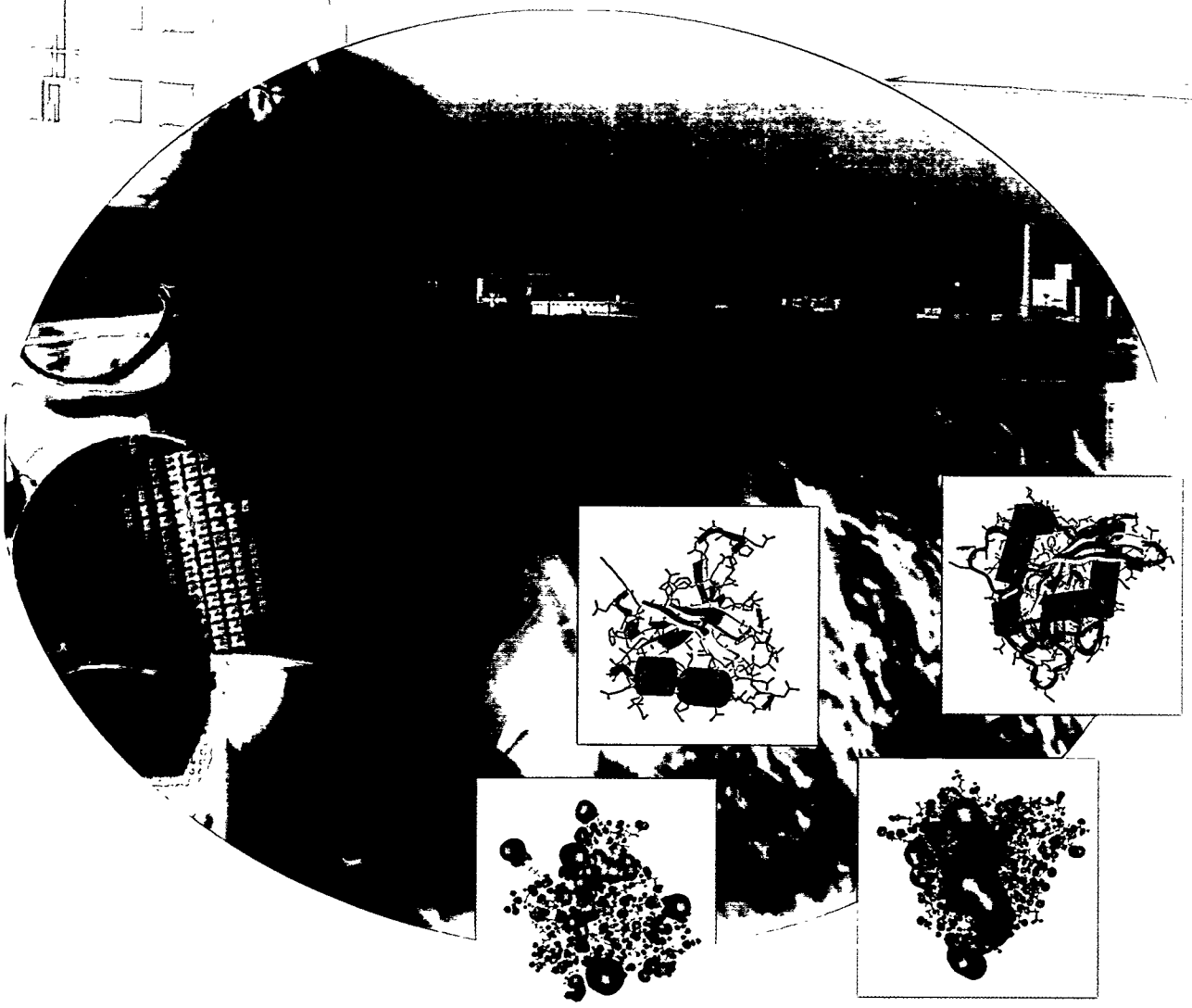
Institutional Plan

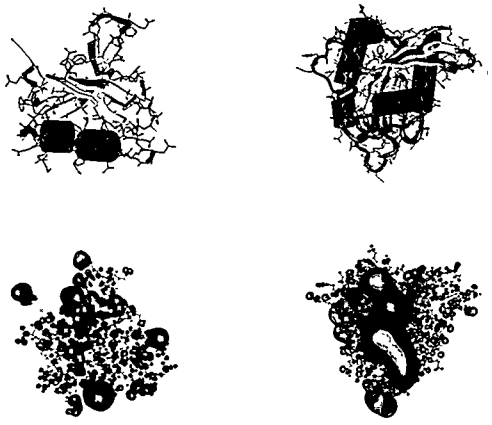
FY 2000-2004



Pacific Northwest National Laboratory

Operated by Battelle for the
U.S. Department of Energy

There is an enormous gap in scientific data related to health consequences of environmental contaminants. In response to these needs, the Pacific Northwest National Laboratory and its partners are developing an Environmental Health initiative — a national, collaborative effort that brings scientists together to address these critical issues. Our primary research focus is on understanding the molecular basis for health impacts.



The figures are visualizations of the results of computational analyses (molecular dynamics and free energy difference evaluations) of the proteins using the crystal structures of the protein obtained from the protein database.

Ras proteins (inside column) are involved in specific signaling pathways important for cell growth. Approximately 30 percent of all human tumors have a mutated Ras. To function properly, Ras must bind to Raf (outside column).

The work illustrated in these figures was undertaken to seek the mechanism(s) of Ras-Raf binding and why changes in Ras might induce tumor formation.

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Pacific Northwest National Laboratory
Institutional Plan
FY 2000-2004

January 2000

Prepared for the
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Pacific Northwest National Laboratory
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Director's Statement

Over the past five years the staff of Pacific Northwest National Laboratory have made what I believe to be truly extraordinary progress. We have greatly enhanced our research capabilities and delivered new science and technology to meet critical national needs. We have entirely overhauled our management systems, increasing efficiency and reducing cost while improving our environment, safety, and health performance. We have made significant contributions to our community, strengthening our reputation as a trusted and valued community asset.

Adrian Roberts, Interim Laboratory Director, Pacific Northwest National Laboratory

Our progress is evident in quantitative measures such as our performance in peer-reviewed competitions, the rapid growth and enthusiasm of the Environmental Molecular Sciences Laboratory user community, our improved cost and operational statistics, and the results of community surveys that show our neighbors' support.

There is no question that the future promises to be as dynamic and as challenging as our past, and we cannot relax our efforts. We will raise our level of performance as much in the next five years as we have in the past five years based on our strategy for achieving simultaneous excellence in science and technology, laboratory management and operations, and community development. By expanding our scientific impact and reputation, we will deliver more significant contributions to DOE's missions. Through continuous innovation and improvement, we will reach even higher standards for excellence in laboratory management. Building on an impressive record of community service, we will become the hallmark for good corporate citizenship.

Delivering Science and Technology

Over the past decade, Pacific Northwest has greatly expanded its scientific and technological reputation and impact, thanks to our staff who have conducted cutting-edge work in areas ranging from molecular science to advanced energy technology. In just this past year, we made extraordinary progress in developing a large and growing user base for the William R. Wiley Environmental Molecular Sciences Laboratory. We made great strides in our initiatives to expand capabilities in environmental health and computational science. Through the Environmental Health initiative, we plan to become DOE's leading laboratory for providing the scientific basis for determining the health consequences of environmental contaminants. By strengthening our computational science capability, we will be able to exploit the progress in computing technology to deliver new scientific insights through modeling of complex physical, chemical, and biological systems.

We also will continue building on the good work we have accomplished in the development of environmental science and technology, including our work in DOE's Environmental Management Science Program and the Natural and Accelerated Bioremediation Research program. In FY 1999, we better defined our environmental cleanup role at Hanford in partnership with DOE and site contractors. We are leading the development of the Science and Technology Plan for the groundwater/vadose zone problem, and are helping DOE deploy an in situ barrier technology to protect the Columbia River from Hanford's legacy wastes. As we look to the future, Pacific Northwest must continue to deliver high-value results in environmental cleanup both at Hanford and around the nation. These results

range from developing the science required to set risk-based standards to deploying technologies required to quickly and cost-effectively meet those standards.

Our work in DOE's energy mission has grown from our traditional role in building standards and energy policy to include a broad array of energy science and technology thrusts. We are prominently engaged in development of new lightweight materials and low-emission power systems for transportation industry applications. Working in partnership with DOE-Fossil Energy and the Federal Energy Technology Center, Pacific Northwest is introducing new research thrusts in fuel cells and distributed generation that support DOE's science-based energy strategy. Building on our past work in climate research and energy efficiency, this year we are launching a new effort to define a carbon management technology strategy that can contribute to stabilization of carbon dioxide in the atmosphere.

Among our most significant roles is helping DOE and the nation meet critical challenges in nonproliferation and arms control. Building on a long history of work in arms control, treaty verification, materials disposition and nuclear safety, our staff took a leading role in DOE's Nuclear Cities Initiative, where the United States and Russia are joining forces to bring jobs and commercial enterprises to Russia's secret "nuclear cities." The science and technology developed through our Detection and Characterization of Biological Pathogens initiative will aid in identifying pathogens sooner and, ultimately, lead to advances in food safety, counterterrorism, air and water quality, and health care delivery. We also established the Pacific Northwest Center for Global Security to serve as a regional hub for nonproliferation activities. Its mission is to promote collaboration among Northwest academic, private, and non-government stakeholders for proliferation prevention and arms control policy.

Becoming Benchmark for Laboratory Management

There is no question that we have made extraordinary progress in improving laboratory operations across the board over the last few years; however, we can not rest on our accomplishments. To fully realize the Laboratory's potential in the 21st century, we must redouble our efforts to support staff development and enhance tools for operational excellence. We will continue the Management Skills Development Program we introduced last year to better train current managers and future leaders of the organization. The Standards-Based Management System (SBMS) developed over the past few years will transition into a second-generation model that provides just-in-time information and tools at the benchtop. The principles of Integrated Safety Management also must be applied to security so that we ensure the Laboratory remains a reliable resource for carrying out DOE's sensitive programmatic work.

The new millennium also will give Pacific Northwest an unprecedented opportunity to add greater value to DOE by working with our sister laboratories to share best management practices. We must draw on the best available capabilities across the entire DOE system, whether developed at this Laboratory or elsewhere.

Serving the Community

While delivering scientific and operational excellence, we must be mindful of our commitment to be a good corporate citizen. For more than three decades, the staff of Pacific Northwest have given generously of their time and money to support the communities in which they live and work. Just this year, we introduced a new program called Team Battelle, which supports our staff as they volunteer in community activities of their choice.

The Economic Development Office (EDO) adds yet another dimension to our value in the community. Since its inception in 1994, EDO has provided a wide range of services that diversify the local economy, develop new technology-based jobs, strengthen small businesses, and attract new businesses. These economic development and volunteer efforts, combined with corporate contributions and science education programs, firmly establish Pacific Northwest as a neighbor of choice.

Another important element of our community service is establishing partnerships with local and regional organizations to enhance science and math education. For the past few years, we have increased our partnerships with smaller regional colleges and universities that have tremendous untapped research talent. We also have focused education efforts on systemic education reform and the professional development of teachers. Through the new Scientist-Student-Teacher High School Research Project, students and teachers have the opportunity to enhance their science literacy by teaming with our researchers on long-term research projects. The participants then are expected to continue their research throughout the academic year. In the future, distance learning technology will continue playing a significant role in our efforts to extend the research experience into the classroom. Diversity will remain a priority as we seek to bring more women and minorities into the scientific and technical workforce.

Looking Ahead

There is no doubt that the tremendous progress we've made in the past will strengthen our position in the future, but we should recognize that demanding challenges are ahead. We'll need to ensure Pacific Northwest, despite tight budgets, has the laboratories, computing capabilities, and supporting infrastructure it will need to meet future missions. Recruiting and retaining quality leadership and research talent while enhancing a diversified workforce will remain a challenge, particularly in key areas such as life sciences and information technology. We must also demonstrate that we can continue to safely and securely manage an increasing role for DOE and other federal agencies, which have agreements with DOE for use of its unique facilities. We also have an increasing obligation to more effectively use our science and technology to enhance U.S. industrial competitiveness, support our region's needs for sustainable growth, and help those countries less well-developed than our own.

The challenges of the next five years will be every bit as demanding and exciting as those we've taken on in the last five years, but I am confident that the staff of the Pacific Northwest National Laboratory is up to the task. If we give our best efforts, we have an extraordinary opportunity to contribute world-class science and technology to DOE, the nation, and the world.

2

Laboratory Mission, Roles, and Technical Capabilities

Mission

Pacific Northwest National Laboratory's vision is to be among the world's premier research laboratories, distinguished by scientific excellence, known for solving the U.S. Department of Energy's most critical and challenging problems, widely recognized for operational excellence, and highly valued by the community and region in which we operate. We have defined three long-term strategic objectives: 1) to be DOE's premier environmental science and technology laboratory, 2) to be the benchmark case for laboratory management, and 3) to be a valued community and regional asset. In line with this vision, we have established the following mission statement:

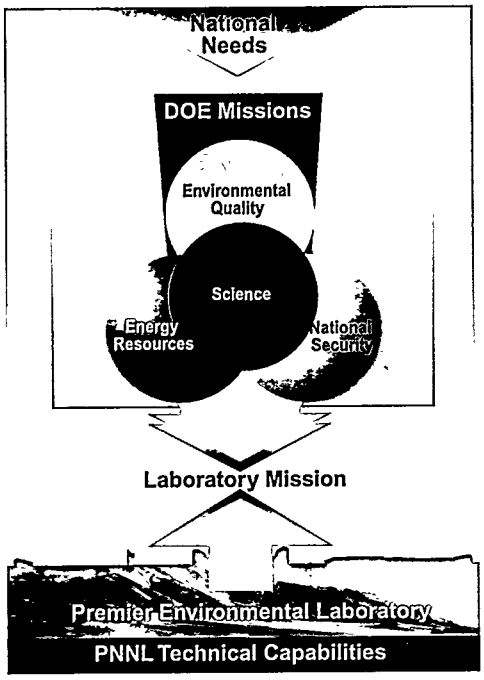
Pacific Northwest National Laboratory's core mission is to deliver environmental science and technology in the service of the nation and humanity. Through basic research, we create fundamental knowledge of natural, engineered, and social systems that is the basis for both effective environmental technology and sound public policy. We solve legacy environmental problems by delivering technologies that remedy existing hazards, address today's environmental needs with technologies that prevent pollution and minimize waste, and lay the technical foundation for tomorrow's inherently clean energy and industrial processes. We apply our capabilities to meet selected national security, energy, and human health needs; strengthen the U.S. economy; and support the education of future scientists and engineers.

Roles

Our role in DOE's missions is determined by the match between DOE mission needs and associated mission research and development portfolios and Pacific Northwest's technical capabilities. Our strengths in environmental science and technology find significant application in each of DOE's missions.

In the **Science mission**, Pacific Northwest's work is concentrated around the Office of Science themes "Protecting Our Living Planet" and "Extraordinary Tools for Extraordinary Science." We operate the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL)—a national user facility with unique nuclear magnetic resonance, high-field mass spectrometry, surface science and other molecular science instrumentation, and the Molecular Science Computing Facility—providing unique molecular simulation capabilities to the scientific community. We play a major role in DOE's environmental science programs in climate research and in understanding the health and ecological consequences of environmental contaminants. Computational science programs at Pacific Northwest focus on chemical modeling and simulation, regional climate modeling, and environmental fate and transport. Pacific Northwest is also home to significant programs in the chemical and materials sciences, including instrument development and analytical chemistry efforts. Well-defined roles in the themes "Exploring Matter and Energy" and "Fueling the Future" include research in molecular processes in condensed phases, in chemistry and physics at solid-liquid interfaces, in complex processes that control living organisms, and in catalysis and design and synthesis of lightweight materials, respectively.

For the **Environmental Quality mission**, we provide leadership and science and technology for both disposal of waste materials and enhancing future land use. We lead and collaborate on new and innovative research projects through DOE's Environmental

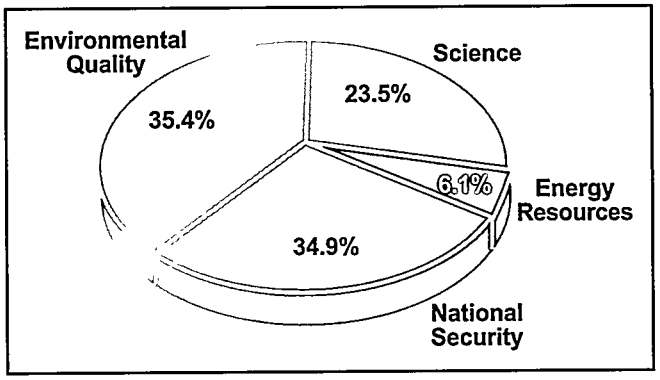


PNNL's mission and roles are determined by the match between DOE's mission needs and PNNL's technical capabilities.

Management Science Program (EMSP). We manage the Tanks Focus Area, a nationwide program to help solve tank waste problems at four DOE sites. We develop innovative methods to retrieve, pretreat, treat, and immobilize high-level waste and assist DOE in implementing privatized treatment and immobilization of the high-level waste at Hanford. We lead a multilaboratory team to evaluate the Hanford groundwater and vadose zone issues and develop and maintain a science and technology roadmap to address site needs. We apply a systems perspective and strength in decision analysis, risk management, and stakeholder involvement to solve several of DOE's other critical problems, including spent fuel disposition and site remediation. Finally, we develop and deploy technologies for groundwater remediation, advanced characterization, and creation of interim and long-term barriers to prevent the future spread of contamination.

In the **Energy Resources mission**, we focus our efforts in four areas: clean and efficient vehicles; efficient, affordable buildings; clean, affordable power; and clean, productive industries. We lead the Northwest Alliance for Transportation Technology (NATT), a public-private partnership to help reduce vehicle weight, increase efficiency, and reduce emissions. We develop and support implementation of energy codes and standards and automated diagnostics for efficient, affordable buildings and develop new and efficient technologies for buildings of the future. We develop new fuel cell technology for advanced propulsion and power systems. We help to ensure reliability and decrease costs for the electric power industry through work in real-time power system control and operations. Finally, we provide a broad range of capabilities from program planning and technical evaluation to technology development and demonstration, including developing renewable routes for value-added chemical manufacture and new separations technologies for industrial applications.

For DOE's **National Security mission**, we provide capabilities in sensitive detection technologies and systems, nuclear science and technology, and information technology and visualization, primarily for arms control and nonproliferation applications. We provide technologies and systems for detection, nuclear forensics, tracking and tagging, and materials protection and accountability to counter proliferation and inhibit nuclear terrorism. Our expertise in high-sensitivity radionuclide collection and analysis is used to monitor compliance with the Comprehensive Test Ban Treaty and supports our role in formulating an integrated diversion/detection "nuclear smuggling" program. We support DOE's nonproliferation programs through the Former Soviet Union Materials Protection, Control, and Accountability Program and the North Korean Agreed Framework program. We provide infrared chemical sensing, sensor development, and data algorithms for effluent detection. We are also developing and deploying technologies in support of national critical infrastructure protection and in reducing the risk of loss of information and technologies to hostile entities. In addition, we have significant



Mission distribution of PNNL's research and development funding (1999 data).

programmatic and technical responsibilities in DOE's effort to reduce the danger associated with production reactors in the former Soviet Union.

The mission distribution of Pacific Northwest's research and development funding is shown in the figure on the previous page. More detailed discussions of these roles in the context of DOE's mission R&D portfolios are provided in Section 5 of this plan.

Technical Capabilities

Our ability to fill our mission roles is based on the strength and vitality of our technical capabilities. To ensure the long-term health of these capabilities, Pacific Northwest maintains a set of technical networks that cuts across mission and organizational boundaries. All research staff participate in one or more of these networks. Leadership for these networks is provided by senior members of our technical staff who are responsible for identifying areas where the capabilities need to be strengthened or renewed. Leaders form a "PNNL Technical Council" and provide science and technology advice to management and organize and lead technical peer reviews of Laboratory Directed Research and Development proposals. Pacific Northwest's core technical networks are listed below.

- Analytical and Physical Chemistry
- Computational Science and Engineering
- Computer Science and Information Technology
- Design and Manufacturing Engineering
- Earth Systems Science
- Energy Technology and Management
- Human Health and Safety
- Information Synthesis (emerging)
- Materials Science and Technology
- Micro/Nanotechnology (emerging)
- Molecular and Cellular Biology
- Nuclear Science and Engineering
- Policy and Management Sciences
- Sensors and Controls
- Separations and Conversion
- Statistics.

3

Laboratory Strategic Plan

National needs and DOE's mission requirements, opportunities in science and technology, and the expectations of the public and our local community are all subject to continuing, and often rapid, change. To ensure the continuing relevance and vitality of Pacific Northwest, we must respond to, and often act in anticipation of these changes. The last 15 years of our history provides several illustrations of this requirement (see the table). During that time, we have significantly strengthened our fundamental science base, brought Pacific Northwest's first major scientific user facility from concept to operation, established clear focus as DOE's premier environmental laboratory, established well-defined roles consistent with our capabilities in each of DOE's four core missions, overhauled our management practices and increased productivity, and increased our contributions to and recognition in our community and region. These actions, each taken in response to or in anticipation of strong external drivers, have significantly strengthened the capabilities of Pacific Northwest and increased the value that we deliver to DOE and the nation.

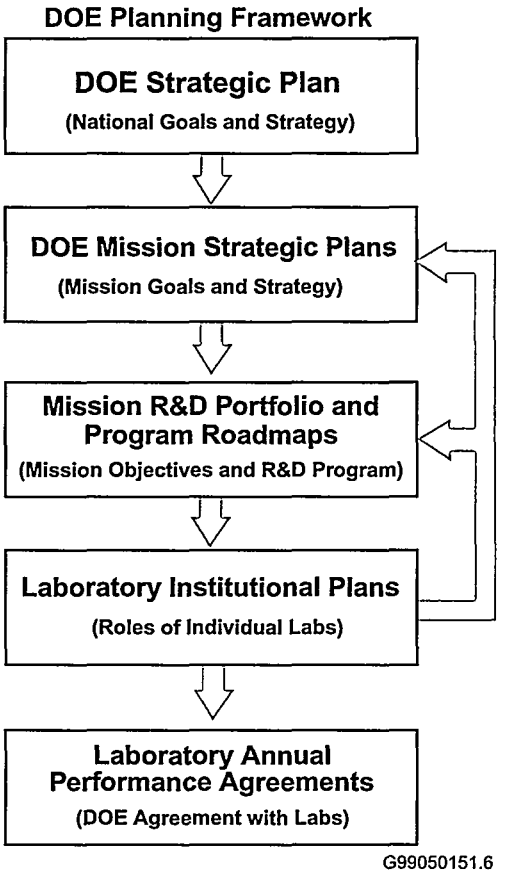
The next few years look to be no less demanding, no less exciting, and to require no less change. The astonishing rate of progress in science and technology that we are experiencing shows no signs of slowing. New science and technology will create tremendous opportunity for discovery and create new solutions to DOE's most demanding mission problems. It will also create daunting challenges to maintain leading-edge capabilities and programs. Pressures on our environment from worldwide population and economic growth, coupled with the increasing public recognition of the need for environmental stewardship, also create both opportunity and challenges, particularly for a laboratory that is focused on

Major Change Initiatives at Pacific Northwest National Laboratory, 1985—Present

Date	Situation	Pacific Northwest Response
Mid-late 1980s	As a (then) Office of Energy Research Laboratory, Pacific Northwest had to significantly strengthen basic science capabilities and participate in DOE-ER's user facility mission.	Launched major initiative in molecular science, carried out recruiting program, and conceived and developed instrumentation and facility concepts leading to the Environmental Molecular Sciences Laboratory.
1994-1996	Clear need for increased productivity and reduced cost identified through Galvin and other reviews and budget pressures.	Carried out major productivity initiative leading to reduced costs and more effective work processes; redesigned management systems to better support mission accomplishment.
	Clear requirement for improved operations identified as a result of performance reviews and unacceptable frequency of operational problems.	Established objective to be best managed laboratory; designed and implemented broad operational improvement program in cooperation with DOE.
	Identified local economic development as primary concern of local community.	Created Economic Development Office and associated small business assistance, entrepreneurial leave, and other economic development programs.
1995-1996	In response to Galvin report and DOE direction, need identified for clearer technical focus at Pacific Northwest.	Pacific Northwest focus defined around concept of "Premier Environmental Laboratory," with strong environmental science and technology core applied to well-defined roles in each of DOE's missions.

environmental science and technology. The rapid evolution of national security needs and the reshaping of the nation's and world's energy industries show that these missions will be equally dynamic and demanding. Requirements for continued improvement in management and operational practices and productivity will also place stiff requirements on Pacific Northwest.

This plan presents our strategy for responding to changing times. In the following paragraphs our planning assumptions and other drivers and Pacific Northwest's strategy for responding to those drivers are presented. Our major research initiatives are described in Section 4. Section 5 provides more detailed descriptions of our role in and strategy for each of DOE's core missions. Section 6 summarizes our strategy for maintaining and operating the facilities and support functions required to enable mission accomplishment. In total, this plan lays out our roles in DOE's missions and our plans for ensuring that Pacific Northwest remains a vital, productive research institution in the years to come.



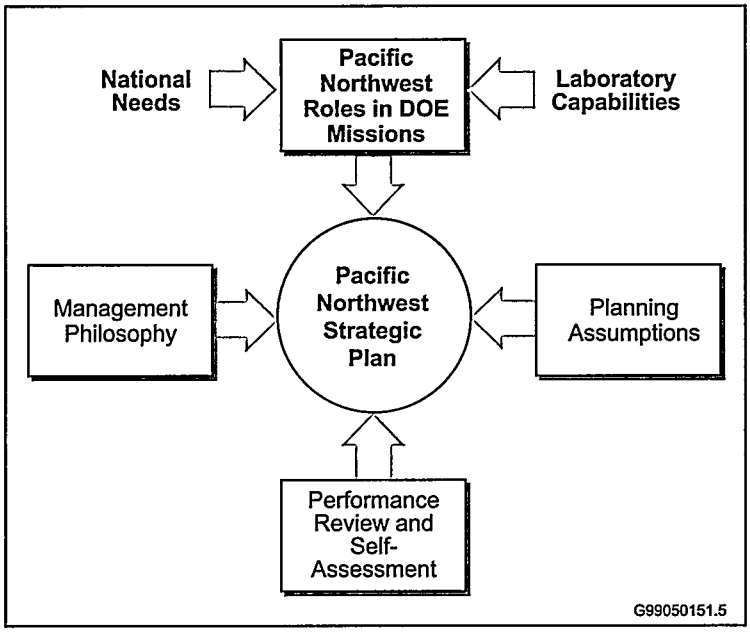
Pacific Northwest's Institutional Plan is part of the DOE planning framework. Laboratory Institutional Plans describe laboratory roles in meeting DOE's objectives as laid out in DOE's strategic plan and mission-specific plans and the R&D programs defined in the mission R&D portfolios. The Institutional Plans also serve to propose new initiatives for inclusion in DOE's planning.

Key Planning Assumptions

Pacific Northwest National Laboratory's strategic plan is derived from four primary factors (figure next page):

- A set of planning assumptions that captures our best understanding of the issues that will primarily drive national needs, and in particular, DOE missions; the science and technology opportunities that will allow us to address those needs; and the policy and budget climate within which we will operate.
- An overall management philosophy that requires simultaneous excellence in science and technology, laboratory operations, and community relations, and that emphasizes both effective performance on current programs and long-term institutional stewardship.
- The roles that Pacific Northwest plays in each of DOE's missions as determined by the match between the objectives laid out in DOE's strategic plan and Pacific Northwest capabilities (described in Section 2 and in more detail in Section 5).
- The results of our ongoing self-assessment efforts and DOE's annual performance appraisal.

Our planning is strongly influenced by a set of assumptions regarding national needs, trends in science and technology, science policy and budgets, and management of DOE and the DOE laboratory system. These assumptions and their implications are laid out in the following table.



PNNL's strategic plan is based on the laboratory's roles in DOE's missions, a set of fundamental planning assumptions, management philosophy and approach, and the results of annual performance reviews and self-assessments.

Planning Assumptions and Implications

Assumption	Implications for Pacific Northwest
National Needs and DOE Missions	
The impact of economic development and human needs on human health and global and local environments will continue to be a primary driver for long-term science and technology investments. Societal response will be based on perceived impacts on human health and well-being.	Improvement in the understanding of natural systems and our ability to forecast the impact of human activities on those systems is required, as is a better understanding of the consequent impacts on human health. Technologies that allow economic growth while maintaining our environment will remain critical.
Preventing the proliferation of weapons of mass destruction into the hands of rogue states and terrorist groups will be a significant driver for national security for the forseeable future. Counterterrorism at home and abroad will continue to grow in importance as will cyber security issues. Addressing international nuclear safety, fuel disposition, and related matters will remain a priority.	High sensitivity instrumentation and related capabilities required to detect nuclear, chemical, and biological weapons activity are required. Nuclear science and technology capabilities will find significant application in dealing with international reactor safety and materials protection and disposition issues.
Science and Technology	
Advances in information technology will continue at a rapid rate. Modeling and simulation will become increasingly important in many scientific fields. The ability to embed "intelligence" will transform everything from consumer products to sophisticated scientific instrumentation.	Continuing investments in the Information Technology (IT) knowledge, expertise of staff, research equipment, and in IT infrastructure are required. To maintain current mission roles, Pacific Northwest must continue to enhance computational science capabilities.
Understanding biological systems at the molecular level will be a dominant science and technology focus. Advances will have dramatic effects, not only on medicine and human health, but on industrial process technology and on our understanding and management of the environment.	To maintain current mission roles, Pacific Northwest must strengthen life sciences capabilities both internally and through partnerships.
The ability to manipulate matter on the molecular and even atomic scales will also be a major scientific theme of the coming years. Transforming effects are likely on everything from human health to industrial production technology.	There will be significant opportunities to develop energy-efficient, low-pollution scaleable technology for a variety of applications. Engineering of microscale and nanoscale devices, design of chemically active surfaces, and systems engineering will be significant growth areas.

Planning Assumptions and Implications (contd)

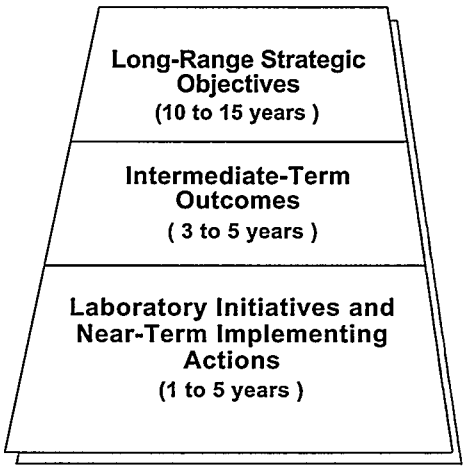
Assumption	Implications for Pacific Northwest
Science Policy and Budgets	
Investment in government-funded research will be at least stable and perhaps show modest growth, with most funding going toward research areas linked closely to a specific societal need. DOE resources will be limited.	DOE and its laboratories must demonstrate a clear link between research programs and potential societal benefits. Multiagency partnerships will be important.
Accountability for delivery of tangible results from public investment will continue to grow in importance.	DOE and its laboratories must deliver significant outcomes that impact DOE's mission objectives from its research programs and collaborations.
Industrial research and development will continue to be characterized by a focus on product development issues with limited investment in longer-term basic research.	Industry will continue to look toward government spending in basic research to provide the new knowledge from which breakthrough commercial technologies can arise. Strong industrial partnerships will be required to ensure the greatest public return from the nation's R&D investment.
DOE and the Laboratory System	
DOE and its national laboratories will remain under fierce pressure to improve management practices and increase productivity. The pressure for excellence in operations will be intense. Research facilities that are perceived as posing hazards to nearby populations will be extremely difficult to operate.	Laboratories must continue to improve performance through using best commercial practices, developing outcome-oriented performance measures, and eliminating low-value-added activities.
There will be substantial pressure to improve performance on security.	We must demonstrate reliably outstanding performance on security to ensure that Pacific Northwest can be trusted with sensitive work while maintaining its role in DOE's international programs.
DOE will continue to expect the national laboratories to operate more closely as a system when carrying out major programs.	Laboratories must give increasing emphasis to building capability through partnerships with other national laboratories and universities.

The Laboratory Agenda

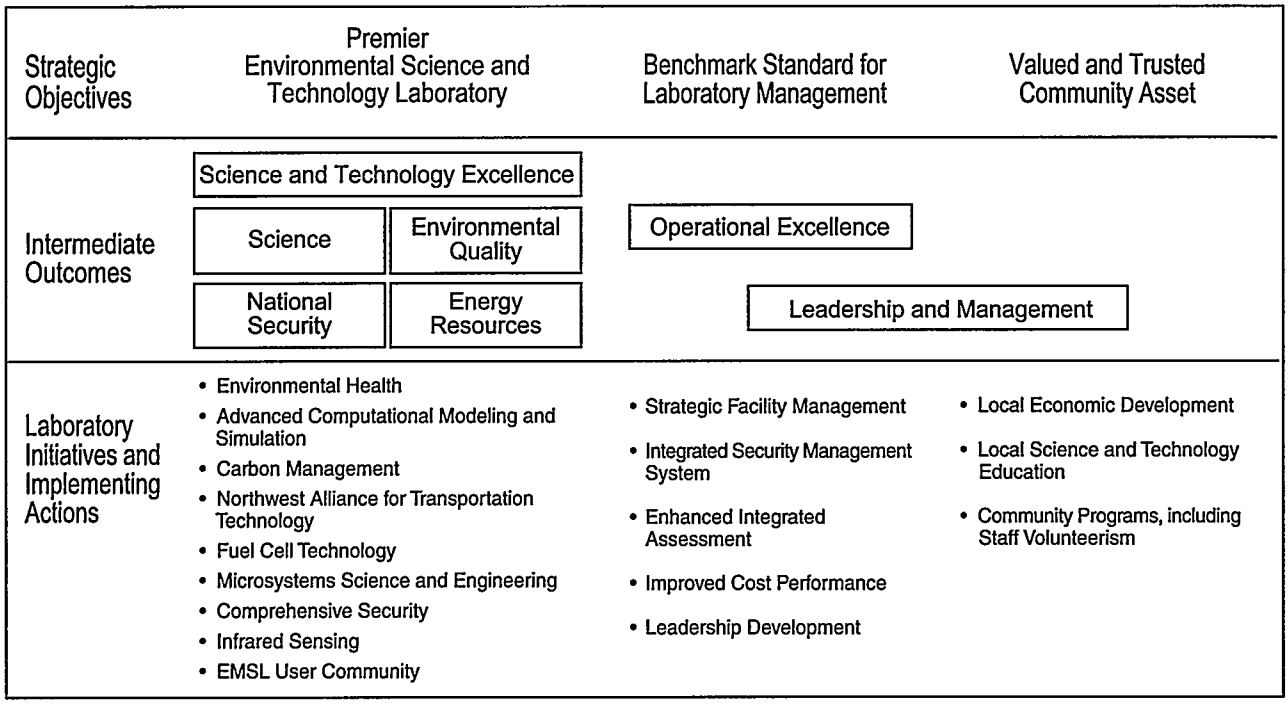
The major elements of Pacific Northwest's strategy are captured in our Laboratory Agenda. The Agenda provides a structured framework for Pacific Northwest's long-term strategic objectives, intermediate-term outcomes, and the initiatives and actions to achieve those outcomes. This structure, represented in the figure, is updated from the top down using information developed through our annual planning process. The Agenda includes clear statements of the primary results that Pacific Northwest will deliver to DOE over the next few years, and the major science and technology, operational improvement, and community relations initiatives that we are undertaking to deliver those results.

The structure and selected key elements of our FY 2000 Agenda are shown in the figure on the next page, and they are further described in the following paragraphs. The discussion is structured around the three long-term strategic objectives introduced in Section 2 of this plan.

Laboratory Agenda Framework



Major elements of PNNL's Laboratory Agenda consist of long-range strategic objectives, intermediate-term outcomes, and short-term laboratory initiatives.



The major elements of PNNL's strategy are captured in our Laboratory Agenda.

Strategic Objective 1—Pacific Northwest Will Be DOE's Premier Environmental Science and Technology Laboratory

Pacific Northwest intends to be DOE's premier environmental science and technology laboratory, making significant contributions toward solving the nation's and world's most critical environmental challenges. We also will deliver significant contributions to each of DOE's missions in well-defined roles derived from our environmental science and technology and other distinctive capabilities. Pacific Northwest will be widely recognized for scientific excellence and innovative, high-value technology solutions and home to unique research facilities that are an integral part of the nation's science and technology infrastructure. Over the next several years, we will deliver a number of major actions in line with this objective, as described below.

1. **Science.** Pacific Northwest will conduct basic research that develops new knowledge and understanding that underpins the missions of the Department of Energy. In particular, Pacific Northwest will

   - Operate the William R. Wiley Environmental Molecular Sciences Laboratory with distinction as a national scientific user facility and a fundamental research laboratory contributing to DOE's environmental and science missions.
   - Become a nationally recognized leader in environmental health research through delivery of the fundamental knowledge required to understand, predict, and mitigate the health impacts of environmental contaminants.
   - Become a leading center for computational science, distinguished by development of robust, high-performance software suites, and delivery of significant new science and impact to DOE's energy, environment, and national security missions.
   - Contribute to a basic understanding of the science of global environmental change by operating DOE's Atmospheric Radiation Measurement program, by conducting research that improves knowledge of and the ability to model the effects of energy

production and use on the environment, and by developing the knowledge and tools needed to assess and mitigate the social, economic, and environmental impacts of global change.

2. **Environmental Quality**. Pacific Northwest will deliver fundamental improvements in science and technology that provide for a healthy global environment and enable sustainable world development. In particular, Pacific Northwest will

   - Deliver science and technology critical to productivity improvements that enable DOE to accelerate cleanup and closure schedules and lower the overall life-cycle cleanup costs at Hanford and across the DOE complex.
   - Contribute to the development of the basis for long-term management at Hanford and other DOE sites.
   - Develop and apply innovative solutions that contribute to enabling sustainable world development while addressing DOE activities to ensure a cleaner environment, the nation's natural resource management issues, and other environmental issues that impact sustainable development.

3. **National Security**. Pacific Northwest will enhance national and international security by developing and applying new science and technology and delivering creative and innovative solutions to arms control and nonproliferation, infrastructure protection and counterterrorism, and other major national security needs. In particular, Pacific Northwest will

   - Anticipate emerging threats and respond to existing threats through the establishment of Nuclear City Initiative centers, development of the critical infrastructure protection and analysis laboratory (cyber security), and other programs.
   - Develop, apply, and deploy the science, technology, and human resources necessary for implementing policy development and actions pursuant to policy, including effective operation of the International Nuclear Safety Program and the development of new infrared sensing technologies for detection of effluents from proliferation of nuclear, chemical, and biological weapons.
   - Develop and deploy innovative solutions based on existing technology to respond to national security needs, including complete materials protection, control, and accountability upgrades at selected sites, and assume science implementation leadership roles for existing and future treaties and agreements.

4. **Energy Resources**. Pacific Northwest will demonstrate leadership and technical quality in energy-efficiency programs and will impact energy utilization and carbon management issues. In particular, Pacific Northwest will

   - Deliver science and technology critical to clean and efficient vehicles.
   - Develop leadership, direction, and technical program support for the development of advanced power systems programs.
   - Provide the sustaining leadership for programs in building codes and standards and demonstrate leadership in the development of a program in intelligent buildings.

In support of these objectives, and in line with the implications of our planning assumptions, Pacific Northwest is undertaking a number of implementing actions, including several strategic science and technology initiatives. Major implementing actions are described below.

- The Environmental Health initiative will build the scientific foundation for improved understanding of the health impacts of environmental contaminants and strengthen our experimental and computational capabilities in molecular biology and related areas.

- The Advanced Computational Modeling and Simulation initiative will build integrated capabilities in computer science, applied mathematics and computational science (with emphasis on molecular science), regional climate prediction, subsurface and atmospheric reactive transport, and engineering modeling and simulation.
- The Microsystems Science and Engineering initiative will develop a fundamental understanding of and device engineering capabilities in microscale heat and mass transfer, device fabrication, and surface modification with potential applications to DOE's energy, environmental quality, and national security missions.
- The Cyber Security initiative is designed to build forefront capabilities in cyber security and critical infrastructure protection.
- The Northwest Alliance for Transportation Technology initiative is building capabilities and partnerships required to enable the use of advanced lightweight materials in transportation applications.
- An initiative in carbon management will provide DOE with an integrated approach to the problems of climate change and carbon management, encompassing global- and regional-scale effect prediction and the technology options of energy efficiency, nonfossil energy sources, and carbon sequestration.
- The fuel cell technology initiative will provide leadership to support DOE's solid oxide fuel cell program and new fuel cell materials, fabrication techniques, and systems integration approaches.
- The infrared sensing initiative will provide new means to detect and identify chemicals in the atmosphere and on surfaces, which are associated with the proliferation of nuclear, chemical, and biological weapons.
- Pacific Northwest is continuing efforts to strengthen the contribution of the EMSL, expanding and broadening its user base and increasing its scientific productivity.

Details on our initiatives are provided in Section 4.

Strategic Objective 2—Pacific Northwest Will Be the Benchmark Case for Laboratory Management

Our second strategic objective is that Pacific Northwest will be the benchmark case for laboratory management, delivering high-quality, relevant science and technology at the lowest possible cost, operating our facilities and programs with distinction, and protecting the environment and the health and safety of our staff and the public.

Operational Excellence. Pacific Northwest will conduct work and operate laboratory facilities with distinction, fully supportive of the science and technology mission and fully protective of workers, the public, and the environment. In particular, Pacific Northwest will

- Manage the physical plant to provide a set of facilities and the supporting infrastructure that are aligned with future mission needs.
- Sustain and enhance Pacific Northwest's integrated processes and training for ensuring excellence in safety, health, and environmental protection.

Leadership and Management. Pacific Northwest will provide the leadership that ensures science and technology excellence and maintains the infrastructure necessary to accomplish DOE's missions and will operate as a good neighbor in the community. This outcome is also part of the third strategic objective of being a valued community and regional asset. In particular, Pacific Northwest will

- Provide leaders and staff necessary to ensure the achievement of simultaneous excellence in science and technology, operations, and community relations.

- Ensure that Pacific Northwest has a clear identity separate from Hanford, is viewed as a good corporate citizen, makes a difference in key regional issues, and enhances the science and mathematics education efforts in the area.
- Drive continuous improvement through comprehensive self-assessment.

Major implementing actions for this strategic objective include

- Development of a comprehensive security management system designed to strengthen our security systems, increase staff awareness of security issues, and ensure the reliable protection of classified and other sensitive information.
- Enhance the existing integrated safety management system by implementing a rigorous self-assessment and broadening its deployment.
- Development of a strategic facilities management plan to ensure that our physical plant meets expected mission requirements in the years to come and that support services obtained through the Hanford Site and the private sector are cost-effective and commensurate with mission requirements.
- Conduct a comprehensive evaluation of the internal and external factors affecting laboratory costs to identify opportunities for near- and long-term cost reductions.
- Ongoing implementation of a comprehensive leadership development program designed to provide training and support for staff entering leadership positions and to broaden and diversify our leadership pool.
- Continuing development of our integrated assessment management system designed to provide early and reliable detection of operational and other issues and to support continuous improvement in management and support functions.

Strategic Objective 3—Pacific Northwest Will Be a Valued Community and Regional Asset

In line with our philosophy of simultaneous excellence in science and technology, laboratory operation, and community relations, our third strategic objective is that Pacific Northwest will be a valued community and regional asset, making significant contributions to local economic development, science education, and other major community interests; playing an integral role in the national and regional science and technology infrastructure; and making significant contributions to regional environmental and other issues. This objective is also supported by the Leadership and Management outcome stated above. Primary implementing actions include

Team Battelle members staffed a booth on pollution prevention at the Earth Day Festival in Howard Amon Park, Richland, Washington.

- Continuing operation of Pacific Northwest's Economic Development Office, supporting the formation of new companies, providing support to local and regional economic development agencies, and providing access to our capabilities for small businesses. Pacific Northwest will work to strengthen its technology transfer function to increase its effectiveness and value.
- Continuing Pacific Northwest's successful science and technology education programs to improve the overall quality of science and technology education in the local community.
- Continuing a variety of community programs including minority outreach and implementation of the "Team Battelle" staff volunteer program at Pacific Northwest, supporting staff in their community activities, and increasing the visibility of Pacific Northwest participation.

4

Major Laboratory Initiatives

Our proposed science and technology research initiatives[a] are designed to strengthen our capability to respond to current and anticipated DOE mission needs. These initiatives help to ensure that Pacific Northwest remains intellectually viable and able to contribute to DOE missions for many years to come. Over time, successful initiatives will result in the development of significant new DOE research programs and capabilities that have significant application to existing programs. The knowledge, tools, and other scientific capabilities created through successful initiatives often lead to new scientific or technical opportunities.

Our portfolio of initiatives supports our roles in all four of DOE's primary missions. Often initiatives are directed toward creating new knowledge in areas that affect one or more of DOE's missions or major programs. For example, our Environmental Health initiative is directed toward providing fundamental understanding of cell signaling processes that we believe can significantly impact our understanding of the effect of environmental impacts on human health and ecosystem function. Similarly, our Microsystems Science and Engineering initiative is designed to provide the underlying scientific understanding and technology of building blocks necessary for application of microtechnology-based devices

Laboratory initiatives are intended to explore innovative ideas and strengthen or create technical capabilities in areas consistent with PNNL's roles in DOE's missions. Laboratory initiatives are usually targeted at leading-edge fundamental research or novel technologies, and the resulting capabilities often have potential application to two or more of DOE's missions.

Relevance of PNNL's Initiatives to DOE Missions

Initiative	Science	Environmental Quality	Energy Resources	National Security
Environmental Health	P	S	S	S
Advanced Computational Modeling and Simulation	P	S	S	S
Microsystems Science and Engineering	S	S	P	S
Cyber Security				P
Northwest Alliance for Transportation Technology			P	
Carbon Management	P		P	
Detection and Characterization of Pathogens	S	S		P
Environmental Contaminants and Remediation	S	P		
Science and Technology for Environmental Processing	S	P	P	

Note: P = Principal focus
S = Supporting focus

(a) Initiatives are provided for consideration by the Department of Energy. Inclusion in this plan does not imply DOE approval of or intent to implement an initiative.

in DOE's Environmental Quality, Energy Resources, and National Security missions. Other initiatives are directed toward supplying the science and technology base for a specific mission requirement; for example, our Cyber Security initiative is intended to help build the technical foundations for DOE to reduce the risk of losing information and technologies to foreign and domestic entities that are hostile to U.S. interests.

The research themes used by the Office of Science to provide a framework for DOE's science programs provide an alternative look at our initiatives. In line with the "Extraordinary Tools for Extraordinary Science" theme, the Advanced Computational Modeling and Simulation and Environmental Health initiatives proposed in this plan are aimed at creating significant national assets for multidisciplinary research. In keeping with our core environmental mission, these two initiatives are aligned with the theme "Protecting Our Living Planet." In addition, we are proposing a new effort in Carbon Management. The concluding initiatives in Environmental Contaminants and Remediation and Science and Technology for Environmental Processing are also aligned with this theme.

In line with the Office of Science's "Fueling the Future" theme, several of our scientific initiatives are also intended to support DOE's efforts to ensure abundant and clean energy. For example, our ongoing initiative in Microsystems Science and Engineering should provide the underlying science and fundamental engineering knowledge for technologies that improve the efficiency of energy production, conversion, and use or allow the mitigation of environmental impacts through such things as carbon sequestration.

PNNL's research initiatives are strongly aligned with three of the major research themes articulated by the Office of Science.

How PNNL Initiatives Support Office of Science Research Themes

Initiative	Protecting Our Living Planet	Extraordinary Tools for Extraordinary Science	Fueling the Future
Environmental Health	Fundamental knowledge to address an organisms's response to the environment	Instrumentation and modeling concepts for understanding molecular processes in living cells	
Advanced Computational Modeling and Simulation	Tools to predict the fate, transport, and impact of contaminants	Advanced software for modeling complex physical, chemical, and biological systems	
Microsystems Science and Engineering		Simulation tools for investigation of heat and mass transfer at the microscale	Microstructures with high rates of heat and mass transfer for energy-efficient devices
Carbon Management	Provides fundamental and applied science for carbon management		Technologies to reduce the environmental impact of energy production
Detection and Characterization of Pathogens	Fundamental and applied science for detecting and characterizing microorganisms		
Environmental Contaminants and Remediation	Science research to optimize new-generation contaminant remediation technologies		
Science and Technology for Environmental Processing	Science for advanced separations and conversions for environmentally acceptable processes		Science for advanced separations and conversion for energy-efficient processes

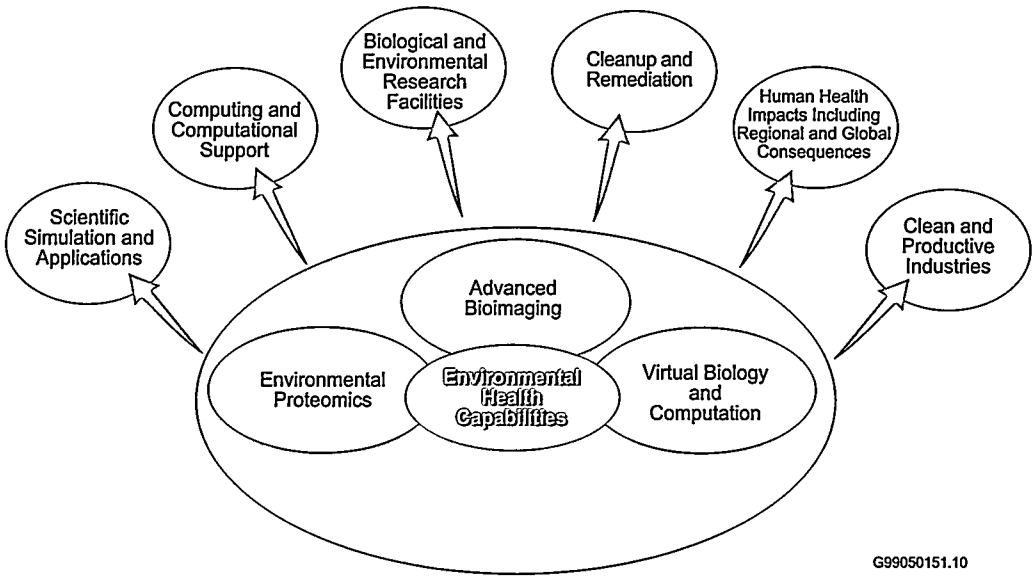
Current Initiatives

Environmental Health

Pacific Northwest National Laboratory is establishing an initiative for a national collaborative research program focused on the integration of emerging science and technology in molecular biology, biochemistry and physics, and advanced computation to substantially advance our ability to identify, understand, and mitigate environmental health threats. The combined insight from a variety of scientific disciplines is required to understand the complexity of exposure pathways and related health effects at the cellular level from which mutations and repair mechanisms are initiated, and to the organ and system levels where symptoms of disease are most often observed. Recent advances in molecular chemistry and physics have led to an increased understanding of the transport and reaction of pollutants in the environment and to the development of more effective mitigation technologies. Yet, understanding the links to biological mechanisms and how living organisms are affected by pollutants remains an enormous challenge. This initiative will take an integrated systems approach to understanding agent sources, distributions, exposures, and biological impacts with a focus on advancing the fundamental science at the molecular level of the health effects of environmental pollutants.

Link to DOE Research Agenda

The Environmental Health initiative directly serves a number of DOE missions including Science (human health effects of low-dose exposures, genetic susceptibility, microbial genomes); Environmental Quality (worker and public health risk assessment, environmental remediation); National Security (chemical/biological weapons nonproliferation); and Energy Resources (clean and affordable power, efficient and productive energy use). It aims to strengthen the basis for environmental decision making by providing greatly improved scientific understanding of the impacts of environmental contaminants on human health and environmental quality. We believe that the lack of such understanding is a major gap in our ability to establish appropriate standards for environmental remediation, set priorities for cleanup and pollution prevention efforts, and determine acceptable limits on environmental emissions. This initiative addresses two major themes of DOE's science



The capabilities being developed by the Environmental Health initiative help to provide a scientific basis for cleanup and energy management.

portfolio: "Protecting Our Living Planet" and "Extraordinary Tools for Extraordinary Science." DOE's research agenda must include development of an understanding of the health effects of environmental pollutants to better understand the impacts on people and the environment of energy-derived products and related technologies. Powerful new observational instruments and advanced computation and modeling will be required to attack the fundamental questions of biological mechanisms and effects at the molecular and cellular levels.

The scientific foundation for this initiative is the study of the complex cell signaling networks responsible for biological function. In the post-genomic era, understanding these networks and mechanisms will help us translate genetic mapping data into relevant knowledge about integrated biological functions in living organisms. Cell signaling is fundamental to the survival and function of organisms and is accomplished through a complex set of pathways and interconnected networks. It is the communication function that provides organisms with the means of responding and adapting to their environments. Via signaling processes, individual cells maintain intracellular integrity, sense their surrounding environment, communicate with each other, coordinate activities at a community level, and respond cooperatively as a population. The influence of environmental agents on human health is largely determined through these cell signaling processes.

Cell signaling research requires the development of new instruments and tools that allow the observation of complex biological systems in vivo. Through this initiative, we have already developed an initial state-of-the-art compound microscope that combines high-resolution nuclear magnetic resonance (NMR) with optical methods. We believe that this program may at some point require a facility to accommodate the unique instrumentation, supporting research capabilities, and collaborative environment required to perform the envisioned research.

Research Strategy

The research strategy for the Environmental Health initiative will incorporate research elements required to deliver an integrated systems approach to environmental health that encompasses environmental distribution of pollutants, exposure-to-dose, and downstream biological mechanisms and health effects. Research currently under way is focused on cell signaling. Cell signaling processes underlie major research frontiers in biology, including biological control mechanisms, learning and brain function, ecosystem function, and development of comprehensive predictive models (from cells to organisms). All living systems respond to their environment by integrating the functions of hundreds of interacting metabolic pathways and control networks. A coordinated, multi-pronged research strategy is required to map and elucidate complex hierarchical signaling systems and the responses of those systems to environmental influences. As the initiative focuses on a specific set of biological problems, mechanisms, organisms, and cell types, careful consideration will be given to the combinations, scale, and direction of investigation that provides the greatest synergy for understanding of environmental responses at the aggregate level of interest. This may involve a combination of bottoms-up elaboration of intracellular protein interactions and top down investigations from the organ (e.g., liver, lung) or whole systems level. Studies of simpler, multi-cellular organisms may be combined with parallel studies of human cell lines or systems. We have identified three critical research directions: 1) analyze and understand cellular components involved in cell signaling, 2) study cell signaling in vivo, and 3) synthesize acquired knowledge into an integrated cellular context via computation and modeling. These research areas will require the development and acquisition of science and technology capabilities currently unavailable to the scientific community, and they are the basis for proposing a significant research initiative.

We are building a program that will 1) enable cell signaling research, 2) effectively capitalize on information available in the post-genome era, and 3) serve the scientific community. We believe that this initiative will provide DOE and the scientific community with capabilities that significantly extend current DOE plans for functional genomics and provide a science and technology base that supports DOE missions. Research is being coordinated conceptually through the construct of an Environmental Cell Signaling Laboratory. This laboratory

will integrate research in molecular cell biology, computational biology, and environmental proteomics and will support essential collaborations with other centers of excellence in cell signaling. Key resources at EMSL (NMR, mass spectrometry, optical spectroscopy, computational chemistry), university centers of excellence, and other DOE national user facilities must be linked. Advances in computing and communication technologies now make it possible to share instrumentation, data, and data analyses, and EMSL continues to pioneer development of a "virtual laboratory."

The laboratory concept includes three key enabling components:

- **Cellular Observatory**—Biological function cannot be understood outside of the living cell. Biological processes occur on and around organized intracellular structures, are modulated by participation of associated processes, and are controlled by intact signaling pathways organized and integrated into interactive signaling networks. All biological information obtained to date can be adequately modeled, but none of the models can predict an outcome in a living system. Only when it is possible to make in vivo dynamic measurements in real time can biologically relevant measurements be made that can be used to construct predictive models. Accordingly, we are building a program to develop new in vivo measurement techniques. In the Cellular Observatory, two compound instruments have been identified, and both are being designed and assembled. Neither instrument has an existing successful counterpart. EMSL's combination of optical spectroscopy, magnetic resonance (NMR, EPR), x-ray spectroscopy, mass spectrometry, and computation-modeling capabilities will provide the base for genesis of a "cellular observatory" and the use of data through modeling and computation. The x-ray imaging capabilities at the Advanced Light Source and Advanced Photon Source synchrotron light sources will be valuable to this effort. Partnerships with other national laboratories that hold these user resources are being established in support of this research.

- **Virtual Biology Center**—The long-term goal of the Virtual Biology Center is to develop the framework and models needed to simulate biological behavior at the cellular, organ, and systems levels using advanced computational methods. This will enable us to 1) guide measurements of normal cellular behavior in living systems, 2) ascribe biological phenomena to the appropriate sets of molecular processes, 3) predict the biological responses induced by changing environmental conditions, and 4) predict cellular response to external stimuli. The very nature of cell signaling as the hierarchical controller of complex biological functions requires the synthesis of knowledge into an integrated cellular context; models (and supporting bioinformatics technologies) are the means for integrating our collective knowledge. The cell is a sophisticated, three-dimensional structure that performs like a chemical plant; it consists of many complex "unit processes" generating products in an aqueous medium. Using results of dynamic measurements from the cellular observatory, computational techniques can develop equation-based models that will enable scientists to predict cellular responses to external stimuli (i.e., environmental conditions). The computational architecture will allow adaptation and scaling horizontally across various cell types and upward through tissues, organs, and ultimately (in conjunction with other national and international research efforts) the "virtual body." The development and integration of the overall architecture and appropriate structural and functional models at multiple temporal and spatial scales of interest will require significant computational capabilities in terms of massively parallel hardware, data storage systems, networking, and software including the type of collaboratory environment being pioneered at EMSL. Key scientific capabilities include applied mathematics, computer science, bioinformatics, computational chemistry, and computational biology. We are defining initial research targets, mobilizing and developing a set of key internal capabilities necessary to address those immediate targets, and developing a capability development and partnering strategy. As in other efforts in the Office of Science (SC), large-scale computation and modeling will play a key role in the integration of experiment and analytical theory to address the complex issue of environmental health.

- **Environmental Proteome Center**—Proteins mediate cell signaling. While DNA chip technology is invaluable, cell signaling will never be understood solely with nucleic acid-based tools. The post-genomic frontier is in protein research. The conduct of biomolecular experimentation and the development of revolutionary observational technologies to study control pathways and their organization into networks demands availability of proteins. The Proteome center will produce proteins in sufficiently large quantities (and where needed with appropriate "labeling") for structure and function analyses. The center will also focus on characterizing the protein components of the cell using advanced mass spectrometry and array technologies.

Other research thrust areas in environmental systems and exposure-to-dose will emerge as the initiative matures. Successful cultivation of this ambitious, integrated research strategy will depend in large part on long-term participation in and leverage across existing, competitive, peer-reviewed funding programs at the Office of Science and Office of Biological and Environmental Research (OBER) and other agencies and institutions.

Advanced Computational Modeling and Simulation

Modeling and simulation on advanced computing systems have been signature capabilities of the national laboratories since they were created. Indeed, the national laboratories have been one of the key drivers in the paradigm shift that has occurred over the past 20 years. Computational science has grown into a third branch of science, a full partner with theory and experiments and a vital element of DOE Science mission. This change is due to the revolution that has occurred and is continuing to occur in computer technologies and in the development of new software and powerful new algorithms, with major contributions from DOE laboratories. It is becoming possible to solve the complex equations which describe natural phenomena such as the Schroedinger equation for electronic motion in molecules or the Navier-Stokes equations for fluid flow at accuracies that are comparable to, and in some cases, better than those available from experimental measurements. These advances not only help address DOE's Science mission, they also provide the technologies for modeling and engineering capabilities for DOE's Energy Resources and Environmental Quality missions.

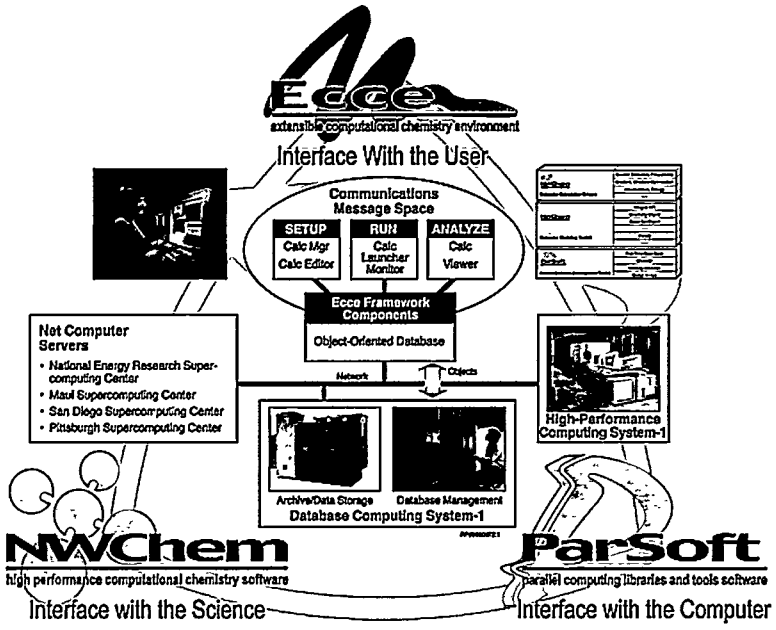
Research Agenda

The goal of the Advanced Computational Modeling and Simulation initiative is to bring modeling and simulation to bear on the missions of Pacific Northwest and of the Department of Energy through the use of high-performance computing technology. To this end, this initiative is focusing on

- the development of high-performance, portable, and scalable algorithms and software for massively parallel computer systems
- the development of the associated computational infrastructure, especially parallel computing frameworks and collaborative problem-solving environments
- the development of an applied mathematics infrastructure to support the computational science effort
- selected application areas of Pacific Northwest missions, focused on complex environmental and engineering issues.

This investment will position Pacific Northwest to support major DOE computational science initiatives, including DOE's participation in the national "IT^2" initiative now before Congress. The Laboratory's investments are designed to provide enduring value to Pacific Northwest by strengthening our capabilities in areas of computational modeling and simulation, which are critical to our long-term goals.

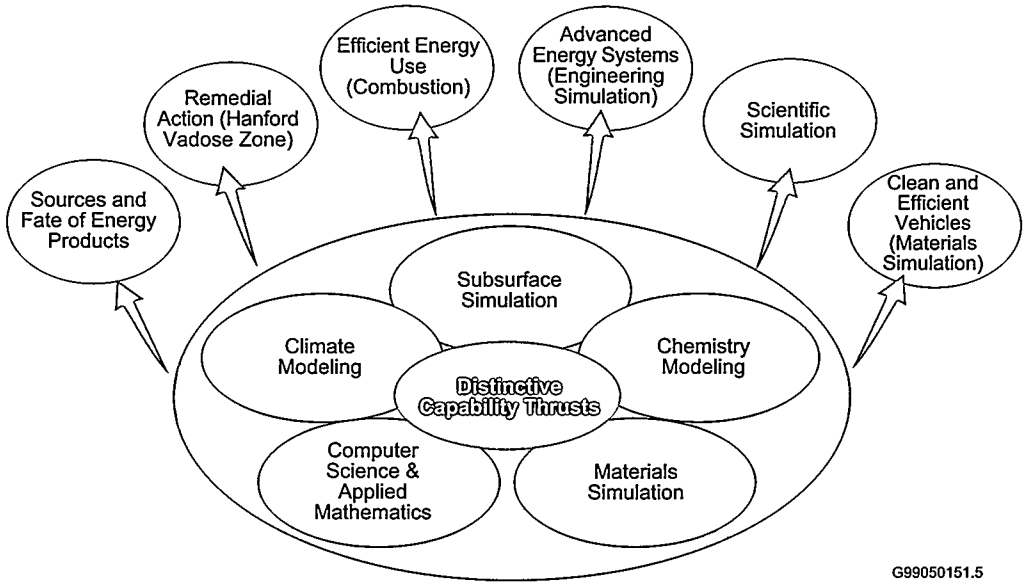
1999 R&D 100 Award Winner



MS3 is the first general-purpose software that allows a broad range of chemists to easily use high-performance, massively parallel computers for a wide range of applications. It is a unique, comprehensive, integrated suite of software that enables computational chemists to focus advanced techniques on finding solutions to complex issues involving chemical systems. The system allows scientists to easily combine advanced computational chemistry techniques like simulation and modeling with the power of massively parallel computing systems. They even can access these computing systems from their desktop workstations. The software system allows chemists to predict characteristics of chemical systems with a level of accuracy equal to that of the most sophisticated experimental approaches.

Investments are being made in the following areas:

- Subsurface sciences, with a focus on developing high-fidelity reactive transport codes applicable to a wide range of environmental problems, including the vadose zone at the Hanford Site.
- Atmospheric sciences, with a focus on developing a prototype Regional Climate Center, one of the key features of DOE's proposed Accelerated Climate Prediction initiative, and developing other modules, such as aerosol chemistry for inclusion in global climate models.
- Combustion sciences, with a focus on improving the performance and capabilities of NWChem for the types of thermochemical and chemical kinetics calculations critical to combustion simulation and modeling.
- Materials engineering, with a focus on developing material models capable of accurately predicting the behavior of materials for energy-efficient automotive and aerospace applications. Technical objectives include increasing the ability of commercial simulation and modeling software (solid modeling, finite element analysis, crash simulation, etc.) to operate efficiently on massively parallel computing architectures, creating an engineering problem-solving environment that allows non-specialists to effectively use state-of-the-art hardware and software resources, and developing material models capable of accurately predicting the behavior of a selected class of materials.
- Computer science, with a focus on developing the base infrastructure for the construction and maintenance of discipline-specific problem-solving environments for both climate modeling and combustion modeling, as well as providing the computer science basis for high-performance scalable and portable computer codes for present and future massively parallel computing systems.
- Applied mathematics in support of the various application areas and high-performance parallel computing.
- Planning for multi-teraflops scale computing facilities, with a focus on the next generation of massively parallel computers for software development and applications, as well as the gigabit networks and infrastructure required to support such computers and applications for a national user base.



The capabilities being developed in the Advanced Computational Modeling and Simulation initiative tie to many of DOE's missions R&D portfolio elements.

Scientific simulation makes defining contributions to almost every area of science and engineering. The efforts of this initiative are strongly tied to many missions of DOE and the Office of Science. There is direct relationship to the following parts of the Office of Science portfolio:

- Fueling the Future—Efforts are being made to improve our 1) knowledge of combustion processes at the molecular levels and our ability to model combustion processes; 2) modeling capabilities in the areas of metals, ceramics, and advanced materials; and 3) ability to design catalysts from first principles with a focus on energy production from fossil fuels.

- Protecting Our Living Planet—Our efforts are focused on helping to clean up the environment by providing tools to understand the fate and transport of contaminants in the subsurface and in the atmosphere from a variety of anthropogenic sources. We are also developing new tools to aid in minimizing pollution and energy use in chemical production processes, as well as for the design of new materials for environmental cleanup and remediation.

- Exploring Energy and Matter—The software being developed under this initiative is directly relevant to modeling simple and complex molecular systems, as well as modeling biomolecular systems such as proteins, enzymes, DNA, and polysaccharides/ lipids. In addition, there is a significant effort under way to investigate the fundamental relationships involved in the behavior of systems at different scales that underlies the behavior of complex systems.

- Extraordinary Tools for Extraordinary Science—Efforts are focused on providing groundbreaking applications in software, computer science tools, libraries, and infrastructure to solve complex problems on the world's fastest computers, as described above.

Our team-based software development approach is based on our successful development of the NWChem software suite for computational chemistry, initially funded under the EMSL Project Office of Biological and Environmental Research and the Office of Computational and Technology Research "Computational Grand Challenge" program in high-performance

computing. A crucial component of this successful effort was the teaming of computer scientists, applied mathematicians, application developers, and users (domain scientists) to design and implement the software. This approach results in a synergy that enables development of the highest-performance software with the best algorithms and the longest in-use lifetime. Such teams also help to minimize long-term development costs by producing software that is, to the maximum extent possible, portable and readily maintained and updated. These factors are especially important when tackling the many "Grand Challenge" computational problems faced by DOE.

High-bandwidth, low-latency networking that supports differentiated services will be a critical component for any teraflops computing site and a critical capability to support major computational activity. Therefore, planning will be carried out to determine the network and infrastructure required to support the next generation of simulation and computing activities at Pacific Northwest. In addition to supporting this initiative, high-performance networking will benefit other initiatives and will position Pacific Northwest to be competitive for other work requiring high-performance electronic communications capability.

Microsystems Science and Engineering

The objective of the Microsystems Science and Engineering initiative is to establish the capabilities to develop miniature systems that rely on microscale structures to radically reduce the size of energy and chemical systems. By taking advantage of the high rates of heat and mass transfer available in microstructures, a wide range of thermal and chemical systems and components can be miniaturized, resulting in high production rates in compact hardware volumes. Examples include such components as heat exchangers, chemical reactors, separation devices, gas absorbers, gas generators, and combustors. Examples of potential miniaturized systems include compact combustion systems, miniature absorption heat pumps, miniature heat engines, compact fuel processors for hydrogen production, compact chemical separations systems, compact CO_2 absorption units, and microscale techniques for improving heat transfer to gases.

Miniature energy and chemical systems directly support DOE missions related to hydrogen production (miniature hydrogen production systems). Other missions relate to cars of the future (miniature hydrogen production systems and miniature heat actuated heat pumps), energy-efficient buildings and homes (miniature heat pumps), carbon sequestration (compact CO_2 absorption units), counterterrorism (compact fuel cell systems for remote power), and waste treatment (compact chemical separations systems).

Research Agenda

In this initiative, Pacific Northwest is developing the required scientific basis and the engineering capability to realize the remarkable potential of microscale technology. Activities are grouped into microtechnology science, microfabrication, and chemical and energy systems miniaturization. Each group of activities is discussed in the following subsections.

Microtechnology Science—Microstructures offer opportunities to exploit molecular interactions and surface effects that otherwise would have been considered as secondary effects within conventional (macroscale) systems. The scientific community, however, currently lacks an understanding of many microscale phenomena and suitable modeling tools for the relevant length and time scales. The expected outcome is focused on the development of appropriate modeling tools and the demonstration of high functionality surfaces. Research thrusts include the following:

- *Lattice-Boltzman Simulation of Micro Fluids Systems*—Lattice-Boltzman simulation is a method of simulating thermal and hydrodynamic processes that are particularly attractive for modeling microscale phenomena. Lattice-Boltzman simulation explicitly incorporates the surface and phase interface effects that are critically important

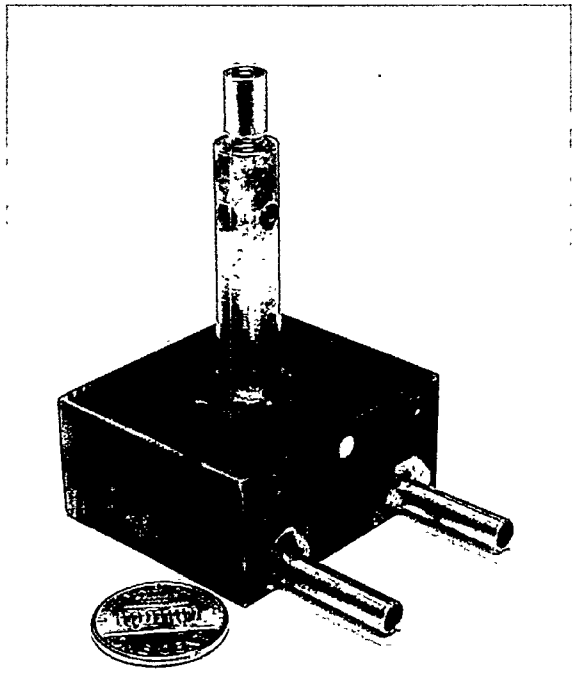
in microscale thermal systems. Heat and mass transfer phenomena can be simulated for single and multiphase flow. Currently, the simulation tool is being used to support funded research.

- *Self-Assembly of High Functionality Surfaces in Microchannels*—Recent advances in molecular sciences have resulted in exciting new opportunities for nanoscale engineering of surfaces to allow the development of high-functionality surfaces and active microscale control of surface properties. This effort focuses on using the capabilities available in the EMSL to develop molecular and polymeric smart surfaces that can be embedded in microscale components and systems. This process will, in turn, provide new concepts for fouling prevention and fluid handling for nanoscale chemical reactors and heat exchangers.

- *Nanoscale Fabrication for Enhanced Properties*—Using the capabilities available in the EMSL, we are investigating the formation and properties of nanoscale functional structures with the ultimate objective of integrating active nanometer-size components into microtechnology devices.

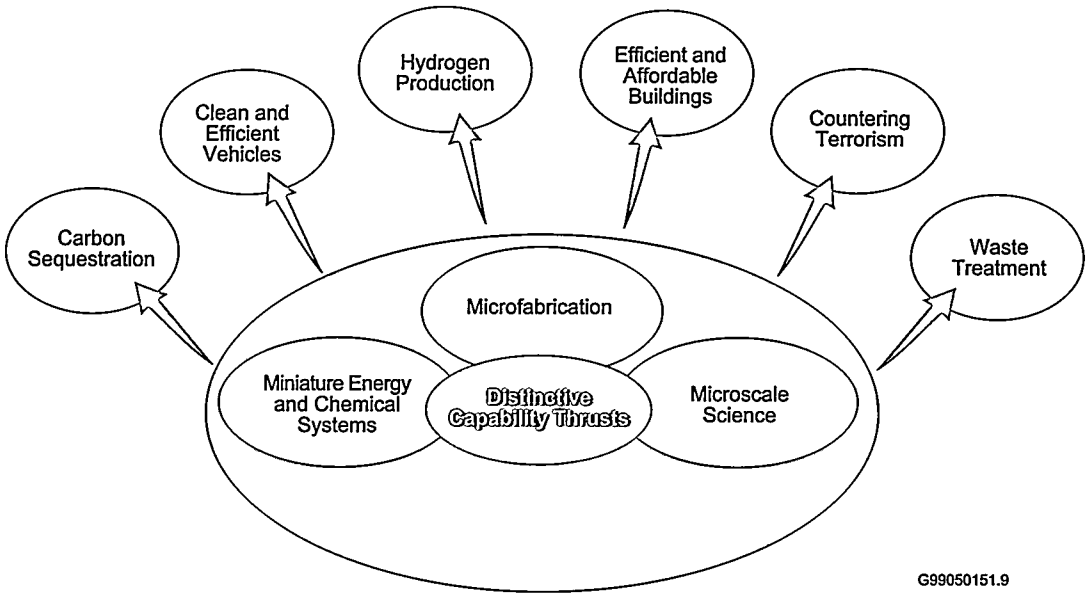
- *Enzymatic Microchannel Reactors*—Efforts are directed toward demonstrating a microchannel enzymatic reactor for an industrially important process. Enzymatic microreactors offer multiple advantages over conventional systems—higher activity, increased active-site concentration, very low pressure drops with high flow rates, and more efficient mass transfer from the bulk or solvent phase to the reacting chamber. Unlike chemical catalysts, enzymes function at room or body temperature and at neutral pH. Some enzymes exhibit nearly covalent binding constants to their substrates, yet easily release their products after catalysis; in some cases, nearly 100,000 reactions are catalyzed per second.

1999 R&D 100 Award Winner



This palm-sized combustion unit weighs less than 0.2 kg (5 oz.) and can provide heat for portable personal heating/cooling devices, indoor heating systems such as baseboard heaters, in-line heaters, and fuel cell systems. An array of modules can heat a house efficiently and reduce energy losses by 45 percent. It is the first device of its kind and offers unique opportunities for miniaturizing heating and heat pump devices. MicroHeater achieves its small size, affordability, and very low levels of emissions by relying on high rates of heat and energy mass transfer though specially fabricated microchannels carrying hot water.

Microfabrication—Efforts in microfabrication are focused on extending our existing capabilities to include high-precision, rapid prototyping, and low-cost fabrication techniques in microsystems technologies. New capabilities include high-precision laser micromachining, microscale electrochemical micromachining, and low-cost laminate fabrication. The expected outcome includes the demonstration of inexpensive, high-aspect ratio fabrication for metals, ceramics, and plastics, as well as the capability to design, develop, and demonstrate low-cost, advanced microsystems manufacturing techniques for use in mass production.



Capabilities developed in Microsystems Science and Engineering support all of DOE's mission areas with particular emphasis on the energy R&D portfolio.

Chemical and Energy Systems Miniaturization—Pacific Northwest is undertaking to develop and demonstrate specific microtechnology-based components and systems. The expected outcome is the demonstration of miniature energy and chemical systems that are relevant to a range of DOE missions, including hydrogen production, cars of the future, energy-efficient buildings and homes, carbon sequestration, counterterrorism, and waste treatment. Specific activities include the following:

- *Hydrocarbon Processing with Microchannel Reactors*—Pacific Northwest has demonstrated that use of microchannel catalytic reactors for hydrocarbon processing provides short residence times and a high degree of control over other reaction parameters. Such control allows a radical reduction in size for such components as steam reformers, water gas shift reactors, partial oxidation reactors, and fuel vaporizers. Our goal is to demonstrate compact systems for hydrogen production and chemical synthesis for automotive, portable, and distributed energy, and for chemical processing applications.

- *Microtechnology-Based Heat-Actuated Heat Pump Demonstration*—The high heat and mass transfer rates available in microscale devices can be used to radically reduce the size of heat-actuated heat pumps. This effort focuses on demonstrating a compact absorption cycle heat pump for automotive and space conditioning applications. To date, Pacific Northwest has succeeded in demonstrating all of the components of an absorption heat pump. Current research is focused on integrating the components into a functioning system.

- *Development and Testing of Microchemical and Separations Systems*—Pacific Northwest has demonstrated that properly designed microstructures enable rapid mass transfer between fluids. These phenomena are being exploited to produce compact separations systems with very high processing rates. These compact systems will have industrial and environmental remediation applications and can be used for CO_2 sequestration.

- *Microchannel Recouperator Development*—Gas-to-gas recouperators are used in many energy systems, such as gas turbines and hydrogen production systems. However, these devices are large and often have low effectiveness. The use of microstructures can significantly reduce the size of gas-to-gas recouperators. Pacific Northwest is demonstrating small recouperators for automotive and defense applications.

Cyber Security

The Administration has made combating terrorism one of its highest policy and budgetary priorities. A recent Presidential Decision Directive calls for a national effort to ensure the security of the United States' increasingly vulnerable and interconnected infrastructures. Another Directive reinforces the missions of the U.S. agencies (including DOE) with roles related to defeating terrorism—including increasing infrastructure security, enhancing response capabilities, and protecting the computer-based systems that lie at the heart of America's economy.

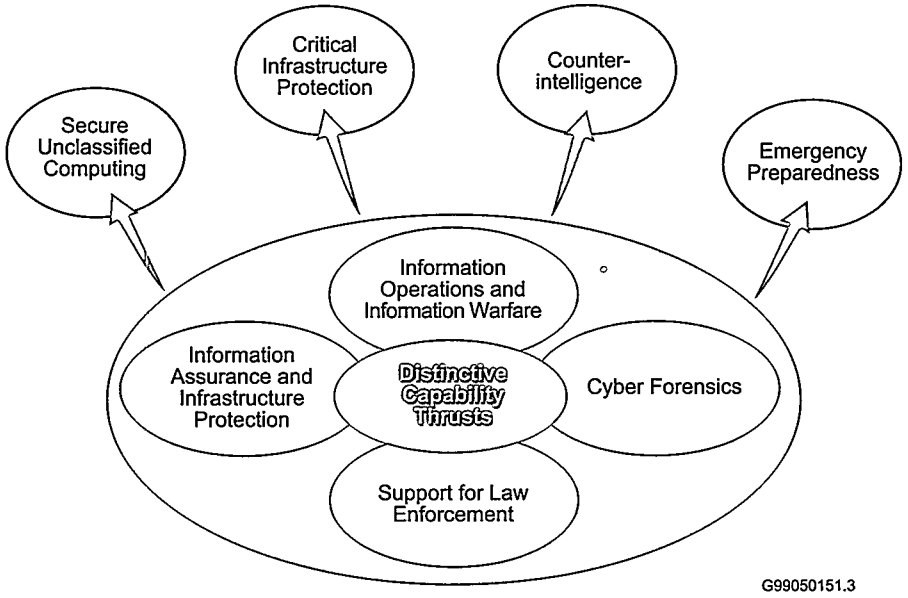
To support DOE in their efforts to protect American citizens, properties, and critical infrastructures against attack, this initiative will build on Pacific Northwest's capabilities in network and host-based cyber countermeasures, data management, statistics, information technologies, and sensitive analytical techniques to complement the following critical areas:

- information assurance and infrastructure protection
- law enforcement support and cyber forensics
- automation of cyber attack/defend tools.

Research Agenda

The intent of the Cyber Security initiative is to enhance our capabilities in the area of information assurance and infrastructure protection and to increase the impact of our existing capabilities in the areas of cyber forensics and automation. In information assurance and infrastructure protection, technologies and techniques are being developed to 1) safeguard key elements of critical infrastructures from exploitation, degradation, and denial of services; 2) support command and control functions; and 3) protect friendly information assets and infrastructure from an adversary.

Critical infrastructures are those physical and cyber-based systems essential to the operations of the economy and government. They include, but are not limited to, telecommunications, energy, banking and finance, transportation, water systems, and emergency



Capabilities being developed in the Cyber Security initiative are an enhancement to our existing capabilities in information and computer sciences and technology and primarily support the national security R&D portfolio elements.

services, both governmental and private. Many of the nation's critical infrastructures have historically been physically and logically separate systems that have little interdependence. As a result of advances in information technology and the necessity of improved efficiency, these infrastructures have become increasingly automated and linked. The massive interconnection of computerized communications and information networks across the public and private sectors has increased the vulnerability of the entire system and has provided existing and potential adversaries with a means to attack U.S. interests.

Under the Cyber Security initiative, an information security research facility is being established at Pacific Northwest. The facility has an isolated computer network with a broad range of computer platforms and systems such that vulnerability testing and research can be performed without the constraints imposed on an open network in the United States today. This laboratory allows for unimpeded vulnerability testing both for new software agents, tools, and "carbon copies" of clients' computer systems and networks. This technical approach allows for a full attack on target systems within the facility, permitting a level of stress testing simply not done today.

Core technical capabilities are being developed to protect critical infrastructures. One specific area is intrusion analysis tools; this will use information technology to fully characterize intruders, including the identification of skill sets, motivation, and specific areas of interest. Another area is the development of countermeasures and mitigating strategies for technology vulnerabilities. The third area is the establishment of a flexible, modular, and interoperable command and control workspace environment to successfully detect, defend against, and mitigate or neutralize attacks on an organization's information and infrastructure functions and systems.

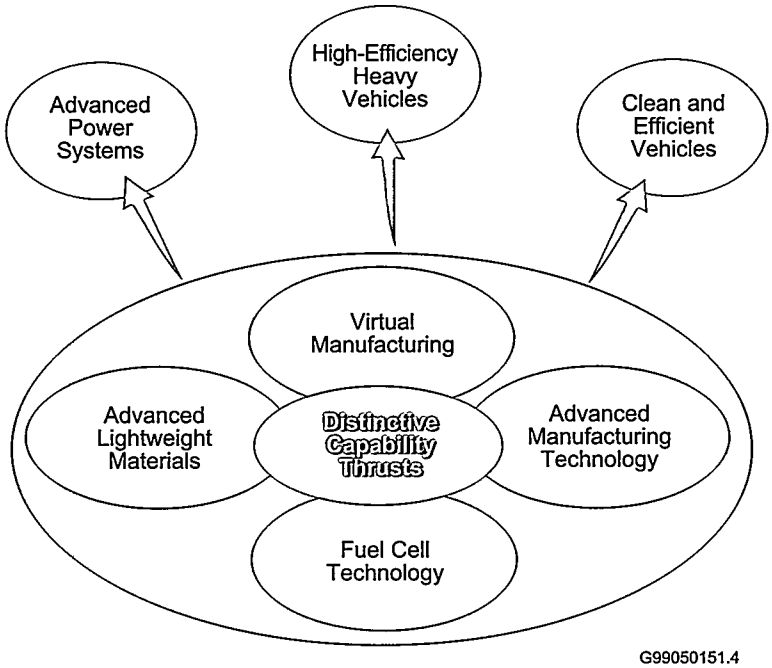
Northwest Alliance for Transportation Technology

The Northwest Alliance for Transportation Technology (NATT) is an initiative that is positioning Pacific Northwest as a significant player in mission critical areas of the DOE Office of Transportation Technology (OTT). NATT draws upon a broad range of existing laboratory capabilities, and through its expanding scope and funding base is creating opportunities for the development of new research capabilities.

The strategic intent of NATT is to link the competencies of Pacific Northwest with a broad range of university and industrial partners to develop advanced transportation system technology. Initiative research objectives include automotive system design, materials innovation, virtual system simulation, manufacturing process innovation, and emission control technologies that will support the national goal of increased fuel efficiency and reduced vehicle emissions. Research areas are directed to ensure that NATT is adding value to the missions, objectives, and critical outcome drivers of the DOE-OTT. The strategic alliances developed under this initiative will help ensure that strong partnerships are formed and that commercially viable technology and intellectual property is available for transfer and commercialization.

Link to DOE Research Agenda

The NATT initiative is directly tied to the multiple missions of the DOE-OTT. This includes the Office of Advanced Automotive Technologies supporting the objectives of the Partnership for a New Generation Vehicle (PNGV), which seeks to design and build an 80 mile-per-gallon family car with ultra-low emissions by 2004. Based on the increasing fuel consumption and emissions associated with light- and heavy-duty vehicles, NATT will increasingly be focused on the program objectives of the Office of Heavy Vehicle Technologies (OHVT) and their mission to reduce fuel consumption of Class 1-8 vehicles by over 40 percent. NATT supports DOE-OTT by applying highly integrated laboratory and industry research and development capabilities to complex vehicle system challenges such as lightweight materials and structures, manufacturing process modeling and simulation, and advanced emission treatment technologies. Crosscutting both Office of Advanced Automotive Technologies and OHVT programs is an advanced virtual manufacturing modeling and simulation program thrust that will involve a strategic alliance between Pacific Northwest and Oak Ridge National Laboratory.



Capabilities developed under the NATT initiative primarily support DOE's Energy Resources mission R&D portfolio elements.

Research Agenda

Advanced Automotive Materials and Manufacturing Technology

The NATT initiative initially focused on support of the PNGV program through the Office of Advanced Automotive Technologies. Significant contributions to this program include lightweight materials and manufacturing process development, development of important projects with northwest suppliers, and the application of Pacific Northwest's unique low-temperature and non-thermal plasma technologies for emission reduction. The NATT strategy in support of PNGV and the Office of Advanced Automotive Technologies is to develop a focused research portfolio that includes cooperative research projects and cost-shared contracts with industry partners to develop innovative materials and manufacturing technology that are needed for fuel-efficient, low-emission vehicles. Because PNGV is a maturing program with a target completion date of 2004, NATT has actively refocused its research thrusts to include longer-term, higher-risk materials and manufacturing technologies, that will carry beyond the PNGV goals and completion date. As a result, NATT will emphasize development projects in the following research areas:

- *Magnesium Materials Development and Application*—A high priority for the Office of Advanced Automotive Technologies is the development of creep-resistant magnesium alloys that can be used in a broad range of automotive applications. NATT is focusing on developing internal expertise in the fundamental mechanisms of magnesium creep behavior, leading to a major role in the Office of Advanced Automotive Technologies's magnesium focus area. Capability development is based on established expertise in microstructural modeling of material behavior and recent investment in the modeling of specific creep modes and their correlation with industry test methods.

- *Thermoplastic Composite Materials*—Polymer composite materials represent a major long-range focus of the Office of Advanced Automotive Technologies. Significant opportunities exist in the modeling and simulation of thermoplastic composite materials and manufacturing processes. NATT is positioning Pacific Northwest for a major role in this technology area by a combination of internal capability development and teaming with Oak Ridge National Laboratory in the area of composite durability and performance.

- *Aluminum Metal Matrix Composites*—Through previous industrial teaming efforts and leadership of the Office of Advanced Automotive Technologies metal matrix composite roadmap effort, NATT is developing a major new programmatic start in advanced aluminum metal matrix composite materials. This effort supports the Office of Advanced Automotive Technologies long-range materials roadmap and will bring together key industry and university participants under a comprehensive program led by Pacific Northwest.

Light- and Heavy-Vehicle Technologies for Improved Efficiency and Reduced Emissions

Major growth in NATT includes development of technology to reduce the weight of popular pickup/sport utility vehicle frames by 40 percent for improved fuel efficiency and reduced emissions, and the application of lightweight materials and advanced manufacturing processes for heavy trucks. Emerging technical opportunities include a systems-based emission reduction technology program for light- and heavy-duty diesel vehicles, and the strategic development of fuel cell based heavy vehicle auxiliary power systems. This latter area will include support to a strategic alliance between OTT and Fossil Energy to advance vehicle-based fuel cell technology. The technical content of NATT will continue to include significant emphasis on advanced modeling and simulation, and development of new laboratory capabilities in crosscutting vehicle emission reduction technologies and advanced materials that offer value to both the automotive and heavy-vehicle offices of OTT. Specific research includes the following:

- *Lightweight Pickup/Sport Utility Vehicle Frame*—A key priority for OHVT is to improve the fuel efficiency and reduce emissions of the growing number of light-duty pickup/sport utility vehicles. NATT has overall responsibility for developing a major new program focused on lightweight frame technology for this class of vehicle, and will participate on multipartner projects that will develop and demonstrate materials, modeling, and manufacturing technology for a lightweight pickup/sport utility vehicle frame.

- *Advanced Materials and Manufacturing Technology for Class 7-8 Trucks*—Program goals for OHVT in the heavy-vehicle sector includes reduction of tractor/trailer weight by up to 35 percent. By developing industry partnerships with the major heavy-vehicle manufacturers, we are now positioned to lead a new program start to develop lightweight materials and manufacturing technology for Class 7-8 vehicles. An important aspect of this program will be development of advanced manufacturing technologies that will leverage Pacific Northwest's capabilities in superplastic forming, hydroforming, and manufacturing modeling and simulation.

- *Auxiliary Power Generation for Heavy Vehicles*—NATT, in combination with the Fossil Energy initiative, is developing a significant new technical area that will bring advanced solid-oxide fuel cell technology together with heavy-vehicle design and engineering expertise to develop a vehicle-mounted auxiliary power system to run heaters and air conditioners. Technology development will include a diesel-fueled reformer system, high-temperature materials, solid-oxide fuel cell design and manufacturing, and system analysis and modeling of the integrated power system. Research will leverage a number of key Pacific Northwest capabilities, including fuel cell, materials, microtechnology, and modeling and simulation expertise.

- *Emission Systems Technology Integration*—A critical technology need for OHVT is the capability to bring together all of the fuels, diesel engine, exhaust aftertreatment, and sensor and control technologies into a systems-oriented program. The basis for this approach is that all aspects of emission control and after-treatment must be considered as a system to successfully meet the increasingly stringent emission regulations. Because the low-emission diesel engine is the centerpiece of the OHVT strategy, NATT leadership of a systems approach to emissions represents a key value-added strategy.

Emerging Initiative

Carbon Management

The question of whether it is necessary to limit atmospheric carbon dioxide concentrations and, if so, at what level, to avoid undesirable climate effects is open both scientifically and politically. However, given projections for population and economic growth, and the consequent projections for growth in energy production and use, particularly in China, India, and the balance of the developing world, it is clear that stabilization of atmospheric concentrations at any reasonable level will present formidable challenges. Stabilizing atmospheric concentrations of CO_2 at levels currently under discussion will ultimately require reducing global emissions to less than half of the 1990 levels in the face of substantially increased energy production.

A comprehensive response to the challenges posed by climate change requires improved understanding of the climate system and the natural cycles that govern carbon dioxide concentrations; quantitative understanding of the technological, economic, and social systems that result in human release of carbon to the atmosphere; and the development of technology that allows achievement of U.S. policy goals while maintaining economic growth. Building on our long-standing roles in climate research and in the economic and technology modeling required to project future carbon emissions under different scenarios, we are in the process of developing a Carbon Management initiative. The goals of this effort are to

- support DOE in building and maintaining a leadership position in the technologies required to limit carbon release to the atmosphere
- develop new science and technology programs that are consistent with industry and government needs.

We anticipate that the initiative will draw heavily on capabilities in materials science, microtechnology, biotechnology, computational science and other areas, and that it will involve development of extensive collaborations with university, national laboratory, and industrial researchers.

Technical plans for this initiative are under development and will be reported in the next Institutional Plan.

Transitioning Initiatives

The three following initiatives have achieved their primary technical goals and the results are finding application in a number of DOE programs. These initiatives are presented in this section of the Institutional Plan for the last time. Future developments will be covered in Section 5 in the appropriate mission area or areas.

Detection and Characterization of Pathogens

The Department of Energy is helping to fight chemical and biological terrorism by applying extensive expertise of the national laboratories to contribute advanced technological solutions to the chemical and biological threat. The mission of the DOE Chemical and Biological Nonproliferation Program (CBNP) is to develop, demonstrate, and deliver technologies and systems that will lead to major improvements in the U.S. capability to prepare for and respond to chemical or biological attacks.

The technology development initiatives within the CBNP include biological foundations, chemical and biological detection, modeling and prediction, and decontamination and restoration. In addition to these technology thrusts, the program calls for system integration

by means of domestic demonstration and application programs. The DOE program was developed in consultation with DoD, FBI, FEMA, Health and Human Services, and the intelligence community.

The Detection and Characterization of Pathogens initiative is consistent with this DOE strategy. This initiative was launched 2 years ago in response to the compelling technological need for improved integrated, robust detection of biological agents on the battlefield. We have drawn on our preeminent capabilities in several technical areas including environmental characterization, environmental microbiology, mass spectrometry, statistics, and chemometrics. The pathogen detection capabilities we are developing will contribute to our ability to detect harmful biological agents, not only on the battlefield but also for domestic terrorist use, food safety, air and water quality, and a variety of other applications. The focus of this initiative was to

- demonstrate the ability to sample and analyze all media—air, water, soil, surface, solid, and physiological samples
- develop access to detection concepts across the spectrum of available bioanalytical methods, either within Pacific Northwest or via strategic partners
- assemble pathogen detection technology components and the scientific and engineering staff with skills to build integrated systems, composed of one or more detection components, tailored to address diverse user needs whether in defense, counterterrorism, food safety, public health, or air and water quality.

The research of this initiative is aligned along three thrusts: sample acquisition, preparation, and delivery; characterization of organisms against background; and integration of components into overall detection systems. Most of the research projects have arrived at a point of maturity that will enable us to meet the objectives that we set out at the beginning of the initiative. Some additional development is required for some of these research efforts, and in some cases, test results will determine what role the research can play in meeting future pathogen detection requirements in defense, counterterrorism, food safety, medicine, and air and water quality.

Environmental Contaminants and Remediation

The intent of the Environmental Contaminants and Remediation initiative was to develop a fundamental science-based capability to optimize new-generation contaminant remediation technologies being developed for field deployment. The goal of the initiative was to enhance Pacific Northwest's basic research capability in biogeochemistry related to remediation while simultaneously developing approaches to use this basic information for improved environmental technology formulation and design.

Research has focused on the microbiological process of bacterial iron reduction because the metabolism holds promise for the bioremediation of chlorinated hydrocarbons and polyvalent metals and radionuclides in groundwater. Our strategy was to develop new capabilities for characterization and understanding of the selected bacterial process, and to develop theoretical means for extrapolation of fundamental biogeochemical information to the field for improved bioremediation. The initiative has been successful in that regard.

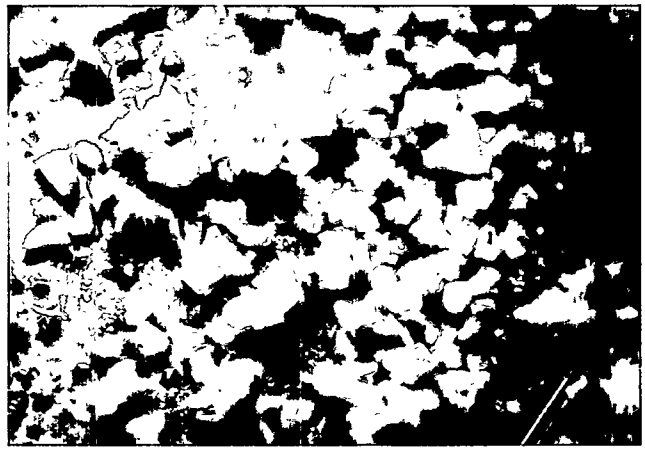
New Pacific Northwest capabilities have been developed in

- thermodynamic and molecular modeling of chemical reaction processes on bacterial surfaces
- electron microscopic techniques to stabilize and image bacteria-mineral associations
- synchrotron-based Mossbauer spectroscopy for high-resolution studies of biogeochemical Fe-valence
- theoretical concepts for upscaling information on microbial processes to the field.

These capabilities are important additions to the Pacific Northwest scientific portfolio and are currently being documented by publication and infused into new proposals.

Capabilities developed through the Environmental Contaminants and Remediation initiative have been instrumental in the development of significant new research programs, and will enable our participation in the Hanford Applied Science and Technology Program, a long-term Hanford Site effort.

1999 R&D 100 Award Winner



Zinc ammonium sulfate hexadydrate crystals.

***Centrate Ammonia Recovery Process**—Centrate Ammonia Recovery (CAR) is a reversible chemisorption process that controls the spread of ammonia (and subsequently nitrates) to waterways and drinking water. Incorporating a newly designed adsorption resin and regeneration solution, the CAR process extracts ammonia out of sewage treatment liquid (centrate) and livestock waste and converts it into standard, commercial-grade, ammonium sulfate fertilizer, a dry, odorless product.*

Science and Technology for Environmental Processing

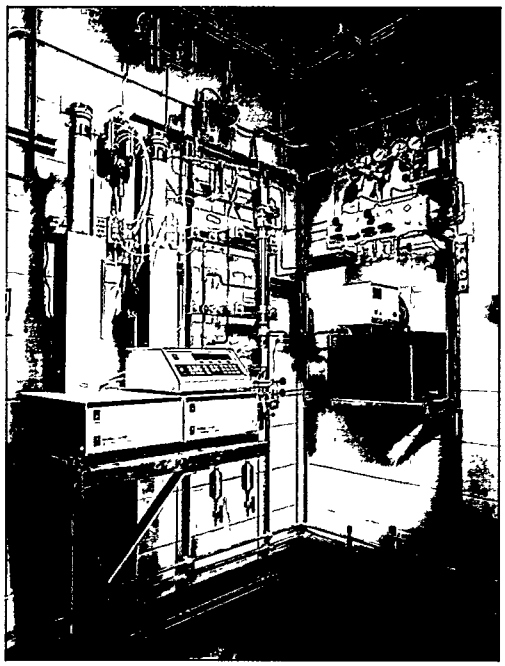
Process technology is a critical need to support DOE's energy and environmental missions. Advanced process technology is an essential component for the production of energy, chemicals, products, and food based on environmentally sound principles. One of the strategic goals of the Science and Technology for Environmental Processes (STEP) initiative is to develop process technologies that minimize the use of inputs to produce products and to significantly reduce any waste products. The foundation for achieving this outcome is based on developing and applying sound scientific solutions to these problems. To significantly impact these issues, the STEP initiative has focused on developing science and technologies in the areas of chemical conversion, separations, and novel synthesis technologies.

The STEP initiative has three distinct thrust areas for developing critical technologies: anion separations, aqueous conversion, and gas-phase corona synthesis. Each of these areas is integrated into the overall objective of the STEP initiative for developing science-based solutions to environmental processing.

Anion Separations

Selective separation of anionic species from aqueous solution is a critical need for a wide range of applications including industrial water recycle and wastewater treatment (e.g., chloride ion removal for the pulp and paper industry, borate ion in the chemical and nuclear industries), drinking water and agricultural waste treatment (e.g., nitrate removal), environmental cleanup (e.g., removal of chromate and nitrate ions), and nuclear waste disposal (e.g., removal of pertechnetate ions). Systems that can achieve highly selective cation separations are increasingly being developed but are not commercially available.

Our work has focused on the development of novel superstructural materials to be used as anion exchangers. Key outcomes from this work include the demonstration of processes based on these materials that selectively remove arsenate and chromate from aqueous solutions in the presence of competing anions. These materials are particularly beneficial in aqueous systems containing sulfate and can selectively remove arsenate and chromate in the presence of high sulfate concentrations. These materials also afford very good anion loading capacity (120 mg/g) and are comparable to cation exchange materials.



This chemical reactor system was created for developing and optimizing processes to make value-added chemical products from basic chemicals derived from renewable feedstocks.

Aqueous Processing

The focus of the aqueous conversion area was to create viable new materials for processes and technologies that will allow for the direct processing of important industrial intermediates and products in aqueous systems. Included in this portfolio of chemicals are organic acids, functional polyol monomers as intermediates for polymers, and solvents. Aqueous phase processing eliminates the need for a wide range of organic solvents and will allow the use of biomass for chemical feedstocks.

A major objective of this work is to develop materials that are stable in aqueous environments at relatively high temperatures (100°C to 150°C) and afford high catalytic activity. Synthesis of several materials based on the controlled hydrothermal processing of zirconia and titania has been completed. These results will be used as a basis for the continued development of new catalysts.

Gas-Phase Corona

The controlled oxidation of organics is one of the "Grand Challenges" of industrial chemical research. Even in the presence of catalysts, organics tend to "burn" in conventional thermally activated oxidations that require temperatures above 400°C to dissociate either the oxygen or the organic, which tends to be completely oxidized to CO and CO_2.

Partial oxidation reactions are exceedingly difficult to perform both because the intermediates are either highly reactive with regard to further oxidation, or because the products are thermally unstable. The ability to specifically control the site and amount of oxidation would enable the use of cheap feedstocks (simple alkanes and alkenes) to make a wide range of commercially important intermediates.

A new technology developed at Pacific Northwest for waste destruction is the gas-phase corona reactor. This plasma-driven chemical reactor also can be used for synthesis, however, using the non-equilibrium plasma to produce high-energy active species that follow different reaction pathways than those available through traditional thermal activation. Efforts focused on the selective oxidation of cyclohexane to cyclohexanol and cycolohanone in a plasma reactor, including selectivity of this reaction and the effect of various catalysts.

Impact on DOE's Missions

The technologies being developed under the STEP initiative directly support DOE's missions related to energy and the environment. These technologies support the efficient use of resources and the conservation of energy as well as waste reduction. All of these technologies are driven by sound scientific principles and will form the basis for developing applied processes that will directly impact DOE's missions.

Pacific Northwest National Laboratory Initiatives[a]
(Budget Authorization $ in Millions)

Initiative	Fiscal Year 1998	1999	2000	2001	2002	2003	2004
Environmental Health							
Office of Science	0.0	0.5	1.0	2.0	4.0	6.0	7.0
Office of Environmental Management	0.0	0.0	0.2	0.5	0.5	0.5	0.5
Nonproliferation and National Security	0.0	0.0	0.5	0.8	1.0	1.2	1.2
Other Federal Agencies	0.0	0.0	1.0	2.0	4.0	6.0	7.0
Capital	0.0	0.0	0.1	0.2	0.3	0.4	0.5
Total Environmental Health	**0.0**	**0.5**	**2.8**	**5.5**	**9.8**	**14.1**	**16.2**
Advanced Computational Modeling and Simulation							
Office of Environmental Management	0.7	1.0	1.7	2.2	2.2	2.2	2.2
Office of Science	0.1	0.4	1.0	6.0	11.0	12.0	17.3
Energy Efficiency and Fossil Energy	0.0	0.0	1.4	3.4	10.4	10.4	10.0
Nonproliferation and National Security	0.0	0.1	0.2	0.3	0.3	0.3	0.0
DoD	0.2	0.2	0.4	0.2	0.0	0.0	0.0
Other Federal Agencies	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Office of Science Capital	0.0	0.0	0.0	4.2	5.0	8.0	18.0
Total Advanced Computational Modeling and Simulation	**1.0**	**1.7**	**4.7**	**16.3**	**28.9**	**32.9**	**47.5**
Microsystems Science and Engineering							
Energy Efficiency and Renewable Energy	1.0	1.2	1.5	2.0	2.5	2.5	2.5
Office of Science	0.2	0.4	0.4	0.4	0.6	0.6	0.6
Fossil Energy	0.0	0.2	0.4	0.6	1.0	1.5	2.0
Office of Environmental Management	0.0	0.0	0.2	0.4	1.0	1.5	2.0
Laboratory Technology Transfer	0.0	0.1	0.2	0.2	0.3	0.3	0.4
NASA	0.0	0.2	0.3	0.5	1.0	1.5	1.5
DoD	1.0	1.5	2.5	2.5	2.5	3.0	3.5
Total Microsystems Science and Engineering	**2.2**	**3.6**	**5.5**	**6.6**	**8.9**	**10.9**	**12.5**
Cyber Security							
Office of Security Affairs (NN-50)	0.0	2.8	3.2	3.5	3.5	3.6	4.0
Office of Intelligence	0.2	0.2	0.3	0.5	0.5	0.5	0.5
Office of Counterintelligence	0.0	1.7	3.5	4.0	5.0	5.0	5.0
DoD	0.0	0.6	0.6	1.0	1.0	1.0	1.0
FBI	0.0	0.0	0.7	0.7	1.0	0.7	0.8
Total Cyber Security	**0.2**	**5.3**	**8.3**	**9.7**	**11.0**	**10.8**	**11.3**
Northwest Alliance for Transportation Technology							
Office of Science	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Fossil Energy	0.0	0.0	0.0	1.0	1.0	1.0	1.0
Energy Efficiency and Renewable Energy	4.1	5.5	6.5	8.5	10.5	12.5	12.5
Total Northwest Alliance for Transportation Technology	**5.1**	**6.5**	**7.5**	**10.5**	**12.5**	**14.5**	**14.5**
Carbon Management							
Office of Science	0.0	0.0	0.3	0.5	0.8	1.0	1.5
Fossil Energy	0.0	0.0	0.3	0.6	1.0	1.5	2.0
Energy Efficiency and Renewable Energy	0.0	0.0	0.3	0.5	1.0	1.5	2.5
Total Carbon Management	**0.0**	**0.0**	**0.9**	**1.6**	**2.8**	**4.0**	**6.0**

Pacific Northwest National Laboratory Initiatives[a]
(Budget Authorization $ in Millions)

Initiative	Fiscal Year 1998	1999	2000	2001	2002	2003	2004
Detection and Characterization of Pathogens							
Nonproliferation and National Security	0.0	0.5	0.9	0.5	0.2	0.4	0.6
Laboratory Technology Research	0.0	0.0	0.8	0.8	0.6	0.4	0.2
Office of Science (OBER)	0.0	0.0	0.0	0.0	0.2	0.2	0.4
FBI	0.0	0.0	0.4	0.4	0.3	0.5	0.6
DoD	0.5	0.2	0.4	0.6	0.8	1.0	1.2
NASA	0.1	0.4	0.2	0.4	0.6	0.6	0.6
Total Detection and Characterization of Pathogens	**0.6**	**1.1**	**2.7**	**2.7**	**2.7**	**3.1**	**3.6**
Environmental Contaminants and Remediation							
Office of Science (OBER)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Office of Science (BES)	0.4	0.8	0.8	0.8	0.8	0.8	0.8
EMSP	0.4	0.8	0.6	0.6	0.6	0.6	0.6
Office of Environmental Management (EM-50)	0.0	0.0	0.2	0.4	0.4	0.4	0.4
Total Environmental Contaminants and Remediation	**1.4**	**2.2**	**2.2**	**2.4**	**2.4**	**2.4**	**2.4**
Science and Technology for Environmental Processing							
Energy Efficiency and Renewable Energy	0.9	0.9	1.0	1.0	1.1	1.1	1.2
Office of Environmental Management	2.5	2.6	2.7	2.8	2.9	3.0	2.7
Nonproliferation and National Security	0.4	0.4	0.4	0.5	0.5	0.6	0.5
Total Science and Technology for Environmental Processing	**3.8**	**3.9**	**4.1**	**4.3**	**4.5**	**4.7**	**4.4**
Total Pacific Northwest Initiatives	**14.3**	**24.8**	**38.7**	**59.6**	**83.5**	**97.4**	**118.4**

(a) Funding projections for the initiatives are given in this table and are not included in the Resource Projections.

5

Programmatic Strategy

Science

Strategic Intent

In keeping with Pacific Northwest's continuing commitment to strengthen its fundamental science base, we focus our scientific enterprise to provide scientific leadership, advance knowledge, and operate user facilities for national, high-impact initiatives in the environmental, energy, national security, and environmental health mission areas. Since increasing our emphasis on fundamental science in the mid-1980s, we have established preeminent capabilities within Pacific Northwest and for the Department of Energy in environmental molecular science and global change research. We have built Pacific Northwest's first major DOE scientific user facility, the William R. Wiley Environmental Molecular Sciences Laboratory (EMSL), which is serving a growing and scientifically productive user community. Pacific Northwest's scientific programs have grown in stature and impact with significant benefit to its intellectual vitality and demonstrated impact on our performance in all of DOE's missions. We intend to increase both the quality and impact of our programs, including significant investments to increase our capability in cellular/molecular biology, computational science, and materials.

Over the next 5 years, we will support this strategic intent by emphasizing

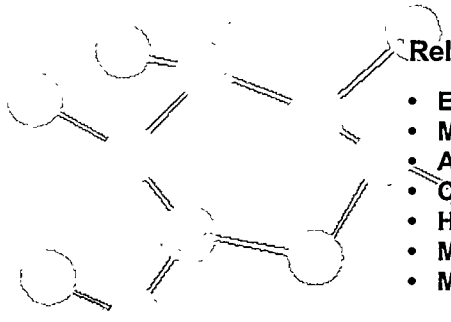
- enhancement of our capabilities contained in the EMSL, delivering forefront science and service to its growing user community, and making it a widely recognized facility in the DOE system
- revitalization of our life science capabilities, focusing on the molecular processes involved in cell signaling, an important element of the science required to understand the impacts of environmental contaminants on living organisms
- strengthening our capabilities in computational science, with emphasis on molecular science, regional-scale climate prediction, subsurface contaminant transport and fate, computer science, applied mathematics, atmospheric chemistry and transport, modeling of living systems, and manufacturing simulation
- providing the greatest possible impact on climate science, broadly construed, from basic understanding of radiative transport and fundamental biogeochemical cycles to the materials and process science required for emissions reduction and carbon sequestration
- development of new measurement capabilities that can serve as a focus for new facilities, particularly in cellular-molecular biology and the enhancement of the capabilities in the EMSL and Atmospheric Radiation Measurement (ARM) facilities.

With these efforts, we expect to continue to impact DOE's research agenda with our research accomplishments and support critical efforts within the other DOE missions.

Our experience is proving that "small science" facilities such as the EMSL can play a very valuable role in the nation's science and technology infrastructure. For example, over this planning period, we intend to explore and, if promising, develop the concept for a similarly scaled facility to provide novel high-resolution imaging and other new research equipment for fundamental life sciences research.

The Science mission of DOE comprises both basic and applied components. This section addresses Pacific Northwest's basic research supported by the Office of Science. To accomplish this research, we will employ a programmatic strategy with five central elements:

- We will use our strong culture of peer review and commitment to excellence to deliver top-quality science with significant impact on DOE mission needs.
- We will strengthen our involvement in the nation's basic research enterprise through effective operation of the EMSL and ARM, through strong partnerships with our colleagues at research universities and other national laboratories, and by participating in the training of the next generation of scientists.
- We will take a "Grand Challenge" approach, building broad, interdisciplinary programs that target central and scientifically demanding problems: researching factors that control climate change; interaction of molecules in complex, dynamic systems; the interaction of environmental contaminants with the genome; and developing efficient, environmentally sound energy systems.
- We will help demonstrate and communicate the value of DOE research programs to the public.
- We will ensure our continued ability to operate complex scientific laboratory facilities by conducting our research in a safe and environmentally responsible manner.



Relevant Technical Capabilities

- **Earth Systems Science**
- **Molecular and Cellular Biology**
- **Analytical and Physical Chemistry**
- **Computational Science and Engineering**
- **Human Health and Safety**
- **Materials Science and Engineering**
- **Micro/Nano Technology**

Science Mission Strategy

Protecting Our Living Planet	Fueling the Future	Exploring Energy and Matter	Extraordinary Tools for Extraordinary Science
Basic research on the physical, chemical, and biological processes to understand the effects of human activities on the environment and to mitigate the negative aspects	Develop synthesis techniques for producing new materials in an environmentally responsible manner; investigate reactions among materials and their environments; provide experience in advanced nanoscale materials, thin-film optical materials, and protective coatings; partner on Joint Catalysis Institute	Integrate knowledge gained about fundamental processes with studies of more complex systems to develop a molecular-level understanding of chemistry at liquid-solid interfaces and in condensed states	Operate the William R. Wiley Environmental Molecular Sciences Laboratory, a national scientific user facility; manage the climate research facilities of the DOE ARM program; computational science

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Science mission strategy.

Our Role in Supporting the Themes and Challenges of DOE Science

Our research at Pacific Northwest is well aligned with the research themes and challenges of the Office of Science: *Protecting Our Living Planet, Extraordinary Tools for Extraordinary Science, Exploring Matter and Energy,* and *Fueling the Future.*

Protecting Our Living Planet

This theme has been, is, and will continue to be central to the research programs of Pacific Northwest. We already have significant accomplishments in environmental molecular science, global change, atmospheric chemistry, and subsurface science. We intend to expand our accomplishment through the application of physical chemistry tools and capabilities and knowledge garnered from the Human Genome Project to address and to understand the molecular and cellular basis of the interaction of living organisms with their environment. We expect to increase emphasis on research to significantly improve our ability to predict and assess the effects of increasing atmospheric concentrations of greenhouse gases on the earth's climate and on the life support systems that depend upon it. We also expect to increase research on managing natural environmental processes to optimize the sequestration of atmospheric carbon and on using biological systems to reduce society's dependency on fossil fuels.

Our broad-based capabilities will support three challenges identified by the Office of Science under the theme *Protecting Our Living Planet: Sources and Fate of Energy Products, Impacts on People and the Environment, and Prevention and Protection.*

Sources and Fate of Energy Products

We will provide accurate physical descriptions of the processes and the life cycles of materials involved in the production and use of energy as well as the activities of the Department of Energy. We will continue to conduct research on fundamental geological, atmospheric, and biological processes to better understand how energy-derived byproducts are transported, concentrated, and localized in subsurface, atmospheric, ocean, and terrestrial environments. Using state-of-the-art tools and facilities, we are studying subsurface science and bioremediation, waste processing and chemistry, climate change, air pollution chemistry and transport, and the transport and transformation of toxic substances in the biosphere.

Research in the area of subsurface science is developing a molecular-level understanding of the surface chemistry and reactivity of environmentally important mineral phases and is coupling that research with advanced transport models. These investments have made Pacific Northwest an international leader in subsurface science and continue in the Natural and Accelerated Bioremediation Research (NABIR) program. As a result, our scientists provide national technical leadership for the Hanford Vadose Zone Project, a major DOE site cleanup issue, where we are translating this knowledge into predictive models that yield usable results for decision makers.

In geosciences research, we are developing a molecular-level understanding of the surface chemistry and reactivity of environmentally important mineral phases, particularly the surface chemistry of carbonate minerals. In the computational area of the program, emphasis is placed on the transfer of information from the molecular scale to the macroscopic or thermodynamic level. The transfer of information across such time and length scales is one of the most challenging problems facing researchers who are applying molecular level information to in-the-field environmental problems, and requires close integration of experimental and computational approaches.

In the atmospheric sciences, the frontiers are in the interaction between meteorology and atmospheric chemistry and in the transformation of pollutants into particles that affect visibility, climate processes, and human health. Over the planning period, we expect to

contribute to the Environmental Meteorology program and the emerging focus on tropospheric aerosols. In these areas we will bring to bear our extensive capabilities in field research, including our G-1 aircraft, computational modeling of both meteorology and chemical processes, and the unique analytic capabilities of the EMSL.

Pacific Northwest National Laboratory operates a Grumman Gulfstream 1 aircraft as a U.S. Department of Energy research aircraft to serve atmospheric scientists in conducting airborne research.

Impacts on People and the Environment

The effects of energy-derived products range from the direct effects of radiation on living organisms to the more indirect effects that are manifest as climate is altered by the increasing concentrations of greenhouse gases. Pacific Northwest programs address many of the most difficult of these problems.

Understanding climate change as it is driven by changing greenhouse gas concentrations requires a detailed understanding of the multiple feedback processes initiated by the seemingly small change in the atmospheric energy balance caused by CO_2 increases. The most dramatic of these feedbacks involves the impact on the hydrologic cycle, most notably the distribution and properties of clouds. The ARM program, a multilaboratory effort with considerable involvement with universities and other agencies, is deepening our understanding of clouds and their impact on atmospheric radiation. This effect is one of the greatest uncertainties in our understanding of the sensitivity of climate to greenhouse gas changes. We not only provide leadership for this program as it enters its second decade, but also contribute to the scientific programs that improve remote sensing, parameterize cloud processes, and elucidate the role of surface properties in the formation of clouds.

We will also perform a range of atmospheric research on the regional and global consequences of climate change. Regional and global general circulation models support investigations into how clouds, trace gases, and aerosols affect global climate and how changes in the global climate are expressed at the regional scale. The regional models provide essential coupling between the greenhouse gas drivers and the effect on human systems, such as agriculture.

On the human side of the equation, our health effects research examines mechanisms by which hazardous physical and chemical agents affect living systems. The emphasis of this research is on determining the molecular bases of receptor-mediated processes at the cellular level. We will employ a multilevel approach to investigating the human health impacts and risks associated with the environment, incorporating studies from the molecular level to the whole-animal level. Using dosimetric, molecular, cellular, and intact animal analytical techniques, we are gaining a quantitative understanding of mechanisms underlying the health effects of chemical and physical agents.

In order to expand our capability in this area, we began a new initiative in environmental health, which will integrate biology in the post-genome era of discoveries with new developments in measurement, computational, and modeling science. The initial scientific emphasis is on describing and explaining cell signaling. This initiative will lead to the ability to

- observe molecular processes inside of living cells
- model complex living organisms at the level of cellular control
- rapidly evaluate the expression of genetic control, as manifest in the proteome, in response to environmental changes.

These unique capabilities may serve as the basis for an EMSL-like facility at some time in the future, but will most certainly allow the exploitation of the results from the human genome and contribute substantially to the DOE network of life science investigators. An important manifestation of this contribution will be to allow Pacific Northwest researchers to contribute to explaining the effects of low-dose exposures to contaminants. Such exposures may be occupational exposures or those received through the environment and may either be the result of ionizing radiation or chemical exposure.

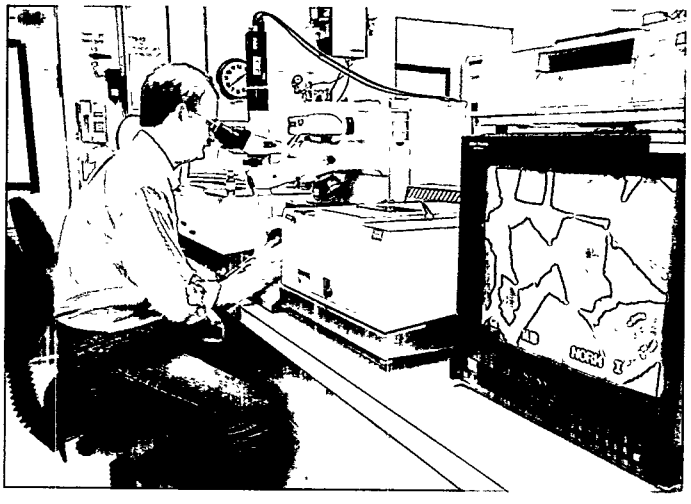
Prevention and Protection

We will provide researched and innovative approaches to preventing the deleterious effects of energy use, mitigating its injurious outcomes, and protecting our environment, both current and in the future. Pacific Northwest's strengths in environmental biotechnology are its well-integrated capabilities in microbial and plant sciences, enzymology, and genomics that are applied to environmental restoration, pollution minimization, and waste processing research.

Aiding in environmental bioscience work, we bring strong capabilities in radiation measurement and radiochemistry, mass spectrometry (organic and inorganic), magnetic resonance spectrometry, laser spectroscopy, surface instrumentation, and computational capabilities that are unsurpassed. These multiple strengths combine powerful scientific and technical support for research programs in carbon management and form the basis of our contribution to the Oak Ridge-Argonne-Pacific Northwest National Laboratories collaboration in the study of the sequestration of carbon in terrestrial ecosystems.

Our groundbreaking work in the development of integrated assessment of climate change will continue to be useful in understanding the policy options available for the minimization or mitigation of climate change. This capability will specifically help us understand the role of technology in the stabilization of greenhouse gas concentrations at internationally acceptable levels.

Prevention and protection also motivate Pacific Northwest's role as a major provider of science and technology for cleanup of DOE weapons production sites. Pacific Northwest performs research in all aspects of the cleanup, including designing novel separations agents for waste processing, understanding radiation effects in ceramic waste forms, understanding tank waste chemistry, and researching and improving passive remediation strategies such as bioremediation and reactive barriers.

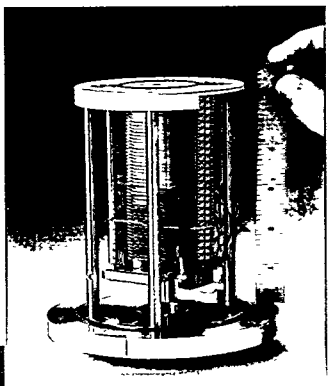


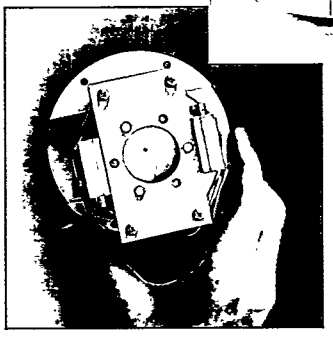
Researcher using a microscope attached to an FTIR instrument to examine sodium pericyanide crystals similar to that found in tank wastes.

Extraordinary Tools for Extraordinary Science

Pacific Northwest's second most significant contribution to the Office of Science themes is in support of Extraordinary Tools for Extraordinary Science. We are leading efforts to define the new generation of user facilities required to support environmental, and eventually health, sciences, bringing a tradition of facility and capability stewardship to match DOE's record in the physical sciences. To this end, Pacific Northwest operates EMSL, a national scientific user facility that is an essential component of our ability to provide the fundamental scientific understanding needed for DOE to achieve its environmental quality, science, and technology objectives. In addition, Pacific Northwest is a key participant in managing and operating the climate research

1999 R&D 100 Award Winner





Electrodynamic Ion Funnel. *This revolutionary tool significantly improves the sensitivity of certain mass spectrometers and other analytical instruments. Mass spectrometry is a tool widely used in environmental, biotechnology, and drug testing applications, as well as in medical, biological, and other broad areas of research. Conventional mass spectrometers retrofitted with an electrodynamic ion funnel use a series of conductive ring electrodes to confine and more effectively focus and transmit ions to be measured. A nearly 100 percent efficiency in moving ions to the analyzer results in an enormous gain in sensitivity, improved data collection, new applications, and greater understanding of the substances analyzed. The tool will be especially useful in biological research, where greater sensitivity allows smaller samples to be analyzed, as in "micro" biopsies.*

facilities of the DOE ARM program. We have also undertaken, through the Pacific Northwest Consortium-Collaborative Access Team, development of two beam lines at the Advanced Photon Source.

In support of scientific simulation, another critical dimension of scientific tools, research at Pacific Northwest is focused on advancing state-of-the-art computational modeling and simulation, and facilitating remote collaborations through the development of new "collaboratory" tools.

Instrumentation for the Frontiers of Science

Two notable areas of Pacific Northwest advanced instrumentation are found in the EMSL and the ARM program.

The EMSL is a national scientific user facility, sponsored by the DOE Office of Biological and Environmental Research that contains cutting-edge instrumentation for studying environmental processes at high resolution. Over 680 scientists from universities, other national laboratories, and industry were users of the EMSL during its first full year of operations, from October 1997 to October 1998. EMSL contains a new generation of experimental and computational capabilities needed to address complex scientific issues raised by environmental problems, issues ranging from structural biology to improved waste treatment methods.

Seven research facilities are available within EMSL for use by the scientific community. The largest groupings of specialized instrumentation are housed in the High-Field Magnetic Resonance Facility, the High-Field Mass Spectrometry Facility, and the Molecular Science Computing Facility. In addition to these major facilities, the EMSL offers four facilities that are made up of collections of both specialized and state-of-the-art equipment: the Nanostructural Materials Research Facility, the Interfacial Structures and Compositions Research Facility, the Reactions at Interfaces Facility, and the Gas-Phase Monitoring and Detection Research Facility.

Experimenters at Designated User Facilities - 1998

	Number of Experimenters	Number of Organizations	Percentage of Use
William R. Wiley Environmental Molecular Sciences Laboratory			
Laboratory	106		15
Other Federal Laboratories	118	23	16
Other U.S. Government			
University	361	103	49
Industry	101	17	14.6
Foreign Laboratory	7	6	1
Foreign University	41	28	4
Foreign Industry	3	3	0.4
Total	**686**	**180**	
Other			
Visiting user	341		50
Remote user	345		50
Total	**686**		

EMSL's range of experimental and computational resources includes instruments for

- nuclear magnetic resonance and electron paramagnetic resonance ion trap mass spectrometry, resonance spectrometry in the High-Field Magnetic Resonance Facility
- an 11.5-tesla Fourier transform ion cyclotron resonance (FTICR) mass spectrometer and 7-tesla FTICR instrument in the High-Field Mass Spectrometry Facility
- a high-performance, massively parallel, 512-processor IBM RISC/6000 Scalable POWERparallel computer system; a 64-processor SMP IBM parallel computer system (Power PC/604e); and a 20-terabyte EMASS hierarchical storage management system in the Molecular Science Computing Facility.

In addition, the other four facilities include a wide range of instrumentation to meet their unique needs. The Nanostructural Materials Facility studies in nanodimensions with laser, photoelectron, and mass spectrometry, as well as apparatus for XRD, field flow fractionation, and surface force. The Interfacial Structures and Compositions Facility examines atomic structures in various combinations of solid, liquid, and gas interfaces, by using scanning probe and electron microscopy, high spatial resolution analysis instruments, as well as laser, ion, and electron spectroscopy. The Reactions at Interfaces Facility uses specialized equipment for creating environmentally unique experiments, including surface photochemical systems, high-vacuum chambers, a low-energy ion beam line, and low-temperature and scanning tunneling microscopes, as well as a range of spectroscopic techniques. The Gas- and Liquid-Phase Monitoring and Detection Facility also uses high-resolution spectroscopy and analytical instruments to monitor gas and liquid injection techniques.

The ARM program, too, uses state-of-the-art instruments and techniques. The major facilities of ARM include the three field measurement sites (in Oklahoma, the Tropical Western Pacific, and Alaska) and the ARM data archive, each operated by other DOE laboratories; and the ARM Experiment Center at Pacific Northwest. ARM field sites provide the research community with broad capabilities for studying radiative transport issues of importance to climate. Pacific Northwest also operates a Gulfstream 1 research aircraft—providing an airborne laboratory to study atmospheric processing and contaminants. The ARM Program Office, coordinating the efforts of DOE's national laboratories, ensures that the ARM facilities are available to and used by a broad spectrum of users in the climate change, atmospheric research, and satellite remote sensing communities.

With a group of U.S. and Canadian universities, Pacific Northwest is part of a Collaborative Access Team that is building two beam lines at the Advanced Photon Source at Argonne National Laboratory. The beam lines are optimized for environmental and micro-focusing experiments and are available to the general scientific community.

In our Environmental Health initiative we are developing new methods of investigation for the biological sciences. These methods will allow us to observe molecular processes in living cells (e.g., giving insight into phenomena such as cell signaling) not possible from more conventional techniques. We also are developing techniques for the rapid and sensitive characterization of the changes in the proteome in response to environmental changes. These methods will be an important complement to the major sequencing capability present at the Human Genome Institute and will put those results in an important context for human and environmental health.

Scientific Simulation

Two major efforts at Pacific Northwest are advancing the state of the art in computational modeling and simulation. One supports the development of a new generation of software for modeling molecular species containing heavy elements. Our researchers are developing and applying the methods of relativistic quantum chemistry to assist in understanding and predicting the chemistry of the actinides and lanthanides, a class of molecules encountered in DOE's environmental management mission. The computational modeling and simulation capabilities developed in this activity will also be applicable to a broad range of other chemical problems involving heavy atoms, for instance, catalysis.

The second effort builds on a set of paradigms for managing the complex memory hierarchy in massively parallel computers. Our approach combines the strengths of a shared-memory-programming model with the scalability and performance of the distributed-memory model, from which the highly successful Global Arrays model has emerged. Current applications include molecular dynamics, computational chemistry, graphics rendering, and security value forecasting. By providing advanced computing and collaboration technologies, our research under the new DOE 2000 Initiative will enhance DOE's ability to accomplish its missions. In this program, Pacific Northwest researchers, in collaboration with scientists from Argonne, Lawrence Berkeley, and Sandia, are designing a Collaboratory Interoperability Framework, a common software infrastructure for communications among national laboratories' computer resources, enhancing data transport, resource location, and security. This collaboration will provide major pieces of the architecture of the DOE 2000 collaboratory environment, which will be used by the DOE 2000 Collaboratory Pilot Projects, the EMSL Collaboratory, and other developing collaborations at Pacific Northwest and in the scientific community.

Institutional Capabilities

The Laboratory Technology Research (LTR) program funds partnership projects with private-sector companies that use the scientific capabilities of the Office of Science multiprogram laboratories to achieve DOE missions, such as materials sciences, biotechnology, mathematics, and computing. The program also has been a key source of assistance to small and regional businesses. Proposals are being advanced to obtain additional resources to enable the LTR program to enhance its efforts in enabling small businesses to access the unique scientific capabilities of multiprogram laboratories. We will extend its resources via frequent and fruitful partnerships with the private sector and universities, as well as with other national laboratories.

Pacific Northwest's Center for Environmental Science Education combines our science, engineering, and technology capabilities with that of our educational partners to create a broad range of environmental science education projects. This program touches students and teachers from elementary school to graduate school and includes the community at large, involving them meaningfully in the research programs at Pacific Northwest.

University and Science Education

	FY 1998			FY 1999		
	Total	Minorities	Women	Total	Minorities	Women
Pre-College Programs						
Student Programs						
Student Research Apprenticeship Program	21	13	18	18	13	14
Scientist, Student, Teacher Enhancement Project	8	0	2	18	0	3
Student Research Internship Program[a]	0	0	0	27	2	7
Teacher Programs						
Teacher Research Participation Programs	10	0	4	11	1	3
Partnership for Arid Lands Stewardship	33	1	18	26	1	21
Scientist, Student, Teacher Enhancement Project	4	0	1	14	0	2
National Teacher Enhancement Project	0	0	0	5	0	4
Undergraduate Programs						
Office of Science Undergraduate Laboratory Fellowship	90	31	38	85	25	42
Laboratory Co-operative Program	186	24	61	217	34	75
Science and Engineering Research Semester[b]	26	5	15	0	0	0
Community College Initiative, Undergraduate[a]	0	0	0	26	5	7
Graduate Programs						
Laboratory Co-operative Program	87	21	33	50	17	17
Postgraduate Programs						
Post-Baccalaureate Program	29	6	13	40	8	24
Post-Masters Program	19	3	8	29	2	9
Postdoctoral Program	134	51	31	130	40	35
Faculty Fellowships	52	4	7	58	18	11
Faculty Travel Grants	3	0	0	9	1	1
Faculty Sabbatical	5	0	2	1	0	1
Community College Initiative, Faculty[a]	0	0	0	2	0	0
Visiting Scientists	27	10	3	18	4	1
Other Programs						
Leadership and Assistance for Science Ed. Reform[a]	0	0	0	421	(c)	(c)
Sharing Science with Schools	1588	(c)	(c)	1707	(c)	(c)
Shadowing Program	87	(c)	(c)	46	(c)	(c)

(a) New Program in FY 1999.
(b) Program discontinued by DOE after FY 1998.
(c) Data on minorities and women are not tracked for these programs.

Exploring Matter and Energy

Pacific Northwest's supports the theme of *Exploring Matter and Energy* with its continued experimental and theoretical studies of the fundamental natural materials and processes at a molecular level and in their combinations in complex systems.

Components of Matter

The essential contribution of research at Pacific Northwest is increasing understanding of molecular processes in the condensed phases, characteristic of natural and contaminated environments. Using sophisticated computational tools, this research program integrates experimental studies of fundamental molecular processes with the modeling of complex molecular systems found in the environment. Internationally known work in electron microscopy and spectrometry is conducted at Pacific Northwest that examines the fundamental properties of individual molecules and their assemblages, as well as experiments that look at molecules and atoms at their surfaces and interfaces. The chemistry and physics at interfaces provides the fundamental understanding necessary to make advances in understanding and applying catalysis to industrial processes as well as understanding the complex processes that control living organisms.

Complex Systems

We will play a niche role in understanding complex systems focused on developing a molecular-level understanding of chemistry at liquid-solid interfaces and in condensed phases. Researchers in chemical structure and dynamics are exploring reactions at a wide variety of solid/liquid interfaces, the dynamics of biological systems, and development of new analytical methods. One application of this research is in unraveling environmental conundrums at contaminated waste sites, in the atmosphere, and in outer space.

Our molecular theory and modeling programs are producing sophisticated and useful methods of studying groundwater chemistry, chemistry at aqueous/mineral interfaces, separations chemistry, and nuclear waste forms.

Our molecular-level approaches to the study of complex systems have led to fundamental understandings of liquid-liquid interfaces (for instance, water and carbon tetrachloride) and the transfer of molecules, such as chloroform, between phases.

Fueling the Future

Pacific Northwest actively anticipates the nation's needs for information about and approaches to the sources, uses, management, and mitigation of energy use. Research that supports the DOE theme Fueling the Future and other DOE themes is described in this section. Examples include microbiology and plant physiology, fundamental research in geologic sciences, surface and interfacial chemistry and physics, and nuclear magnetic resonance imaging.

Pacific Northwest's research programs in molecular processes are also focusing on energy-intensive chemical conversions. We conduct fundamental studies of reactions in supercritical fluids, free radical chemistry at high temperatures, laser spectroscopy, and theoretical and experimental studies of heterogeneous catalysts. Our research on rhodium catalysts has established a more quantitative relationship between surface structure and catalytic activity for the reduction of nitrogen oxide (NO_x). This knowledge is being directed toward developing better automobile catalytic converters to control exhaust emissions.

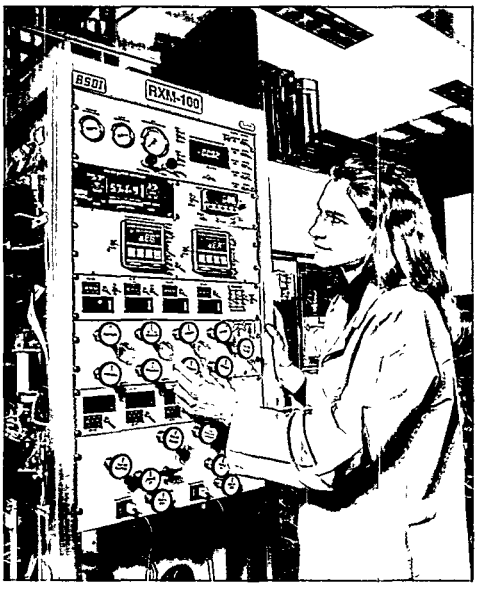
Clean and Affordable Power

Catalysis will be an increasingly important process in the design of clean and affordable energy systems. Pacific Northwest developed a cooperative teaming arrangement with Los Alamos and Lawrence Berkeley

1999 FLC Award Winner

Reverse Micelles—*The persistent team took basic research on reverse micelles done at Pacific Northwest and worked with a new company, MICELL Technologies, Inc., Raleigh, North Carolina, to license the technology. The road taken to bring this technology from discovery to commercialization is a case study of the teamwork and long-term commitment needed to bring basic discoveries to the marketplace. It is also a classic demonstration of the important role the national laboratories must now play in keeping the U.S. competitive in the global economy. MICELL is now manufacturing and selling highly effective, environmentally friendly carbon dioxide-surfactant cleaning systems to the dry cleaning and parts cleaning industries, among others. These systems are an alternative to solvent cleaning methods—providing the same cleaning power as organic solvents but without the hazards.*

1999 Presidential Early Career Award



Pacific Northwest scientist was selected for a Presidential Early Career Award for Scientists and Engineers.

National Laboratories and three universities to promote the development of a Joint Catalysis Initiative. The team submitted five joint proposals to the FY 1999 Climate Change Technology Initiative. This partnership will focus on developing improved catalysts that will be key factors in technology directions to address carbon management. One of our scientists won the 1999 Presidential Early Career Award for Scientists and Engineers for her work in developing new catalytic processes reducing air pollutants emitted in automobile exhaust.

A long-term goal of Pacific Northwest research focused on developing advanced structural materials for the high neutron flux regions of fusion power systems. In the near term, our efforts concentrate on developing materials that meet safety, economic, and environmental performance criteria. A principal aim is to assemble fundamental knowledge on the effects of fusion and of variations in material composition and microstructure on engineering properties. We are experimentally determining the response of materials to neutron irradiation and developing new materials with useful properties, such as reduced activation. In addition, computer models are being developed to predict the effects of neutron irradiation on materials.

Pacific Northwest's research in nanomaterials yielded Self-Assembled Monolayers on Mesoporous Supports (SAMMS), which is a new class of materials that can remove metals and radionuclides from aqueous and organic liquids and gaseous streams. SAMMS has potential applications in soil and water cleanup at sites where mercury contamination is prevalent, as well as industrial wastewater treatment and metal recovery.

Efficient Energy Use

We will continue studying energy-efficient materials and techniques to improve the nation's energy efficiency, emphasizing the development of unique synthesis techniques for producing new or improved materials in an environmentally conscious manner, and investigating the reaction of materials with their environments. These activities underpin many technological issues relevant to DOE. We are examining energy-enhancing materials in three areas: thin-film optical materials and protective coatings; synthesis and characterization of advanced nanoscale composites, ceramics, and intermetallics; and mixed conductors for low-temperature gas separation. Research that may affect materials' length of life includes work on ceramic stability and stress corrosion and corrosion fatigue of metals and ceramics.

Our research has resulted in the development of new biomimetic coatings produced from aqueous solution using a surface-induced mineralization process. This process involves low temperatures and an aqueous solution that can save energy and money.

In research programs studying superplastic behavior, we are studying fundamental interfacial structure and composition to understand the underlying mechanisms of grain boundary sliding and precipitation effects on crystallization. The studies have resulted in the development of new superplastic materials that are ideal for the automotive industry. Other programs are developing alloys suitable for downstream industrial use.

The Advanced Energy Projects program funds innovative research directed at exploring new approaches to energy-related problems. Pacific Northwest is also exploring metal-ion promoted and semiconductor-catalyzed selective oxidation of alkanes to assess the technical advantages and limitations of a potentially energy-efficient reaction sequence for selectively oxidizing hydrocarbons.

Research Thrusts

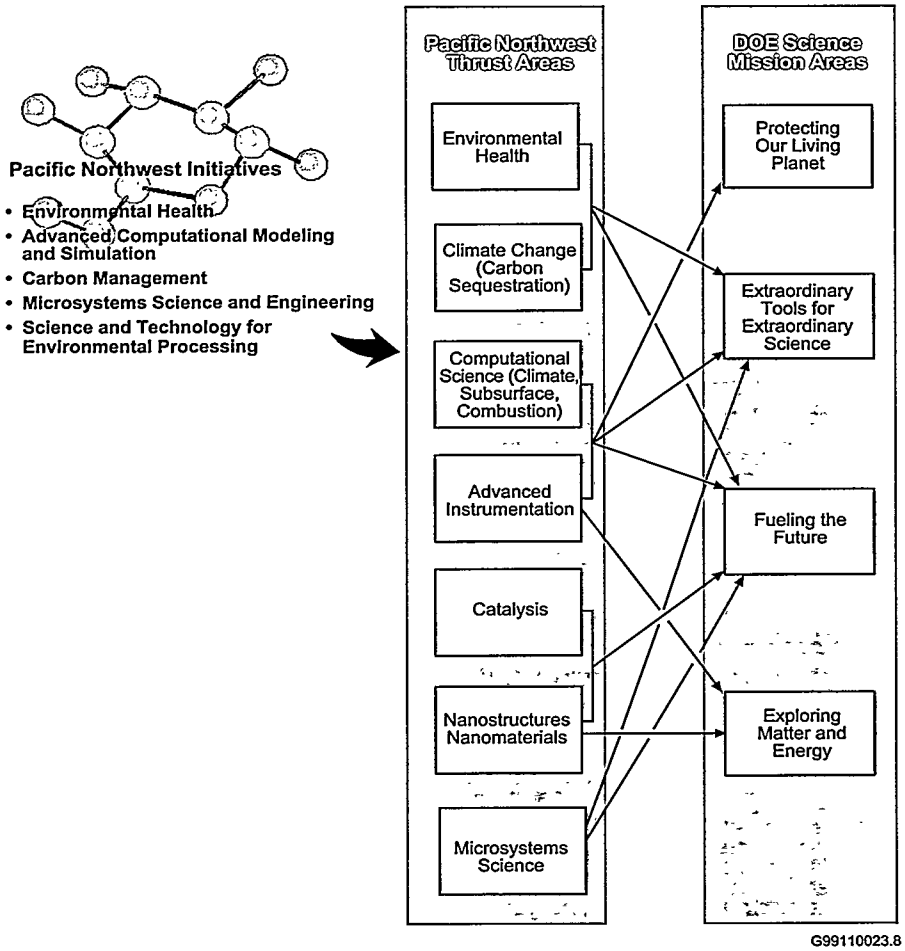
Pacific Northwest invests discretionary resources to maintain its environmental sciences programs at the forefront and to develop new leading-edge capabilities for its programs. New multidisciplinary capabilities are being developed in all of the areas mentioned above.

Pacific Northwest has made significant investments in the following six areas. The DOE science themes they support are indicated in each paragraph.

Environmental Health and Cell Signaling (*Protecting Our Living Planet*): Pacific Northwest researchers have developed an Environmental Cell Signaling Laboratory that will integrate research in molecular cell biology, microbial biology, and environmental proteomics to examine biochemical interactions at the cellular level, where the ultimate potential for health effects is determined. Unique instruments and facilities, including those of the EMSL, will equip Pacific Northwest for studies that will help us to understand the impact of the environment and contaminants in the environment on human life and health. Noninvasive NMR methods, in combination with other microscopies, will enable scientists to monitor how live cells respond as they are exposed to changes in their environment, and high sensitivity mass spectroscopy will yield unique insight into proteomic responses to the environment.

Climate Change (*Protecting Our Living Planet*): Pacific Northwest plays a major role in the ARM program, developing and operating state-of-the-art instruments and techniques. The major facilities of ARM include the three field measurement sites (in Oklahoma, the Tropical Western Pacific, and Alaska) and the ARM data archive, each operated by other DOE

Major Research and Development Thrusts



Major Science research and development thrusts.

laboratories, and the ARM Experiment Center at Pacific Northwest. ARM field sites provide the research community with broad capabilities for studying radiative transport issues of importance to climate. Pacific Northwest also operates a Gulfstream 1 research aircraft—providing an airborne laboratory to study atmospheric processing and contaminants. The ARM Program Office at Pacific Northwest coordinates the efforts of DOE's national laboratories and many other participants, ensuring that the ARM facilities are available to and used by a broad spectrum of users in the climate change, atmospheric research, and satellite remote sensing communities. We hope to replicate these assets and approaches in creating new classes of virtual research facilities for DOE and the broader community.

Computational Science (*Protecting Our Living Planet—Fueling the Future—Extraordinary Tools for Extraordinary Science*): In computational science, our investments will build on two significant past accomplishments: the development of the Molecular Science Computing Facility (MSCF) in the EMSL, and the EMSL collaboratory. The MSCF broke ground in the development of an advanced simulation environment with its concurrent development of software, hardware, and problem-solving environment. The collaboratory created a symmetric collaboration between computer scientists, domain scientists (physical and biological sciences), and sociologists. The extension of these approaches to the many computational challenges faced by DOE, such as climate, combustion, and a variety of basic science applications is an important part of our plans for future collaboration.

Advanced Instrumentation (*Extraordinary Tools for Extraordinary Science—Exploring Matter and Energy*): Pacific Northwest's EMSL offers a comprehensive array of state-of-the-art equipment for research in the environmental molecular sciences at one location. These capabilities can be integrated as needed by multidisciplinary teams of scientists to address complex problems. EMSL equipment and capabilities are grouped into seven facilities: 1) High-Field Magnetic Resonance Facility, 2) High-Field Mass Spectrometry Facility, 3) Molecular Science Computing Facility, 4) Nanostructural Materials Facility, 5) Interfacial Structures and Compositions Facility, 6) Reactions at Interfaces Facility, and 7) Gas- and Liquid-Phase Monitoring and Detection Facility.

Environmental Catalysis (*Fueling the Future—Protecting Our Living Planet*): Pacific Northwest has conducted theoretical and experimental studies of heterogeneous catalysts. Our research on rhodium catalysts has established a more quantitative relationship between surface structure and catalytic activity for the reduction of nitrogen oxide (NO_x). This knowledge is being directed toward developing better automobile catalytic converters to control exhaust emissions.

Nanostructures and Nanomaterials (*Fueling the Future—Exploring Matter and Energy—Extraordinary Tools for Extraordinary Science*): The Nanostructural Materials Facility at EMSL is directly involved in a wide range of research, from fundamental studies of the unique properties of molecular clusters to the creation of new types of materials for removing contaminants from the environment. Unique, well-defined oxide surfaces created by MBE and CVD are being used to gain new information about environmental and biological interactions at surfaces. Microfabrication capabilities are being used to develop new microanalytical capabilities with nuclear waste and biological applications. Other advanced characterization methods can be applied to studies as varied as exploring environmental damage to fruit and examining the stability of a nuclear waste form.

Microsystems Science (*Extraordinary Tools for Extraordinary Science—Fueling the Future*): The objective of the Microsystems Science and Engineering initiative is to establish the capabilities necessary to develop miniature systems that rely on microscale structures to radically reduce the size of energy and chemical systems. By taking advantage of the high rates of heat and mass transfer available in microstructures, a wide range of thermal and chemical systems and components can be miniaturized, resulting in high production rates in compact hardware volumes. Examples include components such as heat exchangers, chemical reactors, separation devices, gas absorbers, gas generators, and combustors. Examples of potential miniaturized systems include compact combustion systems, miniature absorption heat pumps, miniature heat engines, compact fuel processors for hydrogen production, compact chemical separation systems, compact CO_2 absorption units, and microscale techniques for improving heat transfer to gases.

Science Program Roles

DOE Office	Pacific Northwest Role
Biological and Environmental Research	
Life Sciences Division (SC-72)	Pacific Northwest employs a multilevel approach to incorporating studies from the molecular level to the whole animal level. Emphasis is placed on understanding effects at low-dose exposures to radiation received occupationally or through the environment. We seek a quantitative understanding of mechanisms that underlie the health effects of physical and chemical agents using dosimetric, molecular, cellular, and intact animal analytical techniques. We have begun a process to establish a new initiative in Environmental Health, with scientific emphasis on cell signaling.
Medical Sciences Division (SC-73)	Pacific Northwest builds on its past contributions in radiation physics, dosimetry, and biophysics. Current research provides methodologies for medical applications, including ing novel uses of magnetic resonance imaging coupled with high-performance Fourier transform ion cyclotron resonance mass spectrometry. We are continuing efforts in efficient radiochemical separation methods and improved generator designs to make radium-223, actinuim-225, and bismuth-213 available to clinical researchers.
Environmental Sciences Division (SC-74)	Pacific Northwest supports BER programs in environmental processes and environmental remediation, including fundamental and applied research in atmospheric science, global climate change, ecological research, subsurface science, microbial genomics, and molecular science. Component programs to which Pacific Northwest makes important contributions are the Atmospheric Radiation Measurement Program, the Climate Prediction Program, and the Atmospheric Science and Integrated Assessment programs. We are a key contributor to the Environmental Science Management Program and the Natural and Accelerated Bioremediation Research Program, and we provide national leadership in operating the Environmental Molecular Sciences Laboratory, a national scientific user facility.
Basic Energy Sciences	
Materials Sciences Division (SC-13)	Pacific Northwest primarily focuses on 1) the development of unique synthesis techniques for producing new or improved materials in an environmentally responsible manner and 2) investigating the reactions between materials and their environment.
Chemical Sciences Division (SC-14)	Pacific Northwest focuses on chemical physics and molecular processes. Our research in chemical physics focuses primarily on developing a molecular-level understanding of chemistry at liquid-solid interfaces and condensed phases important to problems at DOE contaminated waste sites. Our molecular theory and modeling programs develop new theoretical and modeling methods and apply these methods to the study of groundwater chemistry, chemistry at aqueous/mineral interfaces, separations chemistry, and nuclear waste forms. Our chemical, structure, and dynamics programs explore 1) reactions at a wide variety of solid/liquid interfaces, 2) the dynamics of biological systems, and 3) development of new analytical methods.
Engineering and Geosciences Division (SC-15)	Pacific Northwest is developing a molecular-level understanding of the surface chemistry and reactivity of environmentally important mineral phases. In the computational area, the emphasis is on the transfer of information from the molecular scale to the macroscopic or thermodynamic level. The experimental program focuses on the surface chemistry of carbonate minerals and is well integrated with the theoretical program.
Advanced Scientific Computing Research	
Mathematical, Information, and Computational Sciences Division (SC-31)	Pacific Northwest focuses on advancing the state of the art in computational modeling and simulation, facilitating remote collaborations through development of collaboratory tools, and linking developments from our basic research activities with industrial needs to foster revolutionary technology spinoffs. We have two major efforts that are advancing

Science Program Roles

DOE Office	Pacific Northwest Role
	the state of the art in computational modeling and simulation. First, we are developing a new generation of software for modeling molecular species containing heavy elements. Second, we are building upon a set of powerful and proven paradigms for managing the complex memory hierarchy in massively parallel computers, and fully integrating that functionality into key areas of the Action and Commitment Tracking System toolkit. We also make key contributions to the DOE 2000 Initiative in which we are collaborating with Argonne, Lawrence Berkeley, Sandia, and Oak Ridge National Laboratories on various projects that will provide major pieces of the architecture for the DOE 2000 Collaboratory Environment.
Office of Fusion Energy Sciences	
Science Division (SC-55)	Work at Pacific Northwest focuses on determining the response of candidate materials to neutron irradiation, developing new materials with improved properties, reduced activation materials, and theory and modeling to predict the effect of neutron irradiation on materials. The predictive capability resulting from this research is needed to account for differences between the neutron spectrum of fission reactors where these experiments are performed, and that of fusion power systems.

Environmental Quality

Strategic Intent

Researcher determining a material's reactivity using accelerating rate calorimetry (an adiabatic calorimeter), one of the many thermoanalytical methods used in the Radiochemical Processing Laboratory to investigate the stability and reactivity of materials.

Pacific Northwest's core capabilities in environmental science and technology will continue to play a major role in DOE's Environmental Quality mission. We intend to be a key provider of the science and technology necessary to

- define endpoints and make sound decisions for environmental cleanup
- eliminate the most urgent environmental risks
- optimize the life-cycle cost and risk reduction of cleanup
- support the safe, long-term management of selected waste to achieve the greatest protection at the least cost.

One key to delivering environmental science and technology is through the advanced research provided within the EMSL and the Radiochemical Processing Laboratory (RPL). Examples of the research under way are found within work currently funded through the Environmental Management Science Program (EMSP). The advanced instrumentation within the EMSL and staff capabilities are an essential part of the success of the EMSP work, as are those in RPL. Some of the EMSP projects most applicable to the Environmental Quality mission are described throughout this section.

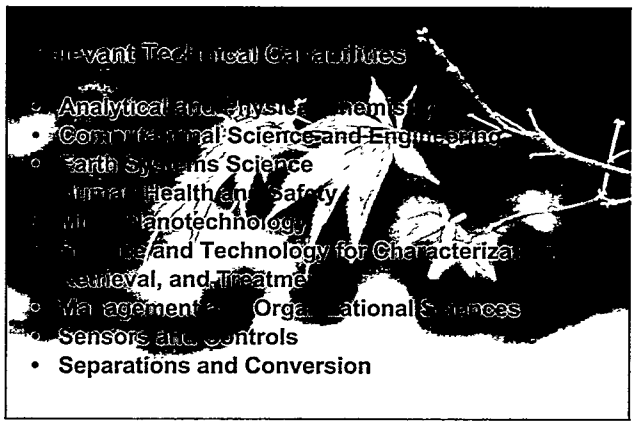
We will continue to support the Office of Science and Technology with their strategic planning to develop their 5-year research agenda and their multiyear program R&D roadmaps. In addition, we will contribute to the delivery of new technologies

that increase the timeliness and effectiveness of the cleanup projects by our continued management of the national Tanks Focus Area and our participation in all focus areas where we can offer unique technology concepts and research capabilities.

We will also support the Department of Energy in their planning efforts to help provide better synergy between the science and energy missions of DOE and with other federal agencies where common objectives could lead to better focused and more impactful environmental research programs at a lower cost to the federal government.

At the Hanford Site, we will focus much of our attention on the identification and resolution of technical and programmatic risk within the cleanup projects where we can have significant impact on achieving large cost reductions and enhancing safety. We intend to continue to support DOE's roadmapping efforts. We also intend to deliver the science and technology to the selected Hanford cleanup projects that represent the largest challenges to site closure. These include the tank waste remediation system and the groundwater/ vadose zone integration project along with selected projects for the handling and disposal of special nuclear materials and spent fuel.

In addition, our efforts to create a technical basis for establishing end-state requirements and a strong systems assessment capability is helping to lay the foundation for early thinking about a long-term management mission at Hanford and preparing the way



Environmental Quality Mission Strategy

Disposal/Disposition of Waste Materials			Enhance Future Land Use
Management of High-Level Waste	**Disposal of TRU/MLLW**	**Disposal of Nuclear Materials and Spent Fuel**	**Remedial Action**
Provide technical management of the Tanks Focus Area, providing all necessary science and technology for HLW remediation; implement private treatment and immobilization of HLW stored at Hanford	Develop programs to resolve DOE waste issues; composite hydrogen gettering; and existing technologies to address Hanford needs	Provide nuclear materials characterization and analytical services using our facilities and expertise	Contribute clear endpoints for cleanup; establish approaches acceptable to stakeholders and regulators; provide science and understanding of technical issues; develop and deploy new technologies to address difficult cleanup actions

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Environmental Quality mission strategy.

for future negotiations between DOE and the regulatory agencies. Our specific goals related to support for the Hanford cleanup effort over the 5-year planning horizon included the following:

- provide DOE with the tools and methodologies for the identification and mitigation of technical and programmatic risks
- support the national cleanup program through the delivery of impactful science and technology to solve EM's most enduring cleanup problems
- maintain the critical technical capability base for long-term management of the cleanup site, and position Pacific Northwest for stewardship roles at Hanford and elsewhere in the complex.

Our Role in the Environmental Quality R&D Portfolio

Pacific Northwest will advance DOE's mission by making significant contributions to the following objectives defined in the Environmental Quality research and development portfolio.

Management of High-Level Waste

We will continue to provide technical management in the Tanks Focus Area, a nationwide program responsible for delivery of technical solutions to the priority tank waste problems at five DOE sites. Our goal is to provide the highest quality science and technology necessary to reduce the technical and programmatic risks associated with the tank remediation baselines at the DOE sites. In partnership with industry and our national program partners, we have recently delivered both hardware and scientific data to tank waste problem holders to meet their requirements and enable high-level waste remediation to proceed. We delivered technical performance data to meet Hanford compliance milestones and reduce risks of remediation decisions; remote and robotic retrieval technology for sludge wastes to meet compliance and processing requirements at Oak Ridge and Savannah River sites; and characterization and tank inspection technologies to meet regulatory commitments at Idaho National Engineering and Environmental Laboratory.

The laser ablation/mass spectrometer system is a chemical analysis method that can determine the amount of most elemental/isotopic constituents in tank waste samples with no sample preparation. In a hot cell, a pulsed laser beam is used to remove a very small amount of material from the waste sample. The particles in the ablated plume are transported by a carrier gas directly to a commercial inductively coupled plasma/mass spectrometer that determines the composition of the particles.

Pacific Northwest also will continue to assist DOE with implementation of privatized treatment and immobilization of the high-level waste currently stored in underground storage tanks at the Hanford Site. We will assist DOE with the technical aspects in managing the current privatization contract, with integration between the privatization contractor and the Hanford Site management and integration contractor, and with development of the technical scope and contracting approach for future procurements dealing with treatment of waste that is beyond the scope of the current privatization contract. Pacific Northwest also will develop improved methods for identifying and managing risks, and project planning, management, and financing strategies to improve performance in privatized environmental cleanup projects throughout the DOE complex.

In addition, Pacific Northwest is a key science and technology provider of solutions to these DOE programs. We have been instrumental in helping solve the radioactive waste problem for over 30 years with unique science and engineering capabilities. These capabilities include waste retrieval, pretreatment, robust primary

treatment technologies, and secondary treatment technologies. Pacific Northwest also is developing next-generation chemical processes for the treatment of high-level waste, especially microchemical systems. They are compact, exploit the heat/mass transfer and surface effect advantages that can be realized through the use of engineered microstructure, and can be located at the distribution points where chemical products are needed.

Pacific Northwest will continue to be a major contributor to the EMSP, with several projects started in FY 1999 on high-level waste-related research, as well as projects that have been ongoing since EMSP's inception in FY 1996. The EMSP work directly supports critical Hanford and other DOE site science needs and enhances our environmental quality portfolio. To promote rapid deployment and usefulness, Pacific Northwest ensures that technology projects address all technical, policy, regulatory, and economic issues early in the development life cycle.

Disposal of Transuranic and Mixed Low-Level Waste

Cleanup of the DOE complex has and will produce large quantities of transuranic and mixed waste that need disposal. Much of these wastes will require remote handling. Treatment for disposal of these wastes presents unique challenges that Pacific Northwest will help answer. In cooperation with site operating personnel and organizations such as the DOE Office of Science and Technology, we will use our capabilities to make technology available as needed to resolve DOE waste issues. Pacific Northwest provides a unique blend of technical expertise coupled with knowledge of radioactive waste management needs at DOE sites critical to the success of these efforts.

Application to Hanford needs will, in most cases, be performed through partnerships with commercial entities where we provide knowledge of the client and facilities and expertise in dealing with radioactive wastes while the industrial partner provides the actual equipment for performing the operation needed.

Disposal of Spent Fuel and Nuclear Material Disposition

Pacific Northwest's goal is to significantly contribute to solving the nation's spent nuclear fuel problems through the development and demonstration of innovative science and technology. Working with the Project Hanford Management Contractor (PHMC), we provide technical support to help understand the problems, including material characterization and the recommendation of technology alternatives. We also have provided decision analysis, risk management, and stakeholder involvement support, drawing upon our extensive capabilities in these areas. For example, Pacific Northwest aided in the development of a path forward for resolution of spent nuclear fuel and sludge stored in Hanford's K-Basins through the development of a decision analytic framework that greatly assisted the PHMC in evaluating the strategic alternatives.

Contributing science and technology to the cleanup of DOE's production complex is a major focus for Pacific Northwest. This strategy includes developing and demonstrating innovative science and technology at Hanford and leveraging that to other DOE complex production sites following demonstrated performance. This strategy also includes working with Hanford Site contractors and DOE-RL to leverage national program funding in support of Hanford Site goals and expanding our relationship with the Office of Civilian Radioactive Waste Management at DOE-HQ and DOE-NV, which has the mission of oversight of the Yucca Mountain Site and management and disposal of the nation's spent fuel. For example, under the EMSP project "Radiolytic and Thermal Process Relevant to Dry Storage of Spent Nuclear Fuels," Pacific Northwest researchers are studying the radiolytic reactions "drying" processes, and corrosion behavior of actual spent nuclear fuel materials and pure and mixed-phase samples. These studies will determine what is omitted from current models: radiolysis of water adsorbed on or in hydrates or hydroxides, thermodynamics of interfacial phases, and kinetics of drying. A specially designed ultrahigh vacuum system is being constructed in the RPL to enable this work.

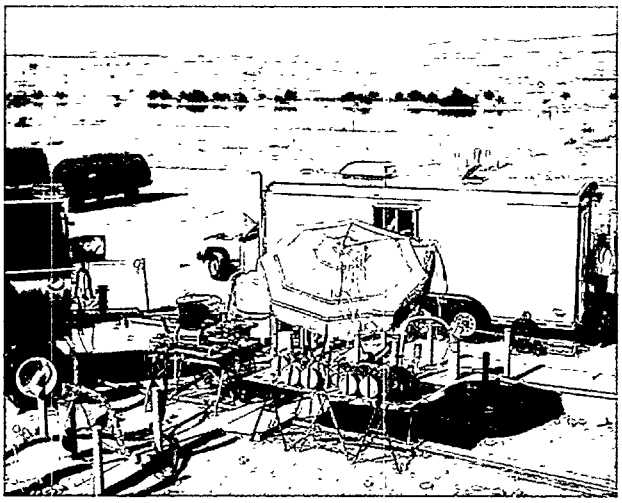
We are contributing to DOE's Materials Disposition Program through the application of our plutonium expertise and hot cell facilities to support pit conversion and vitrification of plutonium. More specifically, in the area of plutonium pit conversion, we are developing radioactive material handling; safeguards and security; and Environment, Safety, and Health to move plutonium materials from a highly secured laboratory environment to an industrial setting. We are also involved in facilitating relations with the former Soviet Union to address their material disposition issues. We are also participating in waste form testing and studies in vitrifying plutonium.

Pacific Northwest also provides technical support in managing environmentally sound storage of our nation's inventory of depleted uranium. Approximately 700,000 metric tons of UF_6 are contained in more than 46,000 cylinders that are currently stored at Portsmouth, Ohio; Paducah, Kentucky; and Oak Ridge, Tennessee. Finally, we will implement the Secretary's decision with regard to the Fast Flux Test Facility at Hanford should it be selected for future production of medical isotopes.

Remedial Action

Pacific Northwest is supplying DOE-RL and the PHMC decision, systems, and risk analysis tools to support their planning of a cleanup program that eliminates urgent risks, reduces mortgages, and applies more site funding to cleanup actions. Our involvement in integrated planning at Hanford will help ensure that our science and technology investments are focused on priority needs. We are providing new technologies, scientific investigations, and other technical services to major programs and a number of direct support services to the site overall, including integrated groundwater monitoring, radiation protection, analytical services, analyses supporting privatization, and environmental assessments.

A major focus of Pacific Northwest's contributions to Hanford Site cleanup includes developing and deploying innovative science and technology to help DOE cope with the inevitable tension between the significant technical requirements at the site and limited budgets. In particular, Pacific Northwest is developing systems assessment tools to help prioritize cleanup activities based upon risk to the human and ecological environments, passive remediation systems such as in situ redox manipulation and surface barriers that allow contaminants to be stabilized or destroyed in place without resorting to costly active cleanup systems, and innovative waste management techniques for high-level waste tanks and spent nuclear fuel.



In Situ Reduction-Oxidation (or Redox) Manipulation (ISRM) is a remarkable new technology that can revolutionize the way contaminated groundwater is treated throughout the world. In the ISRM process developed at Pacific Northwest National Laboratory, a non-toxic chemical reducing agent (in this case, sodium dithionite) is pumped from tanker trucks into groundwater wells to create an in situ treatment zone within a contaminant plume. The treatment destroys or immobilizes chemically reducible metallic and organic contaminants under natural flow conditions.

We are responsible for identifying science and technology needs associated with the assessment of contaminant release and movement through the soils and groundwater at the Hanford Site. Pacific Northwest is leading a multilaboratory team that evaluates four technical elements of the soil-groundwater-Columbia River pathway. Science and technology needs are identified and described for contaminant inventory, unsaturated soils referred to as the vadose zone and saturated (groundwater) flow and transport, and fate and transport in the river. This effort will form the basis for Hanford's Groundwater/Vadose Zone Science and Technology roadmap that will set the research and technology agenda to address site needs. In FY 1999, we delivered the Groundwater Vadose Zone Project Specification to DOE-HQ.

This specification included a site-wide science and technology roadmap detailing the environmental science and technology that would be needed to support Hanford's critical decisions related to removal, treatment, and final closure of Hanford's tanks as well as other waste release sites.

In FY 1999, we deployed In Situ Redox Manipulation (ISRM) at Hanford's 100-D area. ISRM is a passive groundwater remediation technique that destroys or immobilizes contaminants in place. It is the only technology currently identified that can provide an acceptable final remediation solution for the multiple chromium plumes and is planned for inclusion in the site's cleanup baseline (subject to final regulator and stakeholder approval).

In the future, many environmental challenges will focus on quality of life issues, or sustainability of resources. We will provide solid science and technology and policy development to help in the achievement of environmental quality and products and services that foster pollution prevention, waste minimization, risk minimization, total cost reduction, and sustainable operations that are consistent with DOE's mission.

Major Research and Development Thrusts

In order to expand our role in the Environmental Quality research portfolio, we are carrying out two major technical thrusts. These thrusts were identified as being critical for sustainable environmental quality.

Science and Technology for Characterization, Retrieval, and Treatment

Through our management of the national Tanks Focus Area, we are supporting the development of science and technology roadmaps and new technology for a number of tank waste cleanup efforts across the DOE complex. We are also expecting to secure a much stronger leadership role for the science and technology efforts under the Hanford Office of River Protection. Both of these efforts play a major role in identifying technology gaps where significant reductions in cost and uncertainty in the tank remediation activities can be achieved with new science and technology infusion. We are continuing to support the development of strong research capability in the retrieval and treatment of these waste streams through the insights we gain about high impact needs from the former roles in major programs. Our work in the development of advanced analytical tools and new robotic characterization systems are successful examples of where we have made impactful contributions. A related thrust is our effort to move the new scientific knowledge derived from our projects funded by the EMSP into the national focus areas and site cleanup projects.

An example of current EMSP work in this area is "Colloidal Agglomerates in Tank Sludge: Impact on Waste Processing." Researchers are conducting experiments to understand and identify the chemical conditions that control the formation and agglomeration of colloidal particles. In this way, the effect that agglomerate structures have on the rheology and sedimentation properties of the waste can be quantified, and methods for manipulating agglomerate structures to optimize tank waste transfer and processing conditions can be developed. This new knowledge and data will also benefit the cleanup of K-Basin liquids at Hanford and the tank wastes at Oak Ridge and Savannah River sites.

Risk Assessment and Management

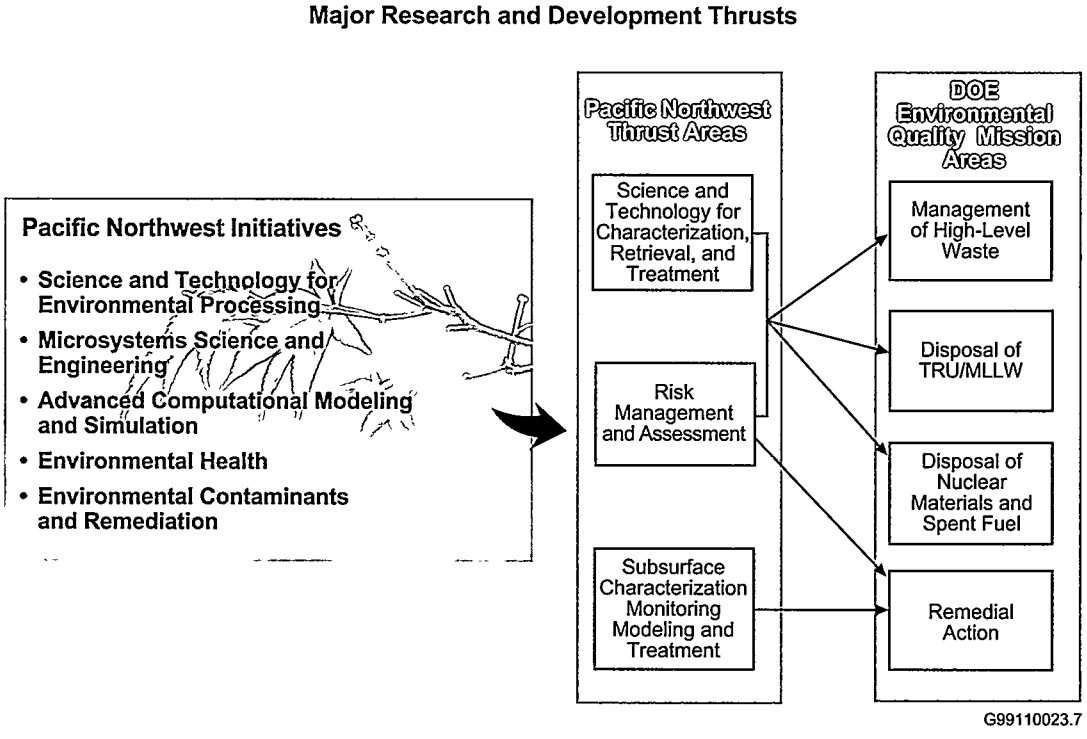
Pacific Northwest has a long history of contributions to the progression and application of both scientific and applied understanding of risk. We are continuing to advance our understanding of the basic processes that drive release, transport, exposure, and health effects through our health science program, including health risk-related projects within the EMSP, the molecular biology program/low-dose initiative, and the Pacific Northwest's Environmental Health initiative. This includes the EMSP project "Mechanisms Involved in Trichloroethylene-Induced Liver Cancer: Importance to Environmental Cleanup," in which

scientists are developing critical data for updating the human health and safety risk-based cleanup standards for trichloroethylene that were developed 20 years ago. These data could potentially allow changes in risk-based standards for trichloroethylene that could reduce complex-wide cleanup costs by several billions of dollars while still protecting humans and the environment. The work involves imaging tumors using magnetic imaging resonance methods within EMSL.

We are currently leading several site-wide risk assessments at Hanford and, in these efforts, we are developing and integrating state-of-the-art analytic methods to deliver credible and broadly accepted risk assessment data supporting cleanup decisions. Extending beyond health and ecological risk, Pacific Northwest's Waste Disposal Integration Team is supporting DOE's River Protection Project (formerly Hanford's Tank Waste Remediation System) by developing and implementing first-of-a-kind methods that link risk allocation schemes with project costs to obtain the best balance of risk and cost in DOE's largest privatization effort. In addition, Pacific Northwest is working with DOE's Center for Risk Excellence and DOE-RL to develop risk-based methods and data for measuring change in the sites' risk profiles as cleanup proceeds and for ascertaining the scope and requirements for long-term management and stewardship of sites as the cleanup mission evolves and comes to closure.

Subsurface Contamination Characterization, Monitoring, Modeling, and Treatment

We are continuing to build a science base for defining cleanup requirements and understanding natural processes in the subsurface through our involvement in EMSP and NABIR projects, and through selected internal Laboratory Directed Research and Development (LDRD) investments in computational science and reactive transport.



Major Environmental Quality mission research and initiative thrusts.

Current EMSP projects in support of Subsurface Contamination Characterization, Monitoring, Modeling, and Treatment include "Mineral Surface Processes Responsible for the Decreased Retardation (or Enhanced Mobilization) of ^{137}Cs from High-Level Waste Tank Discharges." Researchers are investigating the geochemistry of cesium ion adsorption under conditions appropriate to high-level waste tank releases. High sodium concentrations in tank waste are thought to suppress all but the most selective cesium sorption sites on the frayed edges of micaceous particles. The hydroxide and aluminate compounds in high-level waste may alter these sites chemically, leading to faster transport through the soil. The EMSL's atomic-force and high-resolution electron-beam microscopes afford previously unavailable opportunities to visualize and characterize these sites.

Our work in providing the science and technology lead for the Hanford Groundwater/ Vadose Zone Integration Project supports this area of research with a strong emphasis on science and technology roadmapping and development of an overall site system assessment capability. Funding from the Office of Science and Technology is helping to develop and deploy new technologies for in situ stabilization and containment using permeable barrier concepts and reactive treatment wells. The important characterization and modeling work we are doing provides a technical basis for exploring questions related to the long-term management of some waste sites as part of a stewardship role that will remain after cleanup in many cases.

Capability Development: Role of Laboratory Initiatives

Several of Pacific Northwest's initiatives described in an earlier section require building and strengthening our science and technology capabilities required to carry out these thrusts.

- The **Environmental Health Initiative** provides fundamental knowledge to address how humans are affected by environmental pollutants. Research in this area supports our efforts to underpin cleanup plans and requirements with a stronger risk-based decision-making approach.
- The **Computational Science and Environmental Contaminants and Remediation Initiatives** develop the science-based capability to optimize new-generation contaminant remediation technologies and to predict chemical and microbial processes in the subsurface. We are building the technical capabilities and tools to predict the fate and transport of contaminants through the subsurface.
- Pacific Northwest's **Science and Technology for Environmental Processing** initiative develops and applies the science for advanced separations and conversions for environmentally acceptable processes and hazardous liquid and mixed waste treatment.
- **Microsystems Science and Engineering** develops the science and technology for microsystems that takes advantage of low-cost components with high rates of heat and mass transfer for compact in situ treatment and advanced chemical processing or separations applications.

Environmental Quality Program Roles

DOE Office	Pacific Northwest Role
Environmental Restoration and Waste Management	
Office of Waste Management (30)	Pacific Northwest provides support to the Office of Waste Management on numerous waste management activities on the Hanford Site that include spent fuel characterization and general analytical support to waste analysis. Our support to the River Protection Project includes waste tank retrieval planning and review of key deliverables to DOE by the privatization contractor. We also provide support on surface environmental surveillance, Hanford Site planning and integration, and Hanford environmental oversight activities, as well as support to the West Valley site in New York. We also provide the site radiation protection services and manage the cleanup of legacy wastes.
Office of Environmental Restoration (40)	Pacific Northwest provides management and technical support to the Office of Environmental Restoration on many activities. These include groundwater monitoring and the cultural resources programs on the Hanford Site. We also lead the science and technology effort for the Hanford Groundwater/Vadose Zone Integration Project, and we provide project support to numerous activities at Hanford under the direction of the site SC contractor. A key facility in support of activities for this office is the Radiological Processing Laboratory, where research is conducted on radioactive and hazardous materials.
Office of Science and Technology (50)	Pacific Northwest plays a critical role in support of the Office of Science and Technology in their strategic planning and development of their 5-year research agenda and their multiyear program R&D roadmaps. Through our management of the national Tanks Focus Area, we are supporting the development of S&T roadmaps and new technology for a number of tank waste cleanup efforts across the DOE complex. We also are leading and collaborating on new and innovative research projects through the EMSP and moving that knowledge into the national focus areas and site cleanup projects. Other activities include developing and deploying new technologies for in situ stabilization and containment using permeable barrier concepts and reactive treatment wells.
Office of Nuclear Material and Facility Stabilization (60)	Pacific Northwest provides technical support to the Office of Nuclear Material and Facility Stabilization in the spent fuel removal, treatment, and safe storage activities and identifying cost-effective solutions for the K-Basin sludges.
Nuclear Energy	
Office of Nuclear Energy, Science and Technology	Pacific Northwest supports DOE/NE in its nuclear materials management objectives including disposition of legacy depleted UF6; treatment and storage of spent nuclear fuel; and in the selling, production, packaging, and shipping of medical nuclear isotopes. We developed processing/separations techniques for the production of yttrium-90 from Hanford waste for use in diagnostic purposes and recently privatized that activity. PNNL also manages the Fast Flux Test Facility (FFTF) Standby Project Office to prepare for implementation of the Secretary's decision on restart.
Office of Fissile Materials Disposition	Pacific Northwest supports DOE-MD through programs that use our plutonium expertise and hot cell facilities to support pit conversion and vitrification of plutonium.
Environment, Safety and Health	
• Office of Oversight • Office of Environment • Office of Worker Health & Safety • Office of Health Studies	Pacific Northwest supports DOE-EH in their mission to ensure that DOE's activities conform to the applicable laws and requirements governing environmental protection, safety, and health of the worker and public. This programmatic support includes technical assistance in the areas of policy analysis, independent oversight, programmatic assessments, worker protection, and health studies.

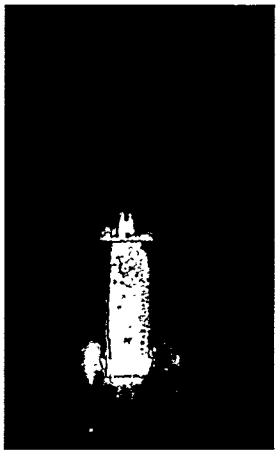
Energy Resources

Strategic Intent

Pacific Northwest will increase the impact and significance of our role in DOE's Energy mission by providing technical competencies in four areas where we can deliver unique value: clean, efficient vehicles; efficient, affordable buildings; clean, affordable power; and clean, productive industries. We will focus the resources of the Laboratory—from basic research to engineering development—to create highly impactful solutions that resolve critical gaps in the capacity of industry to respond to DOE's mission outcomes. Pacific Northwest will seek to accomplish these outcomes through highly effective collaboration with industry and by building on our long history of industrial research.

Pacific Northwest's capabilities in advanced materials, sensors, computational modeling, systems design, and manufacturing process innovation will be used to demonstrate technical outcomes important to DOE's strategic energy goals. We intend to maintain our strength in building standards and significantly increase the scientific and technical content of our energy programs in power and transportation systems, industrial efficiency, and climate change issues.

We will link with private-sector partners to achieve high impact outcomes that support critical energy missions. We will rapidly bring new technologies into practice through our proven approach of using public-private partnerships to leverage basic research into technology demonstration programs. Supporting our strategy for impactful innovation, we



Relevant Technical Capabilities

- **Computational Science and Engineering**
- **Design and Manufacturing Engineering**
- **Energy Technology and Management**
- **Material Science and Engineering**
- **Management and Organizational Sciences**
- **Sensors and Controls**
- **Separations and Conversion**
- **Computer Science and Information Technology**
- **Micro/Nanotechnology**

Energy Mission Strategy

Efficient and Productive Energy Use			Clean and Affordable Power	
Clean and Efficient Vehicles	**Efficient and Affordable Buildings**	**Clean and Productive Industries**	**Advanced Power Systems**	**Enhancing Utility Infrastructure**
Develop lightweight materials and new manufacturing technologies for vehicles and fuel cell technology for novel propulsion systems	Develop model energy codes and standards; invest in technology for intelligent buildings and new building materials	Deliver novel processing technology and computational manufacturing process simulation tools	Contribute advanced fuel cell design for scalable distributed generation and address associated fuel cell materials and design issues	Develop wide-area monitoring of utility grid and advanced decision support operations and maintenance

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Energy Resources mission strategy.

are investing internal resources in technical thrust areas of efficient vehicles and automotive structures, intelligent building systems, fuel cell systems technology, and engineering simulation and modeling. Through these investments, Pacific Northwest will provide leadership to DOE's Energy Resources agenda.

Finally, we will support Energy Resources in developing robust strategies that address the technological implications and market impacts of carbon management. Each element of the Pacific Northwest Energy Resource strategy is integrated into a crosscutting carbon management agenda. We are providing a balanced perspective to the technological, ecological, and economic dimensions associated with stabilizing, then ultimately reducing atmospheric carbon levels.

Our Role in the Energy Resources R&D Portfolio

Pacific Northwest will advance DOE's mission to provide efficient and productive energy use and clean and affordable power by making significant contributions to five high-level objectives defined in the Energy Resources Research and Development portfolio. We will strive to develop cleaner, more efficient vehicles, create more efficient and affordable buildings, introduce technologies that aid industry, and reduce cost while increasing the reliability of distributed and hybrid advanced power systems.

Clean and Efficient Vehicles

We will develop lightweight materials and new manufacturing technologies that support vehicle gas mileage reduction in light and heavy vehicles. We also support developments in fuel cell technology for novel propulsion systems and advanced vehicle emission reduction technologies.

Pacific Northwest is developing fuel-efficient automobiles that are less harmful to the environment. Researchers are working on the technology and materials for exhaust after-treatment devices for diesel engines to reduce nitrogen oxide emissions.

Our leadership in the Northwest Alliance for Transportation Technology (NATT) initiative highlights our role in achieving clean and efficient vehicles. This initiative is a public-private partnership designed to meet the challenges of developing automobiles and trucks that obtain significantly reduced emissions and higher fuel efficiency. NATT will position Pacific Northwest as a significant player in mission critical areas for automotive manufacturing. The strategic foundation of NATT is to establish a systems management approach that links our technical competencies in system design, materials innovation, virtual system simulation, and manufacturing process innovation. This linkage will ensure that Pacific Northwest adds value to the missions, objectives, and critical outcome drivers of key initiatives of both the Partnership for the Next Generation Vehicle and DOE's programs for heavy vehicles. Strategic alliances developed with the automotive industry will ensure that industry needs are met, strong partnerships are formed, and that commercially viable technology and intellectual property is readily transferred and adopted by the auto industry. This initiative is also developing new capabilities and program thrusts in crosscutting vehicle emission reduction technologies and advanced lightweight materials.

Equally important, the adoption of new materials and manufacturing processes requires development and adoption of new engineering simulation and design tools. Building on

Pacific Northwest's strengths in large-scale, high-speed scientific computation, we are working closely with the auto industry and the leading software providers to adapt computation tools that can take advantage of next generation parallel computers.

Efficient and Affordable Buildings

We will provide technology for "smart buildings," including new building materials, micro-scale heat pump devices, and automated diagnostics for operations and maintenance. In addition to providing a place to live for nearly all Americans, our buildings must provide a healthy and safe indoor environment conducive to high-quality living and business performance.

Pacific Northwest focuses on multidisciplinary solutions to the objectives of more efficient energy use associated with building operations, as well as improving the comfort and health of building occupants. We work closely with the building industry and other partners to improve the energy efficiency of the nation's buildings and to increase their use of renewable resources. Such support includes research, development, and deployment activities designed to target areas with high-efficiency improvements in energy and human performance.

Pacific Northwest supports the initiation of the Buildings of the 21st Century program leading to the integration of modern technologies to produce more economical, efficient, and healthy buildings. Pacific Northwest has played a critical role in supporting DOE in developing and implementing model energy codes and standards. We are an established leader in the development of automated diagnostics for building applications and currently are working with industry to develop the technology and capabilities needed for intelligent buildings of the future. We are also developing innovative microscale heat pump concepts for building environmental temperature control.

Clean and Productive Industries

We will deliver novel processing technology and computational tools for the manufacturing process simulation essential to reducing the costs of technology innovation and adoption in the chemicals, forest products, aluminum, and glass industries. Pacific Northwest has also assumed a leadership role for DOE to establish the Industries of the Future Laboratory Coordinating Council. Under a Memorandum of Cooperation, this group facilitates access to the capabilities that can help solve the technology challenges identified in each industry's vision of the future.

The role of Pacific Northwest in supporting the clean and productive industries mission covers a broad range of activities, from program planning and technical evaluation to technology development and demonstration. For example, current technology development programs draw upon Pacific Northwest's process science and engineering competencies to recover energy from industrial wastes, develop renewable routes for value-added chemical manufacture, and apply new separations technologies to enhance pulp and paper plant efficiencies. In addition, we are applying capabilities in sensors and advanced manufacturing technologies to glass fabrication through the use of non-contact stress measurement techniques and advanced process control methodologies. Other novel sensor techniques will help the pulp and paper industry measure pulp slurry characteristics and paper web properties. Characterization of multiphase fluid dynamic behavior in chemical plants is one of the key issues being addressed through national laboratory, industry, and academia collaborations to develop advanced computational techniques of broad application.

Advanced Power Systems

Our fuel cell system program is developing advanced materials and looking at novel microtechnology approaches to fuel reformation. We will contribute advanced, high-efficiency fuel cell systems and controls that are inherently manufacturable and cost-effective for scalable distributed generation. We also will address associated fuel cell materials and system design issues.

In order to reduce the costs and increase the reliability of fuel cells, Pacific Northwest is providing a leadership support role in the DOE Fuel Cell Technology initiative. We will be

significantly expanding our technical contribution to the fuel cell program in advanced materials, fuel cell system modeling and simulation, and manufacturing methods to develop a generation of fuel cells that are inherently cost-effective and efficient. This program has applications for transportation and stationary distributed power generation.

Enhancing Utility Infrastructure

We will provide decision support operations and maintenance technologies for reliable control of power plants, wide-area monitoring technology for the utility grid, frameworks to facilitate deployment of distributed resources, and technologies to support infrastructure security. Much of this work also supports the Efficient and Affordable Buildings mission.

Significant challenges exist to define the federal role in the rapidly changing energy environment in the new age of deregulation. Pacific Northwest has extensive experience working with DOE and the utility industry to address the technology needs for reliable electricity supplies in the 21st century. In particular, Pacific Northwest is positioned to establish partnerships with the utility industry on distributed resource systems and policy studies, grid reliability technology research, and new intelligent system control frameworks. We also have distinctive capabilities in technologies to ensure security and integrity in an unregulated utility industry. In support of these strategic areas, Pacific Northwest will continue to coordinate with federal energy agencies to explore opportunities for collaboration on potential energy test beds and demonstrations.

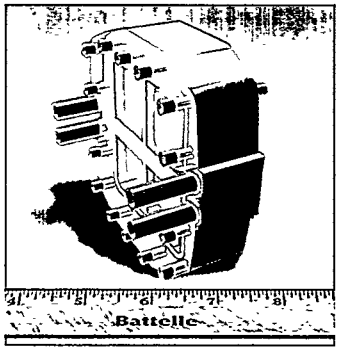
Pacific Northwest has developed a real-time power system control and operation via the Wide-Area Monitoring project, which aids in utility grid reliability. Pacific Northwest has programs in energy resources management, environmental impact studies, and market transformation, which serve the power and energy services entities. We will be supporting the new DOE-EE initiatives in grid reliability and in helping define a new DOE program in Distributed Resources. Finally, Pacific Northwest will seek to deliver advanced operations and maintenance technologies to the power and transmission entities to aid in reducing regional power costs.

Major Research and Development Thrusts

To develop and expand our contributions to the Energy Resources R&D portfolio, Pacific Northwest is carrying out the following major technical thrusts:

- **Smart Buildings Technology**—The vision for the intelligent or smart building system is to operate buildings cost-effectively by using advanced sensor systems to provide a comfortable, productive, healthy environment for building occupants. Pacific Northwest is working with its peers and with industry to define research needs, development needs, priorities, and investments in areas such as advanced controls and system operability; low-cost, highly reliable, long-lived sensors; automated diagnostics; and advanced microscale heating, ventilation, and air-conditioning (HVAC) technology.
- **Fuel Cell Technology Development**—This program is establishing a systems engineering framework to define the essential technology barriers and to begin working on the specific solutions. The technology development for advanced fuel cells has several needs, including

1999 R&D 100 Award Winner



The Compact Microchannel Fuel Vaporizer (CMFV) is a breakthrough in miniaturizing and intensifying process technology, which, when applied with other reactors, will enable the fuel processing system to be small enough for automotive or portable applications. The CMFV's small size helps overcome one of biggest practical problems of fuel cell-powered automobiles—fitting the device in the available space. Consumer acceptance demands that new technology must not take up current trunk or passenger space. The CMFV will easily fit into an automobile engine compartment.

high-temperature materials, fuel reformation, system modeling, intelligent diagnostics, and control system development.

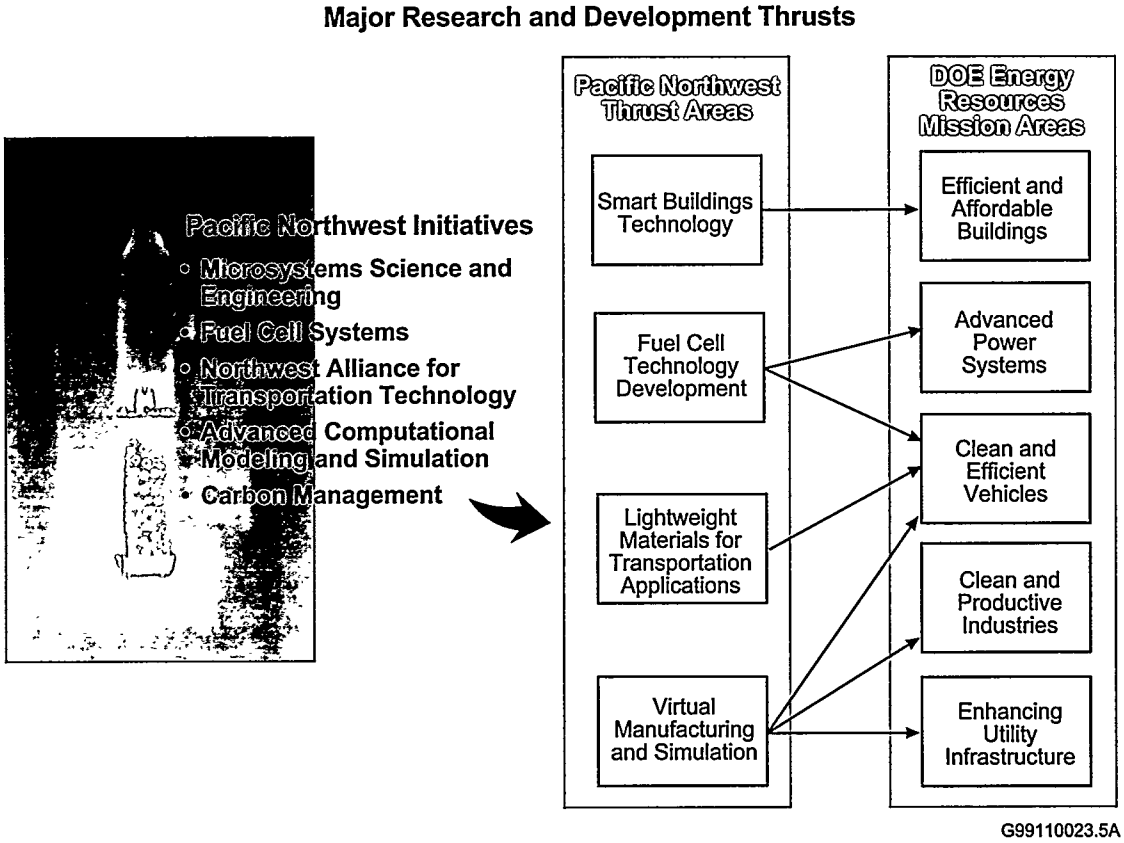
- **Lightweight Materials for Transportation Applications**—Materials manufacturing process development is an important capability to ensure the successful transition from the laboratory to production use of new materials. This program includes process developments in aluminum, ceramics, and composites to aid in weight reduction for vehicles.
- **Virtual Manufacturing and Simulation**—High-performance computational scientific and engineering modeling has been identified as a critical success factor for Pacific Northwest. This initiative combines high-performance computing with advanced simulation and modeling software to create a world-class virtual prototyping and advanced manufacturing capability. Applications in this initiative range from basic materials theory to virtual prototyping to life-cycle assessment. The engineering simulation activities in this thrust support the other thrust areas and have broad impact on the Energy Resources mission areas.

These technology thrusts can be organized in a general carbon management framework that supports the Energy Resources goals.

Capability Development: Role of Laboratory Initiatives

Several of Pacific Northwest's initiatives are building and strengthening the capabilities required to carry out the major research and development thrusts.

- Pacific Northwest's microtechnologies initiative is developing underlying technology required to support concepts for innovative heat pumps for man-portable, vehicle, and distributed heating and cooling applications. The chemical processing techniques for microtechnologies are providing new concepts for fuel reformation.



Major Energy Resources research and development thrusts.

- Our computational science initiative is building the technical capabilities and tools required for virtual manufacturing software applications, including material property studies, advanced engineering mechanics, engineering problem-solving environment, and innovative forming, joining, crash and life-cycle assessment process simulation.
- Our carbon management initiative will build the crosscutting capabilities essential to address reducing carbon in the earth's atmosphere, including both energy-efficiency development and new technologies for carbon capture and sequestration, as the role for both energy-efficiency development and new technologies for carbon capture and sequestration.

Energy Resources Program Roles

DOE Office	Pacific Northwest Role
Office of Energy Efficiency and Renewable Energy	
Building Technology, State and Community Programs	The Building Standards Program plays a critical role in supporting the Office of Building Technology, State and Community Programs (BTS) in developing and implementing model energy codes and standards. We also are key participants in the Rebuild America, Building Systems, Economic and Systems Analysis Program, Market Transformation, and EPACT Commercial Equipment Standards programs that support the development of energy efficiency for buildings and their use of renewable resources.
Bonneville Power Administration	We provide research and development to reduce Bonneville Power Administration (BPA) operating costs and to increase the value of services offered by BPA. Pacific Northwest deploys its capabilities and products to serve Bonneville's transmission group in real-time power system control and operation via the Wide-Area Monitoring project, conducted in partnership with the Electric Power Research Institute and DOE. Pacific Northwest also contributes fisheries and ecosystem science support to BPA's mission to rejuvenate fisheries in the Northwest. BPA has established a regional leadership position in assessing the role that Distributed Energy Resources can play in the Northwest. Pacific Northwest is working with BPA to frame the benefits and options of various DR technologies in this new industry trend, which promises to have significant impact on BPA's future strategy.
Federal Energy Management Program	Pacific Northwest is a key participant in the Federal Energy Management Program to increase the efficiency of federal energy use by facilitating implementation of energy and water conservation measures in federal facilities through policy action, coordination, and assistance with technology and financing tools.
Office of Industrial Technologies	The role of Pacific Northwest in supporting the Office of Industrial Technologies (OIT) covers a broad range of activities, from program planning and technical evaluation to technology development and demonstration. Current technology development programs draw upon Pacific Northwest's competencies in process science and engineering, sensors, and advanced manufacturing technologies. Specific projects address technology needs associated with resource efficiency in the chemicals, glass, and forest products industries. We also support the NICE3 Program and provide leadership to the Laboratory Coordinating Council.
Office of Power Technologies	Pacific Northwest provides technologies and capabilities to the Office of Power Technologies (OPT) and the utility industry on distributed resource systems and policy studies, grid reliability technology research, intelligent system control frameworks, and technologies to ensure security and integrity in an unregulated utility industry.
Office of Industrial Technologies	Pacific Northwest plays a leadership role in NATT, a public-private partnership designed to meet selected goals within the Partnership for a New Generation of Vehicles and DOE-OTT's Office of Heavy Vehicles. We also have a significant role for OTT in the areas of fuel cell technology, fuel reformation, and emission control.
Policy Office	Pacific Northwest provides assistance to the Policy Office in economic and policy analysis. Our assistance has also resulted in improvements in understanding policy approaches to controlling greenhouse gas concentrations and in the development of the Second Generation Economic Model and in supporting international nonproliferation agreements.
Fossil Energy	
Fossil Energy Fuel Cell Program	Pacific Northwest provides leadership in the Fossil Energy Fuel Cell Program and technology developments in support of the evolving Vision-21 and Efficient Fuel Cell initiatives.

National Security

Strategic Intent

Pacific Northwest's growing role in DOE's National Security mission is focused around DOE's goals of reducing the global danger from weapons of mass destruction (WMD) by monitoring nuclear treaties and agreements, preventing and detecting proliferation, countering WMD terrorism, promoting international nuclear safety, and maintaining current/future nuclear weapons capability. To support DOE's National Security mission, Pacific Northwest's strategy is to leverage its science and technology capabilities in order to

- continue making significant contributions to nuclear treaty verification and nuclear nonproliferation, particularly in monitoring instrumentation; materials protection, control, and accountability; nuclear safety; nuclear component disposition; and technical policy
- expand our role in preventing and detecting proliferation of weapons of mass destruction to chemical/biological nonproliferation and arms control
- develop significant capabilities to increase our role in counterterrorism, information security, and infrastructure protection
- bring fundamentally new technologies and approaches to critical knowledge management problems posed by counterterrorism, nonproliferation and arms control, and intelligence analyses
- support maintaining the national stockpile of tritium and safe disposal of excess weapons-grade plutonium.

In addition to Pacific Northwest's programmatically supported national security work, science-based capabilities for national security applications are developed under our LDRD Program. The Infrared Sensing initiative provides capability development for DOE and its role in detecting proliferation of nuclear, biological and chemical weapons, counterterrorism, and environmental research. The Cyber Security initiative builds capabilities to protect critical infrastructures from a variety of threats. Smaller LDRD efforts also address DOE's national security technologies needs.

Pacific Northwest's national security work is conducted principally for DOE's Office of Nonproliferation and National Security, Office of Counterintelligence, Office of Defense Programs, Office of Intelligence, and other federal agencies through the Work for Others Program. DOE and Pacific Northwest also play an essential role in providing technical expertise to the Department of Defense, State Department, Department of Justice, and other government agencies. The ultimate impact of the Congressionally dictated creation of the National Nuclear Security Administration within DOE on Pacific Northwest's national security work is currently unknown but no significant impacts are anticipated for FY 2000.

In the following sections, we describe our role in the DOE National Security R&D portfolio and the technical thrusts we are undertaking to strengthen our contributions and build capabilities to respond to future needs.

Relevant Technical Capabilities

- Analytical and Physical Chemistry
- Information Synthesis
- Micro/Nanotechnology
- Nuclear Science and Engineering
- Management and Organizational Sciences
- Sensors and Controls

National Security Mission Strategy

Monitoring Nuclear Test Treaties	Preventing Proliferation	Detecting Proliferation	Countering Terrorism			Maintaining Current/ Future Nuclear Weapons Capability
Nuclear Explosion Monitoring Technologies	**International Nuclear Safety Program**	**Remote Physical and Chemical Detection**	**Nuclear**	**Chemical/ Biological**	**Critical Infra-structures**	**Weapons Initiation**
Develop radionuclide monitoring technology and provide technical policy support	Provide leadership and technical expertise to reduce the danger from production reactors in the former Soviet Union	Develop innovative technologies and instrumentation for remote detection and analysis of objects and WMD-related chemicals	Develop detection, forensics, tracking, and tagging technologies for countering nuclear terrorism	Provide detection, identification, decontamination, and demilitarization technologies for chemical and biological agents	Provide innovative technologies to protect and secure the nation's critical resources	Contribute advanced fuel rod designs for tritium production requirements

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National Security mission strategy.

Our Role in the National Security R&D Portfolio

Monitoring Nuclear Test Treaties

Nuclear Explosion Monitoring Technologies

For more than half a century, Pacific Northwest scientists and their Hanford Site predecessors have been global leaders in monitoring anthropogenic radioactivity in the environment. Throughout the Cold War, Pacific Northwest operated systems collecting fallout from nuclear tests. In recent years, Pacific Northwest staff have incorporated their scientific and engineering expertise into fully automated, remotely programmable systems for monitoring atmospheric concentrations of radioactive particles and noble gases with sensitivities previously unheard of for near real-time measurements. These capabilities have already been employed in support of DOE's Comprehensive Test Ban Treaty (CTBT) Research and Development program. In cooperation with DOE and other agencies, Pacific Northwest has identified additional radionuclide technology needs that must be satisfied for effective monitoring of foreign activities. When attempting to detect and characterize extremely weak signatures, as is necessary when using a few stations for monitoring the entire globe, it is quite easy to confuse signals and noise, or other irrelevant phenomena. For this reason, statistical methods must be carefully designed and applied to enhance the reliability of interpretations. These CTBT needs benefit from decades of Pacific Northwest experience applied throughout the Cold War for much of the same reasons. We project no end to this need.

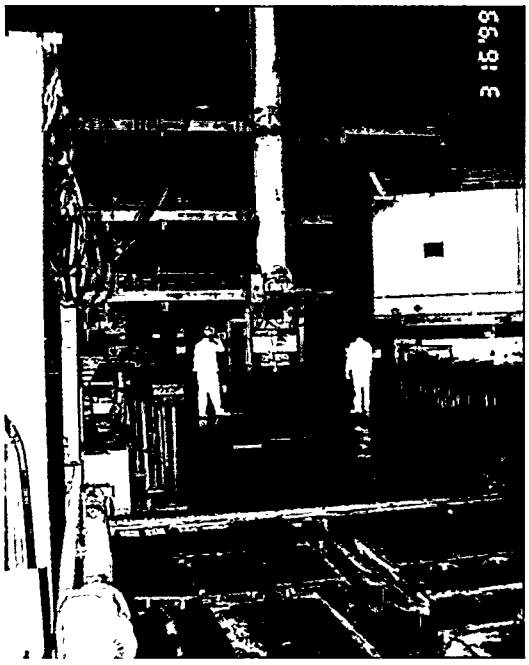
In support of the Department of Energy's National Security strategic goal to "support national security, promote international nuclear safety, and reduce the global danger from weapons of mass destruction," Pacific Northwest is committed to bringing technology and expertise to bear on the problems of monitoring nuclear treaties and agreements. The strategic goal for the program is to enhance the U.S. capability to monitor nuclear test activities of other nations. We approach this goal with the following three strategies:

- Our first strategy is to provide the U.S. government with the enhanced radionuclide collection and analysis capabilities needed to monitor other nations' compliance with the CTBT and to satisfy its monitoring obligations as established in the Treaty. To do this, we develop, transfer, support, and enhance the necessary radionuclide technology.
- Our second strategy is to provide the U.S. government with the experts for the negotiation of cost-effective CTBT implementation measures. We will send radionuclide experts to interagency meetings to advise on technical policy, and provide radionuclide experts to staff the U.S. CTBT Delegation.
- Our final strategy is to provide the U.S. government with statistical tools and expertise needed for optimum processing and interpretation of nuclear test monitoring data. This is accomplished by cooperating with seismic experts at other institutions to optimize processing and interpretation of waveform data, and by developing new statistical tools to minimize the costs of operating monitoring capabilities.

Preventing Proliferation

International Nuclear Safety and Cooperation

Pacific Northwest will continue to provide primary support to DOE with international nuclear safety and security missions. We will provide lead project management, technical, and administrative support for DOE's work to improve international nuclear safety. This work reduces the risks of Soviet-designed reactors by working cooperatively with host countries to upgrade nuclear power plants to meet international standards and to build lasting safety cultures. We will lead bilateral efforts to stabilize the deteriorating "shelter" surrounding the destroyed Chornobyl reactor in Ukraine and support the transition of this work to the European Bank for Reconstruction and Development, which has consolidated international funding and provides an integrated role. Pacific Northwest will provide increasing support to DOE in developing and implementing its nuclear security program to stop the production of weapons-grade plutonium.



Defueling activities at the Chornobyl NPP Unit 1 reactor began in early 1999 and are scheduled to be completed in 2004. In this photo, the transfer cask, loaded with the spent fuel assembly, is being moved to the unloading portal.

This work supports Pacific Northwest's mission of meeting environmental, national security, energy, and human health needs by providing protection for Europe's public, economic, and environmental health and for U.S. personnel in Europe; reducing the risk of destabilizing nuclear accidents in the emerging free-market democracies of the Newly Independent States; working with other countries toward the shutdown of the least safe Soviet-designed nuclear power plants (e.g., the Chornobyl plant); and supporting U.S. nuclear security goals by helping countries eliminate production of weapons-grade plutonium.

Initiative for Proliferation Prevention

Pacific Northwest is a participant in the Initiative for Proliferation Prevention with the Newly Independent States (NIS/IPP) of the former Soviet Union. The goals of this U.S. government program, executed jointly by the Departments of State and Energy, are to stabilize supporting technology, equipment, and facilities to enhance global nonproliferation; develop advanced technology commercial opportunities and markets; enhance U.S. science and engineering capabilities; and engage weapons scientists, engineers, and technicians in nonweapons-based activities. Pacific Northwest was asked to coordinate the chemical and biological cooperative program under IPP.

Material Protection, Control, and Accountability

Effective material protection control and accounting measures will deter suppliers seeking long-term access to material for diversion. The development of real-time inventory and monitoring technologies will play an increasing role in future materials protection, control, and accountability activities. Pacific Northwest will research, develop, and evaluate technologies for rapid inventory and remotely attended monitoring that leverages our investments in microsensor, information technology, and "Collaboratory" technologies.

Detecting Proliferation

Remote Physical Detection

Pacific Northwest will continue to grow its capabilities to provide quality analysis of physical objects using remote sensing data. Our goal is to become a leading innovator and developer of data analysis algorithms and techniques for exploitation of remote sensing data. Pacific Northwest's present focus in remote physical detection includes national security and natural resources. A key future focus will be environmental treaty monitoring. Continued growth in these focus areas will allow Pacific Northwest to increase its support of DOE, DoD, and other government agencies.

Current efforts emphasize a diverse set of innovative technologies to improve the state of the art in image analysis. These include automated feature extraction, multi-sensor data fusion, land-use classification and environmental degradation, a revolutionary approach to data registration and calibration, and visualization of spatial data. We also conduct more applied remote physical detection analysis for a variety of other clients. Examples of applied research and development projects include automated land-use classification at Mount St. Helens; rangeland management; agricultural analysis; and mineral, oil, and gas exploration.

Future technologies being developed by Pacific Northwest include enhancing the statistical analysis of data, automating data processing, improving data visualization, and creating links to other forms of information technology. These capabilities will enhance our ability to serve the evolving needs of national security clients and develop new clients in environmental monitoring.

Remote Effluent Detection

Pacific Northwest's objective is to develop solutions to a wide array of civil and national security needs related to detection and identification of chemicals in field environments. Among the national security needs that can be addressed are the identification of chemical effluents from the production of nuclear, biological, and chemical (NBC) weapons; identification and mapping of chemical warfare agents on the battlefield; wartime intelligence collection and targeting; battle and collateral damage assessment from strikes against NBC and industrial targets; and counterterrorism. Civilian applications include counter-narcotics operations, atmospheric chemistry and meteorology, environmental monitoring and remediation, and industrial and agricultural process control. Based on infrared technologies, most of Pacific Northwest's chemical sensing activity is focused on NBC proliferation detection and is sponsored by DOE/NN-20. Current efforts include generating

infrared spectral data for effluent chemicals, advanced sensor science and component technology research, small-scale instrument system development, and limited development of data exploitation algorithms. An example of technology under development is Dewar assembly for Pacific Northwest's portable Light Detection and Ranging (LIDAR) system. Pacific Northwest has profound strengths in a wide array of science, technology, and engineering fields related to infrared chemical sensing, and these strengths provide the basis for a much broader program. In addition, Pacific Northwest enjoys an excellent reputation for technical depth and creativity, programmatic loyalty and integrity, and cost-effective product delivery at DOE/NN-20. The Infrared Sensing Initiative strategy is to develop a broader array of Pacific Northwest capabilities and expand participation in NN-20's remote chemical detection program, and to use the capabilities developed through NN-20 funding as leverage for participation in other DOE and DoD markets.

The NN-20 remote chemical detection program is in transition as major programs change focus, the Hyperspectral Infrared Imaging Spectrometer (HIRIS) passive detection program undergoes a major transition, and NN-20 contemplates funding the development of a hybrid Differential Absorption LIDAR (DIAL)/passive prototype. The hybrid prototype requires numerous optimization trade studies and major technique/technology developments, and is therefore an opportunity for growth in Pacific Northwest's sensor science and technology activities. The HIRIS program transition provides opportunity for Pacific Northwest expertise in infrared signatures, algorithms for exploiting and interpreting the data from complex sensor systems, and field intelligence, as well as access to a major new customer for infrared sensing products.

Countering Terrorism

Nuclear

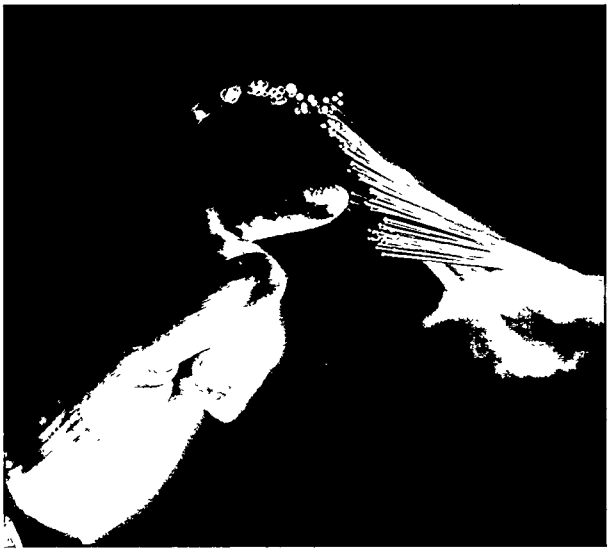
Pacific Northwest will continue to grow its position as a national resource for technologies to countering nuclear terrorism. It is anticipated that Pacific Northwest research and technologies will have a significant impact on reducing the nuclear danger.

The research and development will draw heavily on the Hanford experience and core competencies that support the enduring mission of environmental science and technology. These efforts leverage Pacific Northwest's unique understanding and expertise in this area, as well as world-class researchers and facilities. Along with meeting aggressive requirements for sensitivity, selectivity, and cost, a major goal continues to be satisfying user needs while advancing the state of the art.

Countering nuclear terrorism consists of the following focus areas: detection systems, nuclear materials tracking and interception, nuclear materials forensics, and attribution assessment.

Pacific Northwest will research new technologies to exploit the intrinsic

1999 FLC Award Winner



Fiber-Optic Neutron and Gamma Ray Sensor— *A creative and innovative team from Pacific Northwest created, recognized the potential of, and then successfully commercialized a new kind of radiation sensor that uses glass fibers to detect the presence of radionuclides. Early in its development stages, they saw the potential of the Fiber-Optic Neutron and Gamma Ray sensor as a nuclear weapons deterrent, for environmental cleanup, and as a valuable tool in nuclear medicine. The team faced substantial obstacles to commercialization—from resistance by commercial vendors who were reluctant to embrace such an innovative technology—to a foreign licensee and cumbersome processes of patenting and licensing.*

and stimulated radiation signatures of special nuclear materials and evaluate their performance in various scenarios. The development of advanced technologies will find application in future generations of detection systems. Specific emphasis will be placed on new gamma-ray sensors such as CdZnTe that operate at room temperature and offer adequate resolution for many applications, cryocoolers, advanced low-power electronics, highly enriched uranium detection, and cost-effective detector technologies.

Pacific Northwest will continue to research, develop, and evaluate nuclear materials tracking and tagging technologies that will improve law enforcement and the broader counter-terrorism community's capability to respond to diversion of materials. These technologies will support real-time material tracking, material search, near-field pursuit, and infrastructure protection.

Forensic analysis and interpretation of forensic data will be developed to facilitate the identification of the source and illicit route of seized nuclear materials. Pacific Northwest will continue to develop technologies and procedures for the attribution assessment of illicit nuclear materials. Specific focus will be placed on rapid in-field analysis, nuclear forensic techniques, and methodologies for source and route attribution and international collaborations.

Chemical/Biological

Pacific Northwest science and technology is helping to defend against national chemical and biological threats. Pacific Northwest supports the DOE Safeguards and Security Program in helping to protect sensitive operations across the DOE complex from the threat of use of chemical or biological agents in the hands of terrorists or adversaries. Laboratory scientists are helping to define the national priorities in how to protect the U.S. civilian population against chemically or biologically armed terrorists. Our scientists are being sought out increasingly to work in partnership with the Centers for Disease Control (CDC), National Institutes of Health (NIH), and the regional public health services to inform, prepare, and protect the true first responders in a biological agent attack: the country's health care providers. Finally, Pacific Northwest is helping to develop technologies to help protect American soldiers against chemical or biological agent attacks. Our work in support of the national defense against chemical and biological weapons derives from several sources. Basic research in technologies that can serve to detect proliferant production of weapons of mass destruction is sponsored in the DOE-NN-20 research program. The DOE Chemical and Biological Nonproliferation Program (CBNP) supports Pacific Northwest research in biological signatures as well as in the use of the Aerosol Research Facility as a biological agent detector test bed. Through the Work for Others mechanism, we provide research, development, and analysis to the Department of Defense, the FBI, the State Department, and the Intelligence Community.

Activities in the Chemical and Biological Defense program align closely with those of DOE-NN-20, DOE-NN- CBNP, and DOE-IN. We expect to continue to emphasize particular Pacific Northwest strengths in providing an increasing degree of support in chemical and biological defense, with specific focus continuing in the following areas:

- chemical and biological detection
- remote sensing, signatures analysis, aerosol hazard characterization and mitigation
- decontamination and demilitarization, including decommissioning demilitarization facilities.

Pacific Northwest has for years provided support to DOE and other government agencies in chemical detection and remote sensing as it applies to chemical effluents from a variety of military and industrial processes. Laboratory scientists continue to receive recognition from DoD, FBI, and other agencies for the work deriving from our prior LDRD investment in biological pathogen detection. Pacific Northwest's mission in environmental remediation

of former nuclear weapons production activities provides an outstanding basis for turning those capabilities to address chemical and biological hazard characterization and mitigation, specifically, possible clouds of chemical and biological agents. In this work, we are seeking to ensure that the Aerosol Research Facility, one of two environmental wind tunnels in the world and uniquely suited to conducting complex experiments on agent fate, is being used to the greatest advantage in support of our defense against these types of weapons. Finally, as an environmental remediation laboratory, we have experience that applies directly from the nuclear materials arena to the decontamination and demilitarization of chemical and biological weapons agents and production facilities.

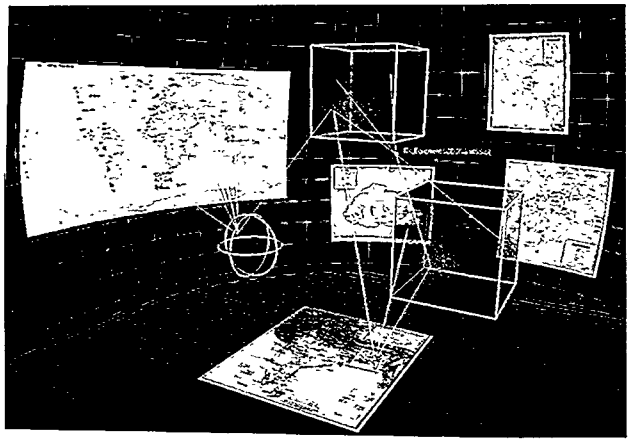
Critical Infrastructure

As part of its National Security mission, Pacific Northwest is taking a proactive role to ensure that the nation's critical resources are protected and secure. Pacific Northwest has ongoing programs in materials security, physical security, information security, critical infrastructure protection, and transportation security. Although countering terrorism is a common theme that runs through the thrust area, the collective work at Pacific Northwest has a much broader focus. Pacific Northwest's goal is to take a leadership role in providing the technologies, processes, and capabilities that will protect society, its organizations, and resources from any threat—external or internal.

Pacific Northwest is involved with the protection of special nuclear materials and government property across the DOE complex. In conjunction with the Raytheon Company and the DOE Chicago Field Office, Pacific Northwest is tasked with ensuring that appropriate safeguards and security interests are protected and controlled at the Pit Disassembly and Conversion Facility which will be located at the Savannah River Site. At the Hanford Site, Pacific Northwest supports the Hanford safeguards and security program, including managing the safeguards organization under subcontract to Protection Technology. And under the auspices of the DOE Office of Safeguards and Security, Pacific Northwest and the U.S. Army Special Forces perform vulnerability assessments and conduct force-on-force security exercises at various DOE sites.

In the areas of information security and critical infrastructure protection, Pacific Northwest has developed information visualization technologies (STARLIGHT and SPIRE) that accept volumes of text and presents them in a visual format that is natural for the human mind. Both are currently being used to analyze network transcripts and connection logs to help identify actual and potential cyber intrusions at over 100 DoD computer sites around the world. Discussions are currently under way to architect a similar program for the DOE complex.

The Information Security Resource Center (ISRC) was established at Pacific Northwest by the DOE Office of Safeguards and Security to provide technical assistance to DOE's security programs, security requirements, and security countermeasures. The ISRC is networked into the resources of the DOE national laboratories and other federal and industrial organizations to promote, develop, and support information assurance initiatives. The ISRC has continued to expand its resident subject matter expertise in information security,



STARLIGHT, an advanced three-dimensional visualization technology, has been developed by Pacific Northwest to help solve the problem of information overload. Already in use by the U.S. intelligence community, STARLIGHT can be applied to a variety of other fields, such as medical data analysis, environmental security, and current events monitoring.

power grids, and the national information infrastructure to keep pace with related technology innovations and evolving cyber threats to the nation's critical infrastructures.

The DOE Office of Safeguards and Security established the Information Assurance Outreach Program to provide the nation's energy industries with access to skills and expertise developed for the protection of information assets. This effort is consistent with the findings and recommendations of the President's Commission on Critical Infrastructure Protection and assists DOE with the discharge of its responsibilities mandated by Presidential Decision Directive 63.

Recently, Pacific Northwest established a Critical Infrastructure Protection and Analysis Laboratory (CIPAL) dedicated to information assurance/operations, critical infrastructure protection, and related research. The CIPAL contains a heterogeneous network for most major computational platforms, so that computer and network systems can be connected to the CIPAL for extensive vulnerability testing and the conduct of research for new network/computer protection tools. The scope of the research focuses on information and network technologies, vulnerability assessment, evaluation of hacking tools, and computer forensic activities.

Over the past several years, Pacific Northwest has pioneered the development of microwave and millimeter-wave holographic surveillance systems for transportation security. This was in response to a need by the Federal Aviation Administration, airports, commercial airlines, and the traveling public for a personnel surveillance system capable of detecting concealed weapons fabricated from plastic and ceramic and explosives made out of liquid and plastic.

Maintaining the Nuclear Deterrent

Weapons Initiation

Pacific Northwest will continue to support the DOE Office of Defense Programs in areas where our technical capabilities uniquely contribute to accomplishing their mission strategy. Specifically, Pacific Northwest capabilities contribute to maintaining the nation's tritium stockpile, as well as safely disposing of excess weapons material.

Pacific Northwest has played, and will continue to play, a significant role in the DOE plans to produce tritium for the weapons' stockpile by irradiation of tritium-producing burnable absorber rods (TPBARs) in commercial light water reactors. This technology is based on designs and fabrication processes developed by Pacific Northwest.

In support of the Secretary of Energy's selection of the commercial light water reactor option as the preferred approach for meeting the nation's tritium stockpile requirements, Pacific Northwest will develop a reactor-specific design of the TPBAR for the first tritium production mission; provide technical support to DOE for the competitive procurement of a commercial TPBAR fabricator; transfer the technology needed to design and fabricate TPBARs to the commercial fabricator; develop tritium extraction processes; and continue to research and evaluate methods and materials to improve the effectiveness and reduce the cost of TPBAR components.

Other areas of support to the weapons thrust include 1) assisting Defense Programs in interpreting safeguards and security policies and identifying cost-effective implementation procedures, 2) consultation to DOE weapons laboratories, 3) technical expertise to support DOE environmental compliance on defense missions, and 4) support to DOE in the safe disposal of excess weapons-grade plutonium.

Major Research and Development Thrusts

To develop and expand our role in the National Security mission area, Pacific Northwest is leveraging its research and development in four distinct comprehensive technology thrusts:

- **Detection and Analysis of WMD**—Developing new fundamental methods and instrumentation for detecting, identifying, and characterizing nuclear, chemical, and biological agents.
- **Policy Support and Analysis**—Providing technical analysis and assistance for treaty negotiation and verification protocols, and integrating technical data from multiple resources to support national and international WMD and security policy.
- **Information Technologies**—Applying innovative information analysis tools to strengthen data collection and analysis, uniquely visualize data, and support information assurance.
- **Nuclear Science and Technology**—Bringing basic nuclear science to new detection methods, nuclear forensics, tagging and tracking, materials security, and tritium generation.

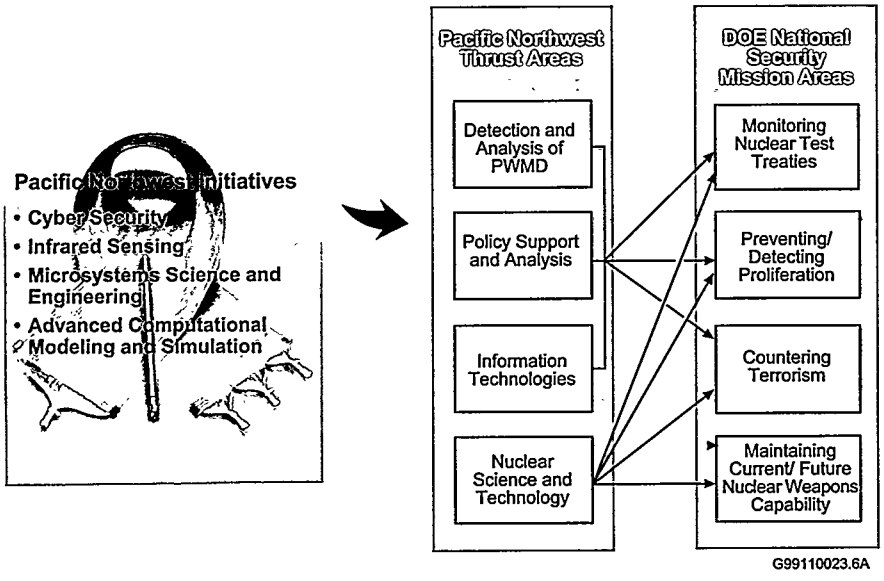
Capability Development: Role of Laboratory Initiatives

In addition to the four major technical thrusts, our Cyber Security and Infrared Sensing initiatives are central to building capabilities required to carry out our National Security mission. Several of our initiatives described in the previous section are also building capabilities that will be applied in the National Security mission.

- Microsystems Science and Engineering initiative is creating energy-efficient, portable power generators and heat exchangers applicable to man-portable protection systems, remote instruments, and distributed power sources.
- Advanced Computational Modeling and Simulation initiative is developing advanced methods of analyzing data applicable to interpreting satellite information, forensics tools, and critical infrastructure protection.

These technology thrust areas and initiatives are related to the research and development portfolio, as shown in the figure.

Major Research and Development Thrusts



Major National Security research and development thrusts.

National Security Program Roles

DOE Office	Pacific Northwest Role
Office of Nonproliferation and National Security	
Office of Research and Development (20)	Pacific Northwest supports the Office of Research and Development in nuclear, chemical, and biological nonproliferation research and development for treaty negotiation, development, and verification in the areas of on-site systems, regional monitoring, remote sensing, and advanced systems.
Office of International Nuclear Safety and Cooperation (30)	Pacific Northwest serves as the overall integrating contractor for the Office of International Nuclear Safety and Cooperation, and provides assistance in Soviet-designed reactor safety, Chornobyl bilateral assistance initiatives, action to cease production of plutonium in Russian production reactors (the Core Conversion Project), fuel technology transfer to Ukraine, and related nuclear safety and security activities in the former Soviet Union as well as Central and Eastern Europe.
Office of Arms Control and Nonproliferation (40)	Pacific Northwest supports the Office of Arms Control and Nonproliferation in several major areas, the core of which is in the area of nuclear weapons of mass destruction. Activities related to delivery system proliferation prevention and arms control, conventional weapons arms control, international treaty negotiations and implementation, and other regional security issues support this core area. Other key areas of support to NN-40 include international safeguards, treaty negotiations and implementation activities, Initiatives for Proliferation Prevention, Nuclear Cities Initiatives, export control, isotope separations and analysis, and conventional weapons arms control and humanitarian activities.
Office of International Material Protection and Emergency Cooperation (50)	Pacific Northwest supports the Office of International Material Protection under the Materials Protection, Control & Accountability Program (MPC&A). This program is responsible for assisting the Russian government and its nuclear facilities in the protection, control, and accounting of weapons-usable nuclear material. Activities are in the areas of physical protection and material control/accounting system upgrades as well as development of the Russian infrastructure (regulations, training, etc.) to provide long-term sustainability for such upgrades.
Office of Security and Emergency Operations	Pacific Northwest supports the Office of Security and Emergency Operations through the development and deployment of technical tools to assist in the collection and assessment of incident and threat data.
Office of Intelligence	Pacific Northwest directly supports the DOE Office of Intelligence. We perform intelligence analysis and computational modeling that addresses national issues in nuclear weapons materials production, nonproliferation of WMD, nuclear energy resources, environmental security, and other tasks as appropriate. Additionally, in cooperation with Office of Intelligence, we perform intelligence-related work for other government organizations on these and additional proliferation issues concerning WMD, including chemical and biological weapons, and means of delivery. Pacific Northwest has also grown its support to the DOE-IN Special Technologies Program by drawing on various areas of scientific and engineering expertise in Pacific Northwest to provide specialized technology products for DOE and its intelligence community customers.
Office of Counterintelligence	Pacific Northwest supports the DOE Office of Counterintelligence by enhancing counter-intelligence capabilities through development of relevant technologies that will assist in ongoing local and national efforts to prevent, identify, and neutralize adversarial efforts targeted against Pacific Northwest, DOE, and the entire Intelligence Community to gain unauthorized access to classified and sensitive information and technologies.
Office of Defense Programs	Pacific Northwest supports the Office of Defense Programs through safeguards and security activities; developing new technologies for long-term stabilization of plutonium; continuation of the Tritium Target Qualification Program, including additional target development, manufacturing, and privatization; consultations with DOE weapons laboratories; and providing technical expertise to support DOE efforts in environmental compliance, safety, and health issues on defense missions.

6

Operations/Infrastructure Strategic Plan

In this section, the key elements of our supporting operations and infrastructure are discussed, including how they support our overall strategy and the most critical issues affecting each. Some of the key issues include our need to aggressively recruit, a requirement for greater emphasis on safeguards and security, the need to consolidate secure space and address other critical facilities issues, the need to continuously upgrade our information technology infrastructure, and our ongoing commitment to local economic development.

Human Resources

Pacific Northwest National Laboratory's Human Resources strategy is designed to support and enable the achievement of the missions that provide high-value products to DOE and other customers, as well as to support the achievement of Pacific Northwest's critical outcomes. This includes the continued improvement of human resource management processes and operations to better and more effectively serve the needs of the Laboratory, as well as the stewardship of governmental resources.

The Human Resources Directorate supports these strategies by developing and implementing programs, policies, and processes to enable Pacific Northwest to hire, develop, and reward a highly qualified and diverse staff within the guidelines of federal and local

Equal Employment Opportunity
(CY 1999)

Occupational Codes	Total		Minority Total		White		Black		Hispanic		Native Americans		Asian/Pacific Islanders	
Gender	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Official/ Manager	475 (82.6)	100 (17.4)	23 (4)	3 (.5)	452 (78.6)	97 (16.9)	3 (.6)	1 (1)	13 (2.7)	2 (2)	4 (.8)	0 (0)	3 (.6)	0 (0)
Professional	1358 (68.5)	624 (31.5)	111 (5.6)	52 (2.6)	1247 (62.9)	572 (28.9)	9 (.6)	4 (6.4)	28 (2)	14 (2.2)	10 (.73)	4 (.6)	64 (4.7)	30 (4.8)
Technicians	104 (63)	61 (37)	11 (6.7)	4 (2.4)	93 (56.4)	57 (34.5)	2 (1.9)	1 (1.6)	5 (4.8)	2 (3.3)	3 (2.9)	0 (0)	1 (.9)	1 (1.6)
Clerical	19 (3.6)	511 (96.4)	0 (0)	54 (10.2)	19 (3.6)	457 (86.2)	0 (0)	16 (3.1)	0 (0)	26 (5)	0 (0)	5 (.9)	0 (0)	7 (1.3)
Craftsmen/ Laborers	149 (92.5)	12 (7.5)	17 (10.6)	4 (2.5)	132 (82)	8 (4.9)	4 (2.7)	0 (0)	12 (8)	4 (33.4)	1 (.7)	0 (0)	0 (0)	0 (0)
Service Workers/ Apprentices	24 (48)	26 (52)	2 (4)	1 (2)	22 (44)	25 (50)	1 (4.2)	0 (0)	0 (0)	1 (3.8)	1 (4.2)	0 (0)	0 (0)	0 (0)
Trainees	0 (0)	19 (100)	0 (0)	3 (15.8)	0 (0)	16 (84.2)	0 (0)	1 (5.3)	0 (0)	2 (10.5)	0 (0)	0 (0)	0 (0)	0 (1.6)
Totals	2129	1353	164	121	1965	1232	19	23	58	51	19	9	68	38

Numbers in parenthesis () are %.

Laboratory Staff Composition

Full and Part-Time Employees	Total #	(%)	PhD	MS/ MA	BS/ BA	Other
Professional Staff						
Scientists	390	(11.3)	68	162	155	5
Engineers	822	(23.8)	374	233	207	8
Management and Administrative	1339	(38.8)	167	306	508	377
Support Staff						
Technicians	163	(4.7)	0	1	17	145
All Other	736	(21.3)	0	1	50	685

(a) Data as of October 1999.

laws and normal business practices. The delivery of these strategies and support is achieved through a decentralized, distributed Human Resource Manager network with assistance from Human Resource core services—compensation/benefits/Human Resources Information System, staffing programs, labor relations, leadership and staff development. The Directorate also provides consultation and advice to management in leading and managing Pacific Northwest's human assets as well as acting as an advocate for all staff in representing their needs and interests in the quality of work life at the laboratory. In these endeavors, the Directorate sponsors a Supportive Work Environment Advisory Board and conducts periodic quality of work life surveys.

In support of Pacific Northwest's various R&D missions, the human resources strategy over the short and long term will emphasize the recruitment and development of key personnel. The recruitment needs of the divisions and directorates will be addressed and supported through 1) assigning specialized human resources recruiters, 2) recruiting referral bonus programs, and 3) increasing our use of Internet recruiting tools. All recruitment will continue to include emphasis on the hiring of minorities and females.

To fully develop existing human resources, we initiated a Leadership and Staff Development Program in 1999, which includes key components to develop leadership and staff capabilities: 1) management/leadership succession planning, and 2) development of core management skills and competency enhancement through formal training and developmental/rotational assignments. In 2000, we have created a Leadership and Staff Development Department to further and expand the successful early results of the initiative. The results of the recruitment and staff development programs will be monitored through our own self-assessment program and the regular quality of work life survey of all staff.

Environment, Safety, and Health Management

The Environment, Safety, and Health (ES&H) Directorate is responsible for six management systems: Environmental Management Services, Facility Safety, Integrated ES&H, Radiological Control, Training and Qualification, and Worker Safety and Health. Our goal is to provide the highest-quality, most cost-effective products and services in support of Pacific Northwest's mission to fully satisfy our customers. Our Integrated ES&H Management System (IESHMS) highlights the linkages with other supporting management systems and their contributions to the overall ES&H program.

Much of the ES&H organization is funded directly from staff using ES&H services. ES&H is responsible for understanding the customer demand for those services and for managing their resources in line with that demand. We provide our project managers and line organizations with the maximum possible control over their costs while ensuring that operations are carried out in a safe manner.

ES&H Directorate Vision, Mission, Goals, and Objectives

The ES&H Directorate's vision is for Pacific Northwest to be the benchmark standard for a research and development laboratory in ES&H management. The Directorate will provide innovative services and systems that enable and support ES&H excellence in laboratory operations.

The mission of the ES&H Directorate is to provide our principal products and services, management systems, ES&H technical support services, and environmental management operations. We enable Pacific Northwest's work to be conducted in a safe, efficient, and environmentally sound manner that supports compliance.

To realize the vision and support the mission, the ES&H Directorate has developed four strategic objectives. These strategic objectives will be used to guide future planning for management systems within the Directorate and outline the strategy to support the achievement of operational excellence at Pacific Northwest in ES&H. The objectives, as outlined in our ES&H strategic plan, are

- management systems fully developed and deployed
- optimization of ES&H staff involvement, ownership, and development
- optimization of ES&H customer satisfaction
- excellence in management of Pacific Northwest's ES&H resources.

Strategies to achieve the objectives will be developed and used to guide future planning for management systems within the Directorate and enable achievement of operational excellence in ES&H at Pacific Northwest.

Current Laboratory ES&H Conditions

Compliance with ES&H requirements, incorporated into our operating contract with DOE,[a] is achieved through implementation of established management systems. Major initiatives conducted over the past several years have established a firm operating basis for ES&H and Conduct of Operations as confirmed by the Excellent rating in the Operational Excellence Critical Outcome, supporting the overall rating of Outstanding in the FY 1998 DOE-RL evaluation of Pacific Northwest. Pacific Northwest is now focusing on refining processes and enhancing self-assessments to ensure line management's ability to sustain long-term ES&H excellence.

The strategic focus for Pacific Northwest in the area of ES&H is similar to that of the ES&H Directorate, where the goals are to fully develop and deploy management systems and support tools and to optimize staff involvement, ownership, and development of ES&H activities.

Issues and Strategies to Ensure Compliance with ES&H Requirements

The following are strategies on how we manage continuous improvement in management systems that impact ES&H activities.

- The IESHMS has developed an internal project management plan to identify, track, and address weaknesses in all management systems contributing to the Integrated ES&H Program. The highest priorities or areas needing significant improvement addressed under the project plan are chemical management, project management, and hazards assessment.

(a) DE-AC06-76RLO 1830 Modification M255, Clause I-64, entitled *Integration of Environment, Safety, and Health Into Work Planning and Execution (June 1997).*

In addition, for those issues identified in the validation of the Integrated ES&H Program and areas of weakness identified in the FY 1999 EH-2 Follow-up Assessment, corrective actions are being tracked and closed out within the Assessment Tracking System and are included in the project plan.

- The IESHMS is working with Integrated Assessment to create measures of maturity in the development and deployment of supporting management systems. The Integrated ES&H Program has the responsibility to evaluate continuous improvement in the IESH program annually. As new crosscutting issues are identified in the measurement of IESHMS maturity, they will be evaluated and added to the continuous improvement plan. The continued incorporation of performance-based measures into the contract, coupled with aggressive self-assessment and independent oversight is also critical to the strategy.
- Continue the rollout of the Integrated Operations (IOPS) concept and tools (e.g., upgrading SDTP). The IOPS tools include the capability for providing hazard identification and communication (including radiological hazards), identification and tracking of training requirements related to hazards, hazard mitigation through self-assessment, detailed work practices, and user access authorization and control. Perhaps its most important feature is the empowerment of a cognizant space manager for each laboratory to provide a more positive work control and evaluation process.
- The development of a Hazard Analysis Program description along with improvements in the electronic prep and risk tool. As these improvements are fielded, the assessment of hazards at a project level will be translated to bench-top hazards mitigation.
- IESHMS and Requirements Management have developed a requirements integration and tailoring (RIT) process to identify an appropriately tailored set of requirements that are current, accurate, and relevant. The process is needed because over 30 percent of the requirements listed in Appendix D of the Pacific Northwest contract are either archived directives or are based on archived directives. Additionally, the current contract calls for a DOE-approved process for requirements tailoring. An implementation plan for the application of the RIT process has been developed, and the outcome of the plan will be the removal of archived and/or non-applicable directives from the contract by replacing them with a current, appropriate requirements set. The RIT process will be applied beginning in early FY 2000 and continue on an "as needed" basis as work scope and requirements evolve.

Non-R&D Activities at Pacific Northwest Funded by the Office of Environmental Management

DOE-EM is funding several activities of vital importance to ES&H at Pacific Northwest. The most significant operations-related activities include

- Miscellaneous building surveillance and maintenance configuration management activities to maintain the safety envelopes for radioactive materials and radiation areas within the Radiochemical Processing Laboratory (RPL) Building and several 300 Area laboratory buildings. This includes preparing as-built drawings to show the current configuration of the facility. Safety systems and utilities in the RPL Building have been assigned priorities so that the highest-risk areas are first to have as-built drawings prepared.
- The Waste Operations and Management (current generation) activity provides the infrastructure (assay, analysis, acceptance, handling, storage, packaging, and shipment) needed to dispose of newly generated wastes to comply with environmental requirements. This includes effluent monitoring, which provides radiological air emissions sampling and monitoring of Pacific Northwest facility emission points to meet requirements and standards.

Potential Issues, Actions, or Funding Problems that Could Adversely Affect Other Missions

Strategic Issues

The first issue involves the transfer of funding for currently generated waste management from the Office of Environmental Management to the Office of Science (SC). For FY 2001, the funding to be transferred consists of $1.2M, which is being transferred to dispose of user/project-generated wastes.

Pacific Northwest has implemented a cost system whereby users of services pay directly for those services. Specific successes include our space-charging system, radiological waste disposal cost allocation to generators, and ES&H Field Service Representatives deployment. The success of these programs is based on matching services with the user requirements and, to the maximum extent possible and practicable, placement of accountability/control of the service with the user. This approach has reduced costs and maximized service provided in these programs. In an effort to continue such successes, Environmental Management Services is reengineering the types and cost allocations of its services and developing appropriate systems for assigning costs in a manner that places accountability/control at the most appropriate level to drive effective and efficient waste management. This reengineering effort will address the EM proposed transfer of budget allocation.

The second issue involves the management and disposal of Pacific Northwest legacy waste and contamination. These legacy issues remain from past DOE technology support projects and cannot be appropriately managed without adequate funding. Our operations cannot be conducted efficiently as long as these legacy wastes remain because of the residual risks to on-site workers, the environment, and the public. Additional imposition could occur as a result of delayed compliance with Tri-Party Agreement (TPA) Milestone Series M-92, which specifically governs the schedule for removing legacy issues from the 300 Area. The radioactively contaminated legacy facilities that are excess to mission needs and the ground contamination sites assigned to Pacific Northwest cannot be maintained in a safe and compliant manner without adequate funding. This condition imposes additional safety and environmental risks as buildings continue to deteriorate or safety boundaries are breached by unauthorized intrusions. Resolution of the legacy facility issue is not likely until a formal agreement is reached between the various landlord programs regarding the responsibility for funding and final disposition of these facilities.

To address the issue noted above, Pacific Northwest has taken interim aggressive measures to retire surplus facilities and deal with their associated legacy waste in accordance with the Hanford Site cleanup mission through investment of available overhead, carryover, and program efficiency funding sources. In FY 1998, $1.4M was identified from cost savings from within the program and another $1.4M in FY 1997 carryover funding provided the resources needed to initiate the tasks to quantify, characterize, and initiate in limited situations the removal of legacy materials and to begin remediation of facilities or sites.

Emerging Issues

Pacific Northwest's self-assessment activities have identified a third ES&H Program issue. The improvement issue identified below appears to be within the ability of existing resources to address.

As Pacific Northwest continues to consolidate its laboratory structure, more and more lab transfers/cleanouts between buildings are expected. During lab transfers/cleanouts, the waste volumes managed by our waste system increased significantly, thus increasing the risk of failure.

Pacific Northwest's waste management organization is working with the research and development organizations and the facilities and operations staff to identify waste generation, management, and disposal options during the planning process of our projects. Two separate activities have been developed to ensure wastes are generated and managed to

minimize final waste disposal requirements. A pilot program is being tested that will identify the following for any wastes to be generated:

- regulatory status of the waste
- options to change constituents during research to decrease or eliminate regulatory status
- opportunities for treating the waste generated and eliminating or decreasing regulatory status prior to final disposal.

In conjunction with the above effort, Pacific Northwest's waste management organization is actively researching waste treatment possibilities to increase options for treating waste on-site and eliminating future costs and liabilities.

Safeguards and Security

Pacific Northwest puts science and technology to work to solve problems for its primary customer, the U.S. Department of Energy, as well as other government agencies, and private industrial customers. To support achieving the research missions, Pacific Northwest deploys effective, ongoing Safeguards and Security (SAS) programs that meet DOE requirements.

The Safeguards and Security program addresses five broad areas:

- physical security and protection operations
- safeguards and security program management
- information security
- nuclear material control and accountability
- personnel security.

These SAS program elements work together to ensure appropriate protection and control of assets while ensuring that Pacific Northwest remains appropriately open to visitors and technical collaboration and exchange.

The protection of special nuclear materials and classified matter are priorities for the SAS program. Protecting information, intellectual property, and physical property is a vital commitment in Pacific Northwest's institutional and operational philosophy. These commitments stem from a historical need to ensure that national security is not compromised and clients' commercial rights to information and property are not impaired or compromised. This commitment to responsible management continues to be reflected and implemented in day-to-day operations.

The successful protection of security interests requires effective protection strategies and procedures be continually developed, implemented, and maintained. The Safeguards and Security Management System develops and implements these strategies and procedures. The SAS program has been established to assist management in addressing identified threats and associated risks.

Under the direction provided through the Safeguards and Security Management System, an Integrated Safeguards and Security Management (ISASM) Program is being established with an expectation for near-term implementation. Similar to what has been successfully implemented for integrated safety management, this program is intended to integrate SAS requirements into the processes of planning and conducting work at Pacific Northwest. The fundamental premise for the ISASM is that through close attention to work, security measures, and substantial staff involvement, SAS incidents, infractions, and violations are preventable. This program ensures that all SAS program elements are working together effectively to provide a strong protective umbrella for the long-term business strategies.

The ISASM Program is designed to encompass six guiding principles and five core functions that were adopted and modified from the Integrated Environment, Safety and Health Program.

Defense against loss, theft, sabotage, and espionage are essential considerations and are consistent with the following SAS program priorities:

- physical protection, control, and accountability for nuclear and special nuclear materials
- protection of classified matter
- protection of physical and intellectual property (which includes operating facilities, sensitive information, sensitive property, and equipment)
- ensure the SAS performance objectives and supporting milestones agreed upon by Safeguards and Security Services, Pacific Northwest management, and DOE are conducted in a cost-effective manner as required alignment of SAS processes in support of our critical outcomes and expanding business areas.

Physical Security and Protection Operations

Physical security measures are designed and intended to provide increasing levels of protection to facilities and property inward from the facility/area perimeter, as required by the nature of the material and work involved. Physical security measures are applied in a graded manner dependent on the value of the asset and/or the consequences of its loss or misuse. Asset Protection Agreements (APAs) are developed to document the identification of the security interest activities and associated protection measures by facility location. APAs are established on a graded fashion and take into account the nature of the security interest, protection requirements identified in appropriate directives, threat potentials and countermeasures, and assign a defense or safeguards priority position based on a composite evaluation of these factors.

Physical security also involves minimizing the risk to security interests by developing ways to minimize the number of facilities/locations in which classified or sensitive work, or work involving special nuclear materials, is conducted. These alternatives take into account facility suitability and constraints as well as programmatic requirements and compatibility with other activities.

Safeguards and Security Program Management

The total security environment is regularly reviewed through SAS Program Management to ensure that protective measures are properly deployed and remain effective. Protection program planning considerations are examined and weighed in conjunction with levels of management support, staff awareness, status of physical and administrative control systems, financial support and constraints, number and proficiency of SAS resources and facilities, and operational requirements. Laboratory operations, including classified and sensitive work, or work involving special nuclear materials, are reviewed to determine if options exist for reducing vulnerabilities and risk exposures, and for economizing facility and security system costs or by initiating or strengthening administration processes and systems.

Information Security

Information security measures are designed and intended to address the protection and control of classified and sensitive information. Information security also ensures that individuals effectively protect classified information and sensitive unclassified information to which they have access or custody.

The Information Security Program includes the following programs

- Operations Security (OPSEC)
- Classified Matter Protection and Control (CMPC) - including Security of Foreign Intelligence Information (FII), Sensitive Compartmented Information (SCI), and Special Access Programs (SAP)
- Classified Information Systems Security (ISS)
- Communications Security (COMSEC), Emissions Security (TEMPEST), and Technical Surveillance Countermeasures (TSCM)
- Protection of Unclassified Controlled Nuclear Information (UCNI), Official Use Only (OUO), Naval Nuclear Propulsion Information, and other sensitive information.

The Information Security Program establishes a protection system that requires higher degrees of protection for each higher classification level (Confidential, Secret, Top Secret). It is intended to ensure that classified and sensitive information is not released to the public until it has been reviewed for applicable release restrictions. A rigorous OPSEC program also is in place to assist management in the identification of threats and mitigation measures. OPSEC activities at Pacific Northwest directly relate to and support Counterintelligence Program initiatives. The Counterintelligence Program is administered through the National Security Directorate and is described in more detail in the Programmatic Strategy Section, National Security.

Nuclear Material Control and Accountability

A Safeguards program is in place to ensure the physical protection and accountability of all nuclear materials. The nuclear material movements and measurement control activity ensures the effectiveness of the measurement systems and the ability to obtain precise and accurate values for use. Nuclear materials accounting is used to maintain accurate records of Pacific Northwest's nuclear material inventories. Nuclear materials safeguards develops, administers, documents, and maintains program plans and procedures (including emergency plans and response) involving the protection and control of nuclear materials. To support programmatic requirements and provide for cost-effective operations, nuclear materials management ensures planning for future nuclear material needs, making the best possible use of current inventories, tracking and reporting usage, coordinating the disposition of excess materials, and managing day-to-day activities that affect the availability of nuclear material inventories.

Personnel Security

A Personnel Security Program has been implemented to ensure that individuals are processed for, granted, and retain a DOE access authorization (clearance) only when their official duties require such access. The program also ensures individuals are allowed access to DOE classified matter and special nuclear materials only when it has been determined that such access will not endanger the common defense and security and is clearly consistent with the national interest. The program was implemented to maintain the numbers and types of clearances at the minimum levels necessary to ensure the operational efficiency of DOE classified and special nuclear materials programs and operations; to periodically evaluate individuals retaining clearances to confirm their continued need-for-access and access authorization eligibility; and to promote proactive participation in personnel security activities at the international, national, and interagency levels to ensure the adequate expression and consideration of DOE mission and program interests.

Visitor control is provided through personnel security by developing and enforcing procedures for processing visits to and from Pacific Northwest to ensure that only officially authorized visitors are permitted access to classified or sensitive information, materials, or areas. Incoming visits of U.S. citizens and foreign national visits and assignments are coordinated, processed, and tracked, as well as outgoing visits of staff to other locations.

To complement visitor control activities, a Foreign National Activities Coordination function has been implemented to provide a review process that ensures Foreign National Visit and Assignment activities (including hiring) are coordinated and reviewed from an integrated perspective to determine the overall need and associated benefit.

Site and Facilities Management

Description of Laboratory Site and Facilities

Pacific Northwest National Laboratory comprises a collection of buildings containing 201,000 square meters (2,161,000 square feet). These facility holdings include those owned by DOE as well as those owned by Battelle and leased from others. The distribution is shown in the Laboratory Space Distribution Table. Through formal arrangement with DOE, these facilities make up the Consolidated Laboratory and are used by over 3,400 employees to perform work for DOE, other federal agencies, and private industry.

FY 1999 Laboratory Space Distribution

Location	Area Square Feet (Million)	Area Square Meters (Million)
DOE Main Site (300 Area)	1.042	0.097
DOE Leased	0.108	0.010
Battelle Main Site (RCHN)	0.485	0.045
Battelle Sequim	0.045	0.004
Battelle Leased	0.481	0.045
Total	2.161	0.201

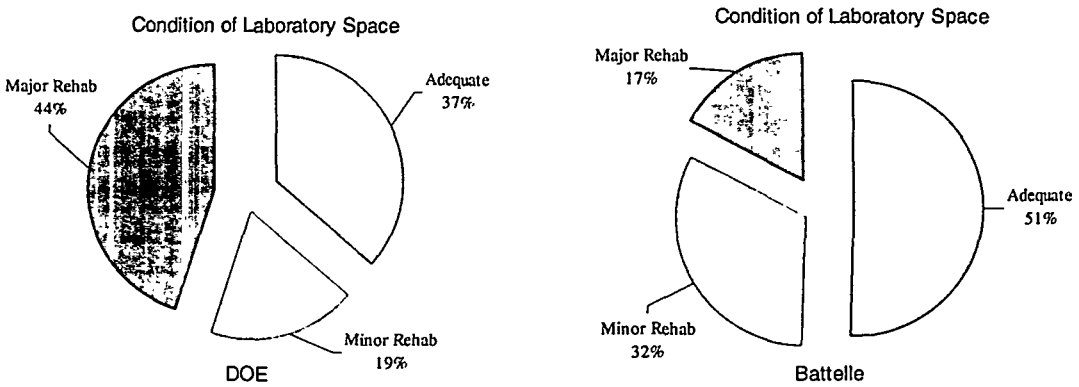
Most DOE-owned facilities are located in the south end of the Hanford Site's 300 Area. The 300 Area occupies approximately 4 square kilometers (1.5 square miles or 960 acres) in the southeastern portion of the Hanford Site, along the west bank of the Columbia River. DOE-leased facilities are located south of the 300 Area and are adjacent to the Battelle privately owned/leased facilities. The Battelle private complex occupies approximately 1.2 square kilometers (0.50 square miles or 300 acres). The other Battelle-owned facilities are located at the Marine Sciences Laboratory in Sequim, in northwestern Washington State.

Pacific Northwest is an occupant of the 300 Area and interfaces with the Project Hanford Management Contractor (PHMC) to obtain all utilities and site infrastructure services. These services are operated, maintained, and upgraded by the PHMC. Operational and maintenance costs of the system are distributed to the 300 Area occupants. The PHMC receives capital investments to upgrade the 300 Area systems.

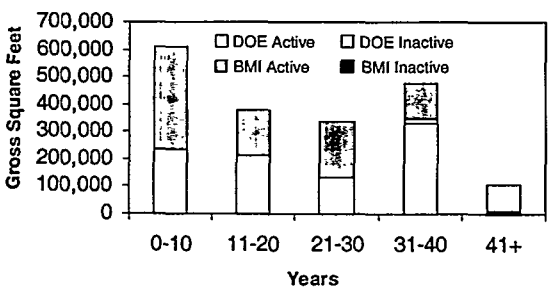
The Office of Biological and Environmental Research (OBER) has landlord responsibility for most of the DOE-owned facilities and equipment. However, because of the dual role that Pacific Northwest serves at the Hanford Site, the PHMC Landlord Program, under the Assistant Secretary for Environmental Management, is responsible for the general-purpose facilities and equipment primarily supporting the Hanford Site mission activities.

Pacific Northwest laboratories are predominantly used for chemistry, materials development, environmental and biological research, computation, electrical/electronics, and applied physics (nuclear and non-nuclear). The remaining space includes administrative, service, storage, and other. The figure illustrates that the general condition of all active DOE spaces is 37 percent adequate, 19 percent minor rehabilitation required, and 44 percent requiring major rehabilitation modifications. The general condition of the Battelle space is 51 percent adequate, 32 percent minor rehabilitation required, and 17 percent major rehabilitation required.

The laboratory age distribution (see the figure) illustrates that 52 percent of the laboratory active DOE-owned facilities and 38 percent of active Battelle-owned are over 20 years old. The average age of the active DOE-owned buildings is 32 years and the average age of the active Battelle-owned buildings is 19 years. The William R. Wiley Environmental Molecular



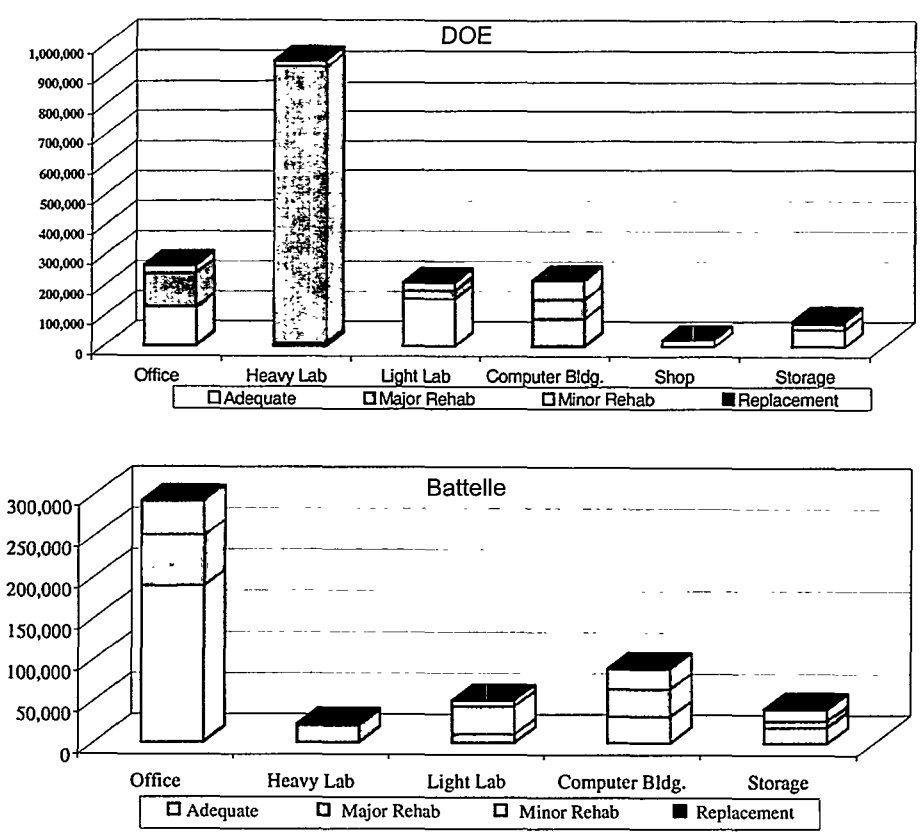
Condition of laboratory space.



Age of laboratory buildings (years).

Sciences Laboratory (EMSL) is the one new DOE-owned facility in our portfolio and the newest Office of Science user facility in the DOE system. Use and condition of space is displayed in the figure.

The facilities replacement value table summarizes Pacific Northwest's active facilities. The 1999 data for the DOE-owned buildings is derived from the Richland Property System, a site-wide computerized inventory of DOE's property holdings. The 1999 data for the Battelle-owned buildings comes from the Arkwright Mutual Insurance Company. The replacement value of $364M for active



Use and condition of laboratory space.

DOE building structures and $87M for the Battelle structures accounts for an extensive array of research, engineering, and computational laboratories and equipment operated by Pacific Northwest.

Facility Replacement Value

Active Facility	Replacement in Current $M
DOE Total	364
Battelle Total	87

Laboratory Site and Facilities Trends

The facility management strategy at Pacific Northwest is to be the highest-quality customer-focused provider of facilities and operating services. A key element of this strategy is deploying a flexible and scalable infrastructure to meet the growing and diverse needs for research facilities and equipment. Through the strategic planning process, annual building work plans, and management of core and purchased services, Pacific Northwest provides facilities that enable the research staff to develop and deploy science and technology to the government, academic institutions, and the marketplace. Over the past 5 years, Pacific Northwest has vacated or removed 70 facilities and is managing 26 vacant, surplus DOE-owned buildings in "cheap to keep" status awaiting disposition. This trend will continue over the next 3 years, when the remaining 5 surplus facilities will be vacated.

Pacific Northwest's philosophy has been to remove older, high maintenance, contaminated, and temporary facilities. This has been an effective means to reduce cost while maintaining newer, more efficient facilities. The largest investment required for facilities is the Operating and Maintenance (O&M) cost. Reducing these costs while maintaining an efficient and safe working environment continues to be an area of focus. Pacific Northwest's investment in this area has continually reduced the operating cost and maintained safe and compliant facilities over the past 5 years. The ratio on replacement plant value versus O&M cost has been maintained at 1.8 percent from FY 1995 to the present. During this 5-year period, the replacement plant value has been reduced significantly with vacating and removing over 70 buildings. Pacific Northwest foresees this trend to increase until the percentage reaches 3.

Pacific Northwest anticipates the need for additional computer modeling laboratory space. The current trend identifies the need in FY 2001 and continuing through FY 2003. Pacific Northwest is assessing the most appropriate option to fulfill the strategic space need.

Facilities Plans and Options

Pacific Northwest aspires to be the world's premier environmental science and technology laboratory. This aspiration cannot be achieved without cutting-edge facilities that are operated and managed through a set of integrated environmental, safety, health, and infrastructure (ESH&I) systems. Pacific Northwest optimizes DOE-owned facilities through the use of an ES&H and mission-driven, risk-based prioritization system. This system ensures the highest return for the DOE customer by having facility capabilities available at the right time, maintaining a safe, reliable working environment, and preventing damage to the surrounding environment. Pacific Northwest's stewardship of DOE facilities demonstrates the principles of Life Cycle Asset Management. The laboratory is in the final stages of the facility consolidation efforts that started in 1995, maximizing investments to strategic facilities only. The strategic facilities include the EMSL and the 320, 325, 326, 329, 331, 337, 338, and 3760 Buildings.

Pacific Northwest's facility strategy supports the laboratory mission to solve DOE's and the nation's most significant environmental research problems.

Pacific Northwest faces a challenging and changing facilities environment as it enters the 21st century. There is the rapid pace of technology development and deployment and emerging research opportunities. Facility capability to accommodate a larger and higher-impact energy business is expected. Additional computational space is needed in the near term. As the Environmental Health initiative develops, a new facility is also envisioned.

Consolidation of national security research activities and the resulting impact on facility requirements is being evaluated. Long-term strategies for facility consolidation, renovation, and disposition as well as utility and other infrastructure delivery mechanisms for 300 Area support to Pacific Northwest are being determined. Integration of these elements, implementation strategy development, and follow-on actions are important priorities for the next several years.

Determining the appropriate future level of maintenance and operation for the 300 Area buildings and utility services is one of the laboratories highest facility-related priorities. PHMC and Johnson Controls, Inc. provide utility services to DOE-owned facilities. Pacific Northwest embarked on the Operational Improvement Initiative to improve services while becoming more efficient. This initiative proved fruitful in enabling the O&M budgets to remain constant while improving the quality of services. Over the past 2 years, Pacific Northwest has invested in a benchmarking effort with industry. This investment assisted in the reduction of the O&M costs of $3M while maintaining safe and compliant facilities. Our objective is to continue making improvements in the level of service while meeting the science and technology requirements. This will require process improvements to continue the trend of maintaining constant O&M investment without compromising safe and reliable facilities. Pacific Northwest continues to work with DOE-RL and the Site Integrated Group to ensure the laboratory's requirements are supported beyond the end of the Hanford project.

Facility Resource Requirements

The laboratory capital facility requirements are summarized in the Major Construction Project Table and the Pacific Northwest ESH&I 5-year plan. The project funding profiles are developed establishing a balance between high-priority ESH&I projects, science and technology needs, and other DOE and congressional priorities. DOE's Capital Asset Management Process is used to rank projects. The highest-priority projects are recommended to and approved by upper management through the annual Pacific Northwest Facility Strategic Plan.

An aggressive facility consolidation program has minimized the impact of decreasing capital investment in Pacific Northwest infrastructure. Even so, the historical trend of capital investments identifies that with less than a $5M annual investment, the backlog continues to increase. An annual funding profile of $2M in general plant projects will likely turn deferred infrastructure projects into higher cost, great risk problems from operations and safety concerns. The continued pressure to reduce budgets complex-wide while facilities and infrastructure age complicates the situation. Pacific Northwest continues to investigate alternative means to invest in the critical facilities. The Energy Savings Performance Contract (ESPC) is one such mechanism that Pacific Northwest has used successfully. Creative investment strategies will continue to be alternative methods to offset the reducing capital investment while maintaining facilities to meet the Science mission.

320 Building Rehabilitation and Reconfiguration (02-E-XXX)

This project was submitted as a FY 2001 project with a total estimated construction cost of $7.8M. The original need was identified and submitted as a line item in FY 1996. The 320 Building has and continues to be one of the core facilities of Pacific Northwest. The research in the 320 Building focuses on analysis of low-level, ultra-trace radionuclear and chemical materials using optical and mass spectrometric equipment and procedures. The building's continuing aging systems have deteriorated to a point where they are in jeopardy of not meeting the mission requirements. This deteriorated condition was confirmed by an independent condition assessment inspection based on the life cycle, life expectancy of the building components. This project scope is designed to replace building piping systems, roofing, and major HVAC components. Interior modifications will address life safety code concerns, inefficient HVAC capacities and controls, and update the building to stay consistent with the American Disabilities Act access and use. The building rehabilitation is complicated by the presence of clean laboratories, whose operation is impacted by the change in building air quality.

Major Construction Projects
(Budget Authorization $ in Millions)

	Total Est. Const. Cost	Fiscal Year 1998	1999	2000	2001	2002	2003	2004
FUNDED CONSTRUCTION								
General Plant Projects								
General Plant Projects (KP)[a]		3.1	3.1					
General Plant Projects EM 60 (EW)			0.3					
General Plant Projects EM								
Multiprogram Energy Laboratories-Facility Support Program Projects (KG)								
Total Funded Construction		**3.1**	**3.4**					
BUDGET CONSTRUCTION								
General Plant Projects								
General Plant Projects (KP)			3.4	2.6				
General Plant Project EM 60			0.3	0.9				
Total Budgeted Construction			**3.7**	**3.5**				
PROPOSED CONSTRUCTION								
General Plant Projects								
General Plant Projects (KP)				0.7	5.0	5.0	5.0	5.0
General Plant Projects EM 60					1.0	1.0	1.0	1.0
Multiprogram Energy Laboratories-Facilities Support Program Project (KG)								
Laboratory Systems Upgrade	9.0					1.5	4.5	3.0
Total Proposed Construction				**0.7**	**6.0**	**7.5**	**10.5**	**9.0**
Total Construction		**3.1**	**7.1**	**4.2**	**6.0**	**7.5**	**10.5**	**9.0**

(a) Budget codes are identified in parentheses.

During the FY 2001 validation in December 1998, the SC-82 landlord endorsed the assessment presented on the aging condition of the facility, but was concerned with the low priority the project would receive compared to the other Multi-Program Laboratory Line Items submitted. This caused Pacific Northwest to develop alternate investment strategies to meet the needs of the building rehabilitation. Pacific Northwest is aggressively pursuing joint funding scenarios with direct involvement with SC-82, SC-74, and direct program support to meet the investments required for the 320 Building.

Assets Management, Space Management, Inactive Surplus Facilities Plan

In 1995, Pacific Northwest reviewed its facility holdings and determined that approximately one-half of the facilities were candidates to be vacated over the next 5 years. Subsequent to this review, actions were taken to consolidate operations for full use of the strategic facilities and closure of nonstrategic, uneconomical, or underused facilities.

The facility transition team was established to manage the reconfiguration of space and the relocation of staff and equipment. They ensured that each facility transition was accomplished safely, efficiently, and in compliance with all applicable requirements. The team's current responsibility is to expedite the final disposition of the excess facilities and ensure that the facilities are appropriately surveyed and maintained until disposition actions are complete. Seventy facilities have been physically removed or transferred to another operator. Two concerns related to the progress of transitioning facilities are 1) cost of the disposition and 2) the final agreement on DOE landlord responsibilities for the contaminated surplus facilities. The following table summarizes the status of the facility transition effort.

Of the 26 inactive surplus facilities, 9 are known to be radiologically contaminated. The majority of contamination in surplus facilities is the result of defense activities related to

fuel processing and production prior to 1971. The estimated annual surveillance and maintenance budget for the surplus facilities is $90,000 but is expected to increase greatly in the near term because of roof replacements. The cost of final disposition of these facilities is included in the site's EM cleanup baseline. Alternatives to demolition are being sought for surplus facilities in good condition. This includes leasing them to private entities.

Facility Action	Number of Facilities
Removed or transferred	70
Now in standby	26
Additional facilities to be vacated	5
Total facilities to be vacated by 2002	**101**

Energy Management

The primary goal of Pacific Northwest's Energy Management Program is to reduce energy and utility costs. With the sharp decline in DOE funding for energy conservation projects, the program's key strategy has been to obtain alternative financing from other than DOE. To date, projects have obtained $11M in capital and achieved $2.6M in annual savings. In FY 1999, savings exceeded contract payments for a net savings of $1.1M. The three largest projects are

- a project with the City of Richland and Bonneville Power Administration for energy features in the EMSL
- an ESPC for the Battelle campus in North Richland
- an ESPC for the Hanford Site steam heat systems.

Several new alternative financing projects are planned for FY 2000 and beyond to provide $3M to $8M additional capital to Pacific Northwest. The major projects are

- an ESPC for Pacific Northwest leased facilities
- a second phase of the Battelle ESPC
- several phases of the Hanford Site ESPC for site water systems, site electrical systems, and individual building modifications.

Altogether, these projects should implement cost-effective upgrades and cover the majority of Pacific Northwest's Hanford and Richland facilities.

The Energy Management Program also targets other goals and activities including the following:

- Minimizing energy and water use and costs. Planned activities include reducing water and sewer use, improving energy-related operations and maintenance, and seeking better energy prices and services.
- Supporting Pacific Northwest research efforts in nuclear safety, fire protection, codes, digital controls, project development, federal/state energy partnerships, and ESPCs.
- Serving the community as a strategic partner in the DOE/Tri-Cities Rebuild America Partnership. The Partnership seeks to make the Tri-Cities more efficient and competitive through transfer and promotion of training and projects.

Information Resources Management

The Information Resources Management program exists for the sole purpose of supporting Pacific Northwest's primary missions in environmental science and technology and the contributing missions in science, technology, energy, and national security. The successful execution of these missions is significantly enabled by convenient, reliable, and cost-effective access to scientific and administrative information, network and telecommunications resources, computational facilities, and user-oriented information services.

Pacific Northwest's overall information technology strategy is to provide staff, collaborators, business partners, and customers a secure, but accessible, Information Technology environment that enhances personal and team productivity through ready access to information, systems, and networks.

Information technology services are focused in three computing environments: scientific and high-performance computing, desktop productivity tools, and business management systems that each serve distinctive customer sets. The information technology environment is based on a web-based distributed computing model, and a common network infrastructure supports all three computing environments.

Current Situation

The network infrastructure is implemented as a mixed 10/100BaseTX Ethernet with a mixed Fast Ethernet/Gigabit Ethernet backbone. The EMSL is served by an ATM backbone over Fiber LAN Switched Ethernet. In FY 1999, the filtering router firewall was replaced with a dual, fully redundant firewall, significantly enhancing protection and intrusion detection and easing management difficulties. In addition, network access to Pacific Northwest Internet, Intranet, and Extranet resources continues to be protected by a smart card token access and authentication system. Telephone services are provided by an aging digital PBX that will be replaced in FY 2000.

External connections are provided by a T3 ESnet link and a T1 link to NorthWestNet, a regional Internet Service Provider. The T3 link is shared with the National Science Foundation-funded Laser Interferometer Gravitational-Wave Observatory and is being upgraded to OC-3 speed in FY 2000.

Business computing is provided by a networked array of Sun SPARC distributed computing systems referred to as the Information Resource Management environment. Using Oracle and Sybase data management software, these systems compose the enterprise computing environment for Intranet web access, the Pacific Northwest data warehouse, decision support applications, and tracking and reporting systems. Commercial software is used to the maximum extent practical for our core applications, including cost accounting, procurement, human resources, payroll, and travel management. Interfaces to these systems are based on a web-centric, browser-accessible model for user access. In FY 1999, the legacy cost accounting system was converted from a mainframe COBOL environment to commercial client-server software.

Standardized WinTel, Macintosh, and Unix platforms acquired through a Managed Hardware Program provide desktop computing. The program features standard hardware and software configurations, on-line ordering, accelerated delivery, and reduced acquisition, installation, and maintenance costs. Application software standards adopted as part of this program include Microsoft Office, Exchange/Outlook, Quick View Plus, Netscape, and Schedule + that are acquired under site licenses.

Supercomputing is available on the high performance IBM RS/6000 SPJ with 512 processors installed in the EMSL and the IBM RS/6000 SPJ with 128 processors that supports the NATT Initiative and is being used for advanced materials and manufacturing simulation and modeling. In addition, Pacific Northwest staff use advanced Silicon Graphics and IBM scientific cluster machines as well as over 400 high-performance Unix-based workstations for a wide variety of modeling, simulation, and visualization applications.

Pacific Northwest is addressing the Year 2000 (Y2K) issue through a comprehensive assessment and remediation program coordinated by the Information Sciences and Engineering (IS&E) organization. Remediation and Independent Validation and Verification and contingency and continuity planning have been completed for all four mission essential systems and the network infrastructure.

Strategies

Y2K remains at the highest priority level for completion. While most Y2K work has been completed, we are continuing to test to ensure a successful transition across the millennium boundary.

The Pacific Northwest technical strategy for computing is executed in accordance with the Information Technology Strategic Plan that is developed annually as part of our strategic planning process. The Pacific Northwest Strategy Council is the primary customer for the plan and establishes the strategic direction and funding levels for Information Technology on an annual basis. Responsibility for developing the plan is delegated to IS&E. IS&E develops the plan with the assistance and input of the Management Information Systems Council, which oversees business information systems, and the Scientific Information Systems Council, which guides planning for scientific and engineering systems.

Internal network strategies are to complete the upgrade to switched 10/100 BaseTX for all local area network users and extend the Fast Ethernet/Gigabit Ethernet backbone to all major network segments. The prototype Public Key Infrastructure initiated in FY 1998 will be expanded for transition to all staff to enhance network security. The virtual private network capability installed and prototyped in FY 1999 will be expanded to a full-service offering with external partners. The Gigabit Ethernet backbone will be expanded as required to support increased computational requirements arising from EMSL and NATT as well as from the other advanced computational initiatives described elsewhere in this plan. The telephone system replacement strategy is to acquire a standards-based system with capability to support data and voice convergence as the technology becomes available.

External network strategies are focused on increasing the speed and functionality of existing ESnet connections. Pacific Northwest is upgrading the ESnet link to OC3 and participating in the Internet 2 gigapop operated by the University of Washington. This system permits the exploration of Multiprotocol Label Switching to support the growing network requirements of the Atmospheric Radiation Measurement program, as well as those expected from our advanced computing initiatives. Upgrades in speed and functionality in the future are strategically important to support the Pacific Northwest vision for advanced modeling and simulation.

In the near term, the last remaining mainframe legacy system is being moved to a client-server environment and two of the earliest server applications, travel and purchasing, are being re-hosted on commercial software. Concurrently, user interfaces for these systems are being converted to a web-based user interface model.

Resources and Initiatives

Resource requirements for direct programmatic research programs are included in program-specific sections of this document (also see the table below). Business information systems and most infrastructure investments are funded from general purpose and overhead accounts. In order to more effectively manage the Pacific Northwest investment in computing, enterprise applications (for example, payroll and human resources) and baseline infrastructure capabilities (those designed for availability to all staff) are funded as core services across the organization. The organizational and functionally specific applications and services (not enterprise-wide) are separately funded, or charged back, by the benefiting organization as value-added components. Budgets for both classes of service are reviewed and approved by senior management as part of the annual budget planning and allocation process.

Information Management Resource Requirements
(FY Budget Authorization $ in Millions)

Category	Fiscal Year 1997	1998	1999	2000	2001	2002	2003	2004
Overhead	10.0	12.0	13.0	13.4	13.7	14.0	14.3	14.6
Chargeback	6.5	6.5	6.7	6.9	7.1	7.3	7.6	7.9
General Purpose Capital Equipment (KP)	0.75	0.8	0.8	0.8	0.8	0.9	0.9	0.9
Total Funding	17.25	19.3	19.5	21.1	21.6	22.2	22.8	23.4

Management Practices and Standards

Pacific Northwest is dedicated to continuously improving its management practices and operations, making it a more effective and efficient organization that is prepared to meet the operational challenges of the 21st century. Our management systems are fully integrated with the methods we use to deliver our products and services and continuously improved to meet changing customer needs and increase performance. Improvements to management systems are planned, monitored, evaluated, and implemented through the Integrated Assessment and Integrated Planning Management Systems. The Integrated Assessment Management system defines the expectations for self-assessment, independent oversight, and peer review. These assessment methods are used in an integrated way to identify strengths and weaknesses across all dimensions of performance and are used to drive improvement. The outcomes of these integrated assessments are used in the planning process of the Integrated Planning Management System.

Key systems have been described and baselined and processes for ongoing control, monitoring, and improvement established. Current efforts are focused on enhancing integration and improving performance through measurement and benchmarking.

Overview of Peer Review Process

Peer review is one of the universally accepted methods of determining the direction and assessing the quality of science, engineering, and technology. Pacific Northwest is committed to the principles and practices of peer review and has a process in place that includes both internal and external peer reviews.

Laboratory-initiated peer review has three primary components:

- Division Visiting Committees
- Laboratory Review Committee
- Internal peer review of communications sent by laboratory personnel.

Each laboratory division has established a Division Visiting Committee to review its science and technology portfolio, and the Division Visiting Committee chairs serve as members of the Laboratory Review Committee. Both committees report to the Laboratory Director. This process, developed in 1997, was fully implemented in 1998. Each of these three components has been formalized and documented by publication in the Standards-Based Management System.

Pacific Northwest also establishes special ad hoc internal review committees to review proposals for major programs by sponsors of research and development (usually DOE). Major DOE Office of Science programs are reviewed annually by panels of subject matter experts brought to Pacific Northwest by sponsors of the research.

Cost-Effectiveness and Continuous Improvement

Improvement programs such as Achieving the Competitive Edge, Operations Improvement Program, the follow-on Operations Improvement Initiative, and Management System Redesign are examples of our commitment to enhance performance. These initiatives have resulted in 1) documentation of our existing management systems; 2) development of new initiatives, such as Standards-Based and Integrated Assessment Management Systems; and 3) delivery of new organization-wide standards, tools, and processes (e.g., facility use agreements). These enhancements not only boost our efficiency, but also improve the safe operations of our facilities. System improvements currently being worked on at Pacific Northwest include the following:

- Improvements in the delivery of information to staff focusing on increasing the ease of access to Pacific Northwest-wide information through additional electronic views and tools in the Standards-Based Management System. This information will be tied to work processes through linkages made in the electronic prep and risk, the tool used by project managers to identify hazards in proposed work.
- Documentation of the flow-down of external requirements into Pacific Northwest's implementing procedures, which will be completed next year. The flow-down of Orders and clauses in our contract with DOE will be completed in FY 1999. Pacific Northwest will complete the documentation of how its policies and federal, state, and local regulations are implemented in FY 2000.
- Periodic redesign or improvements to management systems. Two management systems are specifically targeted for major enhancements in the next year. The Security and Safeguards management system will be updated because of significant security incidents across DOE and concerns within Pacific Northwest about its own system. The Business Development Management Systems will be updated to reflect enhancements in new business development and sales processes.

In addition, enhanced processes are being developed and implemented in two other management systems:

- Records Management System—The records management system is developing an Electronic Records and Information Capture Archive (ERICA) that is an innovative approach to providing on-line access to Scientific and Technical Information (STI). ERICA will provide an internally available, searchable repository of information and records. A subset of the information, the publicly available portion of our STI, will be accessible via Pacific Northwest's external web site.
- Financial Management System—Pacific Northwest is replacing the financial processing system to reduce operating costs and provide project managers and line managers with more timely and accurate cost information. This initiative will replace the general ledger, project accounting, service center, and cost-closing processes that now run on a central computer operated by another Hanford contractor.

Communications and Trust

Pacific Northwest National Laboratory supports DOE in its objective to create awareness and build trust with various audiences through timely communications, community involvement, and public awareness. Effective external and internal communications help provide local, regional, and national support for DOE missions and increase the awareness of Pacific Northwest as a world-class science and technology organization.

Pacific Northwest's communications and trust initiative has six key features:

- Community Relations—Pacific Northwest is committed to involving and benefiting its local communities to ensure that DOE and Pacific Northwest advance the quality of life and remain valued assets to the Tri-Cities and the Northwest region. This will be accomplished through continuous programs in community involvement, economic development, education, and efforts to increase the awareness of Pacific Northwest's capabilities applicable to issues and industries of regional significance.

- Media Relations—Open and timely communications with local, regional, and national media are crucial to building awareness of Pacific Northwest as a premier science and technology research laboratory and can minimize damage to its image from sensitive public relations issues. Media Relations also serves as the chief interface with DOE-HQ's public affairs and press offices and coordinates Pacific Northwest's crisis communications response efforts.

- Promotional Communications—Targeted messages on subjects such as Pacific Northwest's status as a premier environmental laboratory to specific global and national audiences will develop increased awareness and stimulate future projects and business as Pacific Northwest continues to grow and diversify.

- Speaker's Bureau—Local, regional, and national speaking appearances by science and technology leaders will reinforce the significance of DOE and Pacific Northwest National Laboratory programs.

- Technical and Electronic Communications—Sharing the results of major scientific and technological projects will help advance the recognition of Pacific Northwest, enable the scientific community to access laboratory information, and communicate the impact of national laboratory system breakthroughs.

- Organizational Communications—Pacific Northwest staff are the organization's best ambassadors, and well-informed staff are the best liaisons with the general public. Pacific Northwest will further broaden its array of internal communications mechanisms to guarantee that staff are well informed of new developments and future directions.

Today, a leading-edge laboratory cannot survive on scientific accomplishments alone. Its mission and accomplishments must be well understood and supported by local citizens, civic leaders, media, business and government leaders, and many others. Further, it must be valued as a technological and economic engine for local and regional growth and national achievement. The continuing focus of Pacific Northwest's communications and trust program is to continue to meet the needs of the public and assure them of Pacific Northwest's presence in opening doors to a brighter future.

7

Resource Projections

The resource requirements of research and development for Hanford Site support are included in the resource projections of the various funding programs. Research and development for other U.S. Department of Energy sites at other DOE facilities, however, are shown as a separate program. The resource projections for FY 1998 and FY 1999 are actual values.

Laboratory Funding Summary
(Budget Authorization $ in Millions)

	Fiscal Year						
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
DOE Effort	367.5	394.6	387.8	408.3	407.7	399.5	405.1
DOE Site Transfers	(40.0)	(41.0)	(38.0)	(35.0)	(35.0)	(35.0)	(35.0)
Work for Others	85.5	44.7	116.4	78.9	94.6	72.2	58.0
Total Operating	**413**	**398.3**	**466.2**	**452.2**	**467.3**	**436.7**	**428.1**
Capital Equipment	8.7	9.0	10.2	13.1	16.2	16.2	27.2
General Purpose Equipment-GPE	1.0	0.0	1.0	1.0	1.0	1.0	1.0
General Plant Projects-GPP	4.8	0.0	4.2	6.0	6.5	6.5	6.5
Construction Line Items	0.0	3.6	0.0	0.0	2.0	4.0	3.0
Total Laboratory Funding	**427.5**	**410.9**	**481.6**	**472.3**	**493.0**	**464.4**	**465.8**

Laboratory Personnel Summary
(Personnel in FTE)

	Fiscal Year						
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
DOE Effort	1106	1135	1151	1165	1191	1184	1214
Work for Others	251	188	186	197	195	197	185
Total Operating	**1357**	**1323**	**1337**	**1362**	**1386**	**1381**	**1399**
Capital Equipment	1	3	3	4	5	5	7
General Plant Projects-GPP	5	0	5	8	8	8	8
Construction Line Items	0	5	0	0	3	5	4
Total Direct	**1363**	**1331**	**1345**	**1374**	**1402**	**1399**	**1418**
Indirect	1625	1494	1483	1499	1512	1525	1525
Total Laboratory Personnel (FTE)	**2988**	**2825**	**2828**	**2873**	**2914**	**2924**	**2943**

Funding by Secretarial Officer
(Budget Authorization $ in Millions)

	Fiscal Year						
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Office of Science							
Operating	52.7	60.8	63.5	73.1	82.1	83.1	86.1
EMSL Operations - Expense	34.0	27.4	28.0	28.0	29.0	29.0	30.0
Capital Equipment	1.2	5.6	6.9	9.9	11.9	11.9	21.9
EMSL Operations Capital Equipment	4.1	2.2	2.0	2.0	3.0	3.0	4.0
General Purpose Equipment-GPE	1.0	0.0	1.0	1.0	1.0	1.0	1.0
General Plant Projects-GPP	3.1	0.0	3.3	5.0	5.0	5.0	5.0
Construction Line Items	0.0	3.4	0.0	0.0	2.0	4.0	3.0
Total	**96.1**	**99.4**	**104.7**	**119.0**	**134.0**	**137.0**	**151.0**
Office of Environmental Management							
Operating	94.2	98.4	99.0	99.9	99.9	99.9	99.9
Capital Equipment	0.4	0.2	0.1	0.1	0.1	0.1	0.1
General Plant Projects-GPP	1.7	0.3	0.9	1.0	1.5	1.5	1.5
Construction Line Item	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**96.3**	**98.9**	**100.0**	**101.0**	**101.5**	**101.5**	**101.5**
Assistant Secretary for Energy Efficiency and Renewable Energy							
Operating	17.7	24.0	22.8	26.3	29.5	32.2	35.0
Capital Equipment	0.1	0.1	0.2	0.2	0.2	0.2	0.2
Total	**17.8**	**24.1**	**23.0**	**26.5**	**29.7**	**32.4**	**35.2**
Assistant Secretary for Environment, Safety, and Health							
Total Operating	**7.5**	**3.2**	**3.8**	**4.0**	**4.5**	**4.6**	**4.4**
Assistant Secretary for Defense Programs							
Operating	26.4	23.6	26.0	21.0	30.0	19.0	17.0
Capital Equipment	0.5	0.2	0.1	0.0	0.0	0.0	0.0
Total	**26.9**	**23.8**	**26.1**	**21.0**	**30.0**	**19.0**	**17.0**
Office of Materials Disposition							
Operating	1.8	2.3	2.0	2.0	1.0	1.0	1.0
Capital Equipment	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Total	**2.1**	**2.3**	**2.0**	**2.0**	**1.0**	**1.0**	**1.0**
Office of Nonproliferation and National Security							
Operating	37.1	123.0	102.2	110.8	87.8	83.9	82.2
Capital Equipment	2.1	0.6	0.9	0.9	1.0	1.0	1.0
Total	**39.2**	**123.6**	**103.1**	**111.7**	**88.8**	**84.9**	**83.2**
Office of Intelligence[a]							
Total Operating	**4.8**	**6.4**	**6.2**	**6.9**	**7.0**	**7.2**	**7.5**
Office of Counterintelligence[a]							
Total Operating	**0.8**	**4.9**	**8.6**	**7.0**	**7.2**	**7.4**	**8.0**

(a) Office of Intelligence and Office of Counterintelligence were part of DOE-NN in FY 1998.

Funding by Secretarial Officer (contd)
(Budget Authorization $ in Millions)

	Fiscal Year						
	1998	1999	2000	2001	2002	2003	2004
Assistant Secretary for Nuclear Energy							
Total Operating	**69.8**	**1.9**	**3.2**	**4.2**	**2.8**	**4.0**	**4.5**
Office of Security and Emergency Operations							
Total Operating	**4.0**	**3.5**	**4.2**	**4.4**	**4.5**	**4.8**	**5.0**
Assistant Secretary for Fossil Energy							
Total Operating	**1.8**	**3.2**	**5.0**	**7.0**	**8.0**	**8.5**	**9.0**
Office of Policy, Planning, and Program Evaluation							
Total Operating	**0.2**	**0.1**	**0.1**	**0.1**	**0.2**	**0.2**	**0.2**
Other DOE Organizations							
Total Operating	**0.0**	**0.1**	**1.0**	**1.0**	**1.2**	**1.3**	**1.5**
Other DOE Sites							
Operating	14.7	11.8	12.2	12.6	13.0	13.4	13.8
Site Transfers	(40.0)	(41.0)	(38.0)	(35.0)	(35.0)	(35.0)	(35.0)
Total DOE Sites	**(25.3)**	**(29.2)**	**(25.8)**	**(22.4)**	**(22.0)**	**(21.6)**	**(21.2)**
Total DOE Programs							
Operating	367.5	394.6	387.8	408.3	407.7	399.5	405.1
DOE Site Transfers	(40.0)	(41.0)	(38.0)	(35.0)	(35.0)	(35.0)	(35.0)
Capital Equipment	8.7	8.9	10.2	13.1	16.2	16.2	27.2
General Purpose Equipment-GPE	1.0	0.0	1.0	1.0	1.0	1.0	1.0
General Plant Projects-GPP	4.8	0.0	4.2	6.0	6.5	6.5	6.5
Construction Line Items	0.0	3.7	0.0	0.0	2.0	4.0	3.0
Total	**342.0**	**366.2**	**365.2**	**393.4**	**398.4**	**392.2**	**407.8**
Work for Others							
Department of Defense	72.6	25.0	96.6	59.1	74.7	52.2	38.0
Nuclear Regulatory Commission	3.5	5.6	4.6	4.6	4.7	4.8	4.8
Environmental Protection Agency	2.6	1.8	1.2	1.2	1.2	1.2	1.2
Dept. of Health and Human Svcs./NIH	0.0	0.6	0.5	0.5	0.5	0.5	0.5
NASA	0.9	1.8	1.1	1.0	1.0	1.0	1.0
Other Federal Agencies	5.8	9.1	11.4	11.5	11.5	11.5	11.5
Other - Non-Federal Agencies	0.1	0.8	1.0	1.0	1.0	1.0	1.0
Total	**85.5**	**44.7**	**116.4**	**78.9**	**94.6**	**72.2**	**58.0**
Total Laboratory Funding							
Operating	453.0	439.3	504.2	487.2	502.3	471.7	463.1
DOE Site Transfers	(40.0)	(41.0)	(38.0)	(35.0)	(35.0)	(35.0)	(35.0)
Capital Equipment	8.7	8.9	10.2	13.1	16.2	16.2	27.2
General Purpose Equipment-GPE	1.0	0.0	1.0	1.0	1.0	1.0	1.0
General Plant Projects-GPP	4.8	3.7	4.2	6.0	6.5	6.5	6.5
Construction Line Items	0.0	0.0	0.0	0.0	2.0	4.0	3.0
Total	**427.5**	**410.9**	**481.6**	**472.3**	**493.0**	**464.4**	**465.8**

Direct Personnel by Secretarial Officer
(Personnel in FTE)

	Fiscal Year						
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Office of Science							
Operating	293	316	317	339	357	360	373
Office of Environmental Management							
Operating	285	320	320	316	306	309	312
Assistant Secretary for Energy Efficiency and Renewable Energy							
Operating	60	86	79	89	95	104	113
Assistant Secretary for Environment, Safety, and Health							
Operating	25	12	13	14	15	15	14
Assistant Secretary for Defense Programs							
Operating	89	85	91	71	97	61	55
Office of Materials Disposition							
Operating	6	8	7	7	3	3	3
Office of Nonproliferation and National Security							
Operating	125	193	183	186	178	181	184
Office of Intelligence							
Operating	16	23	22	23	23	23	24
Office of Counterintelligence							
Operating	3	18	30	24	23	24	26
Assistant Secretary for Nuclear Energy							
Operating	129	7	11	14	9	13	15
Office of Security and Emergency Operations							
Operating	14	13	15	15	15	15	16
Assistant Secretary for Fossil Energy							
Operating	6	12	17	24	26	27	29
Office of Policy, Planning, and Program Evaluation							
Operating	1	0	0	0	1	1	1
Other DOE Organizations							
Operating	0	0	4	3	4	4	5
Other DOE Sites							
Operating	53	43	43	42	42	43	44
Total DOE Programs	**1104**	**1136**	**1152**	**1167**	**1193**	**1182**	**1213**

Direct Personnel by Secretarial Officer (contd)
(Personnel in FTE)

	Fiscal Year						
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Work for Others							
Department of Defense	207	117	117	130	131	133	121
Nuclear Regulatory Commission	12	20	16	16	15	16	16
Environmental Protection Agency	9	7	4	4	4	4	4
Dept. of Human and Health Svcs./NIH	0	2	2	2	2	2	2
NASA	3	7	4	3	3	3	3
Other Federal Agencies	19	33	40	39	37	37	37
Other - Non-Federal Agencies	0	3	4	3	3	3	3
Total	**250**	**189**	**187**	**197**	**195**	**198**	**186**
Laboratory Direct							
Operating	1357	1323	1337	1362	1386	1381	1399
Capital Equipment	1	3	3	4	5	5	7
General Plant Projects-GPP	5	5	5	8	8	8	8
Construction Line Items	0	0	0	0	3	5	4
Total Laboratory Direct	**1363**	**1331**	**1345**	**1374**	**1402**	**1399**	**1418**
Total Laboratory Indirect	1625	1494	1483	1499	1512	1525	1525
Total Laboratory Personnel (FTE)	**2988**	**2825**	**2828**	**2873**	**2914**	**2924**	**2943**

Resources by Major DOE Areas
(Budget Authorization $ in Millions)

	Fiscal Year						
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Office of Science							
Magnetic Fusion (AT)	1.4	1.3	1.3	1.3	1.3	1.3	1.3
Basic Energy Sciences (KC)	11.8	11.9	12.7	13.3	13.3	13.3	13.3
SC Laboratory Tech. Research (KJ)	4.2	4.3	8.3	12.6	21.1	24.1	26.1
Energy Research Analysis (KD)	0.0	0.3	0.5	0.5	0.5	0.5	0.5
Biological and Environ. Research (KP)	35.3	42.4	40.2	44.9	45.4	43.4	44.4
EMSL Operations - Expense (KP-BER)	34.0	27.4	28.0	28.0	29.0	29.0	30.0
Office of Sci. Pro. Dir. (KX, Univ Sci Ed)	0.0	0.6	0.5	0.5	0.5	0.5	0.5
Operating	**86.7**	**88.2**	**91.5**	**101.1**	**111.1**	**112.1**	**116.1**
Capital Equipment (AT)	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Capital Equipment (KC)	1.0	1.0	0.8	0.8	0.8	0.8	0.8
Capital Equipment (KJ)	0.0	0.0	0.0	3.0	5.0	5.0	15.0
Capital Equipment (KP)	0.2	4.5	6.0	6.0	6.0	6.0	6.0
EMSL Operations Capital (KP-BER)	4.1	2.2	2.0	2.0	3.0	3.0	4.0
Capital Equipment	**5.3**	**7.8**	**8.9**	**11.9**	**14.9**	**14.9**	**25.9**
General Purpose Equipment-GPE (KP)	1.0	0.0	1.0	1.0	1.0	1.0	1.0
General Plant Projects-GPP (KP)	3.1	3.4	3.3	5.0	5.0	5.0	5.0
Construction Line items	0.0	0.0	0.0	0.0	2.0	4.0	3.0
Total Funding	**96.1**	**99.4**	**104.7**	**119.0**	**134.0**	**137.0**	**151.0**
Direct Personnel							
Operating	293	316	317	339	357	360	373
Capital	1	2	2	3	3	3	6
General Plant Projects-GPP	3	4	4	6	6	6	6
Construction Line Items	0	0	0	0	3	5	4
Total Direct Personnel	**297**	**322**	**323**	**348**	**369**	**374**	**389**
Office of Environmental Management							
Technology Development (EW)	20.8	17.5	16.0	16.0	15.0	14.0	13.0
Waste Management (EW)	58.1	65.5	70.0	67.5	67.9	68.9	69.9
Waste Management (EX)	2.5	0.7	0.0	0.0	0.0	0.0	0.0
Environmental Restoration (EW)	12.8	14.7	13.0	16.4	17.0	17.0	17.0
Total Operating	**94.2**	**98.4**	**99.0**	**99.9**	**99.9**	**99.9**	**99.9**
Capital Equipment (EW/EX)	0.4	0.2	0.1	0.1	0.1	0.1	0.1
General Plant Projects-GPP	1.7	0.3	0.9	1.0	1.5	1.5	1.5
Total Funding	**96.3**	**98.9**	**100.0**	**101.0**	**101.5**	**101.5**	**101.5**
Direct Personnel							
Operating	285	320	320	316	306	309	312
General Plant Projects-GPP	2	0	1	1	2	2	2
Total Direct Personnel	**287**	**320**	**321**	**317**	**308**	**311**	**314**

Resources by Major DOE Areas (contd)
(Budget Authorization $ in Millions)

	Fiscal Year						
	1998	1999	2000	2001	2002	2003	2004
Assistant Secretary for Energy Efficiency and Renewable Energy							
Solar Energy (EB)	1.1	0.6	0.6	0.6	0.7	0.7	0.7
Buildings Sector-(EC)	7.7	8.3	8.1	8.7	8.9	9.1	9.4
Industrial Energy Conservation (ED)	2.4	4.4	3.0	3.5	4.0	4.4	4.9
Transportation Sector (EE)	4.0	7.0	8.3	10.3	12.3	14.3	16.3
Utility Sector (EK)	0.0	0.0	0.0	0.2	0.5	0.5	0.5
Policy and Management (EH)	0.0	0.2	0.4	0.4	0.4	0.4	0.4
Federal Emergency Mgmt. (EL)	2.5	3.5	2.4	2.6	2.7	2.8	2.8
Operating	**17.7**	**24.0**	**22.8**	**26.3**	**29.5**	**32.2**	**35.0**
Capital Equipment	0.1	0.1	0.2	0.2	0.2	0.2	0.2
Total Funding	**17.8**	**24.1**	**23.0**	**26.5**	**29.7**	**32.4**	**35.2**
Direct Operating Personnel	**60**	**82**	**79**	**89**	**95**	**104**	**113**
Assistant Secretary for Environment, Safety, and Health							
Envir., Safety, and Health-Non Def. (HC)	4.2	1.8	2.4	2.2	2.4	2.4	2.3
Envir., Safety, and Health-Defense (HD)	3.3	1.4	1.4	1.8	2.1	2.2	2.1
Total Funding	**7.5**	**3.2**	**3.8**	**4.0**	**4.5**	**4.6**	**4.4**
Direct Operating Personnel	**25**	**12**	**13**	**14**	**15**	**15**	**14**
Assistant Secretary for Defense Programs							
Materials Production (GE/DP)	26.4	23.6	26.0	21.0	30.0	19.0	17.0
Operating	**26.4**	**23.6**	**26.0**	**21.0**	**30.0**	**19.0**	**17.0**
Capital Equipment	0.5	0.2	0.1	0.0	0.0	0.0	0.0
Total Funding	**26.9**	**23.8**	**26.1**	**21.0**	**30.0**	**19.0**	**17.0**
Direct Operating Personnel	**89**	**85**	**91**	**71**	**97**	**61**	**55**
Office of Materials Disposition							
Fissile Materials Disposition (GA)	1.8	2.3	2.0	2.0	1.0	1.0	1.0
Operating	**1.8**	**2.3**	**2.0**	**2.0**	**1.0**	**1.0**	**1.0**
Capital Equipment	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Total Funding	**2.1**	**2.3**	**2.0**	**2.0**	**1.0**	**1.0**	**1.0**
Direct Operating Personnel	**6**	**8**	**7**	**7**	**3**	**3**	**3**
Office of Nonproliferation and National Security							
Verification and Control Technology (GC)	15.5	16.6	18.3	19.7	19.5	19.5	19.5
Expt. Control, Nonprolif. & Safeguards (GJ)	20.8	26.5	22.9	24.0	25.2	26.5	27.8
Nonprolif. and Nat'l Sec. Pgm. Dir. (NN)	0.8	0.0	0.0	0.0	0.0	0.0	0.0
INSP (NN-30)	0.0	79.9	61.0	67.1	43.1	37.9	34.9
Operating	**37.1**	**123.0**	**102.2**	**110.8**	**87.8**	**83.9**	**82.2**
Capital Equipment (GC)	0.5	0.6	0.9	0.9	1.0	1.0	1.0
Capital Equipment (GJ)	1.6	0.0	0.0	0.0	0.0	0.0	0.0
Total Funding	**39.2**	**123.6**	**103.1**	**111.7**	**88.8**	**84.9**	**83.2**

Resources by Major DOE Areas (contd)
(Budget Authorization $ in Millions)

	Fiscal Year						
	1998	1999	2000	2001	2002	2003	2004
Direct Personnel							
Operating	125	193	183	186	178	181	184
Capital Equipment	0	1	1	1	1	1	1
Total Direct Personnel	**125**	**194**	**184**	**187**	**179**	**182**	**185**
Office of Intelligence (IN)							
Total Funding	**4.8**	**6.4**	**6.2**	**6.9**	**7.0**	**7.2**	**7.5**
Direct Operating Personnel	**16**	**23**	**22**	**23**	**23**	**23**	**24**
Office of Counterintelligence (CN)							
Total Funding	**0.8**	**4.9**	**8.6**	**7.0**	**7.2**	**7.4**	**8.0**
Direct Operating Personnel	**3**	**18**	**30**	**24**	**23**	**24**	**26**
Assistant Secretary for Nuclear Energy							
Nuclear Energy R&D (AF)	67.1	0.6	2.9	3.9	2.5	3.7	4.2
Fast Flux Test Facility-FFTF (AF)	1.2	0.0	0.3	0.3	0.3	0.3	0.3
Isotope Production (ST)	1.5	1.3	0.0	0.0	0.0	0.0	0.0
Total Funding	**69.8**	**1.9**	**3.2**	**4.2**	**2.8**	**4.0**	**4.5**
Direct Operating Personnel	**129**	**7**	**11**	**14**	**9**	**13**	**15**
Office of Security and Emergency Operations							
Nuclear Safeguards and Security (GD)	3.5	3.2	3.7	3.9	4.0	4.2	4.4
Emergency Management (ND)	0.5	0.3	0.5	0.5	0.5	0.6	0.6
Total Funding	**4.0**	**3.5**	**4.2**	**4.4**	**4.5**	**4.8**	**5.0**
Direct Operating Personnel	**14**	**13**	**15**	**15**	**15**	**15**	**16**
Assistant Secretary for Fossil Energy							
Coal (AA)	0.9	1.1	2.2	3.2	3.6	3.9	4.1
Gas (AB)	0.5	1.6	2.2	3.2	3.6	3.8	4.1
Petroleum (AC)	0.4	0.5	0.6	0.6	0.8	0.8	0.8
Innovative Clean Coal Tech (AZ)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Funding	**1.8**	**3.2**	**5.0**	**7.0**	**8.0**	**8.5**	**9.0**
Direct Operating Personnel	**6**	**12**	**17**	**24**	**26**	**27**	**29**
Office of Policy, Planning, and Program Evaluation							
Policy, Planning, and Analysis (PE)	0.2	0.1	0.1	0.1	0.2	0.2	0.2
Total Funding	**0.2**	**0.1**	**0.1**	**0.1**	**0.2**	**0.2**	**0.2**
Direct Operating Personnel	**1**	**0**	**0**	**0**	**1**	**1**	**1**
Other DOE Organizations							
Total Funding	**0.0**	**0.1**	**1.0**	**1.0**	**1.2**	**1.3**	**1.5**
Direct Operating Personnel	**0**	**0**	**4**	**3**	**4**	**4**	**5**

Resources by Major DOE Areas (contd)
(Budget Authorization $ in Millions)

	Fiscal Year						
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Other DOE Sites							
Operating	14.7	11.8	12.2	12.6	13.0	13.4	13.8
Site Transfers	(40.0)	(41.0)	(38.0)	(35.0)	(35.0)	(35.0)	(35.0)
Total Net Funding	**(25.3)**	**(29.2)**	**(25.8)**	**(22.4)**	**(22.0)**	**(21.6)**	**(21.2)**
Direct Personnel	53	43	43	42	42	43	44
Total DOE Programs							
Operating	367.5	394.6	387.8	408.3	407.7	399.5	405.1
DOE Site Transfers	(40.0)	(41.0)	(38.0)	(35.0)	(35.0)	(35.0)	(35.0)
Capital Equipment	8.7	8.9	10.2	13.1	16.2	16.2	27.2
General Purpose Equipment-GPE	1.0	0.0	1.0	1.0	1.0	1.0	1.0
General Plant Projects-GPP	4.8	3.7	4.2	6.0	6.5	6.5	6.5
Construction Line Items	0.0	0.0	0.0	0.0	2.0	4.0	3.0
Total Funding	**342.0**	**366.2**	**365.3**	**393.4**	**398.4**	**392.2**	**407.8**
Direct Personnel							
Operating	1106	1135	1151	1165	1191	1184	1214
Capital	1	3	3	4	5	5	7
General Plant Projects-GPP	5	5	5	8	8	8	8
Construction Line Items	0	0	0	0	3	5	4
Total Direct Personnel	1112	1143	1159	1177	1207	1202	1233
Work for Others							
Nuclear Regulatory Commission							
Operating	3.5	5.6	4.6	4.6	4.7	4.8	4.8
Direct Personnel	12	20	16	16	15	16	16
Department of Defense							
Operating	72.6	25.0	96.6	59.1	74.7	52.2	38.0
Direct Personnel	207	117	117	130	131	133	121
Environmental Protection Agency							
Operating	2.6	1.8	1.2	1.2	1.2	1.2	1.2
Direct Personnel	9	7	4	4	4	4	4
Dept. of Human and Health Svcs./NIH							
Operating	0.0	0.6	0.5	0.5	0.5	0.5	0.5
Direct Personnel	0	2	2	2	2	2	2
NASA							
Operating	0.9	1.8	1.1	1.0	1.0	1.0	1.0
Direct Personnel	3	7	4	3	3	3	3
Other Federal Agencies							
Operating	5.8	9.1	11.4	11.5	11.5	11.5	11.5
Direct Personnel	19	33	40	39	37	37	37
Other - Non-Federal Agencies							
Operating	0.1	0.8	1.0	1.0	1.0	1.0	1.0
Direct Personnel	0	3	4	3	3	3	3

Resources by Major DOE Areas (contd)

(Budget Authorization $ in Millions)

	Fiscal Year						
	1998	1999	2000	2001	2002	2003	2004
Total Work for Others							
Operating	**85.5**	**44.7**	**116.4**	**78.9**	**94.6**	**72.2**	**58.0**
Direct Personnel	**250**	**189**	**187**	**197**	**195**	**198**	**186**
Total Laboratory Funding							
Operating	**453.0**	**439.3**	**504.2**	**487.2**	**502.3**	**471.7**	**463.1**
Direct Personnel	1357	1323	1337	1362	1386	1381	1399
DOE Site Transfers	**(40.0)**	**(41.0)**	**(38.0)**	**(35.0)**	**(35.0)**	**(35.0)**	**(35.0)**
Capital	**8.7**	**8.9**	**10.2**	**13.1**	**16.2**	**16.2**	**27.2**
Direct Personnel	1	3	3	4	5	5	7
General Purpose Equipment-GPE	**1.0**	**0.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
General Plant Projects-GPP	**4.8**	**3.7**	**4.2**	**6.0**	**6.5**	**6.5**	**6.5**
Direct Personnel	5	5	5	8	8	8	8
Construction Line Items	**0.0**	**0.0**	**0.0**	**0.0**	**2.0**	**4.0**	**3.0**
Direct Personnel	0	0	0	0	3	5	4
Indirect Personnel	**1625**	**1494**	**1483**	**1499**	**1512**	**1525**	**1525**
Total Funding	**427.5**	**410.9**	**481.6**	**472.3**	**493.0**	**464.4**	**465.8**
Total Personnel	**2988**	**2825**	**2828**	**2873**	**2914**	**2924**	**2943**

Subcontracting and Procurement

Pacific Northwest is dependent upon external resources (universities and industry) for support in achieving timely and successful completion of assigned programs and projects. This is accomplished by staff in the Contracts organization who use the procurement acquisition process in acquiring needed equipment, materials, supplies, and services. The table below reflects actual subcontracted amounts for FY 1998 and FY 1999 and projections for FY 2000 through FY 2004.

Subcontracting and Procurement
(Dollar Amounts in Millions)

	Fiscal Year						
	1998	1999	2000	2001	2002	2003	2004
Obligated	258.7	194.2	203.6	198.4	200.3	203.9	206.2
Subcontracting and Procurement from:							
Universities	16.9	14.5	11.9	11.6	11.7	11.9	12.0
All Others	211.7	181.1	162.9	158.7	160.0	193.8	196.2
Other DOE	30.1	25.8	27.5	26.7	27.0	27.6	27.9
Total External Subcontracts and Procurements	**258.7**	**221.4**	**202.3**	**197.0**	**198.7**	**233.3**	**236.1**

Small and Disadvantaged Business Procurement

Pacific Northwest is committed to support the socioeconomic objectives of DOE and has established procedures and programs that support meeting those objectives.

Small and Disadvantaged Business Procurements
(Dollar Amounts in Millions)

	Fiscal Year						
	1998	1999	2000	2001	2002	2003	2004
Procurements from Small Business	48.9	46.9	44.7	43.4	43.9	44.8	45.3
Procurements from Disadvantaged Businesses	12.7	10.3	11.6	11.3	11.4	11.6	11.8

8

Acronyms and Abbreviations

ACPI	Accelerated Climate Prediction Initiative
APAs	Asset Protection Agreements
ARM	Atmospheric Radiation Measurement
BER	Office of Biological and Environmental Research
BPA	Bonneville Power Administration
BTS	Building Technology, State and Community Programs
CBNP	Chemical and Biological Nonproliferation Program
CDC	Centers for Disease Control
CIPAL	Critical Infrastructure Protection and Analysis Laboratory
CTBT	Comprehensive Test Ban Treaty
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
EMSL	William R. Wiley Environmental Molecular Sciences Laboratory
EMSP	Environmental Management Science Program
ERICA	Electronic Records and Information Capture Archive
ES&H	Environment, Safety, and Health
ESH&I	integrated environmental, safety, health, and infrastructure
ESPC	Energy Savings Performance Contract
FTICR	Fourier transform ion cyclotron resonance
HIRIS	Hyperspectral Infrared Imaging Spectrometer
HRM	Human Resource Manager
HVAC	heating, ventilation, and air-conditioning
IESHMS	Integrated ES&H Management System
IOPS	Integrated Operations
IPP	Initiative for Proliferation Prevention
ISASM	Integrated Safeguards and Security Management
ISRC	Information Security Resource Center
ISRM	In Situ Redox Manipulation
IT	Information Technology
LDRD	Laboratory Directed Research and Development
LIDAR	Light Detection and Ranging
LTR	Laboratory Technology Research
NABIR	Natural and Accelerated Bioremediation Research
NATT	Northwest Alliance for Transportation Technology
NBC	nuclear, biological, and chemical
NIEHS	National Institute of Environmental Health Services
NIH	National Institutes for Health
NIS	Newly Independent States
NMR	nuclear magnetic resonance
O&M	Operating and Maintenance
OBER	Office of Biological and Environmental Research

OHVT	Office of Heavy Vehicle Technologies
OIT	Office of Industrial Technologies
OPSEC	Operations Security
OPT	Office of Power Technologies
OTT	Office of Transportation Technology
PHMC	Project Hanford Management Contractor
PNGV	Partnership for a New Generation Vehicle
RIT	Requirements Integration and Tailoring
RPL	Radiochemical Processing Laboratory
SAMMS	Self-Assembled Monolayers on Mesoporous Supports
SAS	Safeguards and Security
SC	Office of Science
SNM	special nuclear materials
STEP	Science and Technology for Environmental Processing
STI	Scientific and Technical Information
TPA	Tri-Party Agreement
TPBARs	tritium-producing burnable absorber rods
WMD	weapons of mass destruction

A Work for Others

Department of Defense

Pacific Northwest National Laboratory's work for the U.S. Department of Defense (DoD) supports the Office of the Secretary of Defense, Navy, Marine, Army, Air Force, the Defense Threat Reduction Agency (DTRA), and the Defense Advanced Research Projects Agency (DARPA) research and development needs in areas and programs that address significant national security problems and issues. This research and development work uses our extensive capabilities in environmental sciences, electronics and sensors, statistics and applied mathematics, computer and information sciences, materials science and technology, chemical and instrumentation analyses, separations and conversion, risk management, and policy and management sciences. Pacific Northwest staff are currently working in the following technical areas:

- environmental science and waste technology
- treaty verification and technology assessment
- information sciences, networking, architectures, and software development
- advanced materials and process development
- sensors, electronic and automated systems, and their applications
- systems analysis and technology evaluation
- pollution prevention and technology development, demonstration, and deployment
- analytical chemistry and radionuclide applications
- advanced graphic technologies, automated training systems, cognitive systems and controls, and advanced workstation technology.

Treaty verification and technology assessment is closely coordinated with DOE and is performed for a number of DoD clients in support of national security needs.

Pacific Northwest has developed network architectures and distributed computing techniques are developed to meet the unique needs of federal and state emergency organizations and the U.S. Army Chemical Biological Defense Command.

We expect to continue to support the U.S. Army in advanced materials and design testing. The Kinetic Energy Projectile Project supports design, analysis, testing, and development of advanced munitions and manufacturing techniques for the Armament Research Development and Engineering Center. Related studies of composite and other unique materials are performed for other DoD clients.

Pacific Northwest has developed unique capabilities in very thin film and high-quality optical coatings. This leading-edge capability has historically met needs for missile guidance filters for the Army and Air Force and large-scale laser mirrors for strategic defense needs. We are now applying this technology base to high-power density battery development, laser protection, low observable materials, and unique identification and paint filters for industrial applications.

Sensors, electronics, and automated-systems development work is also expected to continue. We are developing sensors and integrated collection, detection, and evaluation technologies for chemical, environmental, and biological measurements for DoD. Radio frequency tags being developed for material protection control and accounting applications

are related to use within DARPA, DTRA, Army, and Navy for remote monitoring of system condition and status. New and innovative nondestructive examination and prognostics technologies have been developed and applied to the positive and growing problem of aging equipment and weapons, system health monitoring, and condition based monitoring.

Ultrasonic and electromagnetic imaging systems are being fielded to monitor and evaluate airframe, munitions, and undersea components. The Air Force and Army continue to support our radar cross-section holographic imaging technology. A variety of unique robotics for safety testing and specialized repair and operations tasks has been developed for DARPA. Large and small mobile robots equipped with various sensors have been developed for the DoD, Navy, and DOE communities. We developed a telerobotic system for disposal of explosive ordnance for the Navy. The Air Force has expressed interest in development of robotic systems for automated inspection of craft systems and components.

Pacific Northwest supports DoD environmental program needs for the Army, Navy, and Air Force using our capabilities in process technology, pollution prevention, water and land resources, risk management, environmental and regulatory compliance, marine science, and strategic environmental management. A wide range of integrated products and services are provided to our DoD customers, including system engineering; decision analysis; life-cycle analysis; strategic planning; technology management; site assessments/ characterization/remedial investigations; feasibility studies; National Environmental Policy Act (NEPA) support; environmental toxicology; remediation and pollution prevention; and technology development, adaptation, demonstration, and deployment. The emphasis is on demonstration and deployment of improved and innovative approaches and technologies to assess and clean up complex sites and reduce waste (pollution prevention) from existing and new systems.

Staff at Pacific Northwest provide expert assistance to DoD in systems analysis, technology evaluation, and statistics. This work includes technical support for modernization of major weapons production and logistics elements for the Army; evaluation of organization systems, procedures and methods, safety systems, and functioning of joint programs; and assessments of human factors impacts and training requirements. Industrial base modernization programs evaluate and apply computer-integrated manufacturing in Army production plants and efficient automation technology options to meet specialized maintenance technology requirements of the Army, Navy, and Air Force.

Pacific Northwest has a program with the DARPA Army Medical Research and Development Command for developing medical imaging systems and technologies that improve health care and battlefield treatment of the injured. We are continuing to work with both DoD and DOE to expand this effort into a broad and integrated partnership that would include all the national laboratories and Army and Air Force medical centers. We are also working with DARPA and the Air Combat Command Surgeon General to develop a visual epidemiological tool to detect, analyze, and predict health and disease trends and patterns.

Staff at Pacific Northwest are continuing to develop significant microsystems technology capabilities in areas of microthermal and microchemical systems that are of particular interest to DoD clients. For DARPA, we are developing compact microchannel chemical reactors. Our current efforts consist of the development of an integrated combustor/ evaporator that is designed to serve as a low-NOx heat source to drive man-portable soldier systems such as a compact personal cooling unit, and a liquid-hydrocarbon fuel processor that is designed to support man-portable power generation in a lightweight fuel cell. These projects are benefiting DARPA as leveraged investments against companion efforts to develop compact microsystem-based heat pumps and hydrocarbon conversion units for the U.S. Army Land Warrior Program and DOE. Pacific Northwest is also developing advanced information analysis and visualization technologies for DARPA.

Pacific Northwest continues to manage the International Border Security Support program with the Onsite Inspection Agency. The emphasis of this program is to train foreign border enforcement personnel at the Hanford Hazardous Materials Management Emergency Response (HAMMER) training facility.

Pacific Northwest continues to provide DoD with analytical chemistry support and radionuclide applications development. We have very sensitive and high-precision analytical techniques to meet measurement and testing requirements. Unique skills in analyzing radionuclides support specialized DoD needs.

Nuclear Regulatory Commission

Pacific Northwest National Laboratory's research and technical work supports all of the U.S. Nuclear Regulatory Commission (NRC) program offices and several regional and administrative offices. The work covers all aspects of nuclear safety regulation.

Office of Nuclear Reactor Regulation

Pacific Northwest provides support to the Office of Nuclear Reactor Regulation's (NRR's) Division of Reactor Project Management with technical assistance in improving work processes and supporting staff reviews of decommissioning-related activities and development of regulatory guidance and standard review plans related to the decommissioning process. Pacific Northwest will also provide the Division of Reactor Project Management with technical support in reviewing emergency action levels and developing emergency preparedness training for NRC inspectors.

Pacific Northwest will continue to support NRR's Division of System, Safety and Analysis in commercial in-reactor fuel performance. This work includes performing technical reviews of vendor and utility submittals on fuel designs, fuel performance codes, and control rod assemblies. Our staff will continue to prepare an annual summary of in-reactor fuel performance based on information from the vendors and open literature publications. This summary includes discussions of design trends, failure trends, and other topics of relevance to fuel performance. Another capability is assisting the Nuclear Regulatory Commission in on-site audits and inspection of fuel vendors and utilities.

Staff at Pacific Northwest will provide assistance to the NRR in regulatory and licensing activities in the siting and environmental protection areas, including the Environmental Standard Review Plan update and development effort. We will provide multidisciplinary managerial and technical expertise to assist the NRC in its licensing reviews for operating reactors, license extensions, and in updating regulatory guidance.

Office of Nuclear Regulatory Research

Pacific Northwest staff will continue to provide technical assistance to the Office of Nuclear Regulatory Research (RES) in decommissioning analysis and regulation. Technical analysis and cost estimates are provided for decommissioning licensed nuclear reactor power plants and licensed fuel-cycle and nonfuel-cycle nuclear facilities. The support Pacific Northwest provides to the NRC on short-turnaround analyses and addenda to previous decommissioning analysis reports should continue on a task basis. Current and future work for the NRC includes periodic updates of NUREG-1307 to reflect changes in the low-level waste burial site charge schedules, an analysis of the decommissioning of a large sealed-source user facility, and the reevaluation of the earlier fuel-cycle and nonfuel-cycle facility reports to reflect current financial and regulatory conditions. A computer program has been developed at Pacific Northwest for estimating decommissioning costs.

Nondestructive evaluation projects conducted at Pacific Northwest for RES have provided the engineering databases to support the NRC's position and policy on regulatory guides, position statements, analysis codes, and regulations. The elements of these projects include 1) studying nondestructive evaluation reliability to determine the effectiveness of in-service inspections, 2) optimizing in-service inspection programs using nondestructive evaluation reliability data and parametric fracture mechanics analysis to control risks, 3) assessing new nondestructive evaluation techniques and transferring technology to the NRC regional offices and the utility industry, and 4) developing a technical database for fabrication flaws in U.S. reactor pressure vessels for use in remaining life predictions. The nondestructive

evaluation technologies under study at Pacific Northwest include ultrasonics (including the synthetic aperture focusing technique for ultrasonic testing [SAFT-UT]), eddy currents, and acoustic emission. It is anticipated that when the advanced light-water reactor designs proceed, we will be involved in similar work for the new designs.

Pacific Northwest will continue to provide technical assistance in support of low-level radioactive waste storage. Such support includes classification, characterization, and assessment of waste streams and activated metals; source terms for performance assessments; and characterization of chelating agents.

Pacific Northwest is one of the primary technical resources for RES on commercial nuclear fuel. Issues related to high-burnup fuel in nuclear power plants have high importance for the NRC. Pacific Northwest staff will continue to develop and revise two fuel performance computer codes. This work is closely related to the fuel work being done for NRR.

Office of Nuclear Material Safety and Safeguards

Pacific Northwest will continue to provide technical assistance to the Office of Nuclear Material Safety and Safeguards (NMSS) in regulation of the gaseous diffusion uranium enrichment plants at Portsmouth, Ohio, and Paducah, Kentucky. We will assist NMSS in emergency response planning, seismic qualification, material control and accountability, and criticality safety inspections.

Pacific Northwest continues to provide support to NMSS in chemical safety, security, and safeguards; structural engineering; and international physical protection. As DOE turns over additional fuel cycle facilities to NRC regulation, there will be opportunities to assist NRC in reviewing and inspecting those facilities.

Other Nuclear Regulatory Commission Offices

Pacific Northwest continues to support the Office for Analysis and Evaluation of Operational Data by refining analytical tools used by the NRC's Emergency Response Organization. New and/or improved models that address cloud shine, modify wind fields, process meteorological forecasts, present results graphically, and calculate dose rates will be added to the RASCAL code. After the code is revised, tested, and installed, Pacific Northwest staff will train the NRC staff using the models.

We are also assisting the NRC's Office of Administration, Division of Facilities and Security by preparing a classified automated information systems security program and by revising operational security documents for conformance with revised regulations.

Environmental Protection Agency

Pacific Northwest National Laboratory conducts research to assist the U.S. Environmental Protection Agency (EPA) in its central role of environmental regulation in the United States. We continue to conduct a variety of research and development activities to improve the understanding of exposure, impacts, and risk from pollutants on human health and ecological systems. The primary areas of research that we will conduct for EPA include the following:

- modeling and assessment of the environmental impacts of increasing concentrations of trace contaminants in the atmosphere and potential resultant global climate change
- assessing the technologies and economic impacts of selected international strategies to reduce greenhouse gas emissions
- modeling and analyzing hazardous waste transport and fate in soil, water (both fresh and marine), air, and biota
- measuring and determining mass balance to assess sources and sinks of polychlorinated biphenyls in Lake Michigan

- researching, evaluating, testing, developing, and demonstrating alternative or innovative hazardous waste treatment and radon mitigation technologies
- measuring and analyzing the effects of toxic and hazardous chemicals on terrestrial and aquatic ecological systems, including the marine environment
- modeling the formation, transport, and impacts of acid rain and evaluating the strategies for control.

Pacific Northwest is also investigating the causes and effects of global climate change, and we expect that the EPA will continue to support such research in the Global Climate Research Program. We also are involved in measuring and assessing the impacts of pollutants on ecosystems including the Arctic, Great Lakes, the Everglades, and Northwest watersheds. Our researchers provide technical support to the Environmental Monitoring and Assessment Program by assisting in the design of studies to estimate the current status, extent, changes, and trends in indicators of the condition of the nation's ecological resources on a regional basis. We also provide technical support to the EPA's Ocean Disposal Program by conducting bioassays related to disposal area siting projects. Pacific Northwest also is developing and demonstrating methodologies and technologies to understand and mitigate risks associated with hazardous materials. Recent concerns of the EPA are the effects of contaminants on the reproductive health of humans and other mammals.

Other Federal Agencies and Nonfederal

Several other federal agencies fund work at Pacific Northwest. They include the Department of Defense, Nuclear Regulatory Commission, Environmental Protection Agency, Health and Human Services/National Institutes of Health, and the National Aeronautics and Space Administration. Pacific Northwest's work for nonfederal organizations averages approximately $1 million per year.

B Laboratory Profile Report

Pacific Northwest National Laboratory

Laboratory Information

Location: Richland, Washington
Number of Full-Time Equivalent Employees: 3,100
Scientific and Technical Degrees: 539 PhDs; 1,035 Bachelor's/Master's
Contractor: Battelle
Accountable Program Office: Science
Field Office: Richland Operations Office
Web Site: http://www.pnl.gov

Funding Sources

Science: $96.1 million
Nuclear Energy: $69.8 million
Environmental Management: $59.3 million
Nonproliferation and National Security: $49.3 million
Defense Programs: $26.8 million
Energy Efficiency and Renewable Energy: $18.3 million
Other DOE: $11.5 million
Non-DOE: $85.3 million

Total Funding: $416.4 million

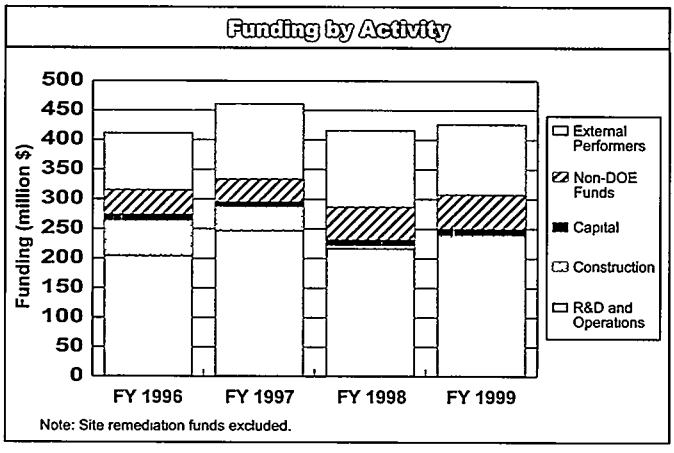
Note: Budget data shown are for FY 1998 and exclude remediation (cleanup) funds.

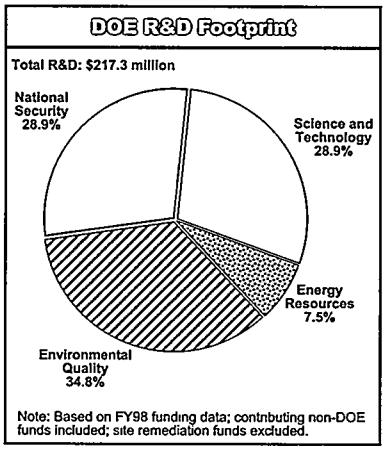
Description

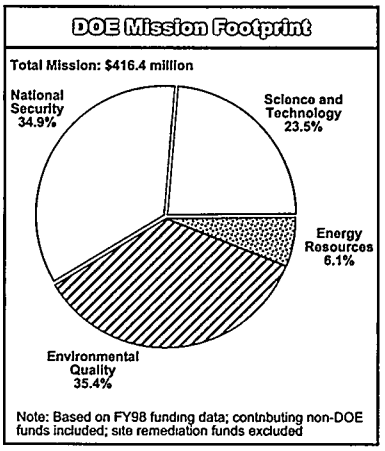
The Pacific Northwest National Laboratory uses its core environmental science and technology capabilities to create knowledge and tools for cleanup of Hanford and other Departmental production sites, and to understand and mitigate health and other consequences from pollution, climate change, and other environmental impacts. Strengths in molecular and measurement science, process science and engineering, computational science, information visualization, materials science and engineering, and nuclear science and technology underpin Pacific Northwest National Laboratory's arms control and non-proliferation, reactor safety, and tritium process development roles in Department's national security mission, and development of lightweight materials for transportation and efficient-building technologies for Department's energy mission. The centerpiece of the Laboratory is the William R. Wiley Environmental Molecular Sciences Laboratory, a user facility dedicated to leading-edge environmental molecular science. Pacific Northwest was established in 1965 at the Hanford Site in southeast Washington to support materials production and nuclear technology development. Staff at the Laboratory are broadly engaged in local economic development, education, and other community programs.

Distinctive Competencies and Major Facilities

Molecular Science: Chemical theory and dynamics, modeling and simulation, macromolecular structure and function, single-molecule optical and other spectroscopies, and chemical processes at interfaces
Computational Science: Advanced algorithms/tools for simulations of climate, chemical reactions, and new material manufacturing
Materials Science and Engineered Applications: Advanced synthesis and molecular-scale characterization of ceramics and lightweight materials
Environmental Science and Technology: Molecular to field-scale studies of the characteristics and performance of various subsurface and surface environmental systems and broadly based assessments of land and marine ecologies and possible restoration processes
Process Science and Engineering: Radiochemical separation processes and in situ and ex situ bio-based and thermal processing
Nuclear Science and Technology: Reactor safety and component design, nuclear waste and fuel management, tritium and isotope production, and nuclear nonproliferation, including ultrasensitive detection and identification of nuclear, chemical, and biological species
Economic and Social Sciences: Human/social/economic consequences of energy generation/use, and human factors and user interface design
Advanced Scientific Instrumentation: Tools and procedures for radiation measurement, mass spectrometry, nuclear magnetic resonance, and optical/laser spectrometry
Major Facilities: The Wiley Environmental Molecular Sciences Laboratory (EMSL), a national user facility, includes unique computational, high field NMR, mass spectrometric, surface science, and other laboratories to perform cutting-edge molecular science targeting the Department's environmental mission. The **Biological and Life Sciences Labs** house studies on genetic effects, exposure responses, biomaterial fabrication and performance, subsurface biologies, and related areas. The **Process Science and Engineering Complex** and **Applied Process Engineering Laboratory (APEL),** a suite of linked government and private facilities, dedicated to developing chemical, thermal, and biological processes for environmental and energy applications. The **Radiochemical Processing Laboratory** provides specialized facilities for a broad array of studies requiring the use of radioactive or other hazardous materials, and the **Marine Sciences Laboratory** provides unique facilities for a wide variety of marine research studies.







Pacific Northwest National Laboratory

Key Research and Development Activities

Science and Technology Mission: The Laboratory conducts basic research in environmental, chemical, life, and materials sciences to provide the fundamental knowledge required for materials for new fuel and power sources and efficient energy use, transport and fate of contaminants, human health and global climate impacts, and computer simulation of complex and environmental systems. Principal activities include:

- Molecular-level investigation of chemical structures at interfaces and investigation of the mechanisms and dynamics of interfacial reactions on atmospheric pollutant particles, materials in the subsurface, and advanced catalysts
- Understanding the nature of subsurface microbial systems and the mechanisms through which they can be used to remediate the environment
- Development of advanced synthesis (vapor, solution, or solid) techniques and understanding of environmental interactions (down to the molecular level) of materials for lightweight vehicles, fuel cells, batteries, and biomedical uses
- Use of computational modeling and structural biology to determine organism, cellular, and molecular responses to environmental contaminants to predict health impacts from exposures
- Development of advanced scientific instrumentation theory and tools to support molecular science investigations and for ultrasensitive measurements for process control, characterization of dangerous wastes, and identification of environmental contaminants
- Development of high-performance computing algorithms and problem-solving environments for modeling large, complex processes and systems such as subsurface contaminant movement and transformation for risk assessment and design of remediation technologies, chemical reactions in complex environments, and performance of metals during high-deformation forming
- Measurement of atmospheric data to support advanced climate models, and assessment of regional consequences of model predictions

Environmental Quality Mission: Principal research focus areas include retrieval, treatment and safety assessment of tank wastes and other radioactive and hazardous wastes; understanding spent fuel materials issues; characterization, containment, and treatment of subsurface contaminants; management of land and marine ecosystems; and social, economic, health, and policy related assessments of environmental problems and possible solutions. Activities include:

- Development of technologies to treat and immobilize stored radioactive and hazardous wastes and technologies to remove, immobilize, and/or destroy subsurface organic and metal contaminants, using chemical, thermal, and biological means
- Development and use of advanced techniques to monitor and characterize radioactive and chemical wastes and contaminated soils and groundwater systems, and development of technologies to fuse, analyze, and display the resulting information
- Development and use of tools and approaches for comprehensive management of natural resources including assessment of ecosystem health and impacts from possible land uses and integration of economic/social/political considerations into land-use and other decisions
- Investigation of marine chemistry, ecological processes, resources, organism health, and adaptive ecosystem management, with emphasis on characterization of the sources, fates, and effects of chemical contaminants
- Measurement of exposures to radioactive and chemical agents and development and use of tools to assess human health impacts
- Technical, social, and economic studies supporting formulation of environmental policies and regulations
- Creation and use of models and associated geohydrological data for predicting the performance of remediation technologies and waste disposal sites
- Improving the safety of foreign nuclear reactors by providing emergency procedures and training, new maintenance techniques, new designs for safety systems and fuel storage, and new regulatory infrastructure.

National Security Mission: Research supports the U.S. objectives of nonproliferation of weapons of mass destruction and maintenance of defense readiness through: test-ban-treaty monitoring technologies and data management, remote physical and chemical detection of proliferation or diversion, control of nuclear and chemical/biological weapons, techniques for tritium production in light-water reactors, care and protection of humans in combat situations, weapons demilitarization, protection of critical elements of the national infrastructure, and enhancement of law enforcement and anti-terrorism. Activities include:

- Development and use of ultrasensitive nuclear radiation detection and analysis systems to monitor creation and control of fissile materials
- Technical support for treaty negotiation and implementation, including information management and training
- Development of integrated systems to detect and characterize pathogens and chemical weapons
- Creation and use of methods, strategies and technologies to support threat vulnerability assessment, risk management, emergency response, information assurance, and infrastructure protection
- Design of in-reactor assemblies and separations processes to produce tritium in light-water reactors
- Creation of new sensors, data fusion, and non-destructive inspection technologies for extending the life of aging military systems and infrastructure
- Development of microtechnologies for compact power generation, man-portable heating and cooling, and chemical processing for fuel conversion and hazardous waste destruction
- Creation, use, and deployment of information visualization tools to facilitate rapid analysis of massive amounts of data, automatic text content discovery, and interactive visualization and analysis for national security and other missions

Energy Resources Mission: Principal research focus areas include advanced material/component designs for high-efficiency cars and heavy trucks; standards and technologies for energy-efficient buildings; technologies for clean, productive, and sustainable industries of the future; and distributed power generation and electrical storage systems. Key research and development activities include:

- Design of lightweight materials (particularly metal alloys) and development of design and manufacturing techniques for high-efficiency vehicle components
- Creation of engineered materials and system designs for fuel cells, batteries, and capacitors for transportation and distributed power generation
- Creation and use of computational mechanics and virtual prototyping to support component design, processing, and advanced lifecycle manufacturing
- Development of intelligent sensors and controls for vehicle operation and improving efficiency, energy efficient buildings, and remote sensing
- Development and deployment of new technologies, controls, and energy standards to improve energy efficiency of homes and buildings
- Development of new technologies to improve industrial processes, and reduce both material requirements and process by-products in the forest product, glass, chemical, and agricultural industries

Pacific Northwest National Laboratory

Significant Accomplishments

Global Climate Assessment (1989 to present): The Laboratory has made significant contributions to understanding the physical mechanisms underlying global climate change, assessing the regional impacts of these changes, and evaluating possible migration methods. Pacific Northwest helped establish, and provides day-to-day management of, the Atmospheric Radiation Measurements (ARM) program, the Department's principal program to understand the role of clouds and atmospheric aerosols on radiative transport in the atmosphere. The Laboratory's Second Generation (Economic) Model (first published in 1991) is one of the most widely used tools to examine the effects of energy policy and technology change on greenhouse gas emissions and to understand the costs and feasibility of alternative paths for stabilizing greenhouse gas concentrations in the atmosphere.

Computational and Analysis Chemistry (1989 to present): Pacific Northwest has led the development of a new generation of computational chemistry codes for advanced-architecture computers to address previously intractable scientific problems and critical environmental and biological applications. The NWCHEM software (first broadly released in 1997) has resulted in a significant extension in the size of problems that can be accurately addressed computationally. It is receiving broad academic and industrial use, and many of its components are being used to advance other computational science applications.

Advanced Scientific Instrumentation: The Laboratory has achieved dramatic advances in the precision and sensitivity of analytical chemistry instrumentation (e.g., new and unique mass spectrometers and field-deployable radiation counting equipment) for environmental, health effects, and national defense applications. Specific advances include techniques for interfacing capillary electrophoresis and plasma source ionization with mass spectrometry, and the development of new atmosphere monitors for international treaty verification. The new technologies have resulted in several R&D 100 awards, technology transfer awards, and commercial adaptation.

Arms Control and Nonproliferation (1988 to present): Pacific Northwest has made significant contributions to the international community's ability to monitor compliance with arms control treaties and the possible diversion or creation of weapons of mass destruction. The Laboratory has developed statistical techniques for analysis of seismic activity from weapons tests and fully automated instrumentation, such as the award winning Radionuclide Aerosol Sampler/Analyzer (first model in 1993 and R&D 100 in 1998), for monitoring treaty compliance and early detection of weapons proliferation and illicit materials trafficking. The Laboratory also has created safeguards and security programs for accountability and control of special nuclear material in the U.S. and abroad, starting in 1992. Specific efforts in information acquisition and visualization, dismantlement of nuclear warheads, and cleanup and accountability of nuclear materials in North Korea have helped decrease the probability of nuclear weapons proliferation.

Subsurface Science (1983 to present): Pacific Northwest has contributed significantly to the fundamental scientific understanding of contaminant transport and fate in the subsurface. The Laboratory's research has led to: the development of sophisticated computer models that incorporate biogeochemical and hydrogeologic processes to predict chemical species and how they move in the subsurface, and to the identification of novel microorganisms in the deep subsurface that may lead to new remediation methods, such as In-Situ Redox Manipulation (R&D 100 in 1998), which modifies subsurface geochemistry to immobilize contaminants.

Radiation and Chemical Health Effects (1970 to present): Pacific Northwest played a major role in developing instruments, calibration methods, and facilities for radiation detection and protection of workers, workplaces, and the environment. Laboratory research contributed to advances in radiation dosimetry and the development and application of dosimetry models. Recent accomplishments include broad application of the more sensitive optically stimulated luminescence (OSL) dosimeters (R&D 100 winner in 1992), real-time dosimeters for the Space Shuttle, and increased understanding of the molecular mechanisms that underlie health effects form low-dose exposures. The Laboratory's recent work on understanding the heath effects from chemical toxins led to the development of a real-time monitor to measure worker exposures to hazardous chemicals (1998).

Energy Technologies (1970s to present): The Laboratory played a principal role in developing energy efficient building standards and associated metering equipment and design tools, such as MECcheck (1997 FLC award). Staff worked with groups such as ASHRAE and over 20 states to deploy the tools and standards, which are projected to save U.S. consumers $2 billion in lower energy bills in the year 2000. The Laboratory is developing advanced fuel cells and new microtechnologies to improve or replace current mobile and distributed power systems. Through public-private partnerships the Laboratory is developing lightweight materials and associated modeling and manufacturing techniques to build new vehicles that can meet future fuel efficiency goals. The Laboratory was instrumental in the development of energy efficiency centers (starting in 1989) in Moscow, Beijing, Kiev, and other Eastern European cities, and which now play central roles in the introduction of new energy technologies and policy development.

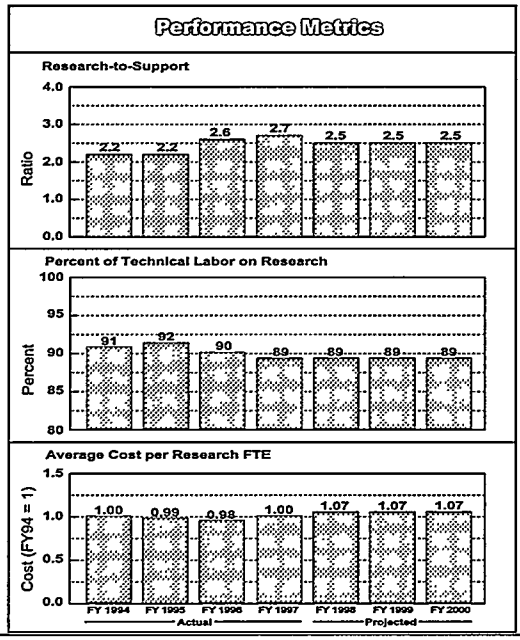
Waste Management and Environmental Technologies (1965 to present): The Laboratory has been a leader in characterizing, assessing, and remediating legacy nuclear and chemical wastes and contaminated sites. It played a major role in the U.S. High-level nuclear waste disposal program, screening of potential repository sites and demonstrating the viability of a variety of waste forms and treatment options, including vitrification technology, which is now used worldwide (1965 to 1985). The Laboratory leads the National Tank Focus Area (1994 to present), a program to develop, test, and deploy new technologies to retrieve and pretreat the Department's highly radioactive tank wastes. Since 1990, the Laboratory has developed literally dozens of technologies to solve Department and industrial environmental problems, in such areas as advanced characterization techniques, new separations agents for reducing wastes volumes, techniques to chemically or biologically manipulate the subsurface to destroy or contain contaminants, and advanced robotic systems for performing hazardous decommissioning work.

Nuclear Science and Technology (1950's to present): The Laboratory and its predecessors have made significant contributions to civilian nuclear power in the areas of power system design, technical foundations for regulations, operator training and qualification, and reactor safety. Accomplishments include alternative reactor designs; development and commercialization of fuel design, fabrication, and reprocessing techniques; the design of the Fast Flux Test Facility; demonstrating production of tritium in light-water reactors (1998); and purification of derived isotopes for medical and other applications. The Laboratory was a major contributor to the first quantitative assessment of reactor accident risks, and to the resolution of critical materials and other technical issues affecting reactor safety and regulation. The Laboratory also played a leading role in the Department's health and environmental response to the Chornobyl accident, and is making significant contributions to improving the safety of the nuclear industry in the former Soviet Union.

Pacific Northwest National Laboratory

Major Partnerships, Collaborations, and Cooperative Research and Development Agreements

Category/Mission	Partners	Description
Science and Technology		*A wide range of academic partnerships promote both scientific discovery and education and, in combination with our lab and industrial partnerships, bring the best talent to the Department's most challenging problems and open Pacific Northwest National Laboratory facilities to the broader scientific community.*
	DOE Labs and universities	**Atmospheric Radiation Measurements (ARM).** Long-term field measurements are taken to improve understanding of processes controlling distribution of energy and water in earth's climate system.
	LANL, LBNL, several university programs	**Joint Catalysis Institute (JCI).** This focuses on development of new catalyses and processes that will mitigate the release of or sequester greenhouse gases resulting from energy conversion and use.
	ANL, LBNL, ORNL, SNL, 3 NW universities	**DOE 2000.** Scientists are designing a collaborative integration framework required for communication among collaboratory tools, data transport, and resource location. Tools that manage real-time collaboration sessions are being developed that will enable scientists to interact as if they were physically co-located.
	7 DOE labs, 15+ universities, and 2 industries	**Natural and Accelerated Bioremediation Research (NABIR) Program.** This is a fundamental science research program on subsurface biological systems and their application to bioremediation.
Environmental Quality		*Lab/industry/university partnerships span the development lifecycle from basic science to final deployment, providing comprehensive solutions to DOE's complex environmental problems and to related problems facing industry and other countries.*
	DOE Labs, universities, and industry	**Environmental Management Science Program.** The focus of the Laboratory's projects is on managing tank wastes, in situ treatment of groundwater, and health effects. Pacific Northwest has partnered with a variety of organizations in its EMSP projects where the work directly supports critical Hanford science needs.
	DOE Labs and contractors, universities, and industry	**Tank Focus Area.** This program develops technologies to safety and efficiently remediate radioactive waste stored in tanks at four Department sites. The multi-lab management and technical teams, with their industry partners, have delivered new waste retrieval systems, characterization tools, and treatment processes.
National Security		*Partnerships bring together the broad complement of resources and highly specialized expertise needed to address the multi-disciplinary nature of many national security issues such as counter-terrorism.*
	DOE Labs, U.S. firms, host countries	**International Nuclear Safety Program.** This program reduces risks of operating Soviet-designed nuclear reactors by working cooperatively with host countries on nuclear safety and supporting technical infrastructure.
	Univ. of Wash. and other NW universities	**Pacific Northwest Center for Global Security.** This center links with Northwest universities and scolars to enhance the information, contacts, and expertise available to the Laboratory's Arms Control and Nonproliferation program and to provide opportunities for students and faculty to contribute to this program.
	DOS, Customs, DTRA, and DOD	**Department of Defense/U.S. Customs Service International Border Security Training.** This program provides comprehensive classroom and hands on training for foreign border enforcement officials to enable them to detect, identify, investigate, and interdict smuggling activities.
Energy Resources		*Partnerships provide direct knowledge of the technical issues facing energy providers and users, and to provide industrial involvement from basic research, through development, to ensure direct deployment of the results in industry.*
	DOE Labs, universities, and industry	**U.S. Council for Automotive Research (USCAR).** The Laboratory and its partners are using their joint capabilities in materials sciences, processing, and modeling to develop advanced forming technologies for lightweight materials.
	Universities and industry	**Northwest Alliance for Transportation Technologies (NATT)** is a public-private partnership covering research universities and industry to address transportation technology goals. Its focus is development of low-cost, lightweight materials and tailored manufacturing processes necessary to achieve the 40% weight reduction goals of the Partnership for a New Generation Vehicle.
	State and federal government, industry, DOE Labs	**Building Standards and Guidelines.** Pacific Northwest chairs the largest energy standard setting committee for ASHRAE, consisting of industry, labs, and state and federal government energy professionals. The Laboratory also has helped over 20 states adopt, upgrade, implement, and enforce their building energy codes.



Pacific Northwest National Laboratory

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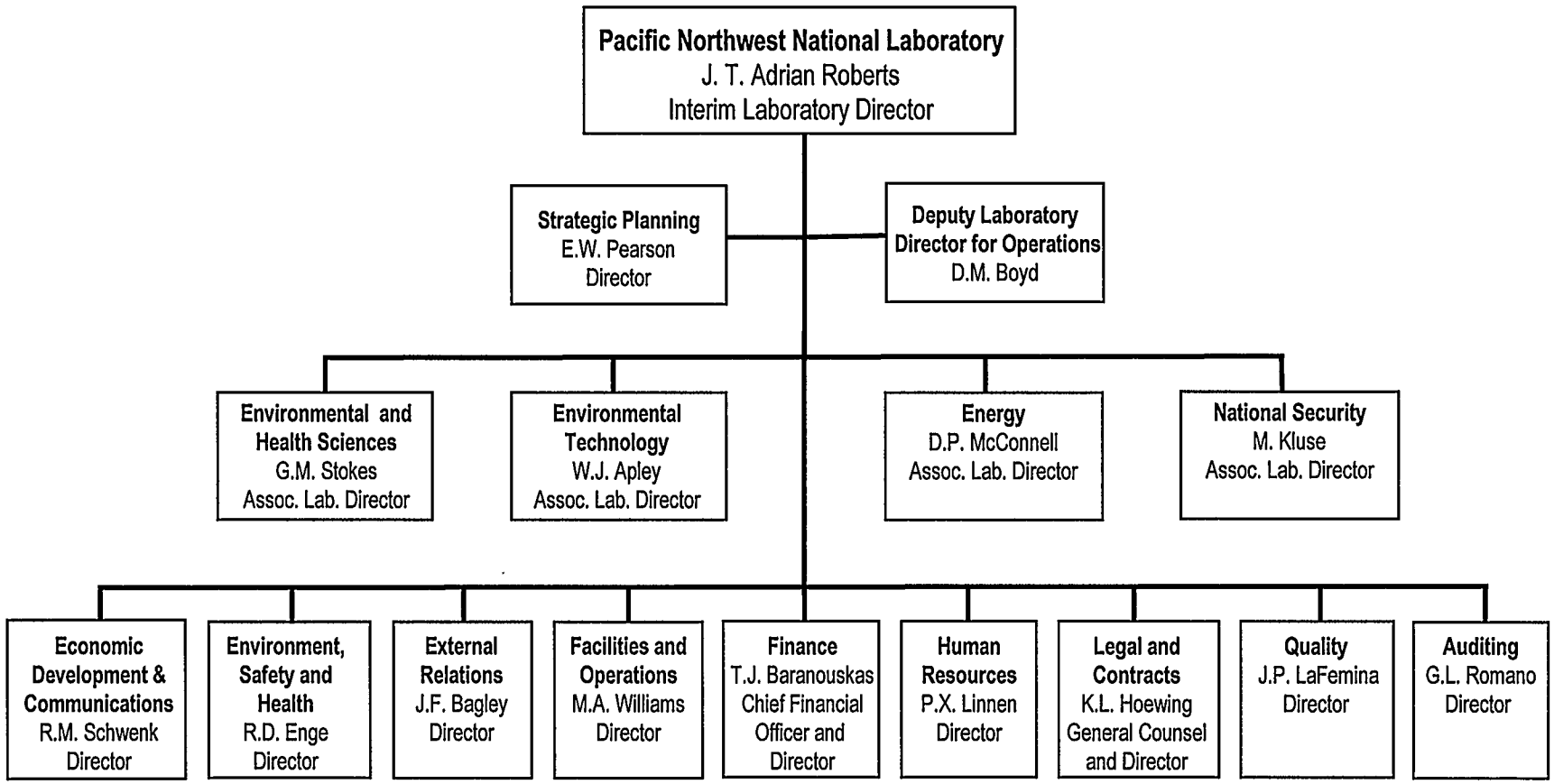

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