and BMDO obligated about $4 million for universities and colleges in FY 2001.

- **National Science Foundation**

NSF is the second largest source of R&D funding for universities and colleges behind HHS, providing a total of $2,634 million in FY 2001. The HRRP membership is well aware of the NSF sources, funding levels, and processes. The basics of applying for funding are found at http://www.nsf.gov/home/programs/guide.htm.

- **General Services Administration**

The GSA operates a web site, http://FedBizOpps.gov, that provides information on all of the current federal procurement notices valued at more than $25,000. While much of the content is for routine equipment and services procurements, the FBO also includes the R&D solicitations that are announced in the Commerce Business Daily. FBO offers subscriber services that include email notification about postings from selected organizations and product service classifications.

- **Community of Science, Inc.**

COS is a privately held company offering services to the R&D community through a web site. Some of the services are free, but premium tools are subscription-based. A comprehensive compilation of R&D funding opportunities is described at http://fundingopps.cos.com/. The data are updated daily and contain more than 400,000 individual funding opportunities. Annual subscriptions are available at reduced prices for non-profit organizations.

- **Virginia Center for Innovative Technology**

CIT maintains a Web site at http://www.cit.org/. The CIT information and the Innovation Avenue Web site at http://www.innovationavenue.com/ contain a wealth of information about industries, regions and resources throughout Virginia. Information about state funding sources is also available. Both sites are free of charge.

- **Regional Information**

The nonprofit Hampton Roads Technology Council provides links to numerous resources, some of which contain information about funding opportunities. The links are located at http://www.hrtc.org/links.html.

- **Private Foundations Funding**

Private funding is substantial. The portion of funding that goes toward R&D is unknown, but the largest funders of private grants are Lilly Endowment Inc., Bill & Melinda Gates Foundation, The Ford Foundation , and the David and Lucile Packard Foundation. All four have assets in the $15 billion range. Comprehensive information resources about private foundations are available online at The Foundation Center at http://fdncenter.org and Foundation Finder at http://fdncenter.org/funders. Pricing for the Foundation Directory Online starts at $20 per month.

Some of the sources for information that will be useful for the major thrust areas are cited below.

- **Nanoscale Sciences**

The nanotechnology field is in its commercial infancy. The National Nanotechnology Initiative is, of course, an important driver, http://www.nano.gov/. This field of research is without question one of the hottest in the world. It is also lean on commercial applications because much of the science has yet to be successfully applied to solving real problems. One of the best comprehensive sources for information about R&D programs in this field is the Loyola University Web site sponsored by the National Science Foundation, http://itri.loyola.edu/nanobase/.

- **Ship Construction and Design**

Information on MARITECH, the Maritime Administration's program for ship construction and design, can be found at http://marad.dot.gov/nmrec/maritech/maritech.html. Joseph Byrne, director, Office of Shipbuilding and Marine Technology, is the main contact at 202-366-1931 or joseph.byrne@marad.dot.gov.

- **National Shipbuilding Research Program**

Information on the NSRP funding programs, primarily through their Advanced Shipbuilding Enterprise, can be found at http://www.nsrp.org/ase_description.html. As stated on their Web site, "NSRP is led by collaboration of 11 U.S. shipyards working as a team with government, industry, and academia to achieve the continuous product and process improvements necessary for the U.S. shipbuilding industry to become internationally competitive, directly resulting in more affordable Navy ships. NSRP is sponsored by the Naval Sea Systems Command." NSRP is also

associated with a Web site maintained by Penn State, http://www.usashipbuilding.com/home.html.

4. Recommendations

In this section, we provide recommendations that contribute to HRRP's goal of using its technology base to generate regional economic development and additional higher-wage jobs. We have focused particularly on activities that will increase R&D funding for HRRP members, technology transfer capabilities and programs, and commercial applications of new technologies.

RTI's recommendations follow directly from the results of the gap analysis, particularly the identification of short- and long-term thrust areas, and are supported by specific actions useful for implementation. In crafting these recommendations, we have also drawn lessons from case studies of three other regions that have a vigorous university or lab-based, technology-driven economy. The case studies for San Diego, Denver, and Albuquerque/Santa Fe appear in Appendix A. They provide relevant examples of techniques and collaborative efforts that have fostered growth in the high technology sector in comparable regions. The recommendations also reflect information gathered as part of RTI's research of funding opportunities in the thrust areas and interviews with area economic development agencies representing Hampton Roads jurisdictions.

Recommendations and actions are divided by short-term and long-term to address both groups of thrust opportunities. A few of the actions are mainly applicable to specific thrust areas, but the majority apply to all thrust areas. Within the short- and long-term categories, we have further subdivided recommendations into the following topic areas and, in some cases, provided an illustrative precedent from the case studies:

- Identification of funding opportunities
- Support for technology commercialization
- Communication, networking, and partnerships
- Public relations and marketing
- Building a broader technology resource base

These recommendations, which are based on the gap analysis and the three case studies, are options for first steps for the HRRP as it begins to develop the thrust area opportunities outlined in this report. It might be useful to extract lessons from other regions that have utilized industry "clusters"[6] to drive economic growth. One source that HRRP should use is the Council on Competitiveness, a Washington-based nonprofit group that seeks ways to improve U.S. economic competitiveness and leadership in world markets. The council has recently completed a study of five U.S. regions as part of its Clusters of Innovation Initiative, which looks at how clusters develop and what regions can do to foster cluster development.[7]

[6] Clusters are defined as geographically close groups of interconnected companies and associated institutions in a particular field, linked by common technologies and skills.
[7] The Council of Competitiveness studied five regions: Research Triangle, San Diego, Wichita, Pittsburgh, and Atlanta. The Council plans to issue its national report on 12/13/01. See http://www.compete.org/bench/bench_index.html

Short-Term Recommendations and Actions

As a preface to the short-term recommendations, we offer several overarching themes for consideration:

- Consistent, well-organized, and interactive leadership is essential to the success of any economic development initiative.
- Demonstrating a pattern of initial success is important for garnering and maintaining public support to achieve longer-term goals.
- Every development initiative needs to establish a performance monitoring system early in the process that includes agreed upon intermediate and long-term indicators of success.
- To ensure a high level and quality of participation, academic and institutional stakeholders need to realize some direct benefits from supporting regional economic development efforts.
- All stakeholders need to demonstrate a commitment to working together over the long haul. Expectations of the amount of time and resources needed to achieve success have to be reasonable.

In keeping with the methodology of the gap analysis, the recommendations for short-term actions take advantage of existing capabilities in both research institutions and the private sector. These capabilities should decrease the amount of time necessary to implement the short-term recommendations and increase the likelihood of success. At the same time, the eight recommendations below (and the proposed actions that follow each) address not only thrust area opportunities but also organizational, political, and economic issues critical to technology-based development.

1. **Recommendation –** Identify federal sources of funding for applied research projects in the short-term thrust areas.

Action – Review the 2002 R&D budgets for each of the federal agencies involved in funding research in the five near-term thrust areas (e.g. Office of Naval Research, National Institutes of Health, and Air Force Research Lab). Visit selected R&D staff to discuss their priorities for the next fiscal year.

Action – Discuss R&D priorities in the thrust areas with staff of congressional committees that are overseeing relevant federal agencies to determine if there are mandated research projects recently funded or planned (particularly staff of Virginia congressmen serving on these committees):

- House Armed Services Committee (Rep. Jo Ann Davis, Rep. Edward Schrock and Rep. Randy Forbes)
- House Committee on Science (Rep. Randy Forbes)
- Senate Armed Services Committee (Sen. John Warner is ranking minority member)
- Senate Health, Education and Labor Committee (Sen. John Warner)
- Senate Commerce, Science and Transportation Committee (Sen. George Allen)

Action – On a systematic basis, review the *Commerce Business Daily* announcements of requests for proposals from relevant federal agencies (use electronic screening to generate alerts).

Action – Seek assistance from Virginia's congressional delegation in establishing a "level playing field," if not preferences, for federal funding of high-priority research projects.

Action – Monitor rollout of the Transportation Infrastructure Finance and Innovation Act (TIFIA)[8] for the addition of aviation and maritime infrastructure projects.

Lessons Learned: San Diego

The San Diego Venture Group provides a forum for entrepreneurs, venture capitalists, and advisors to exchange ideas. Informal monthly meetings feature a panel discussion by cross-industry experts on a specific topic.

2. **Recommendation –** Showcase technology developed locally in the short-term thrust areas and bring together researchers/entrepreneurs and service providers.

Action – Develop a regularly held series of meetings focusing on promising new technologies or products by HRRP members. Invite selected venture and "angel" investors, law firms, potential corporate partners, and area economic development agencies.

[8] TIFIA is a five-year, $10.6 billion program using federal loans, loan guarantees, and lines of credit to support transportation projects, for both military and commercial activities.

Action – Periodically organize educational events to showcase new technologies and bring product developers in contact with funding agencies, service providers, and corporate partners.

Action – Invite university and private researchers working in the short-term thrust areas to serve on an industry recruitment team to promote Hampton Roads research and technology applications to technology companies that are relocating or expanding.

3. **Recommendation –** Serve as a catalyst for recruitment and formation of technology companies and new high-tech applications, and motivate faculty to create spin-off companies.

Action – Increase the technology transfer capabilities of HRRP members (especially for beginning or emerging-level institutions) by setting clear strategic objectives for technology transfer, and coordinating training and networking opportunities. Encourage HRRP members to join the Association of University Technology Managers (AUTM).

Action – Work with HRRP members to create a unified set of policies to support and regulate the commercialization of research, including sabbaticals, ownership and licensing royalties, conflict of interest. Provide licensing, legal and administrative support to faculty interested in commercializing a product.

Acton – Work with HRRP members to create a program of incentives for university/industry collaboration in technology research and commercialization.

Action – Create an HRRP Technology Transfer Office that would act as a "single-point-of-business" for technology transfer assistance and help in identifying and removing barriers to start-up and expansion for private sector partners.

Lessons Learned: Denver

By centralizing key tech transfer functions and educating faculty about protecting, patenting, and licensing intellectual property, the University of Colorado Health Sciences Center's Bio/Medical Tech Transfer Office (BMTTO) has facilitated the growth of strategic collaborations, increased the acceptability of corporate sponsorship, and encouraged university-based spin-off companies in the Denver area. BMTTO expects to offer on-line patenting in the near future.

Lessons Learned: San Diego

Since 1994, the San Diego Software and Internet Council has provided an organized forum for member businesses to exchange ideas, share resources, and work together to advance the industry.

Lessons Learned: Albuquerque

The Next Generation Economy Initiative in Albuquerque has led a collaborative effort to identify and gain regional support for four primary technology clusters. The initiative maintains its broad base through an 11-member private-sector board and a 43-member advisory group with representatives from universities and labs.

4. **Recommendation –** Develop an "information flow" mechanism for interacting with and learning from regions that have experienced growth in the technology sector over the last five years.

Action – Conduct a baseline survey and analysis of the successes and challenges of Hampton Roads and benchmark regions, e.g. complement the survey of the amount and kind of grants funding and technology commercialization services of the phase 1 report with a survey of best practices in relation to, recruitment of world class researchers, availability of start-up support services), job and income growth. Evaluate Hampton Roads' progress on a semi-annual basis.

Action – Provide assistance to interested HRRP members to establish twinning or mentoring relationships with university consortia or private sector economic development organizations.

Lessons Learned: New Mexico

Sandia National Laboratories and Ardesta, a microsystems industry "accelerator," are partnering to transfer lab-developed technologies to start-up companies in Albuquerque. Michigan-based Ardesta has plans to build a fabrication facility in New Mexico within three years. Until its plant is completed, Sandia has offered Ardesta the use of its facility. Within one year of executing a license agreement with Sandia, Ardesta will create microsystems advanced design and training center.

5. **Recommendation –** Encourage partnering and collaboration among HRRP member institutions to better allocate scarce resources and prevent duplication of efforts.

Action –Create a communication mechanism to better inform HRRP institutions about facilities and equipment available for cross-institutional use.

Action – Develop a process for HRRP to identify and alert members to proposal opportunities, grants, and less conventional opportunities in the five short-term thrust areas.

Action – Organize appropriate HRRP members to create a strategy for using the SATSLab project to fund, develop, and showcase new applications to contribute to innovations in personal air transportation.

Lessons Learned: San Diego

The University of California at San Diego has established a formal affiliation called Global CONNECT that offers a mentoring program for local companies with promising new technologies. Mentoring includes presentation of a business plan to a panel of CEOs, venture capitalists, and university researchers.

Action – Create partnering opportunities based on technology areas that are of mutual interest to two or more HRRP members and fall within the thrust areas. For example:

- Determine the areas of overlap of computer modeling/simulation and software development with other thrust areas, (e.g. maritime transportation and aerospace) and create mixed teams of researchers to develop new applications.
- Create a biomedical cluster steering committee led by Eastern Virginia Medical School and comprised of representatives from public and private sectors to craft a business plan

that leverages related activities (sensors, actuators, and devices for patient diagnosis; remote patient monitoring, drug delivery) and focuses on NIH funding.

6. **Recommendation –** Articulate what makes the Hampton Roads area and HRRP unique *vis-à-vis* the state, nation, and world.

Action – Craft a story for Hampton Roads Region that is values-driven, inclusive, memorable, and accurately expresses the distinguishing characteristics of the region. [9]

Action – Forge from within the HRRP membership a set of shared principles and practices that can guide the process of collaboration between universities/labs and the senior partner private-sector companies.

Action – Contracting with a public relations firm, create a recognizable brand name for HRRP that links the organization with technology-driven regional economic development.

Lessons Learned: Albuquerque

Over five years, Los Alamos National Laboratory has directed an increasing percentage of it annual procurements to small business in the seven-county Albuquerque region ($110 million went to 454 firms in fiscal 2000). Los Alamos disseminates information on competing more effectively for federal contracts through a Web site and newsletter, business conferences, and other means.

7. **Recommendation –** Develop a unified regional capability to market the most attractive intellectual properties and new technologies.

Action – Establish a Hampton Roads technology marketing task force comprised of HRRP representatives, progressive corporate partners, commonwealth and local officials, and economic development agencies that can:

- Articulate how Hampton Roads fits into the "new economy"
- Define and obtain consensus on the appropriate roles for commonwealth and local governments, economic development agencies, private companies, and universities/labs in marketing newly commercialized products
- Contract with a marketing firm to obtain assistance in designing a long-term regional marketing strategy

Action – Create an initiative to promote innovations in the region's shipbuilding industry that takes advantage of the close proximity and mutual benefits for key players (shipbuilders, U.S. Navy personnel, area universities, and private industry) located in the VASCIC facility.

[9] Character expression uses a values-driven approach to differentiate a region or business. Instead of creating an image based on rhetoric, the region promotes its current assets, acknowledges weaknesses, and delineates strategies for improvement. Character expression integrates marketing and communications with the delivery of goods and services and uses the news media and word of mouth to deliver its message.

8. **Recommendation –** Create a public relations strategy for disseminating accurate and compelling information, both nationally and globally, about the Hampton Roads area.

Action – Initiate a media campaign to promote to regional and target markets the Hampton Roads area as a "rising star."

Action – Develop and execute a long-term communications plan to periodically update and systematically disseminate the Hampton Roads story.

Long-Term Recommendations and Actions

The recommendations for longer-term actions include methods for strengthening private sector interest and capacity in long-term thrust areas through university- or lab-based spin-off companies and recruitment of established firms to the region. They also highlight the necessity of increased collaboration among HRRP institutions to attract new funding and develop partnerships that foster innovation in the designated thrust areas. While organizational change takes time, improved cohesiveness and communication among HRRP members will create an enabling environment to better utilize existing strengths and create new opportunities.

9. **Recommendation –** Develop a program to attract additional top ranked researchers and start-up or expanding businesses with interests in the longer-term thrust areas to the Hampton Roads area.

Action – Raise money from private sources to fund academic chairs (named for donor) in thrust research areas.

Action – Work with local governments, economic development organizations and businesses to upgrade physical, technical, business, and social infrastructure to compete with other target regions (e.g. broadband access, capital access, business climate, cultural amenities).

Action – Identify and recruit high profile academic and business leaders to the region to bring attention and media coverage to technological and economic advancements.

10. **Recommendation –** Serve as a resource for economic development agencies seeking to recruit new high-tech companies.

Action – Set up and maintain a database of university/lab/private researchers and private companies working in the long-term thrust areas.

Action – Provide regional economic development agencies with recommendations of university and private researchers to include on industry recruitment teams to demonstrate more effectively to prospective technology companies the existing linkages among academic and technology communities.

Action – Work with area economic development agencies to increase employment in the high technology sector by developing projections of the technical skills and labor force training needed to fuel development of long-term thrust areas.

Lessons Learned: Denver

Metro Denver Network is a partnership of 65 Colorado businesses and 42 economic development agencies committed to increasing professional opportunities, building an exceptional learning environment, and enhancing the quality of life in Colorado.

Appendix A: Three Case Studies

Denver: Development of a Health Sciences/Biotech Consortium

The population of the Denver Metropolitan Area is approximately 2.5 million.[10] Major industries include manufacturing, business and financial services, environmental products and services, high technology, renewable energy and natural resources development, and biotechnology. Aviation is also a targeted industry for the City of Denver. The birthplace of cable television, Denver currently serves as a telecommunications hub specializing in the convergence of voice, data, and video. It is the only major U.S. city offering "one bounce" satellite transmission to five continents.

Denver Metro Area Economic Indicators

	1990	2000	Change (%)
Population ***(millions)***	1.980	2.581	+30.4
Median Household Income ***(adjusted to 1998 dollars)***	$46,379	$52,679	+13.5

In the last decade, the Denver Metro Area has become well known for the strength and vitality of its technology sector. Denver ranks as the third largest location in the country for high-technology products and services (information technology, telecommunications, and software) after Silicon Valley and Boston. Moreover, Denver has the largest concentration of biomedical research institutions and healthcare facilities in the Rocky Mountain region and is a national center for medical research. Scientists at area universities, institutes, and private companies work in a variety of research fields, from immunology to DNA testing to the development of new medical devices.

Dubbed the "Wall Street of the Rockies," Denver is a major financial center and home to some of the nation's top performing mutual funds, insurance companies, law firms, and banking institutions.[11] Denver has become a hub of venture capital (fifth in the nation) with nearly 20 firms and several venture associations and incubators.

Denver is a leader in renewable energy and natural resource development (mining, oil, and gas) with over 1,000 firms as well as the Colorado School of Mines. The Denver Metro Area hosts 29 environmental consulting and engineering firms as well as eight of the top ten environmental engineering and construction firms.

[10] The Denver Metro area includes five counties: Adams, Arapahoe, Denver, Douglas, and Jefferson.
[11] Rated 10th on the Thomas Financial Investors Relations Top 15 list.

Success Indicators

The biotechnology industry in Colorado (largely concentrated in the Denver Metro area) has grown from 38 companies in 1996 to nearly 60 today, employing over 3,900 workers. Between 1995 and 2001, the Colorado photonics industry (located in Boulder County and the Denver Metro area) increased at a rate of almost 10 organizations per year.

Selected Biotechnology Organizations

- University of Colorado Health Sciences Center
- Colorado Bioscience Park
- Eleanor Roosevelt Institute
- National Jewish Medical & Research Center
- Ceres Pharmaceuticals Inc.
- Cytokine Services, Inc.
- Kimball Genetics Inc.
- Belle Bonfils Memorial Blood Center (UC)
- AMC Cancer Research Center
- Rose Biomedical Research

Forbes ranks Denver as the seventh best place in the country to do business. Fortune Magazine ranks it in the top 10 cities for business climate, cost of living, and quality of life. Denver is the most desirable U.S. city in which to live according to a survey of 2,000 corporate executives.

The Denver Metro Area has the highest percentage of college graduates in the nation. These residents form the basis for a highly skilled workforce that has fueled the boom in scientific-entrepreneurial activity. Denver Metro exports totaled over $1.8 billion in 1998, an increase of 94% over total exports in 1993.

Several major federal facilities are located in the area, including: the National Renewable Energy Laboratory, National Center for Atmospheric Research, National Institute of Standards and Technology, National Oceanic and Atmospheric Administration, University Corporation for Atmospheric Research, and the Colorado Institute for Research in Biotechnology.

Key research and business organizations, initiatives, and programs include the following:

- The **University of Colorado Health Sciences Center** (UCHSC) is Denver's sixth largest employer, with 37 biotech-related programs. UCHSC operates a **Bio/Medical Technology Transfer Office** (BMTTO) created in 1989 to develop embryonic technologies into useful products by establishing working relationships and contractual agreements between research colleagues, and between researchers and companies interested in commercializing a technology. BMTTO seeks to connect university entrepreneurs with potential partners in the business and financial sectors, helping to develop patent and licensing responsibilities, and monitors spin-off companies established to commercialize university technology. BMTTO also conducts marketing and outreach activities, including educating faculty, staff, and students about protecting, patenting, and licensing intellectual property. UCHSC also houses the **Children's Hospital Research Institute** and the **Center for Pharmaceutical Biotechnology**.

- The **Fitzsimons Redevelopment Authority** (FRA) was created in 1996 under an intergovernmental agreement between the City of Aurora and the Regents of the University of Colorado. FRA is the lead agency responsible for redevelopment of the former Fitzsimons Army Medical Center site, which was closed in 1999. FRA's purpose is to provide ownership, management, maintenance and economic redevelopment services and improvements at Fitzsimons and elsewhere within the redevelopment area. Other FRA development sites include a 25-acre hotel and retail site near I-225 and a nine-acre town center.

- The redevelopment of Fitzsimons Army Medical Center includes the 160-acre **Colorado Bioscience Park**, designed to house biotechnology and biomedical companies. The research park has been planned for an area of up to 3 million square feet and a work force of 4,000. The first of its kind to open west of the Mississippi, the park is affiliated with the University of Colorado, which will serve and support research-oriented companies locating at Fitzsimons.

- The mission of the **Rose Community Foundation** is to address significant health needs of the local community. The foundation provides partial financial support to organizations such as **Rose Biomedical Research** (RBR), which specializes in research leading to the development of medical devices that improve the quality of care and reduce the cost. Two current projects are artificial joints and "Fast Cast," a device that allows diabetics to remain ambulatory during the healing of foot ulcers. Nearly 80 percent of RBR funding comes from private and public sources, such as the National Institutes of Health. RBR expects to use future revenues from licensing and distribution of its products to help finance its research.

- **The Business Advancement Center** of the University of Colorado conducts business and market research to provide clients with cost-effective and current information as a basis for planning and policy decisions and strategies. Center staff conduct many projects annually for small technology-based Colorado companies that focus on market definition, proprietary new technologies, and new products. Affiliated with the center is the **Technology Transfer Society of Colorado**, which focuses on communication and relationships in technology transfer among individuals, companies, federal laboratories, universities, and service professionals interested in technology development, transfer and commercialization.

- The **Mayor's Office of Economic Development and International Trade** maintains a Web site with information about the city and state and their economic development initiatives. The office provides help with site relocation and expansion, demographic and other marketing information, regulatory assistance, job recruitment and training programs, foreign investment and trade information, and financing.

- **Metro Denver Network** is a partnership of 65 Colorado businesses and 42 economic development organizations representing the Denver metropolitan area. The network is committed to increasing professional opportunities, building an exceptional learning environment and enhancing the quality of life in Colorado. Its activities include **Tech Connection,** a service designed to bring together high-tech companies and trade associations to help the industry expand. **The Convergence Corridor** is a $250,000 marketing campaign initiated by the network and **The Grassroots Initiative**.

- The **Denver Technology Center** is a suburban office environment with 950 existing companies and more than 30,000 employees. **URS Greiner Woodward Clyde** is building a new 300,000 square foot office in the Center.

- **Denver International Airport** (DIA) is the world's 10th busiest airport, supporting maintenance, shipping, and travel-related industries. DIA offers non-stop service to more than 110 cities worldwide.

- Founded in 1998, the **Colorado Alliance in Bioengineering** (CAB) is a statewide consortium of academic institutions of higher education. Its membership includes **Colorado School of Mines, Colorado State University, University of Colorado at Boulder**, and **University of Colorado Health Sciences Center**. CAB believes that the most promising areas for the state's future economic growth are bioengineering, biotechnology, and biomedical devices. CAB's mission is to foster excellence in academic-based research in these areas, accelerate its transfer and application, and enhance the competitiveness of Colorado's growing bio-industries through partnerships. In this way, CAB will assist the state to establish world class research stature in bioengineering and to promote its biosciences industries as global leaders.

- **Colorado Internet Keiretsu** was established in 1997 and is based on the Japanese keiretsu concept, wherein a group of companies related to each other in a variety of ways (financial, joint R&D, etc.) work together to achieve common goals.

Development Strategies and Mechanisms

Denver uses low taxes rather than financial incentives to recruit new businesses. In 1998, for example, Denver had the second lowest combined total business taxes of 27 major U.S. cities.

A key factor supporting the high-tech boom is the ability of the Denver Metro Area to attract well-educated young people from around the world. In addition, the state's highly-ranked universities, availability of scientific and management talent, presence of venture capital, fairly low cost of living, and excellent climate all serve as location "drawing cards."

A focus on redevelopment and reuse has enabled Denver to use more fully the limited land resources while supporting growth and expansion:

- Redevelopment of the 577-acre Fitzsimons property has been called the largest medical-related redevelopment project in the nation. The total redevelopment program for Fitzsimons calls for over 10 million square feet of phased new construction representing a capital outlay exceeding $1.5 billion. It is modeled after three similar research parks successfully launched on the East Coast.

- The 4,700-acre former airport is being transformed into a planned community called Stapleton. When fully developed in approximately 20 years, Stapleton will be a mixed-use, pedestrian-scale community of 27,000 residents, 35,000 jobs and 13 million square feet of commercial development. Stapleton will include more than 1,100 acres of parks and open space.

- South of Stapleton, the former Lowry Air Force Base has received national recognition as a mixed-use development of commercial, residential, educational, and recreational communities. Just minutes from two interstate highways, Lowry also offers businesses state-of-the-art infrastructure and an interactive college campus for advanced degrees and corporate training.

Development of international markets is a major focus as well as exporting more biotechnology goods. In this regard, the Denver Mayor's Office of Economic Development and International Trade has partnered with the Colorado Environmental Business Alliance to bring together and support potential strategic partners and industry contacts. As a result, more than 250 delegates from 45 countries have visited 70 companies in Colorado. In London, the Denver Trade Office promotes the city's development areas to European companies seeking a base of operations in the U.S.

The Bioscience Industry as Economic Engine

Denver offers many examples of how bioscience has stimulated the local economy:

- UCHSC has become a catalyst for improvement of the Denver Metro economy by focusing on investment and growth, and garnering a wide range of political and financial support from federal and state legislative leaders, the University of Colorado Board of Regents, local officials, private businesses, and foundations. While only 9 percent of the UCHSC's operational budget comes from state monies, funding from federal grants and contracts has increased from $74 million to nearly $200 million over the last decade. The center's ability to attract research investment dollars has led not only to medical advances but to economic growth – for every $1 million received in outside research grants, 38 new jobs are created. UCHSC researchers have patented 241 inventions and developed 797 intellectual property agreements, primarily with commercial partners.

- Key to UCHSC's economic vitality has been physical planning for expansion. UCHSC has seized the opportunity to relocate all five schools, both hospitals, and half of its research complex over the next 10 years to the redeveloped Fitzsimons site near Aurora. The new 217-acre campus will more than triple its current square footage and double its research capacity. This move will generate over $500 million in construction costs by 2003 and, as those dollars are spent locally, create over $1 billion in gross state product. Moreover, the UCHSC long-term plan projects another $700 million in construction during the last seven years of its relocation project.

- The siting of the Colorado Bioscience Park adjacent to the new UCHSC campus is likely to increase the success rate of start-ups in the biotechnology sector.[12] So far, eight biotechnology companies and research institutes have moved into the recently completed Bioscience Park Center, a 60,000 square-foot facility funded by grants from the Economic Development Administration and matching support from the City of Aurora. As a launch pad for Colorado's biotechnology industry, the Center is designed to meet the needs of dynamic startup and early stage scientific ventures. It contains advanced IT structure and cutting-edge laboratory and office facilities. Special "huddle zones" have been incorporated in the design to bring researchers and entrepreneurs outside their R&D suites for informal discussion and networking. A second and larger research park building is in the planning stages and will accommodate expansion-stage companies in built-to-suit facilities.

- To accommodate the rapid growth of new development in the bioscience sector, the Denver area has been working to complete expanded infrastructure systems by the end of 2001. Larger storm and sanitary sewer systems, high-capacity water lines, and an electrical power sub-station have been fast-tracked. By 2010, a new parkway and additional connections to the adjacent Interstate expressway are expected to be in place.

- In regions where there is a high level of interaction among academic research centers, businesses, and service providers, technology growth has accelerated. Since 1999, the Fitzsimons Redevelopment Authority and other state and local institutions have hosted monthly "Bio Breakfasts." At each breakfast, a featured speaker presents the work of a specific company or discusses an industry issue or scientific advancement. Attendance has tripled, drawing on a variety of organizations such as drug-development and medical device companies, research institutions, tech transfer offices, venture funds, and service providers.

Contact Information

Fitzsimons Redevelopment Authority
Robert Olson, Director
303 363-1940
www.colobia.com

[12] National research has shown that the number one factor in the success of biotechnology firms is proximity to a top academic medical center.

University of Colorado Health Sciences Center
Bio/Medical Technology Transfer Office (BMTTO)
Michele M. Land, Assistant Director
303 724-0220
michele.land@uchsc.edu
www.uchsc.edu/techtran/offcmn

Metro Denver Network
Chad Delong
303 620-8066
www.denvernet.org

University of Colorado Business Advancement Center
Karen Eye, Director
303 554-9493, ext. 13
www.colorado.edu/cubac

Rose Biomedical Research
Ken Weil, President
303 320-2998
kenweil@ix.netcom.com

Mayor's Office of Economic Development and International Trade
City of Denver
Randy Moore
720 913-1609
randy.moore@ci.denver.co.us
www.denvergov.org/moedit

Metro New Mexico: Collaboration of Universities, Federal Laboratories, and State Government

Metro New Mexico is a region in Central New Mexico that includes the cities of Albuquerque, Santa Fe, and Los Alamos. The combined population of the Albuquerque and Sante Fe metropolitan areas is over 860,000, an increase of over 20 percent in the last decade.

Major industries include telecommunication services, electronics/aerospace, information technology and software, optics, tourism, biomedicine/biotechnology, and artisan manufacturing. Metro New Mexico is third among the country's top 50 cities for business expansion and relocation.

Albuquerque/Santa Fe Economic Indicators

	1990	2000	Change (%)
Population	706,174	860,373	+21.8
Median Household Income ***(adjusted to 1998 dollars)***	$33,462	$45,111	+17.4

In the last decade, an increasingly dynamic technology sector has spurred economic growth in the region. Four federal research laboratories, three research universities, three research parks, and rapidly growing high technology industries have become the foundation for the area's reputation as a high tech powerhouse.

Cities in Metro New Mexico have experienced considerable success in developing their high-technology sector. In Albuquerque, the impact of the electronics industry is greater than in any other metropolitan area in the nation, employing 10,000. Over 20 Santa Fe companies make up "InfoMesa," a growing computer-powered industry known as Infomatics that extracts cohesive information from reams of raw data. State support for these industries is concentrated in the New Mexico Office of Science and Technology that teams with federal and state labs, universities, and private agencies to support high-tech business startups.

At the same time, New Mexico ranks first in per capita monies received from the federal government, yet still ranks last in overall per capita income. Metro New Mexico's major employer is government, due to a history of strong presence of federal installations such as Sandia National Laboratories, Los Alamos National Laboratory, and Kirtland Air Force Base. This has resulted in slower job growth than the national average and most neighboring states (1.3 percent statewide) as well as more susceptibility to the effects of national and international economic downturns and U.S. policies.

Success Indicators

New Mexico has over 900 high tech companies employing over 45,000 with an annual payroll of over $2 billion. High tech goods account for 93 percent of all New Mexico's exports and grew 10-fold from 1990 to 1997. The New Mexico Flying 40 is a group of highly successful, locally grown technology enterprises.

Employment in these 40 companies has more than doubled and revenues have climbed 50 percent during the last three years.

National Economic Rankings

Measure	Rank
High-tech Exports	1
Initial Public Offerings	1
Federal Lab Campus Funding	1
Scientists/Engineers (per capita)	2
Small Business Innovative Research	2
Business Incubators	3
Industry R&D	4
Fast-growing "Gazelle" Firms	5

Source: NM Economic Development Department, Metro New Mexico Development Alliance

Using solely private funds, Technology Ventures Corporation has worked with federal laboratories and area universities to facilitate the formation of 46 new technology companies, brought $295 million in investment capital to the state, and created over 5,000 New Mexico jobs.

New Mexico has experienced a 900% growth rate in resident venture capital firms since 1997. The total fund capital among New Mexico's resident venture capital firms is almost $500 million. New Mexico plans to vest more than $161 million in state funds with resident venture capital firms.

Some examples of organizations, initiatives, and programs include the following:

- The **Sandia National Laboratories** is a U.S. Department of Energy laboratory, operated by a subsidiary of Lockheed Martin Corp. With main facilities in Albuquerque and Livermore, CA, Sandia has major research and development responsibilities in national security, energy and environmental technologies, and economic competitiveness. The excellent research programs and frontrunner status of Sandia National Laboratories in the microelectronics field was an important consideration for Intel in siting a semiconductor facility in Albuquerque.

- Adjacent to the Sandia National Laboratories, **Sandia Science & Technology Park** is a 285-acre, campus-style technology center. Tenants include Sandia industry partners and critical suppliers, as well as companies providing services to other high-tech companies in the park. A master plan has been completed for the park and installation of a fiber optic communication backbone is slated for 2002. The park is managed by the **Science and Technology Park Development Corporation**, a nonprofit organization.

- **Technology Ventures Corporation** (TVC) is a non-profit organization founded in 1993 and directly funded by Martin-Marietta, now Lockheed Martin Corporation, as part of a U.S. Department of Energy contract to manage Sandia National Laboratories. TVC's mission is to assist in the creation, expansion, retention and relocation of technology based-businesses, and to create jobs for New Mexico. TVC has separate cooperative agreements with all the federal laboratories and three research universities in the area. TVC's interests include both assisting scientists to create new technologies and bringing those technologies to market. TVC has also played an active role in successfully recruiting venture capital to New Mexico, specifically firms interested in high tech startup companies.

- The **University of New Mexico** (UNM) has a number of centers that support the technology industry through workforce education and research and development in high technology materials, global environmental technologies, space telemetering, and telecommunications systems. UNM also houses the Klipsch School of Electrical and Computer Engineering, the non-profit Computing Research Laboratory, and the New Mexico Engineering Research Institute. The **UNM Science and Technology Corporation** is a non-profit entity formed in 1995 to create commercial opportunities for the university. The corporation's portfolio includes more than 100 patents in the physical sciences. Managed by the Science and Technology Corporation, the park is a master-planned, 153-acre business technology park, with 360,000 square feet of office, R&D, and mixed-use space currently developed.

- **Los Alamos National Laboratory,** a U.S. Department of Energy laboratory managed by the University of California, is the largest employer in northern New Mexico. With an annual budget of approximately $1.2 billion, the laboratory staff includes 6,800 university employees and 2,800 contractor personnel. Research areas include advanced computing, direct chemical analysis, DNA sequencing, materials science, space science and exploration, seismic research, and international security.

- **Santa Fe Institute** is a private, non-profit research and education institute formed in 1984. It is a "visiting institute" with no tenured faculty, accommodating up to 50 visiting scientists and researchers. The institute is affiliated with the University of New Mexico and Los Alamos National Laboratory.

- **Phillips Laboratory at Kirtland Air Force Base** specializes in space vehicles and directed energy research, including lasers and high-energy microwaves.

- **Metro New Mexico Development Alliance** is a cooperative effort by local economic development agencies in Central New Mexico and the NM Public Service Company, the region's electric power provider. Members of the alliance have pooled their marketing resources to design and construct a Web site as a "one-stop shopping" resource for site selection professionals. The alliance's Web site contains a complete listing of available commercial and industrial sites over five acres and office or industrial buildings of over 10,000 square feet. It also contains information on population and labor force, economics and industry clusters, and numerous links to other Web sites that address quality of life issues and provide local community information.

- **The Next Generation Economy Initiative** (NextGen) for Central New Mexico is a nonprofit organization created in 2000 through grants from the U.S. Department of Energy, the U.S. Department of Housing and Urban Development, and local private foundations. NextGen is the

implementing entity for a regional strategic plan developed by a three-county, grass-roots economic development coalition. The initiative is guided by an 11-member private-sector board of directors and a 43-member advisory group, which includes representatives from area universities and federal labs.

- The **Corporate Business Development and Partnerships Center** at Sandia National Laboratories assists with strategic partnerships in industry and academia, and collaboration with other government laboratories. The organization maintains a series of web pages for outreach and information.

- Created in 1983, The **University of New Mexico Center for High Technology materials** (CHTM) promotes staff collaboration with researchers at federal labs as well as private research and development labs in a variety of research areas relevant to government and industry. For example, CHTM has teamed with Sandia and Los Alamos National labs and the Phillips Laboratory to form the **Alliance for Photonic Technology** (APT), designed to enhance U.S. competitiveness in the global market. Local industry collaborators include Emcore, Intel, Lightpath, MODE, Radiant Technologies, Sumitomo, and Southwest Sciences.

Key Organizations and Development Strategies

Assisted by local businesses, NextGen has identified four primary technology clusters with potential to help drive the regional economy forward: information technology/software; biomedicine and biotechnology; optics/photonics; and microelectronics. These clusters originally formed around the core competencies of Sandia National Laboratories, Philips Air Force Research Lab, and the University of New Mexico. To use each cluster to its fullest potential, NextGen works to identify and refer opportunities in the cluster areas to Albuquerque Economic Development, the non-governmental metro agency for industrial recruitment. NextGen also seeks to remove barriers to growth of regional high tech companies, provide assistance to startup companies in assessing market demand for specific high tech products, tap the expertise of venture capitalists to identify market opportunities for commercialization of research, and assist companies with new products in the cluster areas to obtain capital from local banks and venture investors.

The City of Albuquerque endorsed a Memorandum of Understanding between landholders near the Sandia Science and Technology Park to expand development of the 285-acre technology campus. The overall goal of the technology park is to create high tech jobs and industries for area economic development, promote economic diversity, and create unique partnerships between public labs and private industry. The city pledges to expedite land use and infrastructure processes to streamline development. The city invited representatives from the city council, U.S. Department of Energy, Albuquerque Public Schools, and private industry to the signing ceremony.

Over the past five years, the Los Alamos National Laboratory has supported the economic development of northern New Mexico by directing an increasing

percentage of its annual procurements to small businesses in a seven-county region. In FY00, Los Alamos awarded approximately $110 million to 454 firms. Total 2001 expenditures to all small businesses nationally are expected to reach $335 million or 35 percent of total procurements. Specific activities include:

- Establishing a web site and newsletter to inform regional businesses about procurement opportunities
- Hosting business conferences to educate New Mexicans about how they can most effectively work with Los Alamos National Laboratory
- Hosting technology expositions to educate Laboratory scientific and technical staff on the availability of products from small businesses in Northern New Mexico
- Assisting firms in the region to apply for "historically underutilized business" status to increase their competitiveness for federal contracts

Individuals and organizations from the private sector are teaming up with public entities and the program they offer to further private sector growth and attract higher-paying, quality jobs. TVC refers promising companies to the New Mexico Office of Economic Development, which assists entrepreneurs to tap a multi-billion dollar severance tax fund paid by extractive industries. Three percent of this fund has been set aside for use as venture capital. The Governor's Business Advisory Council (GBAC) is a diverse group of over 300 professionals statewide representing a broad cross section of private sector experience, including agriculture and retail, manufacturing and finance, extractive industries and insurance, cattlemen and stockbrokers, and construction and healthcare professionals. The New Mexico High Tech Job Forum offers a free on-line service that links unemployed individuals with technology companies by posting resumes and job openings for its members.

Establishing World Leadership in Microsystems

Sandia National Laboratories is spearheading the development of a microsystems[13] industry that cuts across the technology clusters identified by NextGen. Over the last eight years, microsystems technology research has expanded to become a major contributor to Sandia's primary mission of national security. Batch-produced and inexpensive to make, microsystems contain electrical circuitry, optical devices such as lasers, and microelectromechanical systems (MEMS) – tiny machines that sense changes in their environment to take action. MEMS application areas include ink jet printer heads that dispense controlled amounts of ink and video games in which the player's physical motion becomes part of the game.

NextGen has brought together key players with the expertise and resources already in place to fuel this new regional industry. Sandia is promoting commercialization of microsystems in everyday consumable goods, such as vehicle air bags, to test their reliability for eventual use in national defense systems. The Air Force Research Laboratory uses MEMS in optical laser applications, and UNM trains future microsystems engineers. The Sandia Science

[13] Microsystems are devices smaller than the width of a human hair built on silicon wafers using standard integrated circuit manufacturing.

and Technology Park offers the facilities and high-tech telecommunications infrastructure needed to support microsystems companies. Partnering with the labs are the City of Albuquerque, UNM Anderson Schools of Management, and several private sector organizations, including Wells Fargo Bank/New Mexico, Quatro, and Technology Ventures Corporation.

A microsystems cluster steering committee comprised of representatives from both the public and private sectors is focusing on cluster integration. In response to the committee's request, senior faculty at UNM Anderson Schools of Management and Technological Entrepreneurship Program have crafted a business plan that calls for construction of a microsystems fabrication plant, which would develop and create products for new microsystems companies coming into the area.

In related developments, Sandia National Laboratories and Michigan-based company, Ardesta, have joined forces through a new partnership agreement to help transfer emerging microsystems technologies to start-up companies in the commercial sector. Ardesta invests in start-up and early-stage companies, provides business and technical resources to support these companies, and develops industry-building publications, Web sites, and trade shows. Ardesta is evaluating the feasibility of constructing a microsystems prototyping and fabrication facility in New Mexico within the next three years. Sandia National Laboratories has offered to provide Ardesta with fabrication capability in its Albuquerque facility until Ardesta's fabrication unit is completed.

Among other developments involving Sandia National Laboratories are the following:

- In October 2000, Sandia National Laboratories announced that four of its researchers were creating a spin-off company, MEMX, Inc., to commercialize microsystems technology developed at Sandia. Officials predicted that MEMX would play a critical role in attracting additional small businesses and entrepreneurs to the industry. MEMX will initially focus on producing optical switches for the telecommunications industry based on Sandia's surface micromachine technology, SUMMiT V.[14]

- Sandia National Laboratories has worked with EMCORE Corporation to develop a product to make short-haul fiber optic communications faster and less expensive for Internet service providers. Building on an eight-year history of cooperative research and development, EMCORE chose Sandia to assist with product development due to Sandia's unique capabilities in microsystems integration. EMCORE opened a 67,000 square foot plant at the Sandia Science and Technology Park to expand its Albuquerque operations, and to further develop and manufacture the new fiber optic communications technology. The collaboration has produced cutting-edge telecommunications technology, a reliable domestic supplier for critical components of Sandia's defense programs, and over 300 high-tech jobs.

[14] Sandia Ultraplanar Multilevel MEMS Technology (SUMMiT V) produces more reliable and complex MEMS devices than previously possible.

- Sandia's New Ventures program helps personnel spin off new companies based on lab technology. New Ventures matches technologies to markets, champions laboratory policies that support entrepreneurs, and assists in the formation of new businesses through market research, training related to business formation, and resolution of conflict of interest issues. New Ventures refers entrepreneurs to TVC for help in developing business plans and raising venture capital. Micro-Optical Devices, Inc. (MOD) received $5.6 million in private funding for manufacture and marketing of compound semiconductor lasers, a commercial application of research conducted at Sandia and UNM's Center for High Technology Materials. EMCORE Corporation recently acquired MOD, Inc. in a transaction valued at $32 million.

Contact Information

Metro New Mexico Development Alliance
Susan Johnson
505 241-4416
http://www.newmexicositesearch.com

Next Generation Economy Initiative
Mike Skaggs
505 843-4944
http://www.cabq.gov

Sandia National Laboratories
Corporate Business Development and Technical Partnerships Center
505 284-2001
Steven Grieco, Microsystems Science, Technology, and Components
505 843-4148
http://www.sstp.org

Ardesta
Colleen Robor, VP, Corporate Communications
734 528-6113
www.ardesta.com

UNM Science and Technology Corporation
Phil Askenagy
505 272-7900

New Mexico Office of Science and Technology
Ken Manciki
505 827-0563

Technology Ventures Corporation (TVC)
George Friberg
503 843-4286
http://www.techventures.org and http://www.nmtechjobs.org

MEMX
Paul McWhorter
505 858-1062
www.memx.com

San Diego: U.S. Navy Port and High Technology Center

Charles Lindbergh built his Spirit of St. Louis in San Diego in 1927, and other pioneering aviators were attracted to San Diego. With a contract to build flying boats for the Navy, Reuben Fleet moved his Consolidated Aircraft Corporation from Buffalo, NY to San Diego, laying the foundation for the Convair and General Dynamics Corporation, and securing San Diego's place as a major contributor to the U.S. defense industry.

San Diego Metro Area Economic Indicators

	1990	*2000*	*Change (%)*
Population (millions)	2.498	2.813	+12.61
Median Household Income (adjusted to 1998 dollars)	$44,107	$45,309	+2.7

In addition, San Diego's military presence boomed, as it became home to the Pacific Naval Command and many other military camps and bases. At the end of World War II, thousands of veterans found jobs in the city's growing defense and aerospace industry, which fueled San Diego's economy for decades.

San Diego has also had down periods. During the decline of the aerospace industry in the 1960s, *Time* magazine dubbed it "Bust Town, U.S.A." But the seeds were being planted that would ultimately grow into San Diego's future economy. Two of those seeds took root in La Jolla with the opening of the Salk Institute and the 1,000-acre campus of the University of California at San Diego.

By the 1990s, a broad array of technological industries had replaced a dependency on military spending and aerospace contracts. Today, San Diego has six main industries: bioscience, communications, information technology, defense and space, recreational goods, and software and the Internet. Supported in large part by San Diego's strength in higher education, research-intensive businesses have become a major engine of job creation. San Diego's employment in the communications sector has increased 300 percent since 1992. In an environment of international trade and research breakthroughs, high technology and bioscience companies have helped reshape the economy of the San Diego region. Their activities range from research on the next wonder drug to the production of golf clubs made from space-age materials.

San Diego currently has nearly 1,200 companies in the defense and space industry cluster, which employs more than 21,600 people. The region is a U.S. Navy "megaport" and is home to the Space and Naval Warfare Systems Center (SPAWAR) and the Naval Command Control and Ocean Surveillance Center. This industry is undergoing profound restructuring as the military shifts toward commercialization and privatization of programs. However, San Diego leaders believe the region is well positioned to make the transition due to the strength of its high-tech industry and focus on transferring military technology to commercial applications.

Success Indicators

Some examples of success indictors include the following:

- San Diego's 2000 Gross Regional Product rose a record 20 percent between 1999 and 2000 to $110.2 billion. It is projected to climb to nearly $117 billion in 2001.

- San Diego has more than 240 biotech companies, the third largest concentration in the United States. These companies employ almost 26,000 people and earn revenues in excess of $1.8 billion. San Diego ranks third in the United States for investment dollars in the biotechnology sector. In 1998 close to 1,045 patents were issued to individuals and businesses located in San Diego County, up 44 percent from the year before.

- With the third largest concentration of communications firms in the United States, San Diego is becoming widely known as the "wireless communications capital of the world." Currently, San Diego's 88 communications firms employ almost 20,000 persons. According to the San Diego Regional Economic Development Corporation, San Diego is expected to be one of the top 10 cities in the country for overall job growth through 2025, and emerging high-tech companies in the region are likely to create many of those jobs.

- San Diego has over 650 software companies, employing more than 17,000 people. The robustness of the software development industry is the legacy of the region's earlier reliance on the defense sector.

- San Diego State offers a masters of science in regulatory affairs, the first of its kind in the western United States and one of only three in the nation. This program trains graduate students and industry professionals in the intricacies of getting federal approval for new drugs, medical devices, and other bioscience products.

- Activities in San Diego County accounted for $7.1 billion in defense spending during 1998. The San Diego Defense and Space Technology Consortium formed to promote growth and competitiveness in San Diego's Defense and Space Technology industry through creation of government-industry-academia alliances.

Key Organizations and Development Strategies

San Diego is a major center for higher education, with more than 185,000 students enrolled full- and-part time at 17 institutes of higher learning. The San Diego region is home to one of the most educated workforces in the country; in the City of San Diego, about 30 percent of adults have a college degree. In 2000 U.S. News & World Report ranked The University of California San Diego and the University of San Diego among the top engineering schools in the country.

University of California at San Diego (UCSD) is ranked third (behind Harvard University and Stanford University) in the amount of federal dollars spent on research and development ($351 million in 2000). UCSD has numerous prominent research centers, such as the Center for Wireless Communications, a major research and educational effort in the development of voice, data, imaging, and video through small devices. Forty percent of the people who work in San Diego's biotech industry are employed by one of nearly 150 companies spun off from UCSD. San Diego Supercomputer Center is a federally funded national laboratory and a research unit at UCSD, home to one of the nation's two supercomputers. The computer center provides substantial support to San Diego's defense and space, IT, communications, and software industries. Also at UCSC is the International Center for Communication, which explores ways to link communities through technology. At San Diego City College, an intensive 18-week course helps prepare students for entry-level positions as biotechnicians.

Salk Institute is a nationally recognized private, nonprofit research institute focused on fundamental research in biology and its relation to health. The institute studies the organization and operation of the brain, the control of gene activity, and the molecular origins of cancer, AIDS, and other diseases.

Scripps Research Institute is one of the largest private, non-profit research organizations in the United States. Established in 1955, it is recognized for research on immunology, molecular and cellular biology, chemistry, synthetic vaccine development, and a variety of other areas.

Several organizations play key roles in economic development and regional collaboration, including the following:

- San Diego Regional Economic Development Corporation (EDC) provides client services to technology companies desiring to expand or locate in the region. EDC uses a network of public and private sector partners, nonprofits, and educational institutions to work with companies on research, assessment, and problem solving, providing a one-stop approach to project management. EDC coordinates with local economic development organizations that focus on smaller and, in some cases, economically distressed areas.

- San Diego Regional Technology Alliance (RTA) is a non-profit private/public partnership that assists San Diego's high-tech industries. RTA facilitates community and economic development by equipping entrepreneurs with the tools to develop their technologies into businesses. The RTA creates and supports public-private partnerships that focus on developing the workforce skills needed for the region's future. Staff also conduct research to educate residents about the region's technology strengths. RTA was established in 1993 by state legislation under the California Trade & Commerce Agency in response to the 1990s defense downsizing and base closures.

- Founded in 1986, the San Diego Venture Group (SCVG) is a non-profit organization created designed to bring together San Diego professionals who are interested in new enterprise and the process of creating it.

SCVG's mission is to provide a networking forum for entrepreneurs, venture capitalists and advisors. The SDVG Board of Directors is comprised of some of San Diego's top executives and venture resources. Informal monthly meetings typically feature a panel discussion by cross-industry experts on a specific entrepreneurial topic. A national association, the Association of Venture Capital Clubs, has also been established with the San Diego Venture Group as a charter member.

- San Diego Biocommerce Association (BIOCOM) is a regional membership organization formed to represent and advocate for the biotechnology industry in San Diego. BIOCOM gives the biotech industry a collective voice on relevant policies and issues.

- San Diego Software and Internet Council is a membership organization, formed in 1994, for regional software and Internet businesses. Its main objective is to provide a forum for the exchange of ideas, sharing of resources, and promotion of industry goals fostering communications.

- UCSD CONNECT is supported by membership dues, course fees, grants, and corporate underwriting rather than public funds. By connecting business and university entrepreneurs with business service providers such as venture capitalists, attorneys, and corporate partners, UCSD CONNECT acts as a catalyst for the growth and expansion of the technology sector as well as economic development in the San Diego community. Created in 1985, UCSD CONNECT has approximately 600 members that pay dues on a sliding scale up to $1,000 annually. (See page 56 for more examples of its work.)

Much of the strength of the biotech industry in San Diego is the result of the triangulation of: 1) strong involvement of local governments working to make San Diego an attractive place to do business; 2) a cluster of powerful research institutes and universities producing a skilled workforce and research; and 3) a private sector with entrepreneurial motivation, venture capital support, and existing businesses. As the number of biotech companies in San Diego increases, the momentum to attract other companies to the region builds.

The San Diego region offers a variety of incentives designed to make the region attractive to business. Incentives include an Enterprise Zone and a Foreign Trade Zone, reductions in fees and regulations, permit streamlining, tax credits/rebates, utility discounts and training funds and programs. San Diego also has the lowest business tax rate of the 20 largest U.S. cities, and the public sector has invested more than $150 million in expanding the region's fiber optic infrastructure. The San Diego Workforce Partnership is a non-profit organization dedicated to developing workforce-training programs that respond to the needs of San Diego businesses. The partnership contracts with both public and private entities to help connect people with jobs or training, and employers with qualified applicants.

UCSD CONNECT: A Important Success Story

A useful model for possible HRRP replication can be found in the collaborative programs administered by UCSD CONNECT. UCSD CONNECT has developed a "Meet the Researchers" program, with a goal to facilitate collaboration and technology transfer between researchers at the university and local scientists working in relevant business fields. The program works to expand contacts between researchers, corporate decision-makers and investors, as well as to facilitate research alliances, joint partnerships and new businesses in the San Diego region. UCSD CONNECT staff maintain an extensive database of industry contacts, and coordinate with UCSD department chairs to identify researchers working in particular areas. They organize networking meetings, such as breakfasts or after work mixers, with agendas incorporating presentations of research interests by both university and private industry researchers.

Springboard, one of the most successful programs of UCSD CONNECT, coordinates networking events to bring product developers into contact with potential corporate partners and funding sources. With an annual budget of $1.5 million, Springboard has successfully assisted over 40 companies during the 2001 fiscal year. Springboard events are funded through corporate underwriting of sponsors such as Sempra Energy, Ericsson, Andersen, Cooley Godward LLP, and Pricewaterhouse Coopers.

Springboard staff screen companies to select those with good management, promising new technologies or products, and financial viability. Selected companies are eligible for a six- to 10-week mentoring program that includes presentation of a business plan before a panel of corporate CEOs, venture capitalists, angel investors, and university researchers.[15] The panel provides suggestions for improving business strategies and networking.

For over a decade, Springboard has held educational events such as the Technology Financial Forum and the Innovative New Products Forum, to showcase new companies and bring together service providers and entrepreneurs. More than 500 people attended the Technology Forum in 2001.

In March 2001, Continuous Computing Corporation (CCPU), a Springboard company founded in 1998, announced receipt of over $21 million in equity funding from several venture capital organizations, including Technology Crossover Ventures, Palomar Ventures, Smart Technology Ventures, and W R Hambrecht & Co.

UCSD CONNECT has an affiliate called Global CONNECT to help other localities establish a similar program in their area. UC-Davis and the City of Montreal have indicated an interest in becoming clients.

[15] For example, the chief executive officer of FFA Sciences made a presentation on a new blood test to detect ischemic cardiovascular disease, the major cause of death in first-world nations. FFA Sciences was selected in part because the technology appears to be an advance over the competition and the company has done a good job of researching the substantial market potential.

Contact Information

UCSD CONNECT
Dennis Leidall, Project Manager
CONNECT Springboard
858 534-0677
http://www.connect.org/

Brad McMillan
Gobal CONNECT
858 822-5148

San Diego Regional Economic Development Corporation
http://www.sandiegobusiness.org
www.techsperfectclimate.org

San Diego Regional Technology Alliance
http://www.sdrta.org/

San Diego Software and Internet Council
http://www.sdsic.org/

San Diego BIOCOM
http://www.biocom.org/

San Diego Workforce Partnership
http://www.workforce.org

Appendix B: CorpTech Codes for Thrust Areas

RTI determined the appropriate codes for each thrust area as defined by OneSource Information Services, Inc., CorpTech Division (CorpTech). CorpTech codes are more descriptive of products and services provided by high tech companies when compared to Standard Industrial codes (SIC).

The codes selected here represent only the primary industry classifications for the thrust areas. Adding secondary relationships would have resulted in a much larger list. For example, there are many industries that are relevant to maritime transportation, but are not primary maritime industry classifications (materials, components, services, etc.). These are secondary or crosscutting industries to maritime transportation, and have their own industrial classification. In this list, they are not included under maritime transportation due to their secondary or supplier relationship. Also, note that selection of these CorpTech codes was based on what are referred to as the "major code groups." In some cases, an additional or third level of classification referred to as "product codes" has been listed. The closest corresponding 4 digit SIC code is given to the right of each entry.

Maritime transportation (Shipbuilding – design and development, manufacture of ships and related subsystems)

TRN-MA-Marine systems/equipment	3730
TRN-SV-Services	8700

Aerospace (design and development, manufacture of aircraft and related subsystems)

TRN-AI-Aircraft	3721
TRN-AS-Major aircraft systems	3728
TRN-GS-Ground support equipment for aircraft	3812
TRN-PR-Air/spacecraft propulsion equipment	3724
TRN-SV-Services	8700

Modeling and Simulation

TRN-TS-Transportation training/simulation equipment	3669

Software

SOF-TR-A-Simulation software, aircraft systems, flight	7372
SOF-FO-M-Simulation software, combat, defense	7372
SOF-ZA-G-Simulation software, general non-industrial	7372
SOF-MA-U-Simulation software, manufacturing	7372
SOF-AI-EI-Simulation software, industry-specific	7372
SOF-MA-TS-Simulation software, test software	7372
SOF-GO-M-Simulation software, war games	7372
SOF-CS-E-Simulation/emulation software	7372
SOF-TS-EV-Modeling software, data	7372

Biomedical – medical devices

MED-DG-Medical diagnostics equipment	3841
MED-IM-Implants/prostheses	3842
MED-MO-Medical monitoring equipment	3845
MED-RE-Rehabilitation devices	3842
MED-RP-Medical reproduction related equipment	3841
MED-SU-Surgical/medical equipment	3841
MED-TH-Medical therapeutics equipment	3840

Photonics

MAT-CE-Ceramic materials	3200
MAT-CO-Coatings/coating materials	2851
PHO-LA-Lasers/laser related equipment	3699
PHO-OE-Optoelectronic devices	3679
PHO-OP-Optics and related equipment	3827

Laser Processing

PHO-LA-Lasers/laser related equipment	3699
MAN-MA-Materials processing equipment	3559
MAN-EP-Electronic and photonic manufacturing equipment	3559

Marine Research

TRN-SV-R-Oceanographic R&D services	8700
TRN-MA-O-Oceanographic equipment	3730
ENV-SV-Environmental services	8700

Medical – genetics, bioinformatics

BIO-PE-Proteins/protein engineering systems	2836
BIO-GE-Genetic engineering systems	2836
COM-MS-Supercomputers	3571
SOF-DM-Database/file management software	7372
SOF-TS-Technical/scientific software	7372

Composite Materials

MAT-CM-Composites	3083
MAT-FR-Fillers/reinforcements	2899
MAT-TX-Textiles/fibers	2200
MAT-PO-Polymers	2820
MAT-CE-Ceramics/related materials	3200

Nanotechnology

As a new and emerging technology, this does not fit into specific CorpTech codes, but could have applicability across almost all major code groups.

Wireless Communications

TEL-BR-Broadcasting/receiving equipment	3663
TEL-CS-Communications security devices	3669

Wireless Communications (concluded)

TEL-SM-Satellite and microwave communications equipment	3663
TEL-SV-Telecommunications services	4800
TEL-TE-Telephone/voice equipment	3661