Oak Ridge National Laboratory

FY 1987–1992
Institutional Plan

Printed in the United States of America. Available from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161. NTIS price codes: printed copy, A07; microfiche, A01,

The information in this Plan was obtained with the cooperation of the professional staff of the Oak Ridge National Laboratory. Additional copies of the *Institutional Plan FY 1987–FY 1992* may be obtained from the Program Planning and Analysis Office, Oak Ridge National Laboratory, Building 4500N, P.O. Box X, Oak Ridge, Tennessee 37831-6251. Telephone (615) 574-4168 (FTS 624-4168).

Cover: *The High Temperature Materials Laboratory is a new research center and user facility that will serve a multidisciplinary staff investigating new ceramic and alloy materials that have potential for high-temperature structural and mechanical applications.* Design by V. L. Conner; photograph by J. W. Nave.

ORNL/PPA-86/2

OAK RIDGE NATIONAL LABORATORY INSTITUTIONAL PLAN FY 1987–FY 1992

DATE PUBLISHED–NOVEMBER 1986

Senior Planning Group

H. Postma
F. R. Mynatt
C. R. Richmond
M. W. Rosenthal
D. B. Trauger
R. S. Wiltshire
A. Zucker

Planning Staff

M. L. Sollenberger
J. W. Terry
T. D. Anderson
J. R. Engel
L. L. Horton
J. E. Swift
J. L. Trimble

Oak Ridge National Laboratory
operated by
Martin Marietta Energy Systems, Inc.
for the
U.S. DEPARTMENT OF ENERGY
under Contract No. DE-AC05-840R21400

CONTENTS

ACRONYMS

AACE	Athens Automation and Control Experiment
ACTO	Advanced Control Test Operation
AEC	Atomic Energy Commission
AEOD	Office for Analysis and Evaluation of Operational Data
AGS	Alternating Gradient Synchrotron
AI	artificial intelligence
AID	Agency for International Development
AIM	Accelerator Improvements and Modifications
AIP	Accelerator Improvements Project
AIRD	Acoustics and Instrumentation Research and Development
AMSL	Analytical Mass Spectrometry Laboratory
ANL	Argonne National Laboratory
AR&TD	Advanced Research and Technology Development
ARIM	Accelerator and Reactor Improvement and Modification
ASCE	Assistant Secretary for Conservation and Renewable Energy
ASDP	Assistant Secretary for Defense Programs
ASESH	Assistant Secretary for Environment, Safety, and Health
ASFE	Assistant Secretary for Fossil Energy
ASM	advanced servomanipulator
ASNE	Assistant Secretary for Nuclear Energy
ATF	Advanced Toroidal Facility
BA	budget authorization
BER	Building Equipment Research
BNL	Brookhaven National Laboratory
BO	budget obligation
BRET	Breeder Reprocessing Engineering Test
BTESM	Building Thermal Envelope Systems and Materials
CAMDEC	Ceramic Advanced Manufacturing, Development, and Engineering Center
CBCF	carbon-bonded carbon fiber
CERN	Conseil Européen pour la Recherche Nucléaire
CDEP	Cooperative Developmental Energy Program
CDIC	Carbon Dioxide Information Center
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CESAR	Center for Engineering Systems Advanced Research
CFRP	Consolidated Fuel Reprocessing Program
CFS	central file storage
CH	contact handled

CIT	Compact Ignition Tokamak
CNR	Center for Neutron Research
CWDF	Central Waste Disposal Facility
DARPA	Defense Advanced Research Project Agency
D&T	development and technology
DHHS	Department of Health and Human Services
DIII-D	Doublet III-D tokamak
DNA	deoxyribonucleic acid and DNA—Defense Nuclear Agency
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOT	Department of Transportation
DP	defense program
DSRD	Data Systems Research and Development
EBS	Elmo Bumpy Square
EBT	Elmo Bumpy Torus
ECUT	Energy Conversion and Utilization Technologies
EH&S	environmental, health, and safety
EIA	Energy Information Administration
EMP	electromagnetic pulse
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ERFU	Environmental Restoration and Facilities Upgrade
ESA	Environmental and Safety Activities
ESD	Environmental Sciences Division
ETP	Emergency Technology Program
FDA	Food and Drug Administration
FEDC	Fusion Engineering Design Center
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FMPC	Feed Materials Production Center
FTE	full-time equivalent
GPE	general-purpose equipment
GPF	General-Purpose Facility
GPP	general plant project
HASRD	Health and Safety Research Division
HBCU	Historically Black Colleges and Universities
HERMIES	Hostile Environment Robotic Machine Intelligence Experiment Series
HFIR	High-Flux Isotope Reactor
HHIRF	Holifield Heavy Ion Research Facility
HILI	Heavy Ion Light Ion
HISTRAP	Heavy-Ion Storage Ring for Atomic Physics
HLW	high-level waste
HMW	hazardous and mixed waste

HPRR	Health Physics Research Reactor
HTGR	high-temperature gas-cooled reactor
HTML	High Temperature Materials Laboratory
HVAC	high-voltage alternating current
HVDC	high-voltage direct current
HWM	Hazardous Waste Management
HWERL	Hazardous Waste Engineering Research Laboratory
IAEA	International Atomic Energy Agency
IBD	Ion Beam Deposition
ICH	ion cyclotron heating
IDB	integrated data base
IET	Integrated Equipment Test
IFSMTF	International Fusion Superconducting Magnet Test Facility
INEL	Idaho National Engineering Laboratory
INTOR	International Tokamak Reactor
JAERI	Japan Atomic Energy Research Institute
JET	Joint European Torus
LANL	Los Alamos National Laboratory
LCP	Large Coil Program
LLNL	Lawrence Livermore National Laboratory
LLW	low-level waste
LMR	liquid metal reactor
LTNIF	Low Temperature Neutron Irradiation Facility
LWR	light-water reactor
MGPF	Multiprogram General-Purpose Facilities
MHTGR	modular high-temperature gas-cooled reactor
MRS	Monitored Retrievable Storage
NASA	National Aeronautics and Space Administration
NAVFAC	Naval Facilities Engineering Command
NCI	National Cancer Institute
NCSASR	National Center for Small-Angle Scattering Research
NEESA	U.S. Naval Energy and Environmental Support Activity
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NG	newly generated
NIH	National Institutes of Health
NLM	National Library of Medicine
NMFECC	National Magnetic Fusion Energy Computing Center
NRC	Nuclear Regulatory Commission
NSF	National Science Foundation
NSLS	National Synchrotron Light Source
NTP	National Toxicology Program
OASD	Office of Assistant Secretary of Defense
OCRWM	Office of Civilian Radioactive Waste Management

OEP	Office of Electric Power
OER	Office of Energy Research
OHER	Office of Health and Environmental Research
OJCS	Organization of Joint Chiefs of Staff
ORAU	Oak Ridge Associated Universities
ORELA	Oak Ridge Electron Linear Accelerator
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
ORR	Oak Ridge Research Reactor
ORSEC	Oak Ridge Science Education Center
OSTC	Office of Scientific and Technical Computing
OTA	Office of Technology Assessment
PNC	Power Reactor and Nuclear Fuel Development Corporation (Japan)
R&D	research and development
RAP	Remedial Action Program
RCRA	Resource Conservation and Recovery Act
RCS	Residential Conservation Service
RFTF	Radio Frequency Test Facility
RH	remotely handled
RIMS	Resonance Ionization Mass Spectrometry
RPP	Radiochemical Processing Plant
SCO	Support Contractor Office
SCSS	Sequence Coding and Search System
SDI	Strategic Defense Initiative
SFC	Synthetic Fuels Corporation
SHaRE	Shared Research Equipment
SMAC	Surface Modification and Characterization
STC	Scientific and Technical Computing
STX	Spherical Torus Experiment
SURA	Southeastern Universities Research Association
TCRD	Tennessee Center for Research and Development
TEXTOR	Tokamak Experiment for Technical Oriented Research
TFTR	Tokamak Fusion Test Reactor
TPP	Transuranium Processing Plant
TRU	transuranic
TURF	Thorium-Uranium Recycle Facility
ULCP	University Laboratory Cooperative Program
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
UTK	University of Tennessee at Knoxville
WFO	work for others
WIPP	Waste Isolation Pilot Plant
WMTC	Waste Management Technology Center

Director's Statement

DIRECTOR'S STATEMENT

This *Institutional Plan* for Oak Ridge National Laboratory (ORNL) is composed of two major parts, a strategic view over a fifteen-year planning period and a much shorter view over a five-year planning period. Many important research programs and projects will begin in the next five years, but because these programs will not culminate for more than a decade, they appear small in the extended budget projection and thus seem to lose their significance. They will, however, become important and are consistent with our long-term strategic view.

Two major forces—energy and global competition—provide the greatest long-range direction and motivation for the Laboratory. Energy production, environmental consequences, and conservation will remain very important issues for the United States for the foreseeable future. Research, development, and demonstrations associated with energy production and conservation, as well as basic research in both the physical and life sciences supporting those technologies, will remain the backbone of work at ORNL during this planning period.

The ability of the United States to be innovative and thus to remain competitive in ever-increasing global competition will be an equally important task. Those countries that can most quickly turn innovative ideas into desirable goods will be the winners. Thus, the ability of ORNL to utilize results from its energy work to keep the United States competitive globally will be a strong goal for us during this long-term planning period. Maintaining leadership in energy research and increasing U.S. competitiveness will challenge ORNL to become more involved and more collaborative than in the past and will require us to look for new areas of collaborative research.

In the near term, because of attempts to minimize the national budget deficit and because of the current energy glut, research in energy technologies is at an all-time low; as a result, no demonstration facilities are being built or planned for any area of energy—not solar, fission, fossil, fusion, or conservation. In fact, many large demonstrations, particularly in the liquid fuels area, have been canceled in the past few years.

On the other hand, the base technologies that undergird technological demonstrations and prototypes have continued steadily. During the long-term planning period envisioned in this document, we anticipate that these technologies will be consolidated and that they will culminate in actual demonstrations in a variety of areas. In fusion energy, for example (probably with some international partners), we see the development of an ignition device as well as the demonstration of a small advanced fission reactor that is inherently safe, reliable, and environmentally acceptable. We also see smaller prototype demonstrations of such things as commercial-size absorption heat pumps, all-ceramic heat engines, new fuel-conversion technologies (including coal-conversion technologies), better combustion tech-

niques, and new ways to reduce releases and emissions. The Laboratory intends to participate fully in these technologies as they evolve and to help provide the technical input into demonstrations as they become needed.

Because of this sense of urgency and because of budget constraints, the nation must continue calling upon all of its resources—universities, industry, and national laboratories—to work together in new ways. Thus, during this planning period, ORNL will respond to national needs by seeking an even greater level of collaboration by cooperating with universities, industry, and other government agencies; increasing technology transfer; creating new partnerships and consortia; utilizing our user facilities more fully; and forming joint partnerships to respond to new, urgent requests from industry and government.

From its earliest days, the Laboratory has worked hard to transfer technology and to collaborate fully with others. Reactor technology was transferred to Hanford, results of fuel cycle research to Idaho and Savannah River, nuclear submarine reactor technology to Idaho, and civilian reactor technology to the world through the Oak Ridge School of Reactor Technology. That collaboration has continued over the decades as marked by the extensive use of subcontractors, creation of user facilities, and exchanges of personnel. Recent collaborative efforts included the development of the Tokamak Fusion Test Reactor (TFTR) with Princeton, collaboration with several nations on the International Fusion Superconducting Magnetic Test Facility, work with several universities to optimize biomass production, and collaboration with industry on heat pump technology. The combination of technology transfer, consortia, and collaboration will make the operation of ORNL even more complex than it is now; however, this broad scope is essential to our national role, and the Laboratory will continue to seek new partnerships, new ways, and new missions.

Most of this plan is consistent with these broad objectives, but because it addresses very specific items that are only parts of our overall objective, the larger picture might not be easily seen. Because the planning period is divided into the short and long term, some programs and projects that are just getting started do not show up in the budget yet. Examples of such new programs are those nurtured in the past by the successful seed money program at ORNL, which was favorably reviewed by the Department of Energy this year. A similar, exploratory funds program, which supports new projects for several years, has recently been created and has also become exceptionally successful. Although exploratory fund projects and other embryonic projects are not evident in the long-term budget projections of this document, experience has shown that many of them will grow, change the directions we focus on, and become extremely important to work at ORNL in future years.

Finally, while the Plan does not address it in specific programs, there will be a consistent and complete dedication to quality of results and excellence in execution of all programs.

Herman Postma, *Director*

Laboratory Missions

LABORATORY MISSIONS

The primary mission of the Oak Ridge National Laboratory (ORNL) is to carry out applied research and engineering development in fusion, fission, and other energy technologies and scientific research in fundamental physical and life sciences to underpin work in the energy technologies. A secondary mission of the Laboratory is to use its resources to address other nationally important issues, such as hazardous and chemical wastes and non-nuclear defense technologies, when such work is closely related to the primary mission. In keeping with these missions, ORNL serves as a resource for the Department of Energy (DOE) by providing the technical knowledge needed to develop a sound, stable energy program and assists DOE in defining a comprehensive nuclear-energy program to meet short-term and long-term national needs. In addition, ORNL designs and operates research facilities for the benefit of members of the scientific and technical community and supplies radioactive and stable isotopes that are not available from the private sector.

To fulfill its missions, ORNL focuses its scientific and technical efforts on (1) magnetic fusion, with emphasis on applied plasma physics, experimental and design studies of confinement configurations, development of plasma heating and fueling systems, development of superconducting confinement magnets, and testing of candidate first-wall and blanket materials; (2) nuclear fission, with emphasis on development of nuclear fuel reprocessing, technologies for advanced nuclear power reactors with special emphasis on materials, instrumentation and controls, and robotics, and technologies for managing nuclear and chemical waste; (3) biological and environmental basic and applied research, with emphasis on the interaction of energy-related physical and chemical agents with living organisms; (4) conservation and renewable energy, with emphasis on generic research for high-temperature materials, power systems, biomass production, energy storage, and technology development for building and industry; (5) fossil energy, with emphasis on materials, environmental control technologies, and environmental safety and health research; and (6) basic research in physical sciences, with emphasis in materials research on radiation effects, neutron scattering, and surface physics, in chemical sciences on aqueous solutions, and in nuclear physics on heavy-ion reactions. In addition, ORNL maintains close interactions with scientific and technical personnel in universities and industry.

Laboratory Strategic View

LABORATORY STRATEGIC VIEW

What will happen, what could happen, and what we want to happen are three different ways of thinking about the future. The ORNL "Strategic View" represents the convictions of the Laboratory's senior management about the future and about the role we want ORNL to play in that future. Thus, our strategic view is a reasonable approach to what we want to happen; knowing where we want to go is an important part of getting there. For purposes of this activity, the planning horizon extends 15 years.

Planning Assumptions

General Environment

Within the next five years, energy will once again become an important area for research and development (R&D). Energy supplies in the United States and the world will tighten in the latter part of this decade due to world economic and population growth. A significant influence in the economic growth will be the emergence of some of the Third World countries as important consumers. Demand for the "basics," including energy, will become stronger. Driven by economic growth and continued Middle East instabilities, energy will become an important international issue early in the next decade. By that time, it will become obvious that this nation needs a coherent, sustained R&D program on energy technologies. We assume that many of the present-day, DOE-related projects such as acid rain, the Strategic Defense Initiative (SDI), and hazardous mixed wastes will become a direct part of the DOE mission.

Even before that recognition, we strongly believe that international competition and trade imbalance will be a growing concern bringing about an increasing national resolve to use the DOE national laboratories in a stronger collaborative mode with industry to improve the United States' competitive position.

As before, in the energy crisis, the central issue will be liquid fuels. The production and efficient use of liquid fuels will become focal points for a revived energy R&D program. In the electrical energy area, the rest of the world will continue to move toward nuclear energy in spite of the Chernobyl accident, and it will become evident that the United States' forfeiture of its leadership position in nuclear technology has cost it dearly, not only in terms of energy production but also in terms of lost opportunities in international trade and influence over important matters such as direction, safety standards, and fissile material control. This realization on the part of our federal government will result in a revitalized national effort in fission-power reactor and advanced reactor development with a strengthening of light-water reactor (LWR) technologies. Fusion energy R&D will continue to be an important activity involving strong international cooperation and collaboration. Near the end of the planning period, a large advanced toroidal fusion device will be built on the Oak Ridge Reservation.

The question of hazardous chemical and nuclear wastes will continue to be important nationally throughout the remainder of this century and beyond with increasing emphasis on low-level and high-volume waste. The techniques and technologies for neutralizing existing hazardous waste sites will, for the first half of the planning period, be the highest priority objectives of national R&D programs on waste. Efforts related to waste problems will produce a better understanding of natural water systems. This understanding will lead to new areas of research, such as dilute and dispersed insults and needs and mechanisms for improved water use and conservation, in which DOE will play a major national R&D role.

It is also likely that some form of arms control agreements will be reached with the Soviet Union, and the production and deployment of nuclear weapons will decline. Nevertheless, weapons R&D will remain a very large, important national activity and will continue as the emphasis of the DOE weapons laboratories. Other defensive weapons will become the emphasis of the R&D program and will include a broader range of DOE laboratory involvement.

Important new R&D opportunities will develop in a number of fields related to DOE missions, including computational areas such as artificial intelligence (AI), robotics, teleoperations, intelligent machines, and parallel computing. These areas offer the means by which the United States can once again be an international industrial leader.

Laboratory Boundaries

ORNL will remain a government-owned, contractor-operated R&D institution throughout the 15-year planning period. The federal agency responsible for ORNL will be DOE or a successor agency. Most work carried out at the Laboratory will be for that agency, but some work for other agencies will continue to be permitted. Energy R&D will continue to be the central theme of the Laboratory's work, but other closely related civilian and defense R&D activities will also be important. The defense R&D opportunities will be in areas other than nuclear weapons, which will continue to be the sole province of the weapons laboratories.

As DOE and the nation move forward to clarify the role of all R&D institutions, the missions of the laboratories will continue to become more sharply focused. We assume that Oak Ridge and Argonne will be broad multiprogram laboratories for energy technology and associated basic and life sciences. We assume that the weapons laboratories will gradually withdraw from their dominant role in some areas of energy technologies and will focus primarily on weapons-design technologies and closely associated defense activities. We also assume that the other multiprogram laboratories will retain some of their broad character but will focus more in areas of large physics experiments.

Other critical activities at ORNL will include the stewardship of basic physics research—the conception, design, construction, and operation of unique national user facilities will remain an important part of ORNL's charter. The collaboration and cooperation with researchers from academia and industry will continue to increase because of increased global competition. New forms of collaboration will emerge, such as working for industry groups and forming liaisons with academic and industrial consortia.

The relationship of ORNL to other components of Martin Marietta Energy Systems, Inc., will move gradually toward strengthening the capability to undertake large complex projects of increasing national importance.

Activity Trends

The major change in character of the Laboratory over the next 15 years will be a shift toward major technological missions in energy and in nonweapons areas. Broad goals in these areas include:

- To preserve and advance nuclear power through R&D directed toward
  - — developing a new generation of economical, reliable, and safe power reactors, including an advanced control technology user facility;
  - — ensuring safe and reliable long-term operation of current LWRs through the Nuclear Regulatory Commission (NRC);
  - — removing waste storage and disposal as an impediment to the expansion of nuclear power;
  - — applying advanced nuclear systems to space applications; and
  - — becoming increasingly involved on an international scale with other fission programs, primarily in areas of safety and waste.
- To become the developer of a new power-producing magnetic fusion reactor, with particular emphasis on R&D support for the next major fusion experiment through
  - — developing magnets, heating concepts, fueling prototypes, and materials;
  - — leading the reactor design efforts (nationally) and collaborating internationally;
  - — conducting innovative toroidal experiments; and
  - — becoming host for a large U.S. or international fusion experiment.
- To conduct advanced development work in important focused areas of non-nuclear energy technologies such as
  - — conservation and renewables, with emphasis on high-temperature materials, conservation in buildings, biomass production, and electrical energy systems; and
  - — fossil energy, with emphasis on materials, environment and health effects, environmental control technologies, and innovative research on coal conversion chemistry as related to production of liquid fuels.
- To create a strong technological base in generic areas of energy development in support of the preceding technologies by conducting basic and applied research in
  - — materials sciences (alloys, ceramics, and composites), including hosting large user facilities such as the High Temperature Materials Laboratory (HTML) and the world's best research reactor, the Center for Neutron Research (CNR);

  - — separations sciences (chemical, biotechnological, and mechanical processes);
  - — computational sciences (artificial intelligence, parallel processing, intelligent machines, networking, and information sciences); and
  - — measurement sciences (controls and sensors).
- To identify and understand important environmental and health effects associated with the energy areas of emphasis, including
  - — basic and applied biological research on genetic and somatic effects of radiation and chemical exposures;
  - — relationships of primary energy effluents to global environmental issues;
  - — development of human health and environmental assessments and risk analyses in these areas; and
  - — development of advanced instrumentation, measurement techniques, and methodologies for applying nuclear technologies to medical diagnosis and treatment.
- To carry out basic research in nuclear physics with emphasis on heavy ion and neutron physics, hosting a large heavy-ion storage ring for users.
- To contribute to the development of defensive weapons through major R&D activities on
  - — space power sources,
  - — energy storage,
  - — neutral particle beams, and
  - — rail guns.
- To become an important R&D center for nuclear and non-nuclear wastes
  - — emphasizing surface storage of nuclear wastes, and
  - — using DOE's R&D center for hazardous chemical wastes involving the Oak Ridge Model.
- To actively transfer technologies and techniques to American industry by means of
  - — an active association with industry, including working for industry and consortia;
  - — user facilities;
  - — an aggressive patent and licensing policy; and
  - — ties with selected universities and consortia of universities.

Long-Range Implications

With the expected increase in the energy portion of DOE budgets, ORNL and other energy technology laboratories will increase somewhat in size and missions. This will occur

as the large technology projects needed in a serious energy R&D program are implemented at the appropriate laboratories. In addition, the incorporation of energy-related projects that are not presently part of the DOE mission will significantly increase the R&D budgets. We anticipate that to perform the required R&D, especially the large technological programs, ORNL must be larger, as shown in Fig. 1.

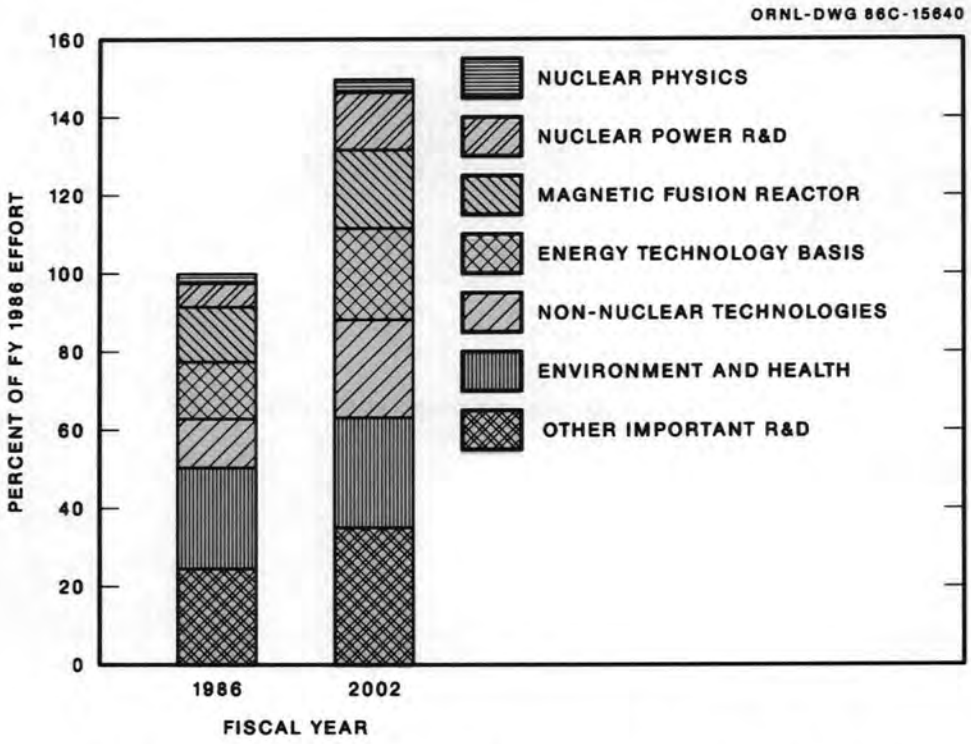


Fig. 1. Trends in internal research and development FY 1986 to FY 2002.

As shown in Fig. 2, moderate shifts in sponsorship will take place over the next several years. These shifts assume consolidation of nationally important energy-related R&D projects within DOE and depend in part upon clarification of the roles and reduction of the energy portfolio of weapons laboratories.

Managerial Implications

As noted previously, it is assumed that energy R&D budgets will increase in the next few years and that DOE will resume its role as an energy R&D agency. It is important now to pay attention to retaining the needed human and physical resources during periods of lower budgets. Thus, the most significant management challenge to DOE and ORNL is to come through the present period of reduced budgets and rapidly changing roles and missions with the essential skills and facilities intact to be able to aggressively solve future energy R&D needs.

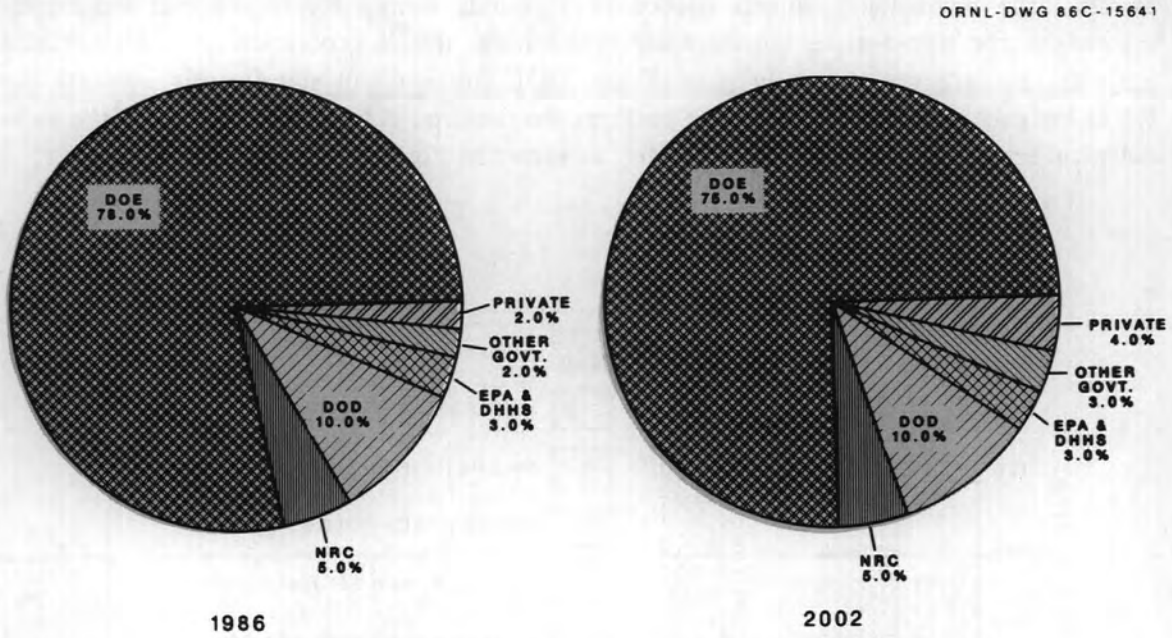


Fig. 2. Sponsors shown as percentages of operating expenditures.

Initiatives

INITIATIVES

Continuing Initiatives

Center for Neutron Research

The Center for Neutron Research (CNR) continues to be a major initiative at ORNL. The focus of this facility will be an advanced research reactor with an intense flux of steady-state thermal, cold, and hot neutrons for neutron scattering experiments that greatly exceeds present worldwide capabilities. In addition, the reactor will have isotope production and materials irradiation facilities superior to those currently available at the High-Flux Isotope Reactor (HFIR). As a national user facility, CNR will provide research opportunities for scientists of a wide range of disciplines from universities, industries, and other national laboratories. The R&D program necessary to design the reactor and research facilities is described in the Basic Energy Sciences (KC) section. This is an extensive, collaborative program that will require approximately five years to complete. Initial construction activities for the facility are proposed for 1990. Construction will require four to five years, with a projected cost of $325 million (1988 dollars).

Heavy-Ion Storage Ring for Atomic Physics

Previously referred to as the Heavy Ion Cooling Ring, Heavy-Ion Storage Ring for Atomic Physics (HISTRAP) is an advanced facility for the study of the atomic physics of multicharged ions. This area of study is important in basic science research, magnetic fusion studies, atomic data verification, and X-ray laser development. The goal of HISTRAP is to provide intense, high-quality currents of highly charged ions. The facility will consist of a synchrotron storage ring with electron-beam cooling capabilities. HISTRAP will be a unique facility in the United States and will help the United States to maintain and advance its leadership role in atomic physics research. HISTRAP will be a national user facility. Additional discussion of HISTRAP can be found in the Basic Energy Sciences (KC) section. Construction of HISTRAP is proposed to begin in 1989 with a four-year construction schedule and a total cost of $14.8 million.

New Initiatives

Advanced Control Test Operation

Three major activities are currently being pursued in the commercial reactor field in the United States: advanced modular reactor designs with inherently safe attributes [both liquid metal reactors (LMRs) and gas-cooled reactors], evolutionary improvement in

LWRs, and retrofitting existing LWRs by incorporating new technology on a piecemeal basis.

None of the above activities includes plans for federally funded demonstration units or prototypes. Costs for large demonstration units have risen to prohibitively high levels in light of the projected growth rate for U.S. power reactors, and regulatory time lags for demonstration projects make them less helpful in test-of-design since often the demonstrative concept is obsolete by the time tests are completed.

In the absence of prototype demonstration units, high-fidelity plant modeling is essential if advanced control technology is to be incorporated into nuclear plant design in the foreseeable future. We propose to develop large-plant dynamic models capable of operation in real time to demonstrate advanced control technology with results sufficiently accurate that new concepts can be confidently incorporated into new designs, innovative LWR designs, and retrofits to existing LWRs. These models will be used in a facility called the Advanced Control Test Operation (ACTO), a major center for the development and testing of advanced control systems for commercial, research, and military reactors. The facility is to be located at ORNL, a "neutral site," for the purpose of demonstrating proposed control schemes to prospective users and regulators. We believe ORNL's pioneering and continuing role in reactor plant simulation and control systems development, as well as our geographic location, contributes to the desirability of locating the ACTO facility here.

The major objective of the ACTO Project is to maximize the benefits the nuclear industry can derive from advanced control technology. Potential benefits foreseen from effective utilization of high-technology control hardware and software are (1) reductions in the number and duration of outages, (2) reductions in the likelihood of "incidents" becoming "accidents," and (3) improvements in operating performance through the use of control systems that are more intelligent, reliable, and hardware fault tolerant. Advanced control systems featuring innovative hardware and software system designs can provide extensive automation, resulting in considerable benefits to the reactor industry. Such advanced systems will not be incorporated into operating reactors, however, without extensive prior testing, qualification, and verification. The driving force behind the ACTO Project is the thesis that effective support for promoting and developing these advanced controls could best be provided by a multi-user simulation and test facility. At the heart of ACTO would be an extensive set of both generic and plant-specific dynamic simulations, along with the requisite data bases, that can be used to support control system development, interfacing, and testing. The new emerging technologies of interest here are advanced computer architectures, telecommunications, software engineering methodologies, very high-level languages, area networking, fault-tolerant control, artificial intelligence and expert systems, and plant-wide design and operational data base management. ACTO would support both local and remote users and would include personnel as well as hardware, software, and communications packages required to support a complete design cycle from initial conception to final testing before installation at the selected plant site. The ACTO facility would provide the development environment and software needed for the various design teams to work together effectively.

The needs of ACTO users will be determined by working initially on actual problems, allowing the evolution, direction, and growth rate of facility hardware and software to be

determined in large part by hands-on experience. In this staged approach, decisions about facility expansion must be based in part on projections of usage. Initially, extensive use will be made of existing simulation and development software as well as existing computers (Table 1).

Industry support is crucial to the success of the ACTO Project. An industry advisory committee will be introduced to the ACTO concept and solicited for comments, critiques, and support. Other support will be garnered through outside participation in facility planning, software development, and demonstration projects.

Table 1. Budget projection by fiscal year for advanced control and system development, including ACTO

($ in millions)

	1986	1987	1988	1989	1990
Operating	1.289	2.0	5.0	5.0	5.5
Capital equipment	0.165	1.15	4.45	4.65	7.0

Waste Management Technology Center

Martin Marietta Energy Systems, Inc., and DOE-Oak Ridge Operations (ORO) have established a new Waste Management Technology Center (WMTC), which serves as the technology component of a comprehensive DOE-ORO waste management coordination effort referred to as the "Oak Ridge Model." The WMTC performs in a centralized manner certain special functions formerly carried out in various waste management organizations in the ORO-managed complex. The charter of the WMTC encompasses treatment, storage, and disposal technologies relevant to the management of transuranic, low-level, hazardous, and mixed wastes. The WMTC also provides technical support for the development and analysis of technical information supporting remedial actions and compliance strategies by DOE-ORO contractors, including Energy Systems. The expertise available in several of the R&D divisions at ORNL will be used in planning and evaluating technology demonstrations and evaluating the associated implications for the protection of human health and the environment and compliance with regulations. These planning and evaluation exercises will be supplemented by a series of technical workshops which will be conducted by the WMTC to assist in evaluating issues and in assessing potentially useful technologies within a broad context.

The WMTC will emphasize a technology demonstration program based on cost sharing, which ensures that the expertise of the private sector is efficiently employed while providing answers to current waste management problems on DOE-ORO sites. The facilities managed by DOE-ORO will be used as a laboratory for the demonstration of waste management technologies using actual DOE wastes. It is intended that demonstrations will be conducted on scales that will provide credible assessments of cost and performance for

full-scale systems and will be adequate to determine regulatory compliance. This techology demonstration program will provide centralized coordination and quality assurance for the procurement, siting, permitting, and performance evaluation aspects of technology demonstration projects and will include active participation by state and federal regulatory agencies in all aspects of the program. Tables 2 and 3 project WMTC budget and personnel.

The WMTC will encourage technology development and application by providing a low-risk demonstration environment through both the partial identification of subcontractors and the protection of patent rights associated with demonstrations on DOE-ORO sites. Special efforts will be made to work with universities that the state of Tennessee has designated as Centers of Excellence in environmental and waste management areas.

Table 2. Budget projects by fiscal year for the WMTC

($ in millions)

1987	1988	1989	1990	1991
2	3	5	5	5

Table 3. Personnel data by fiscal year

	1987	1988	1989	1990	1991
Technical	8	12	15	15	15
Other direct	4	6	8	8	8

Overview of Laboratory Activities

OVERVIEW OF LABORATORY ACTIVITIES

Since 1979, DOE's Office of Energy Research (OER) has been ORNL's largest single sponsor, funding roughly 44% of our total FY-1986 effort, based on total Laboratory direct personnel. The Director of OER also has overall responsibility for the Laboratory. The Assistant Secretary for Nuclear Energy (ASNE), the Assistant Secretary for Defense Programs (ASDP), and the Assistant Secretary for Conservation and Renewable Energy (ASCRE) have also supported large efforts at the Laboratory over the past several years. Figure 3 shows Laboratory effort by major sponsor. In general, the projections contained in this plan are for little variation in relative proportion of overall effort devoted to the various DOE sponsors. A slight shift in work for others (WFO) sponsorship is expected, with the relative share of effort for the NRC decreasing slightly (from 5 to 4%) over the planning period. This shift is balanced by an increase in effort for various branches of the Department of Defense (DOD), which is projected to increase from the FY-1986 level of 10% to roughly 13% in FY 1992. Figure 4 gives information on the distribution of WFO

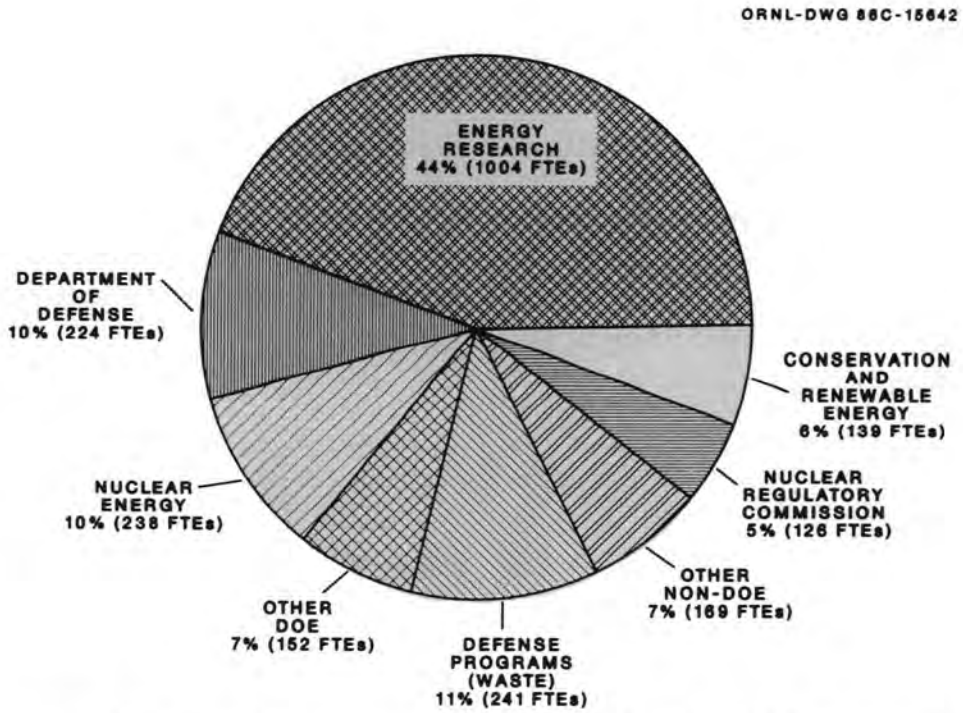


Fig. 3. FY-1986 effort for major sponsors. The total of 2293 direct full-time equivalents (FTEs) includes Computing and Telecommunications Division, Engineering Division, Y-12 Plant, and Oak Ridge Gaseous Diffusion Plant personnel who are charged to Oak Ridge National Laboratory.

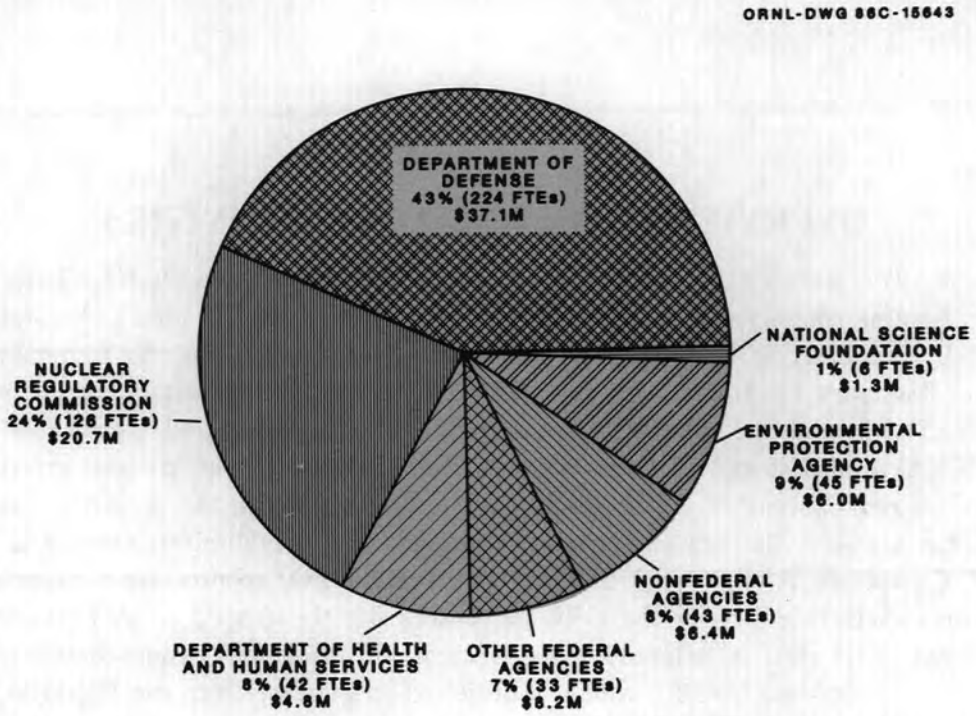


Fig. 4. FY-1985 effort in work for others. The totals of $84.4 million and 519 full-time equivalents (FTEs) include Computing and Telecommunications Division, Engineering Division, Y-12 Plant, and Oak Ridge Gaseous Diffusion Plant personnel who are charged to Oak Ridge National Laboratory.

funding and personnel. Although NRC is no longer dominant, this agency still funds 24% of ORNL WFO tasks.

If the programmatic effort is distributed as projected in this plan, the total number of personnel projected for FY 1992 is slightly above the FY 1981 level. Thus, the Laboratory's overall plan is for slight growth in the near term and moderate growth in the longer term (i.e., to the year 2002).

Scientific and Technical Programs

SCIENTIFIC AND TECHNICAL PROGRAMS

Department of Energy Programs

Office of Energy Research

The Laboratory's major research programs in the basic physical sciences, fusion energy, and biomedical and environmental sciences areas are supported by OER. By supporting roughly 44% of Laboratory personnel, OER is the largest single sponsor of research at ORNL (Table 4).

Table 4. Office of Energy Research major program summary

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1985	1986	1987	1988
AT	Magnetic Fusion	57.86	50.96	49.34	47.24
HA02	Biological and Environmental Research	27.60	28.24	28.48	32.34[a]
KA	High-Energy Physics	0.59	0.45	0.50	0.53
KB	Nuclear Physics	12.96	11.44	11.96	12.74
KC	Basic Energy Sciences	70.61[b]	58.99[c]	65.19	81.22[d]
KD	Energy Research and Analysis	0.47	0.79	0.93	0.93
KE	University Research Support	0.30	0.31	0.46	0.52
KG	Environmental Compliance	5.4	17.64[e]	22.33[f]	26.00[g]
Total		175.79	168.82	179.19	201.52
Percentage of total Laboratory funding—BA		36.6	44.8	44.6	46.4

[a]Includes $2.3 million of construction.
[b]Includes $2.8 million of construction.
[c]Includes $1.2 million of construction.
[d]Includes $1.8 million of construction.
[e]Includes $5.3 million of construction.
[f]Includes $7.0 million of construction.
[g]Includes $12.8 million of construction.

AT—Magnetic Fusion

The Magnetic Fusion Program at ORNL is a major component of the national fusion program and contributes in nearly all aspects of magnetic fusion research. The goal of the national fusion program is to determine whether useful energy can be obtained from the fusion of the light elements, mainly isotopes of hydrogen and lithium. Key issues at the current stage of the program are to (1) understand the behavior of high-temperature hydrogen isotope plasmas in order to develop magnetic configurations that confine plasmas effectively and that have attractive engineering features; (2) understand the physics of burning plasmas; (3) develop technologies for producing, heating, and controlling such plasmas; (4) develop fusion nuclear technologies for components which operate in the fusion reactor environment; and (5) develop materials for the fusion reactor environment.

Support for contributions of the ORNL Magnetic Fusion Program comes in three areas: Applied Plasma Physics (AT05), Confinement (AT10), and Development and Technology (D&T) (AT15). The Applied Plasma Physics subprogram continues to concentrate on theoretical studies, atomic physics, and diagnostic development. The Confinement subprogram is concentrating on the Advanced Toroidal Facility (ATF), a stellarator, which will begin operation in FY 1987. Work in the tokamak area continues through studies for the Spherical Torus Experiment (STX) and contributions to the Compact Ignition Tokamak (CIT) program. Present plans for the "national" CIT project assign responsibilities to ORNL for the pellet injection, ion cyclotron heating, shielding, remote maintenance, and tokamak structure subsystems. The CIT is expected to be an increasingly important part of the ORNL program in future years. Major emphasis in the D&T program is to complete the Large Coil Program (LCP) in the International Fusion Superconducting Magnet Test Facility (IFSMTF), which became fully operational during FY 1986. The Radio Frequency Test Facility (RFTF) is also operational, and it will be a key factor in a vigorous radio frequency heating development program. Work continues in plasma theory, atomic physics, design of advanced fusion devices, pellet fueling, materials, and neutronics. The ORNL program is involved in, and plans to continue, major collaborative programs in essentially all of its activities with other U.S. fusion laboratories and with many foreign countries.

Longer-term goals of the Oak Ridge Program (three to fifteen years) are to (1) study steady-state, high-beta, high-temperature plasmas in ATF and use ATF as a test bed for plasma technology development; (2) design and build ATF-II, a stellarator with a reactor-grade plasma, on a new site in Oak Ridge; (3) perform major engineering and technology development and application roles in the CIT program; (4) develop an important role in the Engineering Test Reactor, including testing prototype superconducting coils in the IFSMTF; and (5) maintain Oak Ridge in a strong position to be the site for future major deuterium-tritium (D-T) burning plasma facilities.

The Applied Plasma Physics subprogram includes theoretical studies to formulate and apply models of plasma behavior in various confinement systems [in recent years, tokamak, stellarator, Elmo Bumpy Torus (EBT), and reversed field pinch]. This activity also encompasses the development of a data base and models for atomic physics and the development of diagnostic devices and technologies. In the tokamak and stellarator areas, work will continue to develop theory, both for comparison with experiment and for predictive calculations, in the areas of magnetohydrodynamics, transport, heating, and fueling. Studies of

critical issues will be made for ATF and STX. Studies of advanced systems such as ATF-2, the CIT experiment, and reactors will continue. In the atomic physics program, a powerful new source of multiply charged ions is operating which considerably expands the range of highly ionized systems available for investigations. The measurement of atomic cross sections on this device, coupled with theory, will sustain a vigorous program in this area for a number of years. In a separate program, the development of a laser-scattering diagnostic device for measuring fusion alpha particles is well advanced.

The Elmo Bumpy Square (EBS) program was not supported by DOE and bumpy torus work was terminated in FY 1986, with the hope that it may be revived in better financial times.

The toroidal area has three major program elements. The off-site assignment of ORNL experimentalists to the Tokamak Fusion Test Reactor (TFTR) will be completed in early FY 1987. However, the associated work in the development and construction of pellet injectors and ion cyclotron heating (ICH) components is expected to increase during the next few years. The second activity is construction of the ATF stellarator; the ATF and support facility modifications required for its operation are proceeding on schedule. This facility will be available for the experimental program to start in early FY 1987, and it is planned to operate into the early 1990s. A device with outstanding capabilities, ATF has the flexibility to study various magnetic configurations and, with a suitable upgrade, to operate with a high-performance steady-state plasma. ATF will provide a major in-house focus for theory and experimentation, diagnostics, and plasma technology. The third element is the definition of physics and engineering issues associated with a tokamak operating at a very low aspect ratio, the spherical torus concept. This device promises higher plasma beta than conventional tokamaks, and the concept offers potential advantages as a reactor. We are planning to resubmit the STX proposal for FY 1988 funding.

The D&T Program continues to make progress on all fronts. An RFTF, based on the prototype EBT proof-of-principle coils, was built and is being used for testing advanced radio frequency (rf) development components. Development of rf systems and components is proceeding with applications planned for the ATF, Tore Supra, and TFTR experiments. Components developed from this work are being used on the Doublet III-D (DIII-D) tokamak, Alcator-C, TMX-U, all U.S. experiments, and the Tokamak Experiment for Technical Oriented Research (TEXTOR) in Jülich, Federal Republic of Germany. The pellet injector program is working on advanced pellet injectors that can provide pellets repetitively at speeds up to 2 km/s. These injectors have been used to fuel the TFTR, DIII-D, Princeton Large Torus, Princeton High Beta Experiment, and Alcator-C experiments in the United States. Systems are under construction for Tore Supra (France), and the Joint European Torus (JET) (European Economic Community). In parallel, concepts are being evaluated for producing even higher-velocity pellets.

In the LCP, the IFSMTF has been at liquid-helium temperatures since January 1986. Each of the six test coils (from four countries) has been individually tested at full current, and all six coils have been operated together to produce the design field of 8 T. The program is scheduled for completion in FY 1987. Plans for continuation of a base development program in FY 1988 have been formulated.

The Plasma Materials Interactions Program is focused on limiter development, wall conditioning/impurity control, scrape-off layer diagnostics, and surface physics. Until startup of the ATF in FY 1987, the activity is concentrating on collaborative programs on Heliotron-E, TEXTOR, and Tore Supra. In the alloy development area, work continues in the HFIR to test candidate first-wall and blanket materials. Specimen irradiations in the Oak Ridge Research Reactor (ORR) have been completed, and modifications are being made to the HFIR to allow all future work to be done there. The program will continue to pursue three primary goals: (1) to provide materials behavior information in support of reactor design studies, (2) to select structural materials and develop a data base for near-term fusion devices, and (3) to develop low-activation alloys for commercial fusion reactors. Programs involving ceramics and copper have been initiated. A multiyear collaborative program with the Japan Atomic Energy Research Institute (JAERI) is under way.

The Fusion Engineering Design Center (FEDC), which is managed by ORNL, collaborates extensively with a number of U.S. industries, national laboratories, and universities. The FEDC is a major contributor to conceptual design of the CIT, which is proposed as the next major focus of the U.S. Magnetic Fusion Program. The FEDC also plays a leading role in physics and engineering studies for the U.S. contribution to the International Atomic Energy Agency (IAEA)/International Tokamak Reactor (INTOR) activity. In addition, the FEDC is involved in supporting the Tokamak Ignition Burning Experimental Reactor (TIBER) engineering test reactor design study at Lawrence Livermore National Laboratory (LLNL).

HA02—Biological and Environmental Research

Goals of the HA02 program are (1) to study the interaction of energy-related physical and chemical agents with living organisms, including their transport, chemical evolution, adverse health effects, and ultimate consequences in humans and their environment; (2) to contribute to DOE's Nuclear Medicine Program and other beneficial applications programs; and (3) to transfer research findings and technological developments outside the Laboratory.

Research areas in biology include mammalian genetics, molecular genetics, protein engineering, carcinogensis, radiation biology, and chemical interactions and effects. Environmental science research covers biogeochemistry, hydrology, environmental toxicology, global ecology, environmental risk analysis, geology, carbon dioxide (CO_2), and acidic deposition. Health and safety research encompasses epidemiology, health assessments, radiation and chemical physics, dosimetry, nuclear medicine, and instrumentation development for sensitive detection and monitoring of chemicals.

In addition, three unique user facilities are supported by the HA02 program: the Health Physics Research Reactor (HPRR), the Oak Ridge National Environmental Research Park (NERP), and the Bioprocessing Research Facility User Resource. The NERP program coordinates all environmental research activities with other land uses and serves as the repository of data on long-term reservation research. The bioprocessing facility integrates physical resources from the Biology and Chemical Technology divisions to include bioreactors, a flow cytometry laboratory, large-volume fermenters, and centrifugal analyzers. Users of these facilities include staff of national laboratories and industry and students and staff from universities.

The ORNL HA02 program is one of the most multidisciplinary life sciences research programs in the nation and covers a broad range of both basic and applied studies. Overall, the HA02 program at ORNL is expected to experience limited growth in this planning cycle although some subprogram elements are proposing modest expansion.

Research in the Biology Division is continuing the trend of the last several years of increased emphasis on mammalian genetics. Approaches will be designed to provide information on the human genome, either directly utilizing human cellular systems or by extrapolation from animal models. These will include characterizing induced or spontaneous mutations and chromosome alterations by molecular techniques and subsequently determining the consequences of these mutations. Mapping selected parts of the mouse genome with restriction enzymes, together with information on conserved gene linkages between mouse and man, will facilitate structural studies of the entire human genome. The molecular characterization of DNA damage and repair, together with the analysis of mutations and chromosome alterations, will allow an understanding of the mechanisms of induction of mutational events.

The research effort in molecular genetics is expected to grow over the next several years. Areas of emphasis in molecular genetics will include genomic structure, regulation of gene expression, and structure and function of gene products. Researchers in the Biology Division will have the capability to visualize higher-order chromatin structure and the three-dimensional structure of nucleosomes (the core particle of chromatin) by utilizing special techniques in electron microscope tomography developed at ORNL and X-ray diffractometry. Cloning of segments of the eukaroytic genome and their subsequent sequencing will provide insights about the nature of regulatory elements of DNA and the propensity of small regions of DNA to undergo spontaneous mutations.

Gene products under close scrutiny include ribulosebisphosphate carboxylase (a determinant of biomass yield), epidermal growth factor (a polypeptide intimately involved in cellular growth and differentiation), enzymes involved in transcription of DNA, enzymes involved in the repair of chemically damaged DNA, and membrane transport proteins responsive to environmental insults.

Protein engineering (site-directed mutagenesis), a new initiative in FY 1985, is unique among DOE laboratories. Protein engineering integrates many activities in molecular genetics. The ability to insert specific mutations into cloned genes will permit the systematic design of new gene products as mechanistic probes of protein function and the tailoring of operons to alter the regulation of gene expression.

The studies of cancer will continue to combine the investigations that elucidate mechanisms and those aimed at the practical problem of risk estimates, especially for high linear energy transfer (LET) radiation. The level of effort in cancer research will remain the same as in FY 1986. Molecular genetic techniques will be used to define the mechanisms of the hormonal regulation of gene expression and of the action of regulatory genes involved in differentiation. Studies will define the role of transposable genes in the development of malignancy and of the genes that control the neoplastic expression of the oncogenes.

Radiation will be used to determine the role of specific molecular and chromosome alterations in the induction of leukemia. In vivo–in vitro epithelial cell systems will be

applied to the determination of the role and mechanisms of cell-cell interactions in radiation carcinogenesis. Studies at different levels of biological organization will be carried out to characterize the relationships of radiation quality and cancer induction and susceptibility and genetic background. The latter will be a keystone in the development of methods of extrapolation across species.

Environmental research is designed to increase our understanding of the transport and effects of energy-related contaminants in the environment. Basic information is developed on mechanisms that govern ecosystem function, particularly in biogeochemical cycling studies on forested landscapes (Walker Branch Watershed) and streams. This forms the basis for research on the ecological response to chemical emissions stressing both aquatic and terrestrial environments. By using process studies with stable elements, radionuclides, and trace organics as well as mathematical simulation models, data and methodologies are developed that enhance our ability to site and operate energy systems in a cost-effective and environmentally safe manner. We will continue our work in hydrology and geochemistry in support of DOE programs in subsurface transport of hazardous substances and will initiate work in subsurface microbiology. Research will continue on quantification of regional landscape patterns and the processes affecting ecosystems at large spatial scales. In the area of global environmental concerns, ORNL has become a center of expertise in the investigation of ecological transport and effects of chemicals in the environment and in the assessment of hazardous wastes, the global carbon cycle related to CO_2-induced climate change, and acid deposition issues. Research on vegetation response to air pollution stress (particularly O_3, SO_x, NO_x, and acid deposition) has achieved national prominence. We propose to expand our research efforts to encompass the role of terrestrial-aquatic linkages in the processing of atmospheric pollutants. As with most technology-related pollution problems, an interdisciplinary approach is required for planning and conducting the appropriate research. Environmental Sciences Division (ESD) research for the Office of Health and Environmental Research (OHER) focuses on biogeochemical cycling at the watershed scale, with Walker Branch Watershed as a central focus, but includes atmospheric deposition inputs, subsurface hydrologic transport, and element cycles and effects in streams and river/reservoir ecosystems. ORNL serves as an important research and modeling center for OER in the fossil fuel emissions of CO_2 and global carbon cycle and provides support for the DOE Carbon Dioxide Research Division through program planning, evaluation, and management.

The scientific goals of the Walker Branch Watershed Integrated Research Program directly coincide with the type of research identified by OHER as being a critical national R&D need. In particular, one of OHER's missions is to understand the physical, chemical, biological, and geological processes that directly and indirectly control the flux of energy-related contaminants from their sources, through the environment, to sensitive receptors or long-term sinks. The research program is coordinated around the primary research site on Walker Branch Watershed. The research centers on environmental transport, transformations, and interactions of biologically active elements. Focus is initially on compounds of carbon, nitrogen, and phosphorus. This focus is appropriate because the transport, fate, and bioavailability of most toxic trace metals and organic contaminants are physically, chemically, and biologically linked to the transport, fate, and effects of natural organic materials, which are controlled, in turn, by biological utilization and recycling of carbon, nitrogen, and phosphorus.

During the next five years, carbon dioxide program activities will encompass new research on technological, social, and economic factors affecting CO_2 emissions in terrestrial carbon dynamics and global carbon cycle modeling, as well as new responsibilities in carbon-cycle research management for DOE. Research efforts will be focused on assembling and implementing disaggregated (multidimensional) models of the global carbon cycle. Management activities will involve the gradual assimilation of a greater share of contract execution activities for the DOE Carbon Cycle Research Program. New work is being initiated on the direct and indirect effects of CO_2 on the physiological responses of both above- and below-ground vegetation, including mycorrhizal associations. ORNL anticipates recognition as a major research center during the new International Geosphere Biosphere Program being planned by the International Council of Scientific Unions.

The Carbon Dioxide Information Center (CDIC) supports the nation's carbon dioxide research program and cooperates in information exchange with the international scientific community addressing global atmospheric CO_2 problems. CDIC is sponsored by DOE's Carbon Dioxide Research Division and is administered by the Environmental Sciences Division at ORNL. CDIC's objective is to provide a focal point for compiling and distributing CO_2-related information under systematic quality control. The center's main function is to serve the information needs of researchers evaluating the effects of increased CO_2 on the global carbon cycle, climate, and vegetative response and the indirect effects of elevated CO_2 levels. The current national CO_2 research program requires CDIC to participate in research and development activities in addition to its information dissemination function. CDIC's multidisciplinary technical staff maintains an information analysis center that interacts with the CO_2 research community and DOE's programmatic components.

Research in the Health and Safety Research Division (HASRD) is directed toward improving knowledge of the detection and bioeffects of energy-related chemical and physical agents, particularly in terms of the overall impact on human health. The majority of the programs deal with fundamental theoretical and experimental research sponsored by OHER. HASRD also conducts work for other federal agencies as it relates to DOE/OER/OHER interests. Although the division's activities are very broad in scope and diverse in style and content, they are nevertheless founded on their relevance to problems associated with detrimental effects of energy production on human beings and their environment; development of measurement capabilities that meet current and future needs for assessing exposures of people to various insults; and development of assessment methodologies that allow quantitative judgments to be made on current and future impact of various energy strategies, energy production levels, and possible energy-related mishaps.

Physical and technological research activities under OHER support are directed toward increasing our knowledge of the interactions of potentially hazardous agents with biological and environmental systems and toward ensuring a technical capability for characterizing and quantitatively measuring such agents in various settings. Much of the work stems from long-range goals associated with a desire to make informed assessments of or to take effective steps toward the amelioration of potential health and environmental risks associated with new and existing energy technologies. This program consists of studies involving the structures and properties of materials of biological or environmental importance, the physical and chemical mechanisms that govern transport and chemical transformations of pollutants in the atmosphere-hydrosphere-biosphere, and the details of direct

interactions of harmful agents with biological materials. Included in the scope of this work are theoretical and experimental studies of interactions at the atomic, molecular, and macroscopic levels in solids, liquids, and gases; on solid surfaces; and at solid-liquid interfaces. Also, detailed Monte Carlo studies are made of the physical and chemical evolution of radiation-induced products in natural media.

Strong emphasis is given to development of techniques that provide advanced instrumentation for characterizing and sensitively detecting a wide variety of chemical species. Included in this effort are unique applications of laser optical techniques, ultraviolet and soft X-ray spectroscopic techniques, electron beam microlithography, and electron microscopy.

A continuing research activity is the development of new instruments and measurement techniques to support evaluation of the potential health and environmental impact of developing energy technologies. Results of this research have led to cost-effective luminescence techniques for rapid screening of samples containing polynuclear aromatic compounds as well as portable instrumentation for on-site use at operating facilities. The DOE/OHER-funded developmental research has resulted in support from other agencies and organizations for applied studies. Transfer of this technology to the commercial sector is an important objective. Coupled with the emphasis on instrumentation for occupational monitoring is the investigation for biological indicators of exposure to chemical pollutants and subsequent physiological response. Research has been recently initiated to determine which biological screening systems may be more predictive of human-level health effects. This research is directly supportive of new health effects assessment methods.

The HPRR, a unique research facility, is heavily used by industry and other DOE laboratories. A small, unshielded, unmoderated fast reactor, the HPRR yields up to 1×10^{17} fissions in the pulse mode and 10 kW in the steady-state mode. The program using the HPRR features research in radiobiology and dosimetry with emphasis on criticality alarm testing, education, training, and instrumentation development.

The Nuclear Medicine Program has received widespread recognition for the design, synthesis, and animal testing of new radiolabeled compounds for use in clinical nuclear medicine and other fundamental biomedical research. A major effort of this program is the development of new, improved radiolabeling techniques and the design of new tissue-specific agents for the evaluation of tissue anatomy, perfusion, and metabolism. The Nuclear Medicine Program is complemented by an active extramural collaborative effort through cooperative programs with medical institutions such as Massachusetts General Hospital and the Boston Children's Hospital. An additional activity for the program will be increased interaction with Oak Ridge Associated Universities (ORAU) and the departments of Nuclear Medicine and Radiology at The University of Tennessee at Knoxville (UTK) to establish a Regional Center of Excellence in Nuclear Medicine Research.

Indoor air quality and water quality as related to human health are receiving increased attention at the national level. Because of the multidisciplinary capabilities for defining exposures and effects, activities in these areas are increasing. Studies in indoor air quality have matured from a new initiative status to an established collaborative program with multiagency funding. Recent public interest in the federal agency attention to indoor air quality has focused on radon in homes. ORNL will play an important role in developing a better understanding of radon source identification, transport assessment, mitigation

effectiveness, and health effects. Radon research will remain a component of a broader, multiagency-sponsored Indoor Air Quality Program at ORNL. The first phase of epidemiological studies on drinking water quality and human health has been completed. These studies have led to formulation of new hypotheses concerning associations between drinking water parameters and human health. Funding is available to continue these studies. New funding has also been developed to implement a battery of in vitro testing systems for complex mixtures of water-borne toxic materials.

A multidisciplinary research effort on biological indicators will be initiated, integrating the resources from several divisions, including Analytical Chemistry, Biology, Chemical Technology, Environmental Sciences, and Health and Safety Research. Research efforts will be directed toward developing, understanding, detecting, and applying biological indicators of exposure and/or human health and ecological effects associated with energy technologies. Examples of human health and biomarkers include direct or indirect measures of internal dose (e.g., DNA adducts, carcinogen metabolites in body fluids) or may be measures of biochemical/biophysical alterations of biological targets of the ecosystem (i.e., fish DNA alterations). These research efforts will provide improved and sensitive tools to monitor critical biological indicators and will also contribute to a better understanding of the effects of energy-related mutagens and carcinogens on human health and ecosystem viability.

Program Construction. Some changes have occurred in the proposed line-item construction projects for the HA02 program (Table 5). The largest item, the Mammalian Genetics Research Facility, was originally proposed for FY 1987 funding but is being rescheduled in FY 1990. DOE/OHER's established genetics research program investigates the genetic effects of energy-related chemicals. For this purpose, it is essential that we

Table 5. HA02—Construction summary

($ in millions)

	Fiscal year				Total estimated cost
	1989	1990	1991	1992	
Upgrade air supply system, Bldg. 9210, part I	0.35	2.15			2.50
Upgrade air supply system, Bldg. 9210, part II			1.00	2.40	3.40
Molecular Genetics Laboratory	1.6	6.4			8.0
Mammalian Genetics Research Facility		2.60	5.00	17.10	24.70
Total	1.95	11.15	6.00	19.50	38.6

have new laboratory and animal space designed specifically to enable personnel to handle hazardous chemicals safely. The air supply system upgrade is essential for achieving a higher number of air exchanges per hour in the experimental animal quarters in the Biology Division, thus preserving a unique resource among DOE contractors.

We have also developed an alternative construction approach—the use of modular buildings at the ORNL Life Sciences Complex to house Biology Division staff as they relocate from their current off-site location (at the Y-12 Plant complex). The first unit, designed for molecular genetics research is planned for FY 1989.

KA—High-Energy Physics

The High-Energy Physics Program includes basic research for the study of elementary particles and supports a group that provides the high-energy physics community with calculated data and develops computer codes for cross sections and transport phenomena. The latter is an essential service for the design of effective detector calorimeters and high-energy accelerator radiation shielding. The elementary particle studies are part of a collaborative program based primarily at UT. The activities of these groups are expected to continue at the current level.

KB—Nuclear Physics

Heavy Ion Physics is the major research area supported by the Nuclear Physics program. The Holifield Heavy Ion Research Facility (HHIRF), operated as a national user facility, is the focus of much of the experimental program. Funding levels are projected to increase slightly over the reporting period, reflecting increased activity in nuclear theory and increased interactions through the UT-ORNL Distinguished Scientist Program, the UT Center of Excellence, and the Joint (ORNL-UT-Vanderbilt) Institute for Heavy Ion Research. An increased research effort will exploit the Compton Suppression System incorporated into the Spin Spectrometer, the HILI (Heavy Ion Light Ion) Detector and the higher energies made available by the extended-tube upgrade of the 25-MV tandem electrostatic accelerator. The theory effort will continue to develop techniques for utilization of the VAX/array-processor system for large theoretical physics calculations. The Light Ion Physics group will continue to concentrate on studies of giant nuclear multipole resonances and charge-exchange reactions. It is anticipated that the HHIRF will continue to be used by DOD and the National Aeronautics and Space Administration (NASA) to investigate semiconductor junction response with single-event-upset experiments. During this period, the relativistic heavy ion experiment at Conseil Européen pour la Recherche Nucléaire (CERN) will come to fruition. Calorimeters designed and constructed at ORNL are an important part of this international, collaborative effort. After completion of the approved experiments at CERN, planning for future relativistic heavy-ion experiments will most likely center on the Alternating Gradient Synchrotron (AGS) plus booster facility at Brookhaven National Laboratory (BNL).

A major new proposal for construction is an intermediate-energy heavy-ion upgrade to the Holifield facility (Table 6). This proposal is an extension of the Heavy-Ion Booster Synchrotron and Storage Ring Proposal presented last year. The principal components of this upgrade are a 15-Tm booster synchrotron and a 10-Tm storage ring. The proposed

Table 6. KB—Construction summary

($ in millions)

	Fiscal year							Total estimated cost
	1986 and before	1987	1988	1989	1990	1991	1992 and beyond	
Funded construction								
Accelerator and reactor improvements Holifield Heavy Ion Research Facility bunching capabilities	0.45							0.45
Accelerator improvements and modifications Holifield Heavy Ion Research Facility 25-MV Tandem, extended tube upgrade	0.12	0.33						0.45
Proposed construction								
Intermediate energy upgrade of Holifield Heavy Ion Research Facility				10.0	30.0	20.0	15.0	75.0

system, developed in conjunction with the Holifield users' group and a broad spectrum of the heavy-ion physics community, would supply high-quality ion beams with energies up to 1500 MeV/nucleon for light ions and 900 MeV/nucleon for heavy ions. The area of physics addressed by this proposal has been identified by the DOE–National Science Foundation (NSF) Nuclear Physics Advisory Committee as a high-priority area for development.

Program Construction. The Extended Tube Upgrade Project for the 25-MV Tandem Accelerator, HHIRF, is a budgeted construction project. The Intermediate-Energy Heavy-Ion Upgrade for HHIRF is proposed for construction starting in FY 1989 (Table 6).

KC—Basic Energy Sciences

Basic Energy Sciences supports a wide variety of research. Nuclear Sciences (KC01) supports the major isotope production facilities HFIR–Transuranium Processing Plant (TPP) and the calutrons, as well as the Oak Ridge Electron Linear Accelerator (ORELA), a national user facility utilized by the physics and energy technology communities for nuclear data measurements and evaluations. Increased funding for the TPP will partially compensate for the loss of funding from the Consolidated Fuel Reprocessing Program (CFRP), will ease current understaffing, and will permit essential maintenance efforts. Without these replacement funds, TPP production activities will have to be shut down. Full 12-month operating cycles are planned for the calutrons to replenish the sales and research

materials collection inventories. Modifications to improve the irradiation capabilities of HFIR will continue. The transuranium element research program will continue to participate in collaborative nuclear studies, primarily with Einsteinium targets.

The Materials Science Program (KC02) supports a variety of materials research as well as several major user facilities. Growth is anticipated in a number of programs. The most significant is the R&D program for a new research reactor for the CNR, a proposed national user facility. The intent of this program is to design the world's best reactor for neutron scattering research and to improve current capabilities for isotope production and materials irradiation studies. The R&D program will be a collaborative effort involving resources and personnel from institutions including ORNL, Argonne National Laboratory (ANL), BNL, Idaho National Engineering Laboratory (INEL), and Los Alamos National Laboratory (LANL). Major areas of emphasis are design of the core, cold source, and hot source; selection, manufacture, and qualification of fuel; corrosion/erosion studies of fuel-cladding materials, including investigation of various methods to reduce corrosion; tests and analyses of thermal-hydraulics; validation of shielding analyses and neutronics performance predictions through critical experiments; and tests and analyses of structural elements; and safety studies. The goal is to design a reactor with a useful thermal neutron flux up to a factor of 10 higher than is currently available for neutron scattering, while retaining the neutron spectrum and flux requirements for materials irradiation studies and transuranium isotope production. Higher fluxes will allow neutron scattering studies of smaller specimens with higher resolution for many applications than are currently possible. In addition, studies of real-time processes will become feasible. Other design characteristics will be optimized to meet anticipated user requirements. Funding requirements for this program will increase through FY 1989 and then taper off as the reactor design and safety analyses are completed. Initial construction activities for the reactor are proposed for 1990 (early design funding) with actual construction beginning in 1991 and requiring four to five years.

Development and utilization of neutrons and other analytical materials characterization techniques will also show increased activity. Electron microscopy will continue to grow as more complex and sophisticated microanalyses are required for studies of interfaces, ceramic and composite materials, and ordered alloys. Addition of an atom-probe field-ion microscope will open new avenues for materials research on the atomic level. The potential of synchrotron radiation at the National Synchrotron Light Source (NSLS) for characterization of surfaces/interfaces and development of an X-ray microprobe will be exploited.

Surface-related phenomena and semiconductor materials are important frontier research areas. Completion of a building expansion for the Surface Modification and Characterization (SMAC) Collaborative Research Facility will allow installation of an implantation accelerator and a dedicated Ion Beam Deposition (IBD) system and a computer/data analyses center. Fabrication and characterization of thin films and artificially structured materials formed by IBD will continue throughout the reporting period. Installation of a second beam line on the tandem accelerator in the SMAC facility will permit high-energy implantation of heavy elements. Upon completion of planned modifications, integrated materials processing and in situ materials characterization techniques will be possible. A portion of the support for the radiation effects program will be redirected to

surface modification studies in FY 1987, allowing expansion into the area of ion beam processing of metal surfaces. Substantial theoretical research will continue to relate to surface science, ion implantation, random alloys, and radiation effects.

Ceramic materials exhibit growing technological importance. In addition to property enhancement with surface modification, development of novel processing and property measurement techniques will be investigated. Planned expansion of these programs includes development of an analytical model for sintering zirconia-toughened composites, including solute stabilizer effects. Development of ceramic materials and aluminide-based alloys for high-temperature applications will continue at the current levels. Efforts to transfer the current aluminide technology to industry will accompany studies to improve the properties of aluminides through alloying.

During this period, the Low Temperature Neutron Irradiation Facility (LTNIF) will become fully operational. Fundamental irradiation effects studies of pure metals, insulators, and transition metal carbides and nitrides are planned. In FY 1987, support will be redirected to LTNIF upon completion of the metal-fracture research program.

The Chemical Sciences subprogram (KC03) supports tasks in Physical Chemistry, Atomic Physics, Chemical Energy, and Separations and Analyses. Growth is anticipated in the Atomic Physics and Separations and Analyses areas. The Atomic Physics program performs accelerator studies with the EN Tandem and HHIRF. Completion of the design and initiation of construction of a HISTRAP at HHIRF are planned for the reporting period. To date, the conceptual design report and related documentation have been completed for this facility. HISTRAP will consist of a synchrotron cooling ring (48-m circumference) to store beams of multicharged heavy ions supplied by the Tandem Accelerator of HHIRF or by a dedicated Electron Cyclotron Resonance–Radio Frequency Quadrupole System. HISTRAP will provide high fluxes of multiply charged ions at energies continuously variable from a few tens of keV per nucleon to MeV per nucleon. An electron-beam cooling system will enhance the quality of the ion beams and will permit electron-ion interaction studies. In addition, HISTRAP will provide the capabilities for exciting new experiments involving ion-atom interactions, low-energy multicharged ion beams, merged beam ion-ion collisions, and spectroscopy. These types of experiments are relevant to both basic science and technology research areas. HISTRAP will operate as a national user facility in a manner similar to HHIRF. The ORNL research program will grow to fully use the potential of HISTRAP.

A new proposal initiating in FY 1986 is the development of a high-intensity, slow-positron source at ORELA. This source would provide two orders of magnitude more flux than conventional radioactive sources. Construction of the Advanced Mass Spectrometry Laboratory at ORNL will centralize mass spectrometry research, modernize the equipment in these programs, and foster collaboration with industries and universities. A new program in the organic mass spectrometry area is development of a Translational Spectrometer for studies of the collisional activation excitation process, the cornerstone of the mass spectrometry/mass spectrometry (ms/ms) technique. In the chemical measurement technique area, a new project will be initiated to develop new concepts for radionuclide detection and measurement. Limited growth is projected for the solvent extraction and multiphase separation tasks. New avenues of separations research supported by this growth include the application of magnetic fields. Exploration of the chemistry of actinides and

fission products will emphasize spectrophotometric studies, including characterization of low-temperature matrix-isolated actinides, and a number of collaborative research projects on extraction, separation, and coordination chemistry.

Chemical Energy research will emphasize studies of fossil fuel chemistry, catalysts, catalytic processes, and solution behavior at high temperatures and pressures. Current research levels in these areas will be retained through the reporting period. Support will remain constant for molecular research using electron spectrometry with synchrotron radiation. It is anticipated that future experiments will use the NSLS in addition to the new 1-GeV facility at the University of Wisconsin.

Substantial growth is projected for the Center for Engineering Systems Advanced Research (CESAR) Program for energy-related research in intelligent control systems supported by Engineering and Geosciences (KC04). Completion of additional laboratory space will provide improved opportunities for experimentation in navigation and manipulation. Research avenues for this period include assembly and characterization of a remote manipulator, development and application of parallel algorithms for robotic tasks (e.g., navigation and vision), and continued evolution of the Hostile Environment Robotic Machine Intelligence Experiment Series (HERMIES). The Geosciences effort will remain stable and emphasize experimental geochemistry with limited field work related to continental scientific drilling experiments. A new project will involve study of oxygen/hydrogen systematics in brines in geothermal and hydrothermal systems.

New funding from the Advanced Energy Projects Division (KC05) will enable study of methods for the recovery of cellulase, an enzyme for the hydrolysis of cellulose, from aqueous solution and undigested solid residues. Funding for the Applied Mathematics programs (KC07) is expected to increase with increasing emphasis on the development of basic algorithms and communication techniques for parallel computing. A new area of emphasis will be the development of techniques for applying parallel computing to problems involving partial differential equations. Collaborations through the UT-ORNL Distinguished Scientist Program will enhance this program, especially in the area of sparse matrix calculations.

Program Construction. Funded construction includes HFIR improvements and modifications for heat exchangers and a remote sampling facility. Proposed for construction are CNR, HISTRAP, and a Reactor Improvements and Modification Project (Table 7).

KD—Energy Research and Analysis

The Energy Research and Analysis Program supports technical and economic assessments of alternate energy technologies. Evaluations are conducted in response to specific requests from DOE-OER. No significant funding changes are expected for the reporting period.

KE—University Research Support

The University Research Support Program (KE) activities stimulate the involvement of the university community in ORNL research programs. In FY 1986, through the University Laboratory Cooperative Program (ULCP), financial support was provided to

Table 7. KC—Construction summary

($ in millions)

	Fiscal year							Total estimated cost
	1986 and before	1987	1988	1989	1990	1991	1992 and beyond	
Funded construction								
Accelerator improvements and modifications								
Calutron Cooling Tower	0.27							0.27
EN Tandem, data acquisition system	0.25							0.25
HHIRF, beam lines for atomic physics		0.05	0.15	0.10				0.30
Accelerator and reactor improvements and modifications								
Bulk Shielding Reactor Facility	0.10	0.10						0.20
Reactor improvements and modifications								
HFIR heat exchangers and Remote Sampling Facility	0.35	0.81						1.16
Proposed construction								
Heavy Ion Storage Ring for Atomic Physics				1.6	6.9	3.2	3.1	14.8
Center for Neutron Research				25.0	40.0	60.0	200.0	325.0
Reactor improvements and modifications								
HFIR Critical Facility			0.25					0.25

over 100 student and faculty research participants under a variety of programs. Approximately thirty-five undergraduate students and four faculty members participated in the Science Semester programs. These programs, in their second decade, permit students to engage in research and take classes under the direction of resident faculty, for which they receive credit at their home institution. Another long-standing program supports the operation of reactor facilities to provide an opportunity for students and faculty to conduct nuclear engineering experiments. Two newer programs were expanded considerably in FY 1986: the Special Summer Program and the Technology Internship Program. Through the Special Summer Program, qualified students from Historically Black Colleges and Universities (HBCU) are employed; the number of participants and the colleges represented was increased by more than a factor of 2 in FY 1986. Conducted with ORAU, the Technology Internship Program provides internships for up to three quarters for stu-

dents working toward an associate degree in energy-related disciplines; the number of participants also increased in this program, especially health physics students. The demand for trained health physicists also prompted the development of a new program that provides advanced training for graduate students in health physics; four students participated in this program in FY 1986. The ULCP also sponsors collaborative faculty sabbaticals, visits to ORNL by HBCU faculty, and other activities aimed at encouraging university involvement in ORNL activities.

Also sponsored by KE is the Industry Technology Exchange Research Program, which provides incremental expenses for the assignment of industrial researchers to ORNL. Two nominations were developed and approved for FY 1986 after the first assignment was completed successfully at the end of FY 1985.

The KE program is expected to grow substantially in FY 1988 and beyond after a modest increase in the funding for FY 1987. Areas to be developed include precollege programs, including some aimed at students in grades K–8, and more programs that address specific manpower needs of DOE. It is also planned that opportunities for college students and faculty will be increased during the academic year, modeled on the successful Science Semester programs. The number of industry participants sponsored by the Industry Technology Exchange Research Program is also expected to grow.

KG02—Environmental Compliance

The Environmental Restoration and Facilities Upgrade (ERFU) Program is a large program supported by program KG, Environmental Compliance. It was initiated in FY 1985 in response to a compliance inspection by the Environmental Protection Agency (EPA) and the state of Tennessee, which emphasized the need to reduce hazardous chemical and radionuclide discharges to the environment and to accelerate environmental compliance activities on a comprehensive basis. This program conducts remedial actions at process ponds, at spill sites, and at locations in the White Oak Creek watershed where past practices have contaminated facilities or the environment to levels that require corrective measures. This effort will involve substantial amounts of site-characterization work, assessment of alternatives for National Environmental Policy Act (NEPA) compliance, and assessment of post-stabilization performance as well as actual remedial actions. The program also coordinates projects to improve or develop systems for collection, treatment, storage, and disposal of radioactive and hazardous chemical wastes and to improve environmental monitoring capabilities for the site. Another important function of the program is development of a plan for decommissioning ORNL facilities that are not eligible for inclusion in DOE's Surplus Facilities Management Program because of their relation to active technical programs.

Capital funding for the program is expected to increase rapidly in the FY 1987–1989 period (Table 8) as work on two large construction line items progresses. A preliminary list of projects is given in ORNL/6141, *Preliminary ORNL Long-Range Environmental Management Plan.* Additional definition and development of the scope and criteria for projects are continuing.

Table 8. KG02—Construction summary

($ in millions)

	Fiscal year							Total estimated cost
	1986	1987	1988	1989	1990	1991	1992	
Proposed construction								
Environmental compliance	5.3	7.0	12.8	15.8	20.0	10.5	8.8	80.2

Assistant Secretary for Nuclear Energy

The Assistant Secretary for Nuclear Energy is the major sponsor of applied nuclear research. Programs funded through this office are multidisciplinary in nature and include, as major activities, those listed in Table 9.

Table 9. Assistant Secretary for Nuclear Energy major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1985	1986	1987	1988
AE	Advanced Nuclear Systems	2.16	2.92	*b*	*b*
AF	Civilian Reactor Development Program	10.21	25.72	30.12	46.18
AG	Convertor Reactor Systems	4.65[c]	*c*	*c*	*c*
AH	Remedial Action Programs	6.60	8.37	9.28	4.18
AP	Commercial Nuclear Waste Management	0.27	0.05	0.03	0.02
AS	Nuclear Fuel Cycle	18.16[c]	*c*	*c*	*c*
CD	Uranium Enrichment	0.74	0.28	0.28	0.28
Total		38.14	37.34	39.71	50.66
Percentage of total Laboratory funding—BA		8.9	9.9	9.9	11.7

[a]Figures include operating BA, capital equipment, and funded/budgeted construction, if any.
[b]Program AE ended in FY 1986, and continuing activities are included in program AF.
[c]Programs AG and AS ended in FY 1985.

AF—Civilian Reactor Development Program Overview

The goal of the U.S. Civilian Reactor Development Program is to ensure the nation's energy future through the establishment of attractive and commercially viable nuclear energy options and the necessary technology base. The program has been restructured to

more broadly address advanced converter reactor systems based on water, gas, and sodium coolants. Although the sodium-cooled breeder reactor is recognized as a vital long-term need to provide an essentially inexhaustible energy supply, current predictions of uranium use reduce the pressure for early breeder development. The LMR concept, however, continues to show promise as an advanced converter. Also, the high-temperature gas-cooled reactor (HTGR) shows promise as a versatile energy source for a broad spectrum of applications, including high-temperature process heat.

ORNL will continue to support DOE's concept development and base technology programs and offer its broad expertise in fission reactor and fuel recycle technology for the restructured program.

Reactor Program. Improved LWR technology is an urgent national need to support improvements in performance and availability of current-generation LWRs as well as advanced concepts. Close cooperation with the Electric Power Research Institute (EPRI), the utility industry, and the nuclear power industry is the basis for planning and implementing this effort. Although the major portion of this effort is to be carried out by industry, we expect to play a prominent role in DOE's expanded LWR program because of our broad expertise in LWR technology. Continuing LWR tasks include updating annually the energy economic data base and producing engineering economic comparisons of nuclear options versus other energy sources. New activities are emerging in support of the EPRI advanced LWR plant requirements documents, advanced LWR control systems in cooperation with industry, and special studies, such as modeling and analysis related to the Chernobyl accident.

Primary emphasis in the national HTGR Program is on development of a modular high-temperature gas-cooled reactor (MHTGR), using steel pressure vessels for the reactor core and steam generators in a side-by-side arrangement. The use of steel vessels facilitates factory fabrication and shipment to the reactor site. The passive safety features of the MHTGR also lead to cost savings because of the potential for high-quality automated factory fabrication, streamlined licensing, standardized construction, non-safety-grade balance-of-plant construction, use of incremental financing, and reduced rate-base impact. In the longer term, MHTGRs show promise of broadening the applications of nuclear power to high-temperature process heat areas and to energy generation in water-limited regions.

The mission of ORNL in this activity is to provide technological expertise in support of the national HTGR Program to develop passively safe, economically attractive HTGRs for electricity production, cogeneration, high-temperature process heat, and high-temperature energy conversion. ORNL has lead responsibility for the Base Technology Development Program. Technical activities include (1) performing qualification tests of HTGR fuel performance and fission product behavior under postulated accident conditions; (2) providing basic data on the mechanical, physical, and chemical behavior of HTGR materials, including metals and graphite; (3) providing analytical evaluation of shielding designs; and (4) providing technical and economic evaluations and assessments.

Advanced LMR converter technology support will be focused principally in the base-technology areas of measurement and control, shielding, materials, structural design, and safety. Emphasis is on tasks in support of (1) innovative, low-cost, and passively safe designs and (2) international collaborative efforts.

Measurement and control activities will include man-machine integration, automated control methods employing artificial intelligence, and high-temperature fission counters and systems for automated surveillance and diagnostics.

A new activity initiated in FY 1986 is the Advanced Control Test Operation (ACTO) concept directed toward establishing a facility for development and testing of advanced control and information-handling technology. This major activity will involve broad participation from both universities and industry.

In the shielding task, experiments at the Tower Shielding Facility will be performed in a collaborative effort with the Japanese to investigate alternative shielding materials such as B_4C for LMR near-core and deep-sodium environments. In addition, analytical and experimental support will be provided for advanced LMR designs.

In materials and structural design, we will continue to develop and code qualify the modified 9 Cr–1 Mo steel, provide improved design methods and criteria, and develop advanced in-service inspection techniques.

The safety work will be concentrated in a joint program between the United States and Japan to develop a centralized advanced reactor reliability data base and operate a reliability data analysis center.

Remote systems technology has been a major element in the fuel recycle technology program over the past several years. Application of this technology in advanced civilian reactors is another emerging area of emphasis within the technology support program.

In addition to these technology development activities, we provide technical support to DOE in review and evaluation of advanced concept design documents and in participation in peer reviews of the advanced concept designs.

The Performance Assurance Project Office will continue to promote the development of consensus industrial standards and special program standards, as required, and to ensure that the information and experience gained in all nuclear programs are made available to the private sector. Program support for DOE's unusual-occurrence-report activities will be continued.

Consolidated Fuel Reprocessing Program. The CFRP plays an important role in the future of nuclear power in the United States. Over the past decade, ORNL has been developing the technology for reprocessing spent fuel, with the major emphasis on the special problems associated with reprocessing breeder fuels. During this time, ORNL has developed improved concepts and techniques that are recognized worldwide. Many similar improvements are being incorporated in foreign reprocessing facilities. ORNL leads the world in efforts to develop improved methods for remote maintenance in reprocessing facilities. Also important is the fact that this innovative remote technology could be applied to a variety of activities in other hazardous environments: fusion, waste disposal, decommissioning, and cleanup of reactors and other nuclear facilities.

ORNL will continue its active role in efforts to foster international technical exchanges and other collaboration. Limited activities under the United Kingdom exchange program continue. Early in FY 1986 an agreement in remote technology was signed with France. A similar agreement is under consideration with the Federal Republic of Germany. Exchange agreements with Japan are in place, and collaborative work is in progress in experimental criticality work and in application of remote technology. Japan's Power

Reactor and Nuclear Fuel Development Corporation (PNC) is providing major funding for the criticality program.

In addition, a broad collaboration with PNC is being developed as a long-term program mission. This program focus is aimed initially at a multimillion dollar per year collaborative R&D program spanning the next five to six years. PNC would contribute a share equal to the U.S. cost of this activity for which Japan would gain access to U.S. reprocessing technology. In addition, the United States would participate in Japan's Hot Reprocessing Pilot Plant, and Japan would purchase certain specialized equipment developed for the plant from the United States.

As a major development, work on the advanced servomanipulator (ASM) is concluded (with full operation of the prototype). Efforts to transfer this technology to industry are being pursued. Interest in seeking a market and commercializing the technology will be sought by requesting cost sharing and fees for an exclusive licensing arrangement with the private sector. Follow-on activities in further development of the ASM will be substantially influenced by the outcome of the technology transfer effort.

The use of centrifugal contactors for solvent extraction process applications offers the advantages of rapid startup, short solution residence time, compact size, high mass transfer efficiency, and potentially lower overall system cost when compared with more conventional contactors. Additional improvements in performance and reliability are being achieved. Futhermore, the potential for simplification of the overall solvent extraction system will be explored. For example, efficient centrifugal contactors may allow systems that have fewer purification cycles. Contactor applications in the nuclear industry include both commercial and defense fuel reprocessing, scrap recovery operations for fuel fabrication and weapons production, and waste processing. Testing and demonstrations of these techniques with small-scale contactor banks will be done using support systems within the Integrated Equipment Test (IET).

CFRP's 9-kW remote laser cutting system can be applied to the development of remote cutting, welding, and special heat treating procedures that have wide applications. The demonstrated ability to remotely control and automatically drive the high-power laser focus head can be shown to have potential use in large industrial applications requiring a high-power laser.

Direct support of the CFRP from the Office of Civilian Radioactive Waste Management (OCRWM) Program is being sought since the repository's surface facility and the Monitored Retrievable Storage (MRS) facility have many requirements similar to a reprocessing facility, such as remote handling of spent nuclear fuel, high-level waste, waste canisters, and casks. All in-cell equipment will have to be maintained and replaced during the facility's lifetime. In addition, the maintenance systems themselves will require maintenance. The use of teleoperations, telerobotics, and robots within the facility already has an existing strong technological base that can be expanded to assist OCRWM as their needs become better defined.

Space Reactor. Improved materials for space missions and terrestrial applications that use heat generated by isotopic power devices are being developed and evaluated. Activities include the production of iridium-alloy-cladding blanks to contain heat-generating radioisotopes and carbon-bonded carbon-fiber (CBCF) insulators to achieve

1300°C operating temperature. In anticipation of resumed production as early as FY 1987, ORNL is maintaining its production capability and inventory of iridium.

In the interim, technology improvements are being pursued. These include (1) development of a process to produce CBCF from a new starting product, (2) development of a consumable arc melting technique and determination of processing ranges for the iridium alloy, and (3) nondestructive examination support for manufacture of advanced thermoelectric elements and the iridium alloy blanks.

ORNL will continue in its lead role in the development and characterization of high-temperature materials for the SDI Program on fission reactor concepts for power levels in the hundreds of kilowatts (SP-100 Project) as well as for the multimegawatt range. In the Ground Engineering System phase of the SP-100 Project, which began in FY 1986, it is anticipated that ORNL will also have a significant role in the technology areas of reactor shielding and measurement and control.

AH—Remedial Action Program

Major activities in Remedial Action Programs (RAPs) involve the conduct of radiological surveys on private properties near inactive mill tailings sites and at facilities formerly used under contract with the Atomic Energy Commission (AEC). Identification, evaluation, and documentation of the current radiological status of sites involved in DOE's RAPs are performed to provide a basis for the reduction of health impacts of fuel cycle activities. To perform its activities in a cost-effective manner, the Uranium Mill Tailings RAP maintains an office staffed by the HASRD in Grand Junction, Colorado. The national importance of this program is manifested by the FY 1986 funding level of $7.5 million, an increase of more than $3 million over FY 1985. Advancing state-of-the-art equipment and methodologies are an integral part of this work. Radiological survey efforts will be maintained at the current level through FY 1987. Survey efforts will be reduced sharply in FY 1989 when nearly all inclusion surveys will be completed. The survey program is expected to stabilize at a level of more than $3 million to fund certification surveys and other work as needed.

AP—Commercial Nuclear Waste Management

The Commercial Nuclear Waste Management Program provides minor support for the Integrated Data Base (IDB). This minor support is expected to continue indefinitely.

CD—Uranium Enrichment

This activity is to support the Energy Information Administration (EIA) in an examination of the economic viability of the U.S. uranium milling and mining industry. The EIA must submit to the Secretary of DOE an annual report that states the size of the world uranium market and U.S. production as a fraction of the total. Additionally, the report must identify and quantify the imports of power reactor fuel into the country and the impact of these imports on U.S. industry. Specific tasks include (1) collecting and analyzing data pertinent to the study, (2) determining the use and development of the international uranium supply, and (3) building demand models that forecast international uranium market conditions.

Office of Civilian Radioactive Waste Management

ORNL's work for the DOE Office of Civilian Radioactive Waste Management (OCRWM) is conducted under the DB program, which is funded by revenues from a 1.0 mil/kWh(e) tax on electricity generated by nuclear reactors plus equivalent amounts to pay for the defense high-level waste (HLW) that will be buried in the repositories. ORNL's DB activities currently involve the first repository (DB01), the second repository (DB02), transportation and system integration (DB04), and program management and technical support (DB05). ORNL expects to play a substantial role in supporting the construction and operation of an MRS facility, if authorized, but there is currently no activity in this area pending the outcome of court and congressional actions.

While the overall outlook for OCRWM programs at ORNL is promising, recent controversy over the first repository site selection and deferral of the second repository could have a substantial detrimental impact on the entire OCRWM effort. The results of on-going congressional deliberations may be that OCRWM budgets will be sharply reduced until the structure and balance of the repository efforts receive congressional approval.

DB—Nuclear Waste Fund

The first repository component of the OCRWM Program supports continuation of the sensitivity and uncertainty analysis task for the salt repository project. This task is developing a computer-based methodology to analyze uncertainty in the results of complex computer codes. Additional work is expected for first repository projects in FY 1987 and succeeding years in a variety of R&D support roles, but the nature and amount of these are uncertain because of the budgetary and programmatic uncertainties previously mentioned.

The second repository component of the program supports the investigation of sedimentary rocks other than salt as potential hosts for a nuclear waste repository. This program has evaluated five sedimentary rocks other than salt and prepared a draft report concluding that shale is preferred. The OCRWM is currently considering the role of shale in the second repository program. Expectations are that shale will continue to be investigated in this application on a basis that is not site specific. The crystalline rock program has funded ORNL transportation analyses in support of the crystalline rock recommendations issued during FY 1986. These activities are expected to be terminated because of major changes in the structure of the program. However, additional work in a number of R&D support roles is anticipated from parts of the second repository program other than shale (Table 10).

The transportation and system integration component of the program supports three substantial activities at ORNL. The first is the Waste Systems Data and Development project, which is charged with developing data bases, performing technical assessments, and developing technology in areas common to multiple components of the OCRWM system. Under the second activity, ORNL will provide integration and technical support and undertake specific technical work related to DOE-ORO's lead responsibility for the OCRWM Transportation Operations Program Office. The third area involves providing

Table 10. Office of Civilian Radioactive Waste Management major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1985	1986	1987	1988
DB	Nuclear Waste Fund	3.58	7.21	7.14	8.06
DC	Civilian Radioactive Waste	0.04[b]	*b*	*b*	*b*
Total		3.62	7.21	7.14	8.06
Percentage of total Laboratory funding—BA		0.8	1.9	1.8	1.9

[a]Figures include operating BA and capital equipment, if any.
[b]Program DC ends following FY 1985.

analytical, experimental, and testing support to the parts of OCRWM's transportation program concerned with cask development and the institutional and economic aspects of transportation. Work in the first and third areas is expected to remain stable or grow modestly; work in the second area is expected to grow substantially from its inception in FY 1986.

The program management and technical support component of OCRWM supports a major portion of the IDB project and the review and evaluation of the environmental aspects of key OCRWM documents. Support in this area is expected to remain stable.

Assistant Secretary for Defense Programs

The major effort for the Assistant Secretary for Defense Programs (ASDP) is in defense waste management and may be divided into four main categories: (1) management of wastes generated at ORNL, (2) development of technology for managing low-level waste (LLW) and transuranic (TRU) radioactive wastes, (3) management of the hazardous Chemical Defense Waste Management Program for DOE, and (4) production of materials involving administration of the national repository for ^{233}U and conversion of 100 kg of uranium from liquid to an inert solid (Table 11).

AR—Defense Waste and Transportation Management

ORNL Waste Management Operations Program. The program included ten tasks in FY 1986 but will be reduced to five tasks in FY 1987, reflecting the focusing of the program into Operations, Remedial Action, TRU Waste Management, and support tasks. The five tasks are

1. LLW Management Operations (solid, liquid, gaseous),
2. Remedial Action,
3. TRU Waste Certification and Volume Reduction,
4. Interim Waste Management Facilities, and
5. Program Planning and Management.

Table 11. Assistant Secretary for Defense Programs major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1985	1986	1987	1988
AR	Defense Waste and Transportation Management	24.11[b]	28.98[c]	32.50[d]	34.61
GC	Verification and Control Technology	0.29	0.32	0.40	0.15
GD	Safeguards and Security	0.48	0.52	0.56	0.47
GE	Materials Production	8.73	5.88	7.02	4.05
Total		33.61	35.70	40.48	39.28
Percentage of total Laboratory funding—BA		7.1	9.5	10.1	9.0

[a]Figures include operating BA, capital equipment, and funded/budgeted construction, if any.
[b]Figures include $1.2 million construction.
[c]Figures include $3.2 million construction.
[d]Figures include $3.4 million construction.

The failure of the Central Waste Disposal Facility (CWDF) Project to provide new disposal facilities by the time existing facilities will be depleted has caused a strategy of "interim storage" to evolve for all Oak Ridge facilities. High-volume, low-activity solid waste will be stored at the Oak Ridge Gaseous Diffusion Plant (ORGDP). Waste unsuitable for interim storage, because of high levels of radiation, or shapes unsuitable for packaging will continue to be disposed in solid waste storage area 6. Techniques providing greater confinement will be used for high-activity waste. The overall solid waste disposal strategy combines improved operations in existing facilities, volume reduction, interim storage, and demonstration of waste treatment and disposal techniques for a new disposal facility expected to be operational by the mid-1990s.

Hydrofracture disposal is not anticipated to be used again at ORNL in this century. Liquid waste management by solidification and near-surface disposal will replace hydrofracture. Volume reduction initiatives have already significantly reduced the waste generated, and these initiatives are expected to continue until volumes are reduced from an average of 12,000 gal/month in FY 1984 to less than 2,000 gal/month by FY 1987.

There are four TRU waste streams at ORNL. They are newly generated (NG) and stored contact-handled (CH) TRU waste, and NG and stored remotely handled (RH) TRU waste. The NG-CH TRU waste stream received approval for certification in June 1986. Planning for the certification of each of the other streams is nearing completion. Certification is the process by which waste is packaged for shipment to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico, so that the acceptance criteria established for the WIPP facility are met. CH TRU waste is packaged in stainless steel 55-gal drums.

The drums are examined by neutron interrogation (to establish the effective ^{239}Pu equivalent nCi/g), segmented gamma scans (to establish what isotopes are present), and X-ray scans (to determine whether prohibited waste forms such as liquids and powders are present). RH TRU waste is currently stored in large concrete casks, which are unsuitable for shipment to WIPP. Management of the RH TRU waste will require that the casks be repackaged in shipping containers approved by the Department of Transportation (DOT). In addition to the solid RH TRU waste, ORNL has approximately 250,000 gal of RH TRU sludge, which will be solidified for shipment. A facility is planned for construction beginning in the mid-1990s to repackage the contents of the concrete casks and to solidify the sludge for shipment to WIPP.

Many of the disposal units for radioactive waste used at ORNL since the early 1940s do not meet current standards for retention of radionuclides. Remedial action is therefore required to bring these units up to current standards so they can be closed. This effort will require characterization of the disposal units and their current performance, assignment of priorities, assessment of closure techniques, selection of appropriate closure action for each unit, and implementation of that action. Postclosure monitoring and modeling will also be included in the remedial action.

Hazardous Waste Program. The Hazardous Waste Program Support Contractor Office (SCO) supports the ORO Hazardous Waste Program in the technology aspects of hazardous and mixed waste (HMW) management at all DOE defense program (DP) facilities. The SCO assists DP facilities with the technologies required for sound management of HMW, including reduction, transportation, treatment, storage, and disposal of wastes and environmental restoration. The SCO performs its functions through identification and evaluation of DP facilities waste management problems and issues, support of technology development and transfer of technologies to handle waste management problems, development of waste management strategies, and assistance to DOE Headquarters staff in HMW policy development.

The SCO developed and maintains the Waste Information Network, a computer-based communications system that allows DP contractors, Operations Offices, DOE Headquarters, and the SCO to exchange information quickly and efficiently. The SCO performs ongoing analyses of both proposed and new legislation and regulations affecting DP waste management and distributes manuals, analyses, and regulatory alerts to the DP waste management community. The SCO will continue to support ORO and DOE Headquarters as waste management needs become better defined and means for dealing with HMW evolve. The Hazardous Waste Program budget is anticipated to increase by approximately 50% in FY 1986 and again in FY 1987.

GC—Verification and Control Technology

Resonance Ionization Mass Spectrometry (RIMS) for the Ultra-Trace Analysis task will exploit a recently developed technique of using laser-induced RIMS to measure isotope ratios of a variety of elements. Begun in mid-FY 1984 and continuing beyond FY 1986, the effort is staff intensive, with minimum costs incurred for materials. Nuclear Fuel Cycle Workshops will continue to be held to acquaint civil servants in various federal agencies with the nuclear fuel cycle, especially aspects relevant to nuclear nonproliferation.

GD—Safeguards and Security

This activity, begun in 1985, involves two projects that include (1) the detection of high explosives in real-time by the technique of mass spectrometry–mass spectrometry and (2) independent fissile inventory verification and tank calibration techniques by mass spectrometry. This work will continue at a constant level.

GE—Materials Production

This program includes the ^{233}U Storage and Distribution Program and the Californium Industrial Sales/Loans Program. Facilities for purification of ^{233}U, located in the Radiochemical Processing Plant (RPP) at ORNL, are being placed in standby condition, and this will be achieved by FY 1989. Safeguarded storage of ^{233}U in the RPP will be continued. A conceptual design is available for installing new ^{233}U processing facilities with significantly improved capabilities should DOE's needs for ^{233}U be resumed. The new facilities would be located in two of the shielded cells at the Thorium-Uranium Recycle Facility (TURF).

The special project of converting 1000 kg of uranium (composed mainly of the fissile isotopes of uranium) from a liquid to an inert solid has been completed successfully. During FY 1987, the equipment and storage tank for this project will be flushed and put in standby.

Facilities for the Californium Industrial Sales/Loans Program were installed in other shielded cells at TURF in FY 1986, and operations are scheduled to begin in early FY 1987. The purpose of this program is to fabricate ^{252}Cf into neutron sources or into bulk packages for sale to industry or for loan to other government agencies.

Assistant Secretary for Conservation and Renewable Energy

ORNL activities for the Assistant Secretary for Conservation and Renewable Energy (ASCE) encompass ten program categories covering a diversity of conservation and renewable energy topics. The programs are devoting increased emphasis to technology transfer and to cost sharing by the private sector. A decrease in the budget for electric energy systems is expected, reflecting the lower DOE request to Congress for FY 1987 funds in this category. Budgets for other categories in FY 1987 may be about the same or slightly lower than the previous year (Table 12).

AK—Electric Energy Systems Programs

Activities in the AK program deal with power systems technology through investigation of new concepts and development of future technology for the electric utility industry. Project technologies offer opportunities to improve efficiency of the electric energy system by reducing costs and conserving resources. Activities are organized into eight task areas: dielectrics, distribution automation and control, systems research, high-voltage alternating current (HVAC), high-voltage direct current (HVDC), materials, electromagnetic pulse (EMP), and electric fields.

A significant accomplishment during FY 1986 was the installation of a major part of the equipment at the Athens Automation and Control experiment and the start of data

Table 12. Assistant Secretary for Conservation and Renewable Energy major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1985	1986	1987	1988
AK	Electric Energy Systems	7.84	3.12	3.50	3.37
AL	Energy Storage Systems	1.08	1.08	0.70	0.70
AM	Geothermal	0.05	0.00[b]	*c*	*c*
CC	Geothermal Resources Development Fund	0.06	0.00[b]	0.00[d]	0.02
CE	Hydropower	0.05	0.05	0.05	0.05
EB	Solar Energy	4.48	6.18	5.70	5.69
EC	Building and Community Services	12.44	11.30	11.02	11.38
ED	Industrial	1.52	1.22	1.06	1.02
EE	Transportation	15.95	9.70	10.47	11.07
EF	State and Local Programs	0.31	0.00[b]	0.32	0.00[e]
EG	Multisector	5.66	5.21	5.80	4.67
Total		49.44	37.86	38.62	37.97
Percentage of total Laboratory funding—BA		10.1	10.0	9.6	8.7

[a]Figures include operating BA, capital equipment, and funded/budgeted construction, if any.
[b]Major portions of FY-1986 costs were supported by prior funding obligations.
[c]Program AM ended following FY 1986.
[d]Major portions of FY-1987 costs are to be supported by prior funding obligations.
[e]Major portions of FY-1988 costs are to be supported by prior funding obligations.

collection. During FY 1987, the installation of hardware at Athens will be completed, and experiments will continue and will be analyzed. Transfer of operating experience and economic analysis to the utility industry will be emphasized.

In the future, the dielectrics research will emphasize liquid dielectrics and SF_6 spark toxicity. Ongoing research tasks will be continued in the areas of EMP, field effects, and power systems. Budget restrictions are expected to curtail activities in HVDC, HVAC, and materials development.

AL—Energy Storage Systems

ORNL has been assigned responsibility for field management of Thermal Energy Storage materials, systems, and use technology in the areas of diurnal storage and industrial processes. Program objectives are to develop (1) concepts for economical heat pump thermal storage, (2) technologies for significantly increased use of high-temperature industrial reject heat, (3) concepts for passive solar heat storage, (4) a data base for new heat storage materials and processes, and (5) effective interactions with the private sector to determine research needs and to transfer developed technologies. The outlook is for continuation of the program at approximately the current level.

AM—Geothermal

ORNL's work in geothermal research includes assisting DOE in the preparation of required NEPA documents by examining proposed installations to ensure that the associated environmental impacts are within acceptable limits. This work is expected to remain at less than one full-time equivalent (FTE).

A new geothermal project starting in FY 1986 will provide measurements of thermodynamic and kinetic data needed for an understanding of phase behavior in geothermal systems.

CC—Geothermal Resources Development Fund

Work in the CC program consists of examining proposed installations that have qualified for geothermal loan guarantees to ensure that environmental impacts are acceptable. This program is expected to remain at a fraction of an FTE.

CE—Hydropower

The purpose of ORNL's work in the CE program is to provide technical assistance to DOE for resolution of specific environmental issues associated with small hydropower development. Technical assistance to DOE Headquarters will continue at a reduced level with ORNL receiving support from the DOE Idaho Operations Office.

EB—Solar Energy

The principal activity in solar energy is technical management of the Biomass Production Program, which consists of long-term research on the production of woody and herbaceous biomass, program planning, and environmental and economic research and assessment. ORNL will assist the Biomass and Municipal Waste Technology Division with the following specific tasks: (1) development and administration of research on woody plants subjected to intensive culturing for high productivity; (2) development and administration of research on herbaceous crop resources; (3) complementary research on economics of energy crops and on environmental effects, physiology, and nutrient utilization; and (4) interactions with the International Energy Agency Biomass Working Group member nations. Approximately level funding is expected during the next several years.

ORNL participation in other solar programs is limited to tasks in which specific expertise is available, including development of simulation techniques for passive thermal storage (EB21) and preparation of brochures on renewable energy for use in less developed countries (EB27).

EC—Buildings and Community Systems

ORNL has been assigned technical management responsibility for four programs in the buildings area: Building Thermal Envelope Systems and Materials (BTESM), Building Energy Retrofit Research, Building Equipment Research (BER), and Residential Conservation Service (RCS). The BTESM Program (EC01) was initiated in response to the need of the insulation and building industries for relevant technical information on the thermal

performance of building envelope systems and in recognition of the impact that improved thermal performance of buildings would have on energy conservation. A National Program Plan, which was developed jointly by DOE, ORNL, and the National Bureau of Standards and subsequently updated by a panel of industry experts, forms the basis for selection of research projects. A highlight of the FY-1986 program was construction of the building to house the Roof Research Center user facility and the start of construction of the environmental chamber for the center. The level of effort is expected to remain approximately constant during the planning period, with increased emphasis on roofing systems, foundations, thermal anomalies, and technology transfer.

In Building Energy Retrofit Research (EC01), ORNL has been assigned technical leadership for single-family and commercial buildings. A multiyear plan has been completed for each sector with ongoing activities to include sector characterization, analysis and monitoring of retrofit performance, improvement of retrofit selection and diagnostic tools, and development of retrofit implementation and technology transfer mechanisms. The level of effort may decline somewhat during the planning period.

The BER Program (EC05) seeks to conserve energy by developing improved heating and cooling systems and appliances and by making better use of space-conditioning energy in buildings. BER activities include analytical studies, development of analytical tools, and laboratory and field experiments. The major program areas are vapor-compression systems, nonazeotropic refrigerant mixtures, ground-coupled heat pumps, absorption heat pumps, Stirling engine-driven systems, and internal combustion engine-driven systems. During FY 1986, predicted performance was achieved in an advanced model absorption heat pump. Funding is expected to remain nearly constant during the planning period.

The RCS Program (EC07), which includes the extension to commercial and apartment buildings, provides DOE with technical support for rule-making activities, technical assistance for implementation of rules, and evaluation of selected state and utility programs. DOE management of RCS is now in the Office of State and Local Assistance Programs. Continuation of this congressionally mandated program is contingent on congressional action.

Smaller, continuing roles have been assigned to ORNL in technology transfer (EC06) and community systems (EC03).

ED—Industrial

ORNL is responsible for two projects in Waste Energy Reduction (ED01). The first of these, Materials for Waste Heat Utilization, provides materials technology support to DOE and its contractors in support of recuperator development and in developing improved ceramic technologies. In the second project, Chemical Heat Pumps, the objective is to develop chemical heat pump technology for recovering industrial and process waste heat.

Under Industrial Process Efficiency (ED02), a new project initiated in FY 1986 will develop continuous chromotography as a method for separating multiple components from aqueous solutions in a single unit.

Funding of all these projects is expected to be stable during the planning period.

EE—Transportation

ORNL assignments include development of ceramic technology for advanced automotive heat engines, analysis of transportation data related to energy use, and technical management of the Alternative Fuels Utilization Program. Operating support for the ceramics technology program may increase during the next two years, in accord with the resource requirements identified in the program plan, *Ceramic Technology for Advanced Heat Engines.* The approach includes determining the mechanisms controlling reliability, improving processes for fabricating ceramics, and testing ceramic materials in simulated engine environments. Research is coordinated closely with complementary ceramics tasks funded by other DOE offices, NASA, DOD, and industry.

A new facility, the High Temperature Materials Laboratory, is scheduled for completion and occupancy in FY 1987 (Table 13). This facility will house laboratories and unique special equipment for high-temperature materials research by ORNL staff and researchers from industry, universities, and other government laboratories.

Table 13. EE—Funded construction summary

($ in millions)

	Fiscal year			Total estimated cost
	1986 and before	1987	1988	
High Temperature Materials Laboratory	19.3			19.3

EP—State and Local Programs

ORNL assignments in state and local programs are to assist DOE in evaluating the effectiveness of several programs, including the Grant Program for Schools and Hospitals, the Weatherization Assistance Program, and the Energy Related Inventions Program. Continuation of this work is contingent upon continued congressional funding for state and local programs.

EG—Multi-Sector

ORNL has technical management responsibility for the Materials Project and participates in the Tribology and Biocatalysis Projects—all in the Energy Conversion and Utilization Technologies (ECUT) Program. In materials, research is being conducted on high-temperature materials, lightweight materials, and materials properties modeling. In tribology, the principal work elements are friction and wear of ceramics. Our biocatalysis research seeks to develop continuous bioreactor technologies for production of chemicals such as ethanol. An additional ECUT project is on the development of microemulsions,

which may have several desirable characteristics for transportation fuels. Our expectation is that funding for the Materials Project will show a modest increase during the next two years, while the other ECUT projects remain at present levels.

Two additional projects within EG are evaluation of the Energy-Related Innovations Program and the National Appropriate Technology Assistance Service. The former is expected to continue during the planning period, while the latter will be completed in FY 1986.

Assistant Secretary for Fossil Energy

ORNL programs for the Assistant Secretary for Fossil Energy (ASFE) cover three major areas: coal, gas, and alternate fuels. The Coal Program (AA) is, however, the primary focus of the Laboratory's fossil energy activities (Table 14). The coal budget is anticipated to remain approximately constant, with primary emphasis on materials and environmental, health, and safety (EH&S) research.

Table 14. Assistant Secretary for Fossil Energy major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1985	1986	1987	1988
AA	Coal	7.13	6.70	5.64	8.08
AB	Gas	0.00[b]	0.00[b]	0.00[b]	0.00[b]
AC	Petroleum	0.00[b]	0.11	0.00[b]	0.16
AZ	Clean Coal Technology	0.00[b]	0.00[b]	0.63	0.00[b]
CH	Alternate Fuels Production	0.00[c]	0.00[c]	*d*	*d*
Total		7.13	6.81	6.27	8.24
Percentage of total Laboratory funding—BA		1.5	1.8	1.6	1.9

[a]Figures include operating BA and capital equipment, if any.
[b]Major portions of costs during the budget period are supported by prior funding obligations.
[c]Major portions of FY 1985 and 1986 were supported by previous-year funding obligations.
[d]Activities will cease at the end of FY 1986.

AA—Coal

The principal emphasis of ORNL's Fossil Energy Program is on materials R&D and on EH&S research. The materials R&D includes management (with DOE/ORO) of the Advanced Research and Technology Development (AR&TD) Fossil Energy Materials Program and the Surface Gasification Materials Program and development of corrosion-resistant alloys and coatings with emphasis on understanding the development and break-

down of protective oxide scales, erosion and wear-resistant alloys and cermets, high-temperature structural alloys ranging from advanced austenitic steels to ordered intermetallic alloys, and structural ceramics with emphasis on the development of whisker- or fiber-reinforced ceramic composites with improved strength and toughness. The EH&S R&D includes characterization and control of bioactivity of coal liquids, assessment of environmental-control technology, treatment of coal conversion wastewaters and development of disposal methods for resulting sludges, characterization of fate and effects of coal liquids on aquatic and terrestrial organisms, performance of industrial hygiene studies, development of disposal methods for solid wastes resulting from coal use, and improvement of current understanding of acid precipitation. ORNL provides broad-based technical support to the ASFE to assist in meeting DOE obligations to the Treasury Department on projects funded by the former Synthetic Fuels Corporation (SFC) as mandated by the Energy Security Act. This support includes multidisciplinary reviews of environmental monitoring plans prepared by sponsors of synfuels projects. ORNL also reviews actual project data from environmental monitoring plans and maintains a related EH&S information system for the ASFE.

Work is also carried out in a broad range of individual projects, which include work on computer modeling and simulation, particularly in the development of oil, gas, and coal supply models; evaluation of coal conversion technologies, including bioconversion concepts; development of automated methods for analysis of coal liquids; and research on coal chemistry related to the production of liquid fuels.

AB—Gas

Work in the Gas Program covers economic and technical evaluations of processes.

AC—Petroleum

Work in the Petroleum Program is focused on the economic and technical evaluation of a wide variety of technology areas of interest to DOE. Technology areas under investigation include enhanced oil recovery, tar sands, oil shale, solid waste management, advanced environmental control technology, and application of biotechnology.

AZ—Clean Coal Technology

Work in the Clean Coal Technology Program involves environmental technical support necessary to prepare appropriate NEPA reviews of site-specific projects in the Clean Coal Technology Program.

CH—Alternate Fuels Production

Work in the Alternate Fuels Production Program, covering modeling of coal gasification process technologies, will be concluded in FY 1986. Further funding in this area is not currently anticipated.

Energy Information Administration

ORNL provides research and management support to the Energy Information Administration (EIA). ORNL programs in support of EIA draw upon multidisciplinary teams from inside and outside the Laboratory. The work consists of data analysis, assessment, and evaluation; model development; economic evaluations; and application of statistical sampling techniques to target respondent universes. These tasks are in support of the four principal offices within EIA (Table 15).

Table 15. Energy Information Administration major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1985	1986	1987	1988
TA	Collection, Production, and Analysis	2.08	0.18	1.18	1.25
TB	Program Service	0.24	0.26	0.20	0.28
Total		2.32	0.44	1.38	1.53
Percentage of total Laboratory funding—BA		0.4	0.1	0.3	0.4

[a]Figures include operating BA and capital equipment, if any.

Assistant Secretary for Environment, Safety, and Health

Most ORNL work for the Assistant Secretary for Environment, Safety, and Health (ASESH) includes development of environmental policy assessment methodologies and models, application of these to analysis of proposed and existing environmental legislation and regulation, and planning and assessment of technologies for dealing with radiological emergencies. Activity at ORNL is funded only under the HA01 program (Table 16).

Table 16. Assistant Secretary for Environment, Safety, and Health major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1985	1986	1987	1988
HA01	Overview and Assessment	2.41	3.74	4.56	5.02
Percentage of total Laboratory funding—BA		0.5	1.0	1.1	1.2

[a]Figures include operating BA and capital equipment, if any.

HA01—Overview and Assessment

With an increasing emphasis by DOE on hazardous waste management and remedial action programs, ORNL is providing technical support to the Office of Environmental Guidance and the Office of Environmental Audit and Compliance. Regulations being promulgated by EPA under the Resources Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the Safe Drinking Water Act potentially have major impacts on DOE installations and operations. ORNL staff are assisting ASESH staff in evaluating regulatory initiatives under these statutes in terms of the technical issues and approaches involved and the potential impacts the initiatives would have on DOE. Our long-term support for compliance with NEPA continues. ORNL also provides support in sampling and analysis for the DOE-wide environmental surveys. ORNL will continue supporting the Office of Environmental Analysis in the development of the Acid Deposition Data Network.

For nine years, ORNL has supported the DOE Office of Environmental Analysis in the development of energy resource assessment models and in the provision of background research for various energy policy issues. This support will continue with increased attention to acidic deposition issues, the Clean Water Act Review, and the potential effects of global trace gas emissions. Sponsors of the Emergency Technology Program (ETP) plan to increase the research component of the program. Under the ETP, ORNL personnel review and assist in emergency planning and preparedness for environmental protection and public safety. ORNL is supporting the DOE Environmental Survey through a program of sample collection and analysis. The Environmental Survey is designed to identify potential environmental contamination problems at DOE sites. ORNL will participate by collecting samples of soils, sediments, ground and surface waters, and by performing analyses for possible contaminants.

Federal Energy Regulatory Commission

ORNL efforts for the Federal Energy Regulatory Commission (FERC) have remained relatively constant over the past year. In addition to the Owens River Basin hydroelectric project environmental impact statement, which was begun last year, ORNL initiated work for the Office of Electric Power (OEP) to assess the environmental impact of a small hydroelectric development on the El Portal River in California. Special studies of this type are expected to continue over the next few years; however, overall efforts for FERC are expected to decline over the planning cycle (Table 17).

Assistant Secretary for Management and Administration

ORNL does a small amount of work for the Assistant Secretary for Management and Administration under two budget and reporting codes, LA and WB. The LA category covers activity related to the DOE Office of Scientific and Technical Information. This funding has ended. No ORNL personnel are supported by program LA. The WB program covers an in-house energy management activity, which is expected to increase throughout the planning cycle. The energy conservation general plant project (GPP), which is associated with WB, will continue throughout the planning cycle. These funds are listed in Table 18.

Table 17. Federal Energy Regulatory Commission major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1985	1986	1987	1988
VP	Other expenses	0.79	1.24	0.55	0.55
Percentage of total Laboratory funding—BA		0.2	0.3	0.1	0.1

[a]Figures include operating BA and capital equipment, if any.

Table 18. Assistant Secretary for Management and Administration major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1985	1986	1987	1988
LA	Technical Information Services	1.21	0.00[b]	*c*	*c*
WB	In-House Energy Management	0.10	0.20	0.40	0.42
Total		1.31	0.20	0.40	0.42
Percentage of total Laboratory funding—BA		0.3	<0.1	0.1	0.1

[a]Figures include operating BA and capital equipment, if any.
[b]Major portions of FY-1986 costs are supported by prior funding obligations.
[c]Activities will cease after FY 1986.

Office of Policy, Planning, and Analysis

Work for the Office of Policy, Planning, and Analysis is now at a very modest level, and only small increases are anticipated (Table 19). This work involves analyses of policies related to the transportation sector and oil markets. A separate task involves forecasting future world oil prices, evaluating demand effects on oil prices and on the domestic production and consumption of oil, and evaluating the effect of federal tax policies on the domestic petroleum industry.

Work for Other DOE Installations

In the Fossil Energy Program, work for other DOE contractors and Energy Technology centers was largely concluded in FY 1986. Future work of this kind likely will be funded directly by the sponsoring agency.

Table 19. Office of Policy, Planning, and Analysis major program summary[a]

[$ in millions—budget authorization (BA)]

Budget and reporting code	Major program	Fiscal year			
		1985	1986	1987	1988
PE	Policy Analysis and System Studies	0.24	0.41	0.35	0.41
Percentage of total Laboratory funding—BA		0.1	0.1	0.1	0.1

[a]Figures include operating BA and capital equipment, if any.

ORNL is presently assisting DOE ORO in complying with NEPA during the renovation of the Feed Materials Production Center (FMPC) presently operated by Westinghouse Materials Company of Ohio. Additional work on environmental assessments and NEPA-related documentation will be performed (Table 20).

Table 20. Other Department of Energy contractors and Operations Offices major program summary[a]

[$ in millions—budget authorization (BA)]

Program area	Fiscal year			
	1985	1986	1987	1988
Fission	9.21	2.44	2.00	2.20
Biological and Environmental	2.40	3.08	2.67	2.59
Basic Physical Sciences	0.92	0.98	0.80	0.73
Fusion	0.47	0.04	0.02	0.02
Fossil	0.27	0.47	0.00	0.00
Conservation and Renewable Energy	0.21	1.58	0.61	0.38
Other	0.22	2.72	1.47	1.66
Total	13.70	11.31	7.55	7.58
Percentage of total Laboratory funding—BA	2.8	3.0	1.9	1.7

[a]Figures include operating BA and capital equipment, if any.

Work for Others

Nuclear Regulatory Commission

Of ORNL's FY 1986 operating and capital equipment budget authorization, about 6% comes from NRC, which amounts to over 24% of all the Laboratory's WFO.

Through its various programs at ORNL, NRC receives research and technical support in areas in which the Laboratory has demonstrated significant expertise. These areas include structural analysis, materials evaluation, fission product behavior, accident sequence analysis, advanced instrumentation and diagnostics, reliability and operating data analysis, integrated risk assessment, and radiation dose and health effects. Based on current NRC budget projections, ORNL efforts are expected to decline in parallel with corresponding decreases in the NRC research budget (Table 21). This will result in unfortunate losses of expertise in several of the areas identified previously.

ORNL activities for NRC are divided into the following six categories, which reflect work for the different offices funding the efforts.

Table 21. Nuclear Regulatory Commission program resource summary[a]

[$ in millions—budget authorization (BA)]

Major program office	Fiscal year			
	1985	1986	1987	1988
Nuclear Reactor Regulation	2.10	0.94	0.72	0.40
Administration	0.70	0.69	0.65	0.69
Nuclear Materials Safety and Safeguards	1.87	2.60	1.62	1.46
Nuclear Regulatory Research	22.35	13.49	14.23	10.48
Analysis and Evaluation of Operational Data	1.97	1.77	1.61	1.71
Other offices	1.02	1.22	0.45	0.12
Total	30.01	20.71	19.28	14.86
Percentage of total Laboratory funding—BA	6.2	5.5	4.8	3.4

[a]Subcontracts and direct FTEs at other sites are reported in the *Institutional Plan* for work for others.

Nuclear Reactor Regulation

For the Office of Nuclear Reactor Regulation, ORNL provides technical consultation and specialized measurements for test methods to detect anomalous behavior in LWRs.

Administration

The Laboratory furnishes technical support for the Office of Administration through the Radiation Shielding Information Center and the Technical Data Management Center.

Nuclear Materials Safety and Safeguards

Efforts on behalf of the Office of Nuclear Materials Safety and Safeguards include shipping-cask analyses, environmental assessments of fuel cycle facilities, technical support and laboratory-oriented evaluation in geochemical areas related to the licensing of radioactive waste repositories, and surveys of metabolic data appropriate to high-level waste dosimetry. Continued interest in environmental assessment tasks and waste management is anticipated; however, NRC's plans to develop a federally funded research center, independent of a national laboratory, to provide technical support to high-level waste repository licensing activities may severely impact this work in FY 1988 and beyond.

Nuclear Regulatory Research

The Office of Nuclear Regulatory Research supports the largest NRC program at ORNL. Relatively large efforts are under way for obtaining an improved data base for the behavior of fission products and aerosols in severe reactor core damage accident situations and for the long-term behavior of reactor pressure vessels. The issuance of a Commission Policy Statement on severe reactor core damage accidents has resulted in a decrease in the fission product research activities. Interest in extending the operational life of existing power plants beyond their original design has increased, and this is expected to result in increased research in aging characteristics of plant components.

Overall, a decrease in ORNL effort is anticipated beyond FY 1986, and changes in research emphasis are expected.

Analysis and Evaluation of Operational Data

Over two-thirds of the funds from the Office for Analysis and Evaluation of Operational Data (AEOD) support the Sequence Coding and Search System (SCSS), which is performed by the Nuclear Operations Analysis Center. The SCSS task involves the development and operation of a new system for increasing the usefulness of the descriptive text contained in Licensee Event Reports. Other activities include operation and maintenance of a non-reactor-related data file and a foreign reactor events file (proprietary). Funding is expected to remain stable through FY 1988.

Other Offices

The Laboratory provides technical assistance in the conduct of inventory verification, analysis of special nuclear materials samples, preparation of site-specific material standards, and review of environmental assessments and operating procedures changes for the regional offices. In addition, ORNL has developed and maintains a computer-searchable data base of construction deficiencies.

Department of Defense

The Department of Defense (DOD) is an increasingly important sponsor of ORNL research. Work is performed for three primary services of DOD (Army, Navy/Marines, and Air Force), as well as joint agencies such as the Defense Advanced Research Project

Agency (DARPA), Defense Nuclear Agency (DNA), Organization of Joint Chiefs of Staff (OJCS), Office of the Assistant Secretary of Defense (OASD), National Aerospace Plane Program, Transportation Operating Agencies, and others. Major ORNL programmatic support to DOD continues to expand in Data Systems R&D (DSRD), Strategic Defense Initiative (SDI), Hazardous Waste Management (HWM), and Acoustics and Instrumentation R&D (AIRD). These major programs as well as other DOD R&D activities are discussed in this section, and these budgets are listed in Table 22.

Table 22. Department of Defense program resource summary[a]

[$ in millions—budget authorization (BA)]

Major program office	Fiscal year			
	1985	1986	1987	1988
Army	10.07	6.10	6.66	7.20
Navy	4.04	4.17	4.51	4.80
Air Force	4.58	1.37	1.47	1.58
Defense Nuclear and others	1.80	1.78	1.91	2.00
Strategic Defense Initiative Office	0.12	7.26	9.92	13.20
Subtotal	20.61	20.68	24.47	28.78
Data Systems Research and Development	74.35[b]	14.00	19.00	22.40
Hazardous Waste R&D	*c*	3.85	5.89	9.20
Total	94.96	38.53	49.36	60.38
Percentage of total Laboratory funding—BA	19.7	10.2	12.3	13.9

[a]Subcontracts and direct FTEs at other sites are reported in the *Institutional Plan* for work for others.

[b]Beginning in FY 1986, management and contract support for the DSRD program were performed outside ORNL.

[c]Included in totals above.

Transportation Operating Agencies

The DOD is making a major investment in modernizing systems throughout its joint transportation operating agencies to improve its capability for planning, scheduling, routing, and managing the movement of military personnel and equipment worldwide. ORNL has played an important technical R&D role in supporting these agencies in the design and evaluation of state-of-the-art concepts in data systems and engineering. Major programs are expected to continue to expand for the Military Traffic Management Command, Military Sealift Command, Military Airlift Command, U.S. Army Forces Command, National Guard Bureau, and other operating agencies. Data systems research and development and

engineering are expected to increase for the development of the Crises Action Management System Mobilization Automated Support System, and the Airlift Deployment Analysis System as well as R&D to support the integration of artificial intelligence throughout related defense management systems.

Army

ORNL research for the Army includes programs in environmental analysis and assessment, data systems research, transportation systems, operations research, materials, waste management, and related work. Major environmental assessments have continued to support the safe disposal of obsolete chemical weapons stockpiles and the Installation Restoration Program for the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). Work continues in the analysis of the physical, chemical, and toxicological characteristics of chemicals and their by-products, including traditional and advanced military fuels, fog oil, dyes, phosporous formulations, explosives, and sorbent compounds. Research on techniques and methods for evaluating chemical and toxicological properties of munition compounds, combustion products, pollution control for explosives, and propellant production was also undertaken. ORNL expects to expand its support of the disposal of hazardous waste and related instrumentation technologies. Support for materials R&D in composites, ceramics, carbon/carbon and related technologies for the development of lighter-weight and tougher components for the Army and the Marine Corps is also expected to increase.

Data systems R&D in support of Army programs has focused on data systems architecture, management, and analysis to help the Army integrate state-of-the-art hardware and software systems. A major activity related to integrated data systems design continued the development of an improved Defense Standard Ammunition Computer System. In addition, R&D support to the Army continued in transportation and fuel research; use of high-volume hazardous waste streams as supplementary feed stocks in industrial boilers; validation of energy and cost savings of energy conservation projects; performance of evaluations and tests of energy conservation equipment and projects; flywheel research; alloy and special material property research for weapon system reliability; remote sensing research; battlefield logistics analysis; technology transfer; and technical assistance to evaluate facility designs, district heating, and energy conservation potentials as part of the Energy Conservation Investment Program and related studies.

Navy/Marine Corps

For the Navy and Marine Corps, ORNL conducts R&D analyses related to engineering systems, instrumentation, reliability and maintenance, materials, fuel supply and use, energy conservation, and waste disposal. ORNL continues a major role in instrumentation and engineering R&D for the David Taylor Naval Ship R&D Center and an increasing role in hazardous materials management and waste cleanup technologies.

Over the planning period, the major emphases are expected to be (1) instrumentation systems engineering and equipment reliability analysis and monitoring and (2) introduction and evaluation of new data systems techniques to modernize naval systems, especially in the areas of logistics, mobilization planning and modeling, command and control, Marine telecommunications, and computer-aided instruction.

Support to the Navy Supply Systems Command, Military Personnel Command, and other agencies provides an opportunity to do data systems R&D in AI, and knowledge processing that will have useful applications in many of the central areas of ORNL work. R&D areas include concept and methodology development and original research on expert systems, decision support systems, resource allocation modeling, and knowledge acquisition and representation. Data system design, data modeling, and information architecture to improve the quality and responsiveness of technical information systems and models are needed to match increasing demands on naval manpower. Combining data base management methodology with predictive systems analysis techniques is an integral part of the Navy technical support activities. Major programs will continue to develop improved methods for computer-aided training and improved accounting methods for tracking and estimating foreign military sales as well as improved command and control systems. Work will also continue in the development of a Financial Management Information System, an Integrated Manpower Planning and Training System, and Computer-Aided Instruction Systems, as well as in development of prototypes in innovative office automation, communications, and management information systems.

R&D in engineering and instrumentation reliability and maintenance is also expected to grow throughout the planning period. Methods and techniques for calibration of Navy systems, studies of the effects of EMP and electromagnetic interference, instrumentation of data acquisition systems, and research on circuit design are expected to continue.

Other ORNL efforts for the Navy include transportation and fuels analysis, experimental studies of metastable negative ions, biological and radiation physics research, materials defect research, laser research, engineering testing of key components of Navy systems and evaluating methods for component replacement, energy conservation, cogeneration and district heating studies, and analytical and experimental work related to shipboard heat pumps and waste heat recovery.

Air Force

ORNL conducts several major programs for the Air Force including R&D support to Air Force Installation Restoration, environmental analysis, and data systems R&D programs and has a growing involvement in the SDI.

ORNL provides the technical and managerial lead for a major segment of the Air Force Installation Restoration Program to analyze and help establish priorities for remedial actions at a wide range of installation sites. In addition, several new assignments will assess the potential environmental effects of Air Force actions or changes in mission with their regions of influence.

Data systems R&D related to advanced-knowledge processing, expert system design and development, computer science, data analysis, and management has grown significantly to support the Air Force Command and Control Information Systems Management Office and other Air Force agencies. Tasks for these agencies include data systems architecture and systems integration, data modeling, and data base design and related work to evaluate future hardware and software development. Technical support includes R&D into cost-benefit analysis, design specifications, configuration management, data management, prototyping and benchmarking of on-line systems, data validation, computing security,

system verification and validation, implementation planning, site planning for operations, and telecommunications.

Other work will include development of new mathematical algorithms appropriate to advanced processors, advanced materials research, study of swift atom-solid collisions, preparation of radioluminescent lights for remote airfields, development of energy data models for peacetime and emergency planning at Air Force facilities, and selection criteria for insulating materials and conservation measures. Use of the HPRR for radiation dosimetry development and for training of Air Force personnel in dosimetry techniques is also expected during the period.

Data Systems Research and Development

The mission of the Data Systems Research and Development (DSRD) Program is to create and apply advanced computer techniques to data and information systems in order to solve important national problems, to transfer the developed technologies to the private sector through rapid and innovative hands-on applications, and to utilize the unique capabilities of the Oak Ridge Reservation. The overall DSRD Program provides centralized direction for data systems development and related work, including both research and application. Since mid-FY 1986, direction, management, and contracting support for DSRD has been performed outside ORNL. Program funding accountability was moved outside ORNL beginning in FY 1986.

ORNL is the research arm of the DSRD Program and is assigned the DSRD work that requires the unique research capabilities of the Laboratory. Other portions of the DSRD work are best handled by central Energy Systems organizations or by private institutions through subcontracting.

Examples of key DSRD research areas being performed at ORNL include (1) expert systems and decision support, (2) enhanced data acquisition, (3) computer security, (4) advanced parallel architecture design, (5) measurement sciences, (6) data base structures, (7) command and control information systems, (8) advanced computing systems, (9) communications systems, and (10) logistics systems development.

Strategic Defense Initiative Office

The Oak Ridge complex has extensive experience in many technology areas closely related to the mission requirements being considered in the DOD SDI. Specifically, expertise in the areas of compact, lightweight power and energy storage systems, neutral particle beam systems, optical components, and shield structures will be applied in the near term.

Oak Ridge will participate in efforts to develop and evaluate power and energy storage systems, resulting in a technology development program. In cooperation with other DOE and DOD laboratories and with private industry, Oak Ridge will implement these technologies into systems to meet SDI requirements. Previous work in neutral particle beam research at Oak Ridge has resulted in the development of negative particle sources having high particle production and low beam divergence, which will be used to help provide the high-intensity, tightly collimated beam needed for directed energy applications. Oak Ridge expertise in mirror fabrication technology, ion implantation, and radiation testing will support DOD in developing radiation-hardened, passive optical components.

Experience in developing shields against natural radiation in space, high-kinetic-energy projectiles, and neutron and gamma fields will be applied to develop shields to increase the survivability of SDI space assets.

Some examples of technology areas to be pursued are (1) for reactors—core performance, two-phase flow, materials, shielding, and instrumentation and controls; (2) for energy storage—flywheel fabrication and testing, thermal-energy storage systems, power conditioning, and system reliability; (3) for beam systems—ion source design, fabrication and performance testing, radio frequency quadrupole design, beam neutralization, and beam steering studies; (4) for optical components—precision machining, surface smoothing through ion implantation, and studies of radiation effects on optical properties of mirrors and windows; and (5) for survivability shielding—shield design, sample manufacturing, sample testing and evaluation.

Other areas of work that will be pursued include (1) kinetic energy technology—especially high-acceleration testing of electronic components, projectile development, and materials studies; (2) surveillance technology—especially discrimination concepts; (3) scientific computing support; (4) lightweight materials development for space structures; (5) new concepts that can lead to major advance in defense system capabilities; and (6) technical information systems.

Funding has increased in FY 1986, but significant growth will be necessary in subsequent years to meet the mission schedules and objectives. Major activities both in-house and through subcontracting will be involved. These include fuels and materials test facilities, component test facilities, thermal-hydraulic and two-phase flow loops, and beam test facilities.

Hazardous Waste R&D

As a result of past operations and changing environmental legislation and standards, Oak Ridge National Laboratory is undertaking major operational and environmental improvements. Significant work is anticipated in a site cleanup demonstration, using actual contaminated sites on DOE property to develop and demonstrate advanced technologies, including in situ stabilization technologies, compaction, monitoring and verification technologies, groundwater diversion, risk assessment, and transportation route logistics—all of which are areas of ORNL prominence. Experience in addressing these problems is in high demand by DOE and other federal agencies.

Because of the aggressive manner in which ORNL has begun addressing existing problems with hazardous and radioactive waste and the broad base of experience ORNL has brought to bear on these problems, other federal agencies (including all branches of the DOD, EPA, and DOT) are requesting technical assistance in the areas of hazardous and radioactive waste management and technology development.

Energy Systems is currently doing hazardous waste work for other federal agencies in three major areas: technical support, remedial action planning, and technology development. Energy Systems provides technical support to the EPA Region IV Superfund Program. This support focuses on technical review and evaluation of proposed groundwater and site restoration technologies. ORNL supports EPA's Hazardous Waste Engineering Research Laboratory (HWERL) by providing R&D and data management expertise

regarding hazardous waste treatment technologies. Technical support for Hazardous Waste Management is also provided by the U.S. Army's Toxic and Hazardous Materials Agency, the U.S. Naval Energy and Environmental Support Activity (NEESA), and the Naval Facilities Engineering Command (NAVFAC).

Remedial action planning involves detailed technical evaluation of potential hazards of existing sites contaminated by hazardous waste, evaluation of potential remedial action alternatives, selection of a preferred alternative, and development of a conceptual design for the selected remedial action.

This activity requires a multidisciplinary technical approach involving environmental sciences, engineering, economic analysis, and design disciplines. Energy Systems has been given responsibility for the U.S. Air Force Remedial Action Planning Program and will manage such analyses and develop necessary methodologies. Remedial action planning work and related R&D are prime areas for future work with EPA, the U.S. Army, and the U.S. Navy.

Hazardous waste technology development is currently provided to the U.S. Air Force Engineering and Services Center, Strategic Air Command, Tactical Air Command, Logistics Command, Systems Command, Military Airlift Command, Air Training Command, NEESA, and NAVFAC. Projects include development of (1) designs for live-fire training facilities that comply with hazardous waste control regulations, (2) state-of-the-art vapor control technologies for jet fuel storage, (3) munitions that are less hazardous during storage and transportation, (4) hazardous materials tracking and emergency response expertise, and (5) robotics for hazardous materials handling. Technology is the major area of growth seen for WFO in hazardous waste management.

ORNL has recently established a Hazardous Waste Technology Program to undertake R&D activities concerning hazardous and mixed wastes. It is anticipated that a major source of funding for these efforts will be DOD in support of their efforts to clean up various waste legacies and bring waste management practices into compliance with current regulations. Activities may include process development, technical assessments, technical support, and planning and integration support, with funding coming from all branches of the military.

Another significant source of expected funding for the ORNL Hazardous Waste Technology Program is EPA, the key agency for regulating hazardous and mixed wastes. Activities may include technical assessments, technical support, and planning and integration support.

Department of Health and Human Services

The Department of Health and Human Services (DHHS) supports research in carcinogenesis, genetics, and toxicology. Its funding is expected to remain reasonably constant through FY 1987 (Table 23). The majority of DHHS funding is from the National Institutes of Health (NIH) with some funding from the Food and Drug Administration (FDA). Various branches of the NIH that support our work include the National Cancer Institute (NCI); the National Institute of Environmental Health Sciences; the National Heart, Lung, and Blood Institute; the National Institute of General Medical Sciences; the National Institute of Child Health and Human Development; the National Institute on

Table 23. Department of Health and Human Services program resource summary[a]

($ in millions—budget authorization)

Major program	Fiscal year			
	1985	1986	1987	1988
Department of Health and Human Services	6.2	4.8	5.0	5.0

[a]Subcontracts and direct FTEs at other sites are reported in the *Institutional Plan* for work for others.

Drug Abuse; the National Library of Medicine (NLM); and the National Toxicology Program (NTP). We expect an expanded effort in radiation carcinogenesis research supported by NCI and a small pilot effort in the data systems area. For FDA, NLM, and NTP, we are developing nationally and internationally available data bases in the areas of genetic, reproductive, and general toxicology. We expect continued funding in FY 1987 from the DHHS portion of the superfund money for our toxicology data bases. This effort is designed to assist in assessing the potential human and environmental health risks of hazardous waste cleanup efforts. NIH also supports development of instrumentation and radiolabeled compounds.

Environmental Protection Agency

Overall, our EPA program will continue at about the FY-1986 level of effort throughout the planning cycle, with fluctuations in specific program areas (Table 24). Our work for EPA addresses numerous health and environmental problems and issues, particularly research into the toxic effects of pollutants associated with energy-production processes and waste disposal. Health risk analysis and epidemiological studies will continue to be important components of this work. Quantitative mutagenicity testing is proceeding but at a lower level of effort than in previous years. Acidic precipitation research activities are generally stable, with major emphasis on the effects of acidic precipitation on forest and

Table 24. Environmental Protection Agency program resource summary[a]

($ in millions—budget authorization)

Major program	Fiscal year			
	1985	1986	1987	1988
Environmental Protection Agency	3.6	6.0	6.3	6.4

[a]Subcontracts and direct FTEs at other sites are reported in the *Institutional Plan* for work for others.

aquatic systems and on ion mobility in soils and with integrated assessment support to the National Acidic Precipitation Assessment Program. The Laboratory's role in data analysis for the national surveys of lakes, streams, and soils will decrease in FY 1987. ORNL also has the lead role for EPA in planning and organizing research in the Terrestrial Effects of Acidic Precipitation Program. At the Laboratory, new emphasis centers on using ecosystem models to assess the risks of chemical releases to aquatic environments as well as to identify the ecological requirements of estuarine species. New research in advanced data systems has begun for EPA's Office of Planning, Budget, and Program Management to develop computer analysis capabilities that will allow EPA to better formulate environmental regulatory policy. New environmental risk analyses began in FY 1986 and will continue with emphasis on assessing risks to marine biota. ORNL will expand its work for the Office of Emergency Response and Waste Management to help develop modern computerized information management systems in support of RCRA and CERCLA.

Data base development activities for EPA decreased in 1984 and 1985; however, significant portions of the Environmental Mutagens, Teratogens, and Carcinogens data base development will continue to be performed in support of EPA's Office of Toxic Substances programs. Several EPA-sponsored or cosponsored projects have been initiated to assess indoor air quality or to develop suitable monitoring techniques for such assessments.

ORNL provides technical support to EPA Region IV programs, such as restoration and remediation of sites listed on the National Priorities List in the Southeastern United States. New research in physiological pharmokinetic models has begun for EPA's Carcinogen Assessment Group. This research will aid in low-dose extrapolation.

National Science Foundation

The National Science Foundation (NSF), in conjunction with DOE, continues to provide support for the National Center for Small-Angle Scattering Research. This national user-dedicated facility makes two main instruments available to users: the NSF-constructed, 30-m, small-angle neutron-scattering instrument and the DOE-constructed, 10-m, small-angle X-ray-scattering camera. These instruments are intended to provide state-of-the-art capability for investigating structures of condensed matter on the scale of tens to hundreds of angstroms. They are used extensively for materials science research, as well as research in biology, chemistry, polymer science, and diffraction physics.

Because of its unique position as a leader in systems and theoretical ecology, ORNL plays a strong role in these fields and works closely with various universities. NSF recognizes ORNL's leadership in ecosystem research and provides support for the study of linked global element cycles and for the development and application of new methodologies for analyzing ecosystem-level problems. A new project has been funded on the resiliency of ecosystems to perturbation. ORNL will explore its potential contributions to the planned Department of Interior (DOI)/NSF/DOE interagency Continental Drilling Program. Another research effort sponsored by NSF involves development of a fiber-optic-based fluoroimmunosensic instrument using monoclonal antibodies and laser-induced luminescence for the detection of trace levels of biological species in body fluids (Table 25).

Table 25. National Science Foundation program resource summary[a]

($ in millions—budget authorization)

Major program	Fiscal year			
	1985	1986	1987	1988
National Science Foundation	1.44	1.30	1.40	1.40

[a]Subcontracts and direct FTEs at other sites are reported in the *Institutional Plan* for work for others.

Federal Emergency Management Agency

ORNL programs for the Federal Emergency Management Agency (FEMA) include a range of research, development, and technical assistance activities in support of national preparedness for major emergencies. At FEMA's request, ORNL serves as an independent center of expertise in areas ranging from engineering assistance to analysis and assessment. Engineering work emphasizes radiation detection and protection and includes developing improved instrumentation, storing certain radiological materials used to test instrumentation, and assisting in hardening civil defense installations against EMP effects. Analysis and assessment activities include building economic models of preparedness options, assisting with the use of computer graphics, working on shelter concepts for emergency protection, and analyzing such issues as evacuation, post-disaster recovery, food reserves, "nuclear winter," responses to warning, ecological problems with contaminated land, expedient supplies of energy and other critical commodities, and data sources for emergency management. These programs are expected to continue at a stable level (Table 26).

Table 26. Federal Emergency Management Agency program resource summary[a]

($ in millions—budget authorization)

Major program	Fiscal year			
	1985	1986	1987	1988
Federal Emergency Management Agency	3.96	3.98	3.85	3.80

[a]Subcontracts and direct FTEs at other sites are reported in the *Institutional Plan* for work for others.

Department of Transportation

ORNL's Conservation and Renewable Energy Program serves DOT as an independent center of expertise, performing work on a variety of small projects that complement and

support DOE programs. The work includes (1) modeling and forecasting highway activities, needs, and travel behavior; (2) applying computers in traffic and transportation research and engineering; (3) managing and analyzing highway statistics and traffic data systems; and (4) performing highway network studies. ORNL expects to continue providing technical support to DOT throughout the planning cycle as a center for research related to transportation energy issues, network and traffic research, and systems planning (Table 27).

Table 27. Department of Transportation program resource summary[a]

($ in millions—budget authorization)

Major program	Fiscal year			
	1985	1986	1987	1988
Department of Transportation	0.31	0.48	0.59	0.60

[a]Subcontracts and direct FTEs at other sites are reported in the *Institutional Plan* for work for others.

Agency for International Development

ORNL serves as the center of expertise for the Office of Energy, Agency for International Development (AID), on technical aspects of energy planning and energy technology (Table 28). ORNL's work includes research and analysis; technical assistance in project development, implementation planning, and evaluation related to energy planning, power system development, renewable energy technologies, and fossil energy technologies; and information dissemination.

Table 28. Agency for International Development program resource summary[a]

($ in millions—budget authorization)

Major program	Fiscal year		
	1986	1987	1988
Agency for International Development	1.26	1.35	1.95

[a]Subcontracts and direct FTEs at other sites are reported in the *Institutional Plan* for work for others.

Department of the Treasury

ORNL performs research for the Bureau of Engraving and Printing of the Department of the Treasury. Current tasks involve ink chemistry, characterization of currency printing flaws, and automation of the inspection process. It is projected that this research will expand to include postage stamps as well as development of inspection systems and analyses of the technical options and systems integration possibilities for a web printing system. Capital equipment for these projects is provided by the funding agency (Table 29).

Table 29. Department of the Treasury program resource summary[a]

($ in millions—budget authorization)

Major program	Fiscal year		
	1986	1987	1988
Department of the Treasury	0.75	1.7	1.3

[a]Subcontracts and direct FTEs at other sites are reported in the *Institutional Plan* for work for others.

Other Federal Agencies

ORNL also provides technical support to a variety of other federal agencies. The Consumer Product Safety Commission, DOI, NASA, the National Oceanic and Atmospheric Administration, and the Department of Agriculture all support small amounts of life sciences research. Some support for FY 1986 came from the U.S. Department of State for work performed for IAEA. Energy conservation program evaluation and energy demand analysis are continuing for the Bonneville Power Administration. Collaborative research for the Park Service is beginning at the Great Smoky Mountains National Park. Also included are the Department of Education, Department of Justice, Department of Labor, and the Tennessee Valley Authority (Table 30).

Table 30. Other federal agencies program resource summary[a]

($ in millions—budget authorization)

Major program	Fiscal year			
	1985	1986	1987	1988
Other federal agencies	0.7	1.9	1.9	1.9

[a]Subcontracts and direct FTEs at other sites are reported in the *Institutional Plan* for work for others.

Nonfederal Organizations

Electric Power Research Institute

Research sponsored by EPRI addresses critical national issues related to electric power generation. Major efforts in this area are directed at (1) understanding the processes and mechanisms by which acidic deposition of energy-related pollutants impacts nutrient cycling and sulfur and nitrogen dynamics of forest ecosystems, (2) delimiting the relative importance and effects of wet and dry deposition of acidic substances in both forest and agricultural systems, (3) measuring submicron aerosol deposition rates in forest canopies, (4) characterizing the role of potentially toxic aluminum mobilization in streams, and (5) determining the effects of acidic deposition on fisheries and lakes. The Laboratory expects to continue these or other programs for EPRI and anticipates that this funding will expand during the course of the planning cycle. ORNL serves a lead role for EPRI in the Integrated Forest Effects of Acidic Precipitation Study and is initiating a new effort in evaluating the response of pine seedlings and associated soils to ozone and acid rain in the Controlled Air Pollution Facility. The Laboratory is also working with EPRI to establish a facility for the testing and evaluation of cool-storage systems for commercial buildings. Various types of ice storage systems will be tested in cooperation with manufacturers according to a uniform set of test procedures. The test results will be used by EPRI, manufacturers, and engineers to improve cool-storage system designs. The facility will draw from the extensive experience and facilities at ORNL, represented by the Thermal Energy Storage Program and the BER Program, and will be of direct benefit to these DOE programs (Table 31). EPRI is participating in the DOE-ORNL Athens Automation and Control Experiment (AACE) and is interested generally in work of the Power Systems Technology Program.

Table 31. Electric Power Research Institute program resource summary[a]

($ in millions—budget authorization)

Major program	Fiscal year			
	1985	1986	1987	1988
Electric Power Research Institute	2.35	2.50	2.50	2.50

[a]Subcontracts and direct FTEs at other sites are reported in the *Institutional Plan* for work for others.

Other Nonfederal Organizations

ORNL performs work for several nonfederal organizations, including state and local governments, universities, and private institutions. Other nonfederal sponsors include the United Kingdom Atomic Energy Agency, the Japan Atomic Energy Research Institute, the

Canadian Atomic Energy Commission, the International Atomic Energy Agency, and the National Institute of Radiation Protection of Sweden; Harvard University and the universities of Georgia, Illinois, Maryland, and Wyoming; the Illinois Natural History Survey; the states of California, Maryland, and Virginia; the Gas Research Institute, Metropolitan Edison/General Public Utility, and Pacific Power and Light; the Florida Institute of Phosphate Research; Gulf Oil; Battelle Laboratories; General Electric; the American Petroleum Institute; and the National Association of Homebuilders Research Foundation. The total funding from all these nonfederal sources is shown in Table 32.

Table 32. Miscellaneous nonfederal program resource summary[a]

($ in millions—budget authorization)

Major program	Fiscal year			
	1985	1986	1987	1988
Other nonfederal organizations	4.13	3.91	3.39	2.86

[a]Subcontracts and direct FTEs at other sites are reported in the *Institutional Plan* for work for others.

Site and Facilities

SITE AND FACILITIES

Laboratory Description

ORNL is the largest and oldest of the five multiprogram energy research laboratories. Its stable programmatic base dictates the long-term use of most existing permanent facilities and continues to cause a significant deficit of adequate office housing and the requirement to replace obsolete temporary housing.

The Laboratory has approximately 4.1 million square feet of gross building area. About 2.7 million square feet is located at the main Bethel Valley site and the adjacent Melton Valley site, and the remaining 1.4 million square feet is located at the Oak Ridge Y-12 Plant. A few buildings are located in the remote areas south of Melton Valley. About 50 ORNL personnel are also located in several facilities at ORGDP.

ORNL has full facilities responsibility for the main site and remote areas. However, for the facilities at the Y-12 Plant site and ORGDP, the Laboratory has full responsibility for the maintenance and upkeep of buildings and limited responsibility for the site's infrastructure.

About half the Laboratory's total existing building area was constructed in the 1940s; over 80% was completed prior to 1965 (Figs. 5 and 6). The age and resultant condition and adequacy of the Laboratory's buildings are significant factors in shaping the long-term building plans.

The Laboratory's infrastructure has received important revitalization funding support in recent years. As a result, major improvements have been or are being made to the sanitary sewer, water, central chilled water, and electrical systems. Major work still remains to

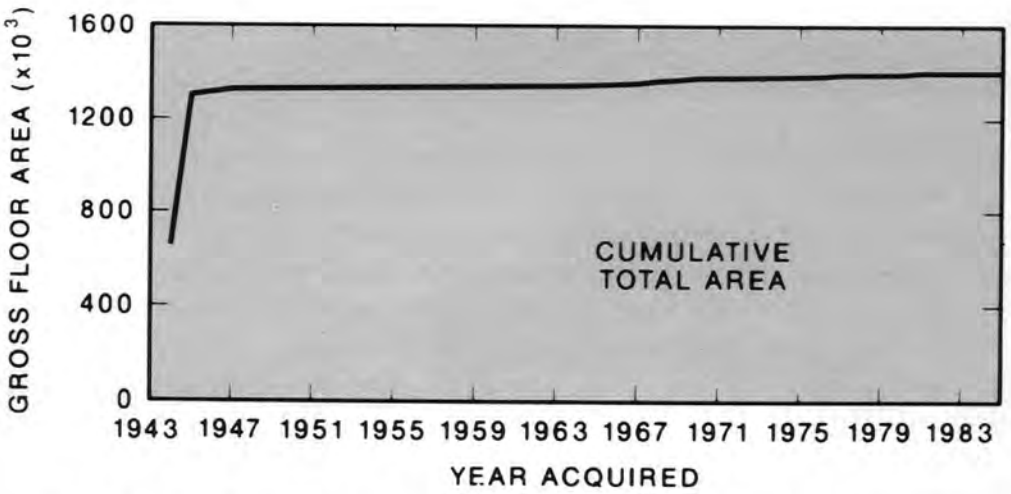


Fig. 5. Over 90% of the existing buildings at the Y-12 Plant are more than 40 years old.

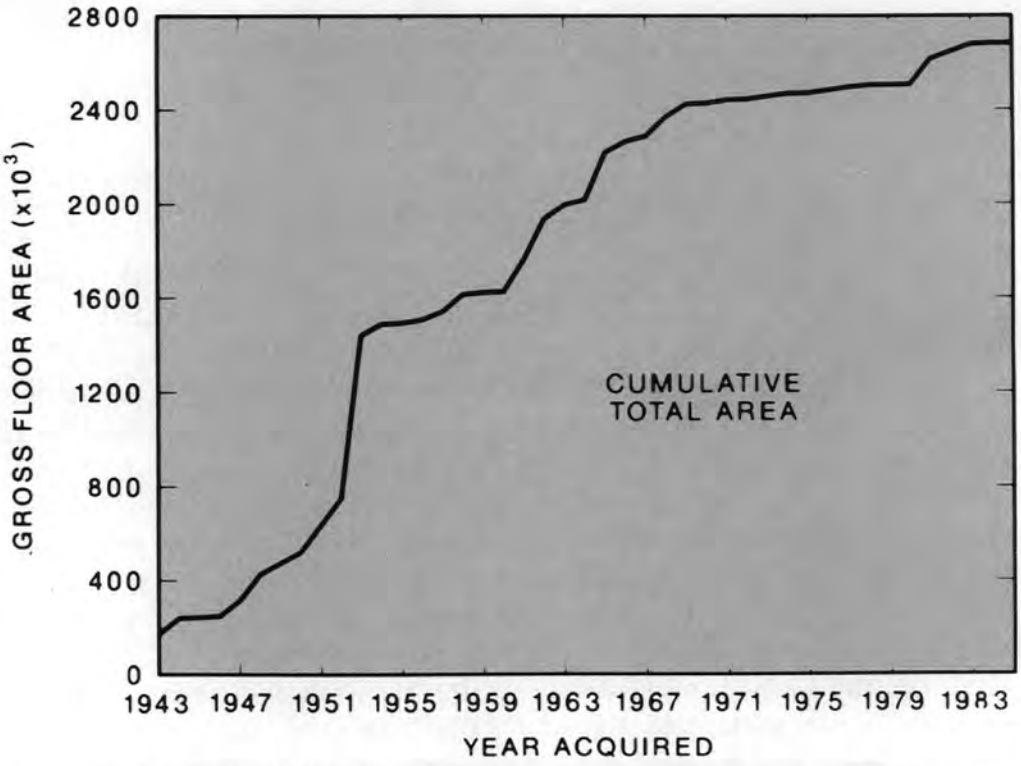


Fig. 6. More than 55% of the existing buildings at the Bethel Valley and Melton Valley sites are over 30 years old, and 82% are over 20 years old.

correct deficiencies in the electrical, steam, and water systems, as well as the nonradiological wastewater and low-level wastewater systems. In addition, work is required to repair roads and parking areas.

Various line items and GPPs are being pursued, in addition to the ongoing maintenance of facilities, to ensure that appropriate facility conditions are maintained.

Facilities Plans and Options

The Laboratory projects the most likely facilities scenario initially to be an extended period of slow evolutionary change. Change, when it occurs, will focus on replacing, updating, or supplementing selected existing facilities in order to maintain their capabilities or eliminate deficiencies. A few facilities will be built which provide new capabilities, but these, in general, will be modest in size and will not significantly alter the overall character of the Laboratory. A notable exception during the initial period will be the Center for Neutron Research, which is a major research reactor project. This project, however, is not projected to impact other facilities materially at the Laboratory.

During this initial period, change would be best described as redevelopment as opposed to development. The overall area of facilities will decline slightly (about 10%), while the average age of facilities will decline more markedly as the oldest obsolete temporary facilities are replaced or removed. The continued development of the Life Sciences

Complex at the Bethel Valley site will provide the opportunity to replace deficient ORNL facilities located at the Y-12 Plant.

The rationale for this initial facilities approach is based on the Laboratory's current and projected stability of program funding. The replacement, updating, or supplementing needs of existing facilities have been documented and accepted as valid requirements in support of the ongoing operation of the Laboratory.

After this initial period, the strategic plan projects the need for a major increase (50%) in the size of the programs at the Laboratory. The impact of such an increase on facilities is dependent on several factors including the status of existing facilities when the increase occurs and the specific facilities requirements needed to support the envisioned activities. Neither of these factors can be adequately defined at this time so as to permit detailed facilities projections. However, the *ORNL Site Development and Facilities Utilization Plan* makes clear that the Laboratory could accommodate this level of growth with further development of the site. The primary source of support for this growth would be programmatic line-item projects.

Facilities Resource Requirements

The line-item resources needed to implement the long-range plan for facilities and those needed to maintain or improve present facilities are shown in Table 33. The comparable GPPs and general-purpose equipment (GPE) resource needs are shown in Tables 34 and 35.

Constraints on facilities funding within DOE, particularly Multiprogram General-Purpose Facilities (MGPF), have prevented the accomplishment of currently needed work in a timely manner. Based on present and projected MGPF funding levels, existing facilities deficiencies would require 20–30 years to correct. Since this period is clearly beyond any realistic detailed planning horizon and since new "existing" requirements will occur in the years ahead, the Laboratory has modified its approach to construction projects listed in Table 33. Only those MGPF projects actively being pursued in the budget process (through FY 1989) are shown with specific title, year, and total estimated cost.

Other existing needs are footnoted and listed in order of priority as they are perceived today. Each year a reassessment of total existing needs and DOE's ability to provide funding support will identify those projects that will be pursued in the next budget cycle.

Data Processing and Telecommunications Requirements

The computational resources available to researchers at ORNL have changed significantly during the past year. The Cray-XMP, originally scheduled for classified computing at ORGDP, was made available to scientific and technical users during the day because the decision was made to operate the Cray in separate classified and unclassified modes. This capacity increase for unclassified scientific and technical users along with the recent acquisition of two Digital Equipment Corporation VAX 8600s has presented ORNL users with substantial computing capacity.

The Office of Scientific and Technical Computing (OSTC) was established during the past year to provide an improved interface with the scientific and technical users and to

Table 33. Major construction projects by fiscal year

($ in millions)

Title	1986 and before	1987	1988	1989	1990	1991[a]	1992	Total estimated cost
Funded and budgeted construction								
Program-related projects								
HTML[b]	19.1							19.1
ARIM,[c] Bulk Shielding Reactor Facility	0.1	0.1						0.2
ARIM, HHIRF[d] buncher	0.5							0.5
ARIM, HFIR[e] heat exchanger and Remote Sampling Facility	0.4	0.8						1.2
AIM,[f] HHIRF 25-MV Tandem extended tube upgrade	0.5							0.5
AIM, Calutron cooling tower	0.3							0.3
AIM, EN Tandem data acquisition system	0.3							0.3
Nonradiological wastewater treatment system	3.0	7.0	8.0					18.0
AIM, HHIRF beam lines		0.3						0.3
MGPF[g] projects								
Cooling water facilities restoration	3.2							3.2
Environmental monitoring system upgrade, phase I	3.4		0.1					3.5
Primary electrical distribution system chilled-water system restoration	0.8 2.0	1.4 2.7						2.2 4.7
Upgrade steam distribution system		2.0	4.8					6.8
Utilities restoration, piping systems (ORNL at Y-12)		0.7	3.1					3.8
Total funded and budgeted	33.6	15.9	16.0					65.6
Proposed projects								
Program-related projects								
RIM,[h] HFIR Critical Facility			0.3					0.3
Bethel Valley LLW[i] collection and transfer system upgrade			4.8	13.1	13.1	4.0		35.0
Advanced Control Test Operation			1.1	6.2	2.7			10.0
Upgrade air supply, part I				1.4	2.1			2.5
Heavy Ion Storage Ring for Atomic Physics				1.6	6.9	3.2	3.1	14.8
Upgrade air supply, part II				1.0	2.4			3.4
Molecular Genetics Laboratory				1.6	6.4			8.0
HHIRF intermediate energy upgrade				10.0	30.0	20.0	15.0	75.0
Mammalian Genetics Research Facility					2.6	5.0	17.1	24.7
Center for Neutron Research					25.0	40.0	60.0	325.0

Table 33 (continued)

Title	1986 and before	1987	1988	1989	1990	1991[a]	1992	Total estimated cost
MGPF[g] projects								
Upgrade fire protection (ORNL at Y-12)			1.8					1.8
Building piping system upgrade			0.5	1.3				1.8
Electrical systems upgrade				2.9				2.9
Central administrative and support building				0.8	4.8			5.6
Roads and parking, modifications and additions				0.4	1.6			2.0
Measurements and Control Support Facility				1.4	1.9			3.3
Upgrade steam distribution—west				0.8	4.5			5.3

[a]Needs to be addressed in 1991 and beyond currently include the following:

	Cost range ($ in millions)
Multiprogram support building	15–20
Multiprogram laboratory/office facilities restoration	40–50
Central research complex restoration	45–55
Hot cell facilities restoration	20–30
Potable water system upgrade	5–10
Technical support facility	15–20

[b]High Temperature Materials Laboratory.
[c]Accelerator and Reactor Improvements and Modifications.
[d]Holifield Heavy Ion Research Facility.
[e]High-Flux Isotope Reactor.
[f]Accelerator Improvements and Modifications.
[g]Multiprogram General-Purpose Facilities.
[h]Reactor Improvements and Modifications.
[i]Low-Level Wastes.

assist with planning for how best to use the current computer capacity and to plan for the conversion from older computer architectures to newer and more efficient ones. As an example of this, extensive upgrades in disk storage and additions to the central file storage (CFS) for the Cray as well as the creation of a CFS system at ORNL to replace the mass storage device are under consideration. The creation of Scientific and Technical Computing (STC) along with improved long-range planning and a closer working relationship with end users will result in better computing resources and services.

While Laboratory budgets for computing are projected as essentially flat for the period FY 1987 to 1992, the trend is for improvements in technology to provide the same capabilities at lower costs. This presents the Laboratory with excellent opportunities for a significantly improved computing environment, leading perhaps to the opportunity to become a center of excellence in some phases of computing if funding methods can be

Table 34. General plant project (GPP) funding needs through FY 1992

($ in millions—budget authorization)

	Fiscal year						
	1986	1987	1988	1989	1990	1991	1992
General Laboratory GPP (AT Laboratory)	7.2	7.2	8.2	11.0	11.0	11.0	11.0
Environmental Compliance (KG program)	3.8	3.0	5.0	5.0	6.0	*a*	*a*
Waste Management (AR program)	1.2	3.2	3.4	3.2	3.2	3.2	*a*
Life Sciences (HA program)	0.5						
Energy Conservation (WB program)	0.0	0.0	0.5	0.5	0.5	0.5	0.5
Total GPP funding	12.7	13.4	17.1	19.7	20.7	>11.5	>11.5

[a]GPP needs in these areas are not yet defined.

Table 35. General-purpose equipment funding needs through FY 1992

($ in millions)

	Fiscal year						
	1986	1987	1988	1989	1990	1991	1992
AT program	3.8	5.3	6.1	10.5	10.5	10.5	10.5
KG program	1.0	1.0	1.0	1.3			

found to accommodate the new technology. The challenge is to provide orderly technology upgrades within changing environments and at the same time provide required services while obtaining economies of scale.

Another important need as the trend for increased end-user computing continues is to educate users on the advantages and cost benefits of portable languages and codes, standard data base query languages, and common interfaces. As technology evolves, portable and modular software adhering to international standards (where available) will become much more cost effective and will reduce total programmatic costs while providing quicker and easier conversion to the newer technologies. If conversion costs can be kept low, the Laboratory can increase its computing capacity through technology improvements while maintaining an essentially flat computing budget.

OSTC will be working during the next year to increase the awareness of the benefits of supercomputing calculations. The effectiveness of the Fusion Energy Division in developing the Advanced Toroidal Facility (ATF) and obtaining funding for it is based in a large part on supercomputing modeling carried out at the National Magnetic Fusion Energy Computing Center (NMFECC) located in Livermore, California, and accessed by

satellite links. This work and other work being pursued by several ORNL users of the OER computers located at Florida State University and at NMFECC is indicative of the caliber of work that can be done by Laboratory personnel who have adequate large-scale computing resources available. In addition, research in parallel computers using existing SEQUENT and NCUBE parallel processors and an INTEL iPSC/d6 hypercube is expected to result in the installation of a major parallel architecture machine by the early 1990s. Such a machine would be the basis of a major research project within the Laboratory. There are many areas within the Laboratory where major new support might be obtained if the emerging supercomputing capabilities at ORNL are utilized for design and modeling studies.

The emergence of the three categories of computing (administrative, scientific and technical, and dedicated) along with the architecture based on four levels ranging from work stations up through supercomputers has produced an increased dependence on proper networking. The backbone of a distributed system is the communications system. At Energy Systems, this system consists of a broadband interplant trunk with local area Ethernets bridged to it. Continued development and improved reliability of this network is essential to the Laboratory. The present heterogeneous computing and networking environment results in the need for improved network interfaces and routing methods. This is an area that will receive more attention, as the entire distributed concept hinges on its success.

The availability of external networks such as BITNET, HEPNET, DDN (ARPAnet), and MFENET to Laboratory users will be improved as many of these networks become available through STC machines. The availability of these external links should enhance the capability of Laboratory personnel to interact with the many offices involved in Laboratory funding along with OER programs and universities.

The future looks very good for computing at ORNL. Technology is moving rapidly; senior management strongly supports computing at ORNL; and many actions have taken place that will provide a basis to acquire necessary computing equipment in a timely fashion, thus improving productivity.

External Interactions

EXTERNAL INTERACTIONS

Designated User Research Facilities

Twelve designated user research facilities are now available at ORNL for use by outside experimenters. Two new facilities opened in 1986 are the High Temperature Materials Laboratory and the Roof Research Center. Table 36 shows the use of these facilities during FY 1985.

Table 36. Experimenters at designated user research facilities[a]

(During FY 1985)

Facility	Laboratory	University	Industry	Total
EN Tandem Van de Graaff	10 (1,360)[b]	15 (1,304)	0	25 (2,664)
Holifield Heavy Ion Research Facility (HHIRF)	65 (629)	91 (702)	0	156 (1,331)
Oak Ridge Electron Linear Accelerator (ORELA)	24 (1,328)	4 (366)	0	28 (1,694)
National Center for Small-Angle Scattering Research (NCSASR)	23 (488)	68 (620)	22 (102)	113 (1,210)
Neutron Scattering Facility	19 (1,119)	36 (946)	1 (12)	56 (2,077)
Shared Research Equipment (SHaRE)	35 (1,213)	48 (193)	0	83 (1,406)
Surface Modification and Characterization (SMAC) Laboratory	41 (1,152)	30 (295)	17 (149)	88 (1,596)
Bioprocessing Research Facility	3 (83)	4 (114)	1 (3)	8 (200)
Health Physics Research Reactor (HPRR)	55 (272)	3 (6)	27 (58)	85 (336)
Oak Ridge National Environmental Research Park (NERP)[c]	36 (490)	18 (133)	2 (20)	56 (643)
Roof Research Center[d]				
High Temperature Materials Laboratory[d]				
Total 12 Facilities	311 (8,134)	317 (4,679)	70 (344)	698 (13,157)

[a]Numbers provided include usage by foreign laboratory, university, and industry organizations. This represents about 9% of the total users and 6% of the user days.

[b]The number of users is provided; the number of user days is in parentheses.

[c]Does not include 800 high school students (400 user days) on environmental research field classes.

[d]Facilities opened in FY 1986; no experimenter statistics are available.

University Programs

Through both formal programs and informal associations, interactions between the Laboratory and the university community continue to provide a two-way flow of technical information. The DOE-OER University Laboratory Cooperative Program (ULCP) supports research participation and training of students and faculty at ORNL through both ORNL and ORAU. The program funding in FY 1985 and FY 1986 was the same following a slight increase from the previous year. Combined with a steady increase in costs, the number of participants supported by both ORNL and ORAU-ULCP funding has declined. However, the support from this program continues to contribute significantly to the number of students and faculty participating in ORNL research, even though the majority receive financial support from the Laboratory's divisions and other sources (such as colleges and universities, fellowships, and grants). Over 1400 guests, with more than 900 university based, participated in ORNL's FY-1985 activities, and the number is expected to increase in FY 1986.

DOE supports a variety of university programs at ORNL, both through ULCP and programmatic funds. Opportunities are provided for associate degree candidates, undergraduate students, graduate students, postgraduates, and faculty to engage in research and/or receive advanced training for assignments as long as two years. ORNL also hosts high school teachers during the summer and high school students year round.

In addition to research participation opportunities, many other activities at ORNL foster university participation. Almost 300 university-based researchers annually conduct experiments at ORNL's 12 user facilities (two of these facilities were established in FY 1986). An additional 800 precollege students and teachers participate in field-study modules at the NERP. Many students and faculty participate in ORNL activities as part of ongoing research and development subcontracts; ORNL sponsors research via subcontracts with over 100 universities.

Many other ad hoc activities take place as part of the university relations program. ORNL contributes to the development of university personnel and equipment resources through staff lectures at universities, equipment purchases under subcontract, and used equipment donations. Assistance is also provided on request in reviewing proposals and developing curricula. Over 30 ORNL staff members are adjunct professors at institutions such as The University of Tennessee, Knoxville College, Tennessee Technological University, and Roane State Community College.

A close relationship exists between ORNL and The University of Tennessee at Knoxville (UTK). In addition to the adjunct faculty, a number of joint activities are under the umbrella of the State of Tennessee Center of Excellence called the Science Alliance. As part of this program, joint appointments to ORNL and UTK have been made of nationally known scientists in the Distinguished Scientist Program. This program, established in 1984, is jointly funded by the state of Tennessee and DOE and is intended to attract select scientists and engineers and to increase the interactions between UTK and ORNL. The goal of the program is to appoint up to 30 distinguished scientists by 1990. A number of joint graduate programs exist; some are long standing, such as the University of Tennessee–Oak Ridge Graduate School of Biomedical Sciences, located in ORNL's Biology Division, and the Graduate School of Ecology in ORNL's Environmental Sciences

Division. New joint graduate programs are being developed in emerging fields such as measurement and control engineering and biotechnology.

Several initiatives are under way to strengthen the university relations program. A recent reorganization placed more emphasis on program development rather than on student placement, and, as a result, more effort is being expended on university outreach. In cooperation with ORAU, efforts have been initiated to better acquaint university faculty and students with opportunities at ORNL. ORNL's existing relationships with university consortia, including ORAU, have been strengthened, and another consortial liaison with the Southeastern Universities Research Association (SURA) is under development.

Emphasis will be placed on involving new groups in our programs as well as strengthening existing relationships. One of the new target groups for involvement is precollege students and teachers. A program initiated in FY 1986 allows exceptional high school students the opportunity to conduct a special study on an advanced topic. ORNL also hosted eleven high school teachers for eight weeks of research participation as part of ORAU's Strive Program, sponsored by NSF, in addition to offering summer employment to two high school teachers. The Laboratory also participates in the national Residence in Science and Technology program that provides summer research appointments to outstanding high school teachers. ORNL was instrumental in encouraging the formation of a local citizens' precollege advisory group and is working with it on development and implementation of programs that will allow the local school systems to access the Laboratory's resources to help educate students.

Another major initiative continues to be the development of the program encouraging the involvement of Historically Black Colleges and Universities (HBCU) in ORNL programs. A program plan was published that focuses on the development of a long-term, consistent relationship with a small number of HBCUs. As part of that plan, a Memorandum of Understanding with Tuskegee University is under development, and a new collaboration with Tuskegee's Carver Research Foundation in the biomass program was initiated. The Laboratory's interactions with Knoxville College were increased, primarily through subcontracts with the Energy Division. ORNL continues to have a strong tie to Fort Valley State College (FVSC) through its participation in the Cooperative Developmental Energy Program (CDEP) sponsored at FVSC by the DOE Office of Minority Economic Impact. The Laboratory employs FVSC CDEP students during the summer and assists with the development of a two-year curriculum in health physics technology. Other major HBCU collaborations are with Atlanta University in fusion-related research on plasma physics and with North Carolina A&T University in testing and evaluation of advanced ceramic materials.

In addition to the subcontracts and other collaborations, ORNL has increased the number of participants from HBCUs involved in summer programs. In FY 1985, the Special Summer Program for undergraduates in science and engineering at HBCUs provided appointments for four students; this number was increased to ten students in FY 1986; also, the number of colleges represented was increased. Additionally, in FY 1986, through programs administered by ORAU, the Laboratory hosted five students participating in Nuclear Energy Training Program and two faculty for research participation appointments. The goal for future years is to increase the number of participants and raise the

mean grade point advantage requirements of the participants. ORNL also continues to participate in the preco-op scholarship program for minority students in engineering by providing summer employment to those who will be entering school at one of the participating HBCUs.

Program planning will begin in FY 1987 for the Oak Ridge Science Education Center (ORSEC); a comprehensive program would intensify our current university relations programs considerably. Based on the successful science semester programs that have operated for almost two decades, ORSEC would support over 300 students and 50 faculty annually for research participation and training, mostly during the academic year. In addition to stipends, students may receive academic credit, and faculty may receive research starter grants. The summer program includes research training and workshops for precollege students and teachers. All participants would be housed in a multipurpose building to be constructed in central Oak Ridge. The program will be phased in over several years with appointments to begin in FY 1988 on about a one-third scale.

ORNL has a demonstrated commitment to increase the involvement of university personnel in its research and development activities. This is imperative to ensure the supply of well-trained, qualified technical personnel for the future. The Laboratory is assisting DOE in achieving this goal by providing opportunities for students of all ages to receive training and perform research and by encouraging students to attend graduate school in energy-related disciplines. The university interactions are also important in transferring science and technology, accomplished through sponsoring faculty research participation and visits at ORNL as well as ORNL staff visits and lectures on campus. Collaborative research programs with university personnel are also a cost-effective method to receive quality assistance in fulfilling the Laboratory's missions; over 300 person years are provided annually by university-based researchers.

Industrial Interactions and Technology Transfer

The primary objective of the technology transfer program is to make innovations developed at Martin Marietta Energy Systems, Inc., readily available to state, local, and federal governments and industry. Our goal is to achieve maximum impact on the U.S. economy through an aggressive program that emphasizes licensing of technologies with commercial potential, effective dissemination of information on nonlicensable technologies, and strengthening the technology transfer process through the formation of consortia and collaborative agreements with industries, universities, and state and local governments.

The Office of Technology Applications (OTA), managed by the vice president of Technology Applications, coordinates all technology transfer activities for ORNL, the Y-12 Plant, and the Oak Ridge and Paducah Gaseous Diffusion plants.

Emphasis has been placed on identifying, evaluating, documenting, and processing intellectual property of commercial value. A licensing policy has been developed, and all patents and copyrights waived to Energy Systems by DOE have been licensed. As a demonstration of our success in licensing, more than $150,000 in up-front fees have been received on the five items of intellectual property assigned to Energy Systems by DOE in the past fiscal year. It is the goal of the OTA to double this amount next fiscal year and be self-supporting from licensing revenues by FY 1989.

Two issues have been addressed during FY 1986: the perception of a conflict of interest between Energy Systems and the Tennessee Innovation Center and the receipt of advance patent rights from DOE. The latter issue remains unresolved; negotiations continue. Until this issue is resolved, licensing activity will be severely restricted.

One of the major obstacles to the effective transfer of technology is the lack of contacts between developers and potential users. OTA historically has encouraged interactions between industry and technology developers through workshops, visits, displays at trade shows, and special publications. Recent emphasis has been on the formation of user organizations to address special problems and develop specific technology areas. An example of the former is the Tennessee Center for Research and Development (TCRD). This center was formed jointly by The University of Tennessee, Tennessee Technology Foundation, and Energy Systems. TCRD is a not-for-profit center which does applied development to the point of commercialization on technologies from any area. The Ceramic Advanced Manufacturing Development and Engineering Center (CAMDEC) is an example of a center which will address a specific area of research. This center is presently in the process of formation. It will be an interdisciplinary ceramic center that will provide a national test bed for advanced ceramic components manufacturing. CAMDEC will be a cooperative development activity with the primary goal of creating intellectual property that will be initially available only to center members.

Future emphasis will be placed on establishing routine, automatic processing of intellectual property from DOE to Energy Systems, value assessment for inventions at the point of disclosure, improved methods for monitoring and assessing licensing progress, and development of a sufficient escrow pool from licensing to make the technology transfer program self-sufficient by FY 1989. Funding and staffing levels for the Office of Research and Technology Analysis are shown in Table 37.

Table 37. Estimated staffing and expenditures for the Office of Research and Technology Applications[a]

	Fiscal year						
	1986	1987	1988	1989	1990	1991	1992
	Funding ($ in thousands)						
ORTA	639	856	1092	1136	1181	1229	1278
Other	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Total	10,639	10,856	11,092	11,136	11,181	11,229	11,278
	Staffing (FTEs)						
Professional							
ORTA	6	6	8	8	8	8	8
Other[b]	57	57	55	55	55	55	55
Total	63	63	63	63	63	63	63
Support	3	3	4	4	4	4	4

[a]These funds are for the ORNL office of the Martin Marietta Energy Systems, Inc., Office of Technology Applications, which includes ORNL, the Y-12 Plant, ORGDP, and Paducah Gaseous Diffusion Plant.
[b]Estimated.

Minority Business Procurement

Purchases of goods and services from businesses owned by persons who are socially and economically disadvantaged was the only "special emphasis area" of our award-fee contract with DOE for two years. Concerted efforts were made to identify new small disadvantaged businesses and provide them with procurement opportunities. ORNL staff has worked with Purchasing Division employees to determine innovative ways to package work that would enable minority businesses to become competitive. The portion of ORNL purchases that comes from small disadvantaged businesses rose from 3.5% in FY 1984 to 5.8% in FY 1986.

Appendix. Resource Projections

Table A.1. Funding by assistant secretarial level office

(millions of dollars)

	FY 1986		FY 1987[a]		FY 1988[a]		FY 1989[a]		FY 1990		FY 1991		FY 1992	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Assistant Secretary for Fossil Energy														
Total operating	6.7	6.8	5.4	7.7	7.9	8.2	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Capital equipment	0.1		0.2		0.4		0.4		0.4		0.4		0.4	
Total	6.8		5.6		8.2		8.5		8.5		8.5		8.5	
Assistant Secretary for Nuclear Energy														
Total operating	37.1	35.3	39.5	39.3	49.8	49.5	56.4	55.9	59.6	59.1	59.5	59.0	59.3	58.8
Capital equipment	0.2		0.2		0.9		0.1		0.1		0.1		0.1	
Total	37.3		39.7		50.7		56.5		59.7		59.6		59.4	
Assistant Secretary for Conservation and Renewable Energy														
Total operating	36.3	37.5	37.0	38.1	36.2	37.6	35.6	35.8	35.6	35.6	35.6	35.6	35.6	35.6
Capital equipment	1.5		1.6		1.7		1.7		1.7		1.7		1.7	
Total	37.9		38.6		38.0		37.3		37.3		37.3		37.3	
Office of Energy Research														
Total operating	147.7	157.8	160.1	160.1	171.1	170.5	183.8	183.1	183.1	182.4	180.6	180.0	178.0	177.4
Capital equipment	13.1		11.8		13.5		15.0		13.3		14.1		13.5	
Construction	8.4		7.3		12.8		0.0		0.0		0.0		0.0	
Total	169.2		179.2		197.4		198.8		196.3		194.7		191.5	
Assistant Secretary for Defense Programs														
Total operating	32.8	32.6	36.0	36.1	34.1	34.7	35.5	35.5	34.6	34.6	33.4	33.4	33.1	33.1
Capital equipment	1.7		1.4		1.8		1.8		1.9		1.8		1.5	
Construction	1.2		0.0		0.0		0.0		0.0		0.0		0.0	
Total	35.7		37.3		35.9		37.4		36.5		35.2		34.6	
Assistant Secretary for Environment, Safety, and Health														
Total operating	3.7	4.0	4.5	4.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Capital equipment	0.0		0.1		0.0		0.0		0.0		0.0		0.0	
Total	3.7		4.6		5.0		5.1		5.1		5.1		5.1	
Federal Energy Regulatory Commission														
Total operating	1.2	1.2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Economic Regulatory Administration														
Total operating	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy Information Adminstration														
Total operating	0.4	1.5	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Table A.1 (continued)

	FY 1986		FY 1987[a]		FY 1988[a]		FY 1989[a]		FY 1990		FY 1991		FY 1992	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Office of Policy, Planning, and Analysis														
Total operating	0.4	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Office of Civilian Radioactive Waste Management														
Total operating	7.0	5.9	7.0	7.0	8.0	8.0	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Capital equipment	0.2		0.1		0.1		0.0		0.0		0.0		0.0	
Total	7.2		7.1		8.1		8.5		8.5		8.5		8.5	
Assistant Secretary for Management and Administration														
Total operating	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
DOE contractors and operations offices														
Total operating	10.8	9.3	7.6	8.9	7.6	8.0	7.8	7.8	7.6	7.6	7.6	7.6	7.6	7.6
Capital equipment	0.5		0.0		0.0		0.0		0.0		0.0		0.0	
Total Program	11.3		7.6		7.6		7.8		7.6		7.6		7.6	
Total DOE														
Total operating	284.4[b]	292.5[b]	300.2[b]	305.2[b]	322.6[b]	324.2[b]	343.6	342.6	345.0	343.7	341.2	340.0	338.1	336.9
Capital equipment	18.0		15.4		18.4		19.1		17.4		18.1		17.2	
Construction	9.8		8.2		14.2		34.9		91.2		72.2		95.2	
Total	312.2		323.8		355.2		397.6		453.6		431.5		450.5	
Department of Defense[c]														
Total operating	13.4	11.9	14.5	13.0	15.6	14.0	15.6	14.0	15.6	14.0	15.6	14.0	15.6	14.0
Department of Transportation[c]														
Total operating	0.2	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Federal Emergency Management Agency[c]														
Total operating	4.0	4.0	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Nuclear Regulatory Commission[c]														
Total operating	20.7	20.7	17.5	17.5	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9
Department of Health and Human Services[c]														
Total operating	4.8	4.8	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Environmental Protection Agency[c]														
Total operating	6.0	6.0	6.3	6.3	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4

	FY 1986		FY 1987[a]		FY 1988[a]		FY 1989[a]		FY 1990		FY 1991		FY 1992	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
National Science Foundation[c]														
Total operating	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Tennessee Valley Authority[c]														
Total operating	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Other federal agencies[c]														
Total operating	3.2	3.2	5.0	5.2	5.1	5.1	4.7	4.7	4.2	4.2	4.2	4.2	4.2	4.2
Strategic Defense Initiative[c]														
Total operating	7.3	7.3	9.9	9.9	13.2	13.2	14.9	14.9	14.9	14.9	14.0	14.0	14.0	14.0
Data Systems Research and Development[c]														
Total operating	14.0	14.0	19.0	19.0	22.4	22.4	25.0	25.0	24.0	24.0	24.0	24.0	24.0	24.0
Hazardous Waste Research and Development[c]														
Total operating	3.9	3.9	5.9	6.2	9.2	9.2	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Electric Power Research Institute[c]														
Total operating	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Other nonfederal agencies[c]														
Total operating	3.9	3.9	3.4	3.4	2.9	2.9	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Total work for others[c]														
Total operating	85.7	84.3	95.2	94.4	103.4	101.8	107.4	105.8	105.9	104.3	105.0	103.4	105.0	103.4
General-purpose facilities	9.4		6.8		10.3		7.6		12.8		*d*		*d*	
General plant projects	12.7		13.4		17.1		19.7		20.7		>11.5		>11.5	
General-purpose equipment	4.8		6.3		7.1		11.8		10.5		10.5		10.5	
Total Laboratory funding	424.8		445.5		493.1		544.1		603.5		>558.5		>577.5	

[a]Escalation factors from FY 1986 to FY 1987 and from FY 1987 to FY 1988 are both 5.5%. Figures for FY 1989 through FY 1992 are in constant FY 1988 dollars.
[b]For FY 1986 through FY 1988, amounts shown for budget obligations exceed budget authorization because DOE Headquarters decreased forward financing requirements.
[c]Subcontracts and direct FTEs at other sites are reported in the *Institutional Plan* for work for others.
[d]Requirements for FY 1991 and beyond are shown in Table 33.

Table A.2. Personnel by assistant secretarial level office

(Full-time equivalents)

	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992
Assistant Secretary for Fossil Energy							
Technical personnel	29.1	29.7	27.7	26.7	26.7	26.7	26.7
Other direct personnel	0.7	0.8	0.9	0.9	0.9	0.9	0.9
Total direct personnel	29.8	30.5	28.6	27.6	27.6	27.6	27.6
Assistant Secretary for Nuclear Energy							
Technical personnel	223.0	215.9	229.2	246.3	249.0	248.6	247.6
Other direct personnel	15.3	21.3	32.0	38.3	43.1	43.0	42.7
Total direct personnel	238.3	237.2	261.2	284.6	292.1	291.6	290.3
Assistant Secretary for Conservation and Renewable Energy							
Technical personnel	131.6	128.6	119.0	111.7	111.5	111.5	111.5
Other direct personnel	6.4	3.7	2.8	2.0	2.0	2.0	2.0
Total direct personnel	138.0	132.3	121.8	113.7	113.5	113.5	113.5
Office of Energy Research							
Technical personnel	793.5	819.4	869.5	909.7	883.4	871.2	863.2
Other direct personnel	162.6	170.1	170.6	177.3	174.4	165.2	163.7
Total direct personnel	956.1	989.5	1040.1	1087.0	1057.8	1036.4	1026.9
Assistant Secretary for Defense Programs							
Technical personnel	229.6	253.4	232.3	230.2	219.1	214.3	215.3
Other direct personnel	10.7	10.3	6.6	14.1	11.2	6.3	5.3
Total direct personnel	240.3	263.7	238.9	244.3	230.3	220.6	220.6
Assistant Secretary for Environment, Safety, and Health							
Technical personnel	15.0	17.0	20.0	20.0	20.0	20.0	20.0
Other direct personnel	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Total direct personnel	20.0	22.0	25.0	25.0	25.0	25.0	25.0
Federal Energy Regulatory Commission							
Technical personnel	8.0	3.7	3.7	3.7	3.7	3.7	3.7
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	8.0	3.7	3.7	3.7	3.7	3.7	3.7

	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992
Economic Regulatory Administration							
Technical personnel	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Energy Information Adminstration							
Technical personnel	3.1	3.9	3.9	3.9	3.9	3.9	3.9
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	3.1	3.9	3.9	3.9	3.9	3.9	3.9
Office of Policy, Planning, and Analysis							
Technical personnel	0.8	0.9	0.9	0.9	0.9	0.9	0.9
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	0.8	0.9	0.9	0.9	0.9	0.9	0.9
Office of Civilian Radioactive Waste Management							
Technical personnel	25.1	24.7	29.0	32.0	32.0	32.0	32.0
Other direct personnel	5.7	5.9	6.0	6.0	6.0	6.0	6.0
Total direct personnel	30.8	30.6	35.0	38.0	38.0	38.0	38.0
Assistant Secretary for Management and Administration							
Technical personnel	0.0	0.7	0.7	0.7	0.7	0.7	0.7
Other direct personnel	0.6	2.5	2.5	2.5	2.5	2.5	2.5
Total direct personnel	0.6	3.2	3.2	3.2	3.2	3.2	3.2
DOE Contractors and Operations Offices							
Technical personnel	50.3	49.9	46.9	49.2	47.2	47.2	47.2
Other direct personnel	8.3	3.6	2.8	0.8	0.8	0.8	0.8
Total direct personnel	58.6	53.5	49.7	50.0	48.0	48.0	48.0
Total DOE programs							
Technical personnel	1509.8	1547.8	1582.8	1635.0	1598.1	1580.7	1572.7
Other direct personnel	215.0	223.2	229.0	246.9	245.9	231.7	228.9
Total direct personnel	1724.8	1771.0	1811.8	1881.9	1844.0	1812.4	1801.6

Table A.2 (continued)

	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992
Work for Others							
Department of Defense[a]							
Technical personnel	59.2	67.5	76.1	76.5	76.5	76.5	76.5
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	59.2	67.5	76.1	76.5	76.5	76.5	76.5
Department of Transportation[a]							
Technical personnel	2.3	3.0	3.0	3.0	3.0	3.0	3.0
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	2.3	3.0	3.0	3.0	3.0	3.0	3.0
Federal Emergency Management Agency[a]							
Technical personnel	7.5	7.0	6.5	6.5	6.5	6.5	6.5
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	7.5	7.0	6.5	6.5	6.5	6.5	6.5
Nuclear Regulatory Commission[a]							
Technical personnel	122.7	108.5	97.9	97.9	97.9	97.9	97.9
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	122.7	108.5	97.9	97.9	97.9	97.9	97.9
Department of Health and Human Services[a]							
Technical personnel	42.0	43.0	43.0	43.0	43.0	43.0	43.0
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	42.0	43.0	43.0	43.0	43.0	43.0	43.0
Environmental Protection Agency[a]							
Technical personnel	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	45.0	45.0	45.0	45.0	45.0	45.0	45.0
National Science Foundation[a]							
Technical personnel	6.0	7.0	7.0	7.0	7.0	7.0	7.0
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	6.0	7.0	7.0	7.0	7.0	7.0	7.0

	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992
Tennessee Valley Authority[a]							
Technical personnel	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Strategic Defense Initiative[a]							
Technical personnel	36.0	48.0	68.0	77.5	77.5	74.5	74.5
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	36.0	48.0	68.0	77.5	77.5	74.5	74.5
Data Systems Research and Development[a]							
Technical personnel	96.0	128.0	128.0	132.0	127.0	127.0	127.0
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	96.0	128.0	128.0	132.0	127.0	127.0	127.0
Hazardous Waste Research and Development[a]							
Technical personnel	32.3	46.0	60.0	70.0	70.0	70.0	70.0
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	32.3	46.0	60.0	70.0	70.0	70.0	70.0
Other federal agencies[a]							
Technical personnel	19.2	36.5	36.9	30.1	27.5	27.5	27.5
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	19.2	36.5	36.9	30.1	27.5	27.5	27.5
Electric Power Research Institute[a]							
Technical personnel	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Other nonfederal agencies[a]							
Technical personnel	29.2	25.2	21.5	19.9	20.1	20.3	20.5
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	29.2	25.2	21.5	19.9	20.1	20.3	20.5
Total Work for Others[a]							
Technical personnel	515.4	582.7	610.9	625.9	618.6	615.7	615.9
Other direct personnel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total direct personnel	515.4	582.7	610.9	625.9	618.6	615.7	615.9

Table A.2 (continued)

	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992
Total direct							
Technical personnel	2025.2	2133.5	2193.7	2261.4	2217.1	2196.9	2189.1
Other direct personnel	215.0	223.2	229.0	246.9	245.9	231.7	228.9
Total direct personnel	2240.2	2356.7	2422.7	2508.3	2463.0	2428.6	2418.0
Isotopes	48	48	48	48	48	48	48
Total indirect personnel	1961	2064	2122	2185	2143	2124	2116
Total Laboratory personnel	4249	4469	4592	4741	4654	4600	4582

[a]Subcontracts and direct FTEs at other sites are reported in the *Institutional Plan* for work for others.

Table A.3. Resources by program

(millions of dollars)

	FY 1986		FY 1987[a]		FY 1988[a]		FY 1989[a]		FY 1990		FY 1991		FY 1992	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Assistant Secretary for Fossil Energy														
AA—Coal														
Total operating	6.6	6.7	5.4	7.6	7.7	8.1	8.0	7.9	8.0	7.9	8.0	7.9	8.0	7.9
Capital equipment	0.1		0.2		0.4		0.4		0.4		0.4		0.4	
Total program	6.7		5.6		8.1		8.3		8.3		8.3		8.3	
Technical personnel	28.8		29.2		27.4		26.4		26.4		26.4		26.4	
Other direct personnel	0.4		0.8		0.9		0.9		0.9		0.9		0.9	
Total direct personnel	29.2		30.0		28.3		27.3		27.3		27.3		27.3	
AB—Gas														
Total operating	0	.01	0	.03	0	0	0	0	0	0	0	0	0	0
Technical personnel	0		0.2		0		0		0		0		0	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	0		0.2		0		0		0		0		0	
AC—Petroleum														
Total operating	0.11	.01	0	0.11	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Technical personnel	0.2		0.3		0.3		0.3		0.3		0.3		0.3	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	0.2		0.3		0.3		0.3		0.3		0.3		0.3	
CH—Alternate Fuels Production														
Total operating	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0
Technical personnel	0.1		0		0		0		0		0		0	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	0.1		0		0		0		0		0		0	
Total Assistant Secretary for Fossil Energy														
Total operating	6.7	6.8	5.4	7.7	7.9	8.2	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Capital equipment	0.1		0.2	0.4			0.4		0.4		0.4		0.4	
Total	6.8		5.6		8.2		8.5		8.5		8.5		8.5	
Technical personnel	29.1		29.7		27.7		26.7		26.7		26.7		26.7	
Other direct personnel	0.4		0.8		0.9		0.9		0.9		0.9		0.9	
Total direct personnel	29.5		30.5		28.6		27.6		27.6		27.6		27.6	
Assistant Secretary for Nuclear Energy														
AE—Advanced Nuclear Systems[b]														
Total operating	2.9	2.9	0	0	0	0	0	0	0	0	0	0	0	0
Capital equipment	0		0		0		0		0		0		0	
Total program	2.9		0		0		0		0		0		0	
Technical personnel	16.1		0		0		0		0		0		0	
Other direct personnel	0.2		0		0		0		0		0		0	
Total direct personnel	16.3		0		0		0		0		0		0	

Table A.3 (continued)

	FY 1986		FY 1987[a]		FY 1988[a]		FY 1989[a]		FY 1990		FY 1991		FY 1992	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
AF—Civilian Reactor Development Program														
Total operating	25.7	23.9	30.0	29.8	45.4	45.1	52.1	51.6	55.3	54.8	55.2	54.7	55.0	54.5
Technical personnel	148.6		152.1		190.4		207.5		210.2		209.8		208.8	
Other direct personnel	14.6		20.8		31.2		37.7		42.5		42.4		42.1	
Total direct personnel	163.2		172.9		221.6		245.2		252.7		252.2		250.9	
AH—Remedial Action Programs														
Total operating	8.2	8.2	9.2	9.2	4.1	4.1	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Capital equipment	0.2		0.1		0.1		0.1		0.1		0.1		0.1	
Total program	8.4		9.3		4.2		4.1		4.1		4.1		4.1	
Technical personnel	57.9		63.5		38.5		38.5		38.5		38.5		38.5	
Other direct personnel	0.5		0.5		0.6		0.6		0.6		0.6		0.6	
Total direct personnel	58.4		64.0		39.1		39.1		39.1		39.1		39.1	
AP—Nuclear Waste Technology														
Total operating	0.05	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Technical personnel	0.3		0.2		0.2		0.2		0.2		0.2		0.2	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	0.3		0.2		0.2		0.2		0.2		0.2		0.2	
CD—Uranium Enrichment														
Total operating	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Technical personnel	0.1		0.1		0.1		0.1		0.1		0.1		0.1	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	0.1		0.1		0.1		0.1		0.1		0.1		0.1	
Total Assistant Secretary for Nuclear Energy														
Total operating	37.1	35.3	39.5	39.3	49.8	49.5	56.4	55.9	59.6	59.1	59.5	59.0	59.3	58.8
Capital equipment	0.2		0.2		0.9		0.1		0.1		0.1		0.1	
Total	37.3		39.7		50.7		56.5		59.7		59.6		59.4	
Technical personnel	223.0		215.9		229.2		246.3		249.0		248.6		247.6	
Other direct personnel	15.3		21.3		31.8		38.3		43.1		43.0		42.7	
Total direct personnel	238.3		237.2		261.0		284.6		292.1		291.6		290.3	
Assistant Secretary for Conservation and Renewable Energy														
AK—Electric Energy Systems														
Total operating	3.0	7.3	3.4	4.6	3.3	4.3	3.2	3.4	3.2	3.2	3.2	3.2	3.2	3.2
Capital equipment	0.1		0.1		0.1		0.1		0.1		0.1		0.1	
Total program	3.1		3.5		3.4		3.3		3.3		3.3		3.3	
Technical personnel	19.0		13.7		12.6		10.5		10.5		10.5		10.5	
Other direct personnel	1.0		0.8		0.5		0.2		0.2		0.2		0.2	
Total direct personnel	20.0		14.5		13.1		10.7		10.7		10.7		10.7	

	FY 1986		FY 1987[a]		FY 1988[a]		FY 1989[a]		FY 1990		FY 1991		FY 1992	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
AL—Energy Storage Systems														
Total operating	1.1	0.8	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Technical personnel	2.8		2.0		1.5		1.5		1.5		1.5		1.5	
Other direct personnel	0.1		0		0		0		0		0		0	
Total direct personnel	2.9		2.0		1.5		1.5		1.5		1.5		1.5	
AM—Geothermal														
Total operating	0	.08	0	0	0	0	.02	0	0	0	0	0	0	0
Total direct personnel	0.6		0.1		0.1		0.1		0		0		0	
AZ—Clean Coal Technology														
Total operating	0	0	0.6	0.6	0	0	0	0	0	0	0	0		
Total direct personnel	0		3.0		0		0		0		0		0	
CC—Geothermal														
Total operating	0	0	0	.02	.02	.02	0	.02	0	0	0	0	0	0
Total direct personnel	0		0.1		0.1		0.1		0		0		0	
CE—Hydropower														
Total operating	.05	0.1	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05
Total direct personnel	0		0.2		0.2		0.2		0.2		0.2		0.2	
EB—Solar Energy														
Total operating	6.1	4.0	5.6	5.0	5.6	5.4	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Capital equipment	0.1		0.1		0.1		0.1		0.1		0.1		0.1	
Total program	6.2		5.7		5.7		5.6		5.6		5.6		5.6	
Technical personnel	14.7		14.7		14.7		14.4		14.4		14.4		14.4	
Other direct personnel	0.6		0.6		0.6		0.5		0.5		0.5		0.5	
Total direct personnel	15.3		15.3		15.3		14.9		14.9		14.9		14.9	
EC—Buildings and Community Systems														
Total operating	0.2	9.2	0.7	11.3	0.9	11.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Capital equipment	1.1		0.4		0.5		0.5		0.5		0.5		0.5	
Total program	11.3		11.0		11.4		11.0		11.0		11.0		11.0	
Technical personnel	39.5		38.6		34.4		0.4		0.4		0.4		0.4	
Other direct personnel	2.9		1.4		1.2		0.8		0.8		0.8		0.8	
Total direct personnel	42.4		0.0		35.6		31.2		31.2		31.2		31.2	
ED—Industrial														
Total operating	1.2	1.4	1.0	1.3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Capital equipment	0		0		0		0		0		0		0	
Total program	1.2		1.1		1.0		1.0		1.0		1.0		1.0	
Technical personnel	7.3		7.6		4.7		4.7		4.7		4.7		4.7	
Other direct personnel	0.8		0.2		0.3		0.3		0.3		0.3		0.3	
Total direct personnel	8.1		7.8		5.0		5.0		5.0		5.0		5.0	

Table A.3 (continued)

	FY 1986		FY 1987[a]		FY 1988[a]		FY 1989[a]		FY 1990		FY 1991		FY 1992	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
EE—Transportation														
Total operating	9.7	8.6	0.5	9.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Capital equipment	0		0		0.5		0.5		0.5		0.5		0.5	
Total program	9.7		0.5		11.1		11.1		11.1		11.1		11.1	
Technical personnel	24.0		26.2		26.2		26.2		26.2		26.2		26.2	
Other direct personnel	0.9		0.6		0.1		0.1		0.1		0.1		0.1	
Total direct personnel	24.9		26.8		26.3		26.3		26.3		26.3		26.3	
EF—State/Local Programs														
Total operating	0	0.4	0.3	0.3	0	0.1	0	0	0	0	0	0	0	0
Technical personnel	1.7		1.6		0.8		0		0		0		0	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	1.7		1.6		0.8		0		0		0		0	
EG—Multi-Sector														
Total operating	5.0	5.5	4.8	5.0	4.2	4.3	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Capital equipment	0.2		1.0		0.5		0.5		0.5		0.5		0.5	
Total program	5.2		5.8		4.7		4.6		4.6		4.6		4.6	
Technical personnel	22.0		23.8		23.7		23.6		23.6		23.6		23.6	
Other direct personnel	0.1		0.1		0.1		0.1		0.1		0.1		0.1	
Total direct personnel	22.1		23.9		23.8		23.7		23.7		23.7		23.7	
Total Assistant Secretary for Conservation and Renewable Energy														
Total operating	36.3	37.5	37.0	38.1	36.2	37.6	35.6	35.8	35.6	35.6	35.6	35.6	35.6	35.6
Capital equipment	1.5		1.6		1.7		1.7		1.7		1.7		1.7	
Total	37.9		38.6		38.0		37.3		37.3		37.3		37.3	
Technical personnel	131.6		128.6		119.0		111.7		111.5		111.5		111.5	
Other direct personnel	6.4		3.7		2.8		2.0		2.0		2.0		2.0	
Total direct personnel	138.0		132.3		121.8		113.7		113.5		113.5		113.5	
Office of Energy Research														
AT—Magnetic Fusion														
Total operating	46.4	54.0	46.2	46.5	44.3	44.3	48.1	48.1	48.1	48.1	48.1	48.1	48.1	48.1
Capital equipment	4.6		3.2		2.9		1.6		1.6		1.6		1.6	
Total program	51.0		49.3		47.2		49.7		49.7		49.7		49.7	
Technical personnel	144.2		141.3		136.8		141.4		141.4		141.4		141.4	
Other direct personnel	115.7		113.1		107.5		111.1		111.1		111.1		111.1	
Total direct personnel	259.9		254.4		244.3		252.5		252.5		252.5		252.5	

	FY 1986		FY 1987[a]		FY 1988[a]		FY 1989[a]		FY 1990		FY 1991		FY 1992	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
HA—Environmental Research and Development														
Total operating	27.0	27.3	27.0	27.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
Capital equipment	1.3		1.5		2.0		2.0		2.0		2.0		2.0	
Total program	28.2		28.5		30.0		30.0		30.0		30.0		30.0	
Proposed construction	0		0		2.0		11.2		6.0		19.5		0	
Technical personnel	130.0		130.0		130.0		130.0		130.0		130.0		130.0	
Other direct personnel	11.0		11.0		11.0		11.0		11.0		11.0		11.0	
Total direct personnel	141.0		141.0		141.0		141.0		141.0		141.0		141.0	
KA—High Energy Physics														
Total operating	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Technical personnel	2.9		2.9		2.9		2.9		2.9		2.9		2.9	
Other direct personnel	1.0		1.0		1.0		1.0		1.0		1.0		1.0	
Total direct personnel	3.9		3.9	3.9			3.9		3.9		3.9		3.9	
KB—Nuclear Physics														
Total operating	9.4	9.7	0.8	0.7	11.5	11.4	11.5	11.4	11.6	11.5	11.6	11.5	11.7	11.6
Capital equipment	1.1		1.1		1.2		1.2		1.2		1.2		1.2	
Construction	0.9		0		0		0		0		0		0	
Total program	11.4		12.0		12.7		12.7		12.8		12.8		12.9	
Proposed construction	0		0		0		0		0		0		0	
Technical personnel	74.3		75.2		74.5		74.5		75.0		75.0		75.5	
Other direct personnel	2.6		1.9		1.9		1.9		1.9		1.9		1.9	
Total direct personnel	76.9		77.1		76.4		76.4		76.9		76.9		77.4	
KC—Basic Energy Sciences														
Total operating	52.0	53.6	59.9	59.9	72.5	72.0	78.6	78.1	75.4	74.8	0.9	0.4	68.2	67.7
Capital equipment	5.1		5.0		7.0		9.5		7.5		7.9		7.3	
Construction	2.3		0.3		0		0		0		0		0	
Total program	59.4		65.2		79.5		88.1		82.8		78.8		75.5	
Proposed construction	0		0		1.8		6.8		28.2		43.1		0	
Technical personnel	368.3		388.1		426.7		444.9		434.2		424.6		416.1	
Other direct personnel	19.6		26.6		32.5		32.5		32.5		23.8		22.3	
Total direct personnel	387.9		414.7		459.2		477.4		466.7		448.4		438.4	
KD—Energy Research Analysis														
Total operating	0.8	1.1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Technical personnel	2.4		2.0		2.0		2.0		2.0		2.0		2.0	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	2.4		2.0		2.0		2.0		2.0		2.0		2.0	
KE—University Research Support														
Total operating	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Technical personnel	3.0		4.5		5.0		5.0		5.0		5.0		5.0	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	3.0		4.5		5.0		5.0		5.0		5.0		5.0	

Table A.3 (continued)

	FY 1986		FY 1987[a]		FY 1988[a]		FY 1989[a]		FY 1990		FY 1991		FY 1992	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
KG—Multi-Program Laboratory Facilities Support														
Total operating	11.4	11.3	14.3	14.3	12.8	12.8	15.5	15.5	18.0	18.0	0	0.0	0.0	0.0
Capital equipment	1.0		1.0		0.4		0.7		1.0		1.4		1.4	
Construction	5.3		7.0		12.8		0	0		0	0			
Total program	17.6		22.3		26.0		16.2		19.0		21.4		21.4	
Proposed construction	0		0		0		15.8	0.0		10.5		8.8		
Technical personnel		68.4		75.4		91.6	109.0		92.9			0.3		
Other direct personnel		12.7		16.5		16.7		19.8		16.9		16.4		16.4
Total direct personnel		81.1		91.9		108.3		128.8		106.7		106.7		
Office of Energy Research														
Total operating	147.7	157.7	160.1	160.1	171.1	170.5	183.8	183.1	183.1	182.4	180.6	180.0	178.0	177.4
Capital equipment	13.1		11.8		13.5		15.0		13.3		14.1		13.5	
Construction	8.4		7.3		12.8			0		0	0		0	
Total	169.2		179.2		197.4		198.8		196.3		194.7		191.5	
Proposed construction	0		0		3.7		43.8	84.2		93.1		78.8		
Technical personnel		793.5		819.4		869.5		909.7		883.4		871.2		863.2
Other direct personnel		162.6		170.1		170.6		177.3		174.4		165.2		163.7
Total direct personnel		956.1		989.5		1040.1		1087.0		1057.8		1036.4		1026.9
AR—Defense Waste and Transportation Management														
Total operating	26.4	26.2	28.3	28.3	29.6	29.6	0.2	0.2	29.9	29.9	0.7	0.7	0.4	0.4
Capital equipment	1.4		1.0		1.6		1.5		1.7		1.6		1.3	
Construction	1.2		0		0		0		0		0		0	
Total program	29.0		29.3		31.2		31.7		31.6		32.3		31.7	
Proposed construction	0		3.2		3.4		3.2		3.2		3.2		0.2	
Technical personnel		173.9		195.1		194.2		194.2		194.6		194.5		195.5
Other direct personnel		7.8		5.0		5.9		9.1		5.5		5.6		4.6
Total direct personnel		181.7		00.1		00.1		03.3		00.1		00.1		00.1
GB—Weapons Activities														
Total operating	.01	.01	.01	.01	.01	.01	0	0	0	0	0	0	0	0
Technical personnel		0.1		0.1		0.1		0		0		0		0
Other direct personnel		0		0		0		0		0		0		0
Total direct personnel		0.1		0.1		0.1		0		0		0		0
GC—Verification and Control Technology														
Total operating	0.3	0.3	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Capital equipment	0		0		0		0		0		0		0	
Total program	0.3		0.4		0.2		0.2		0.2		0.2		0.2	
Technical personnel		2.3		2.3		1.2		1.6		1.6		1.6		1.6
Other direct personnel		0		0		0		0		0		0		0
Total direct personnel		2.3		2.3		1.2		1.6		1.6		1.6		1.6

	FY 1986		FY 1987[a]		FY 1988[a]		FY 1989[a]		FY 1990		FY 1991		FY 1992	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
GD—Nuclear Safeguards and Security														
Total operating	0.4	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Capital equipment	0.1		0.1		0		0		0		0		0	
Total program	0.5		0.6		0.5		0.4		0.4		0.4		0.4	
Technical personnel	4.1		3.2		3.6		2.9		2.9		2.9		2.9	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	4.1		3.2		3.6		2.9		2.9		2.9		2.9	
GE—Materials Production														
Total operating	5.7	5.5	6.8	7.0	3.8	4.4	4.8	4.8	4.2	4.2	2.2	2.2	2.2	2.2
Capital equipment	0.2		0.2		0.2		0.4		0.2		0.2		0.2	
Total program	5.9		7.0		4.0		5.1		4.3		2.3		2.3	
Technical personnel	49.2		52.7		33.2		31.5		0.0		15.3		15.3	
Other direct personnel	2.9		5.3		0.7		5.0		5.7		0.7		0.7	
Total direct personnel	52.1		58.0		33.9		36.5		25.7		16.0		16.0	
Total Assistant Secretary for Defense Programs														
Total operating	32.8	32.6	36.0	36.1	34.1	34.7	35.5	35.5	34.6	34.6	33.4	33.4	33.1	33.1
Capital equipment	1.7		1.4		1.8		1.9		1.9		1.8		1.6	
Construction	1.2		0		0		0		0		0		0	
Total	35.7		37.3		35.9		37.4		36.5		35.2		34.6	
Proposed construction	0		3.2		3.4		3.2		3.2		3.2		0.2	
Technical personnel	229.6		253.4		232.3		230.2		219.1		214.3		215.3	
Other direct personnel	0.7		0.3		6.6		14.1		11.2		6.3		5.3	
Total direct personnel	240.3		263.7		238.9		244.3		230.3		220.6		220.6	
Assistant Secretary for Environment, Safety, and Health														
HA—Environmental Research and Development														
Total operating	3.7	4.0	4.5	4.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Capital equipment	0		0.1		0		0		0		0		0	
Total program	3.7		4.6		5.0		5.1		5.1		5.1		5.1	
Technical personnel	15.0		17.0		20.0		20.0		20.0		20.0		20.0	
Other direct personnel	5.0		5.0		5.0		5.0		5.0		5.0		5.0	
Total direct personnel	20.0		22.0		25.0		25.0		25.0		25.0		25.0	
Total Assistant Secretary for Environment, Safety, and Health														
Total operating	3.7	4.0	4.5	4.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Capital equipment	0		0.1		0		0.1		0.1		0.1		0.1	
Total	3.7		4.6		5.0		5.1		5.1		5.1		5.1	
Technical personnel	15.0		17.0		20.0		20.0		20.0		20.0		20.0	
Other direct personnel	5.0		5.0		5.0		5.0		5.0		5.0		5.0	
Total direct personnel	20.0		22.0		25.0		25.0		25.0		25.0		25.0	

Table A.3 (continued)

	FY 1986		FY 1987[a]		FY 1988[a]		FY 1989[a]		FY 1990		FY 1991		FY 1992	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Federal Energy Regulatory Commission														
VP—Other Expenses														
Total operating	1.2	1.2	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Technical personnel	8.0		3.7		3.7		3.7		3.7		3.7		3.7	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	8.0		3.7		3.7		3.7		3.7		3.7		3.7	
Total Federal Energy Regulatory Commission														
Total operating	1.2	1.2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Technical personnel	8.0		3.7		3.7		3.7		3.7		3.7		3.7	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	8.0		3.7		3.7		3.7		3.7		3.7		3.7	
Economic Regulatory Administration														
UB—Utility Programs and Regulatory Intervention														
Total operating	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0
Total direct personnel	0		0		0		0		0		0		0	
UE—Fuels Regulations														
Total operating	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0
Total direct personnel	0.7		0		0		0		0		0		0	
Total Economic Regulatory Administration														
Total operating	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0
Total direct personnel	0.7		0		0		0		0		0		0	
Energy Information Administration														
TA—Collection, Production, and Analysis														
Total operating	0.2	1.1	1.2	1.2	1.3	1.2	1.3	1.2	1.3	1.2	1.3	1.2	1.3	1.2
Total direct personnel	2.7		3.6		3.6		3.6		3.6		3.6		3.6	
TB—Program Services														
Total operating	0.3	0.5	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Total direct personnel	0.4		0.3		0.3		0.3		0.3		0.3		0.3	
Total Energy Information Administration														
Total operating	0.5	1.5	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Total direct personnel	3.1		3.9		3.9		3.9		3.9		3.9		3.9	

	FY 1986		FY 1987[a]		FY 1988[a]		FY 1989[a]		FY 1990		FY 1991		FY 1992	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Office of Policy, Planning, and Analysis														
PE—Policy Analysis and System Studies														
Total operating	0.4	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total direct personnel	0.8		0.9		0.9		0.9		0.9		0.9		0.9	
Total Office of Policy, Planning, and Analysis														
Total operating	0.4	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total direct personnel	0.8		0.9		0.9		0.9		0.9		0.9		0.9	
Office of Civilian Radioactive Waste Management														
DB—Nuclear Waste Fund														
Total operating	7.0	5.9	7.0	7.0	8.0	8.0	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Capital equipment	0.2		0.1		0.1		0		0		0		0	
Total program	7.2		7.1		8.1		8.5		8.5		8.5		8.5	
Technical personnel	25.1		24.7		29.0		32.0		32.0		32.0		32.0	
Other direct personnel	5.7		5.9		6.0		6.0		6.0		6.0		6.0	
Total direct personnel	30.8		30.6		35.0		38.0		38.0		38.0		38.0	
Total Office of Civilian Radioactive Waste Management														
Total operating	7.0	5.9	7.0	7.0	8.0	8.0	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Capital equipment	0.2		0.1		0.1		0		0		0		0	
Total	7.2		7.1		8.1		8.5		8.5		8.5		8.5	
Technical personnel	25.1		24.7		29.0		32.0		32.0		32.0		32.0	
Other direct personnel	5.7		5.9		6.0		6.0		6.0		6.0		6.0	
Total direct personnel	30.8		30.6		35.0		38.0		38.0		38.0		38.0	
Assistant Secretary for Management and Administration														
LA—Technical Information Management Program														
Total operating	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0
Total direct personnel	0		0		0		0		0		0		0	
WB—In-House Energy Management														
Total operating	0.2	0.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total direct personnel	0.6		3.2		3.2		3.2		3.2		3.2		3.2	
Total Assistant Secretary for Management and Administration														
Total operating	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Technical personnel	0		0.7		0.7		0.7		0.7		0.7		0.7	
Other direct personnel	0.6		2.5		2.5		2.5		2.5		2.5		2.5	
Total direct personnel	0.6		3.2		3.2		3.2		3.2		3.2		3.2	

Table A.3 (continued)

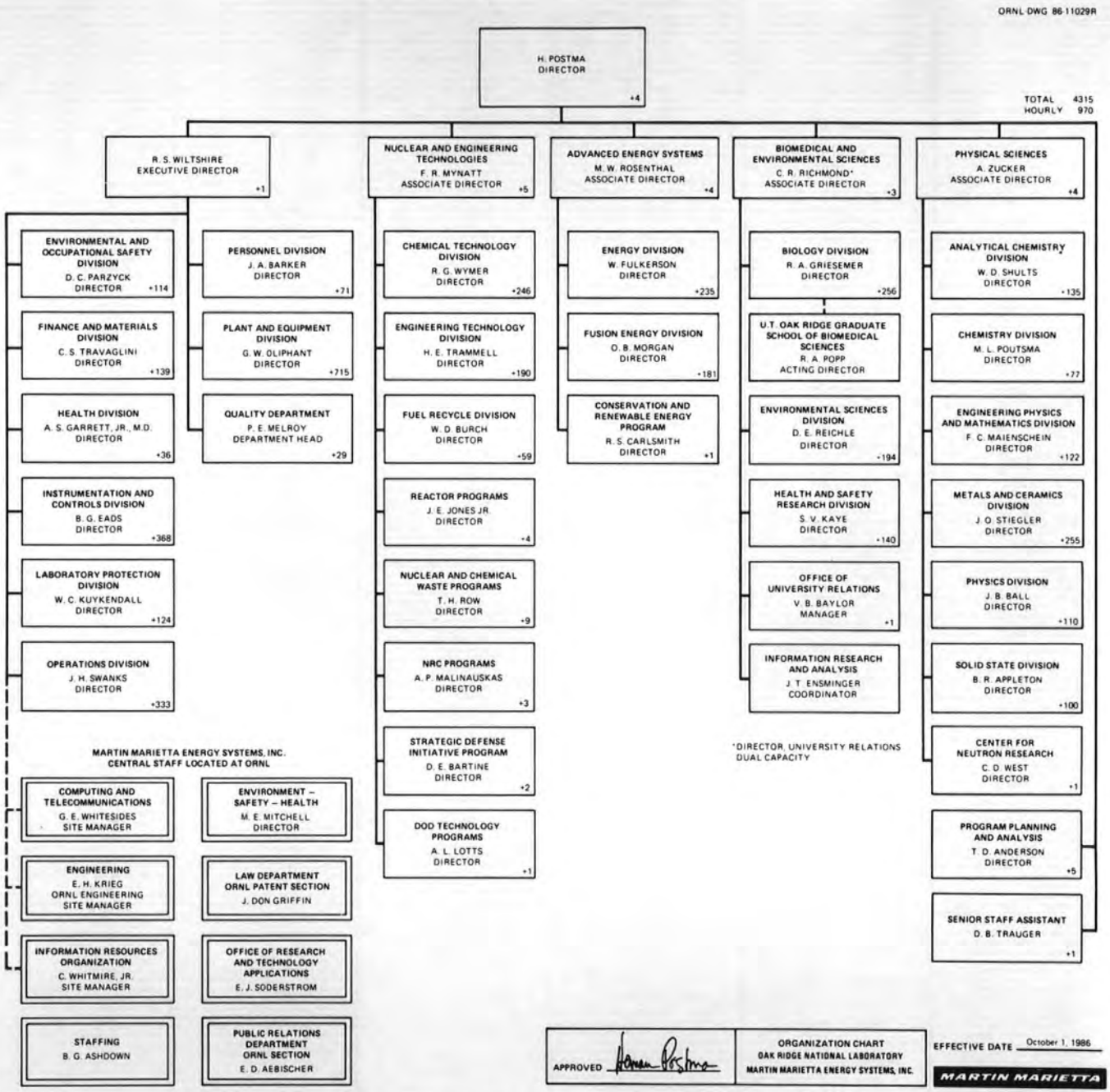
	FY 1986		FY 1987[a]		FY 1988[a]		FY 1989[a]		FY 1990		FY 1991		FY 1992	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
DOE Contractors and Operations Office														
Total operating	10.8	9.3	7.6	8.9	7.6	8.0	7.8	7.8	7.6	7.6	7.6	7.6	7.6	7.6
Capital equipment	0.5		0		0		0		0		0		0	
Total program	11.3		7.6		7.6		7.8		7.6		7.6		7.6	
Technical personnel	50.3		49.9		46.9		49.2		47.2		47.2		47.2	
Other direct personnel	8.3		3.6		2.8		0.8		0.8		0.8		0.8	
Total direct personnel	58.6		53.5		49.7		50.0		48.0		48.0		48.0	
Total DOE programs														
Total operating	284.4[c]	292.5[c]	300.2[c]	305.2[c]	322.6[c]	324.2[c]	343.6	342.6	345.0	343.7	341.2	340.0	338.1	336.9
Capital equipment	18.0		15.4		18.4		19.1		17.4		18.1		17.2	
Construction	9.8		9.1		16.7		34.8		92.4		73.9		92.1	
Total program	312.2		324.7		357.7		397.5		454.8		433.2		447.4	
Technical personnel	1509.8		1547.8		1582.8		1635.0		1598.1		1580.7		1572.7	
Other direct personnel	215.0		223.2		229.0		246.9		245.9		231.7		228.9	
Total direct personnel	1724.8		1771.0		1811.8		1881.9		1844.0		1812.4		1801.6	
Work for Others														
Federal Emergency Management Agency														
Total operating[d]	4.0	4.0	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Technical personnel	7.5		7.0		6.5		6.5		6.5		6.5		6.5	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	7.5		7.0		6.5		6.5		6.5		6.5		6.5	
Department of Defense														
Total operating[d]	13.4	11.9	14.6	13.0	15.6	14.0	15.6	14.0	15.6	14.0	15.6	14.0	15.6	14.0
Technical personnel	59.2		67.5		76.1		76.5		76.5		76.5		76.5	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	59.2		67.5		76.1		76.5		76.5		76.5		76.5	
Department of Transportation														
Total operating[d]	0.2	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Technical personnel	2.3		3.0		3.0		3.0		3.0		3.0		3.0	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	2.3		3.0		3.0		3.0		3.0		3.0		3.0	
Nuclear Regulatory Commission														
Total operating[d]	20.7	20.7	17.5	17.5	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9
Technical personnel	122.7		108.5		97.9		97.9		97.9		97.9		97.9	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	122.7		108.5		97.9		97.9		97.9		97.9		97.9	

	FY 1986		FY 1987[a]		FY 1988[a]		FY 1989[a]		FY 1990		FY 1991		FY 1992	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Department of Health and Human Services														
Total operating[d]	4.8	4.8	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Technical personnel	42.0		43.0		43.0		43.0		43.0		43.0		43.0	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	42.0		43.0		43.0		43.0		43.0		43.0		43.0	
Environmental Protection Agency														
Total operating[d]	6.0	6.0	6.3	6.3	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4
Technical personnel	45.0		45.0		45.0		45.0		45.0		45.0		45.0	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	45.0		45.0		45.0		45.0		45.0		45.0		45.0	
National Science Foundation														
Total operating[d]	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Technical personnel	6.0		7.0		7.0		7.0		7.0		7.0		7.0	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	6.0		7.0		7.0		7.0		7.0		7.0		7.0	
Tennessee Valley Authority														
Total operating[d]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Technical personnel	4.0		4.0		4.0		4.0		4.0		4.0		4.0	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	4.0		4.0		4.0		4.0		4.0		4.0		4.0	
Strategic Defense Initiative														
Total operating[d]	7.3	7.3	9.9	9.9	13.2	13.2	14.9	14.9	14.9	14.9	14.0	14.0	14.0	14.0
Technical personnel	36.0		48.0		68.0		77.5		77.5		74.5		74.5	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	36.0		48.0		68.0		77.5		77.5		74.5		74.5	
Data Systems Research and Development														
Total operating[d]	14.0	14.0	19.0	19.0	22.4	22.4	25.0	25.0	24.0	24.0	24.0	24.0	24.0	24.0
Technical personnel	96.0		128.0		128.0		132.0		127.0		127.0		127.0	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	96.0		128.0		128.0		132.0		127.0		127.0		127.0	
Hazardous Waste Research and Development														
Total operating[d]	3.9	3.9	5.9	6.2	9.2	9.2	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
Technical personnel	32.0		46.0		60.0		70.0		70.0		70.0		70.0	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	32.0		46.0		60.0		70.0		70.0		70.0		70.0	

Table A.3 (continued)

	FY 1986		FY 1987[a]		FY 1988[a]		FY 1989[a]		FY 1990		FY 1991		FY 1992	
	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO	BA	BO
Other Federal Agencies														
Total operating[d]	3.2	3.2	5.0	5.2	5.1	5.1	4.7	4.7	4.2	4.2	4.2	4.2	4.2	4.2
Technical personnel	19.2		37.1		36.9		30.1		27.5		27.5		27.5	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	19.2		37.1		36.9		30.1		27.5		27.5		27.5	
Electric Power Research Institute														
Total operating[d]	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Technical personnel	14.0		14.0		14.0		14.0		14.0		14.0		14.0	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	14.0		14.0		14.0		14.0		14.0		14.0		14.0	
Other Nonfederal Agencies														
Total operating[d]	3.9	3.9	3.4	3.4	2.9	2.9	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Technical personnel	29.2		25.2		21.5		19.9		20.1		20.3		20.5	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	29.2		25.2		21.5		19.9		20.1		20.3		20.5	
Total Work for Others														
Total operating[d]	85.7	84.3	95.2	94.4	103.4	101.8	107.4	105.8	105.9	104.3	105.0	103.4	105.0	103.4
Technical personnel	515.1		583.3		610.9		625.9		618.5		616.7		616.9	
Other direct personnel	0		0		0		0		0		0		0	
Total direct personnel	515.01		583.3		610.9		625.9		618.5		616.7		616.9	
Total program resources														
Total operating	369.7	376.7	395.5	399.6	426.0	426.0	451.0	448.4	450.9	448.0	446.2	443.4	443.1	440.3
Capital equipment	18.0		15.4		18.4		19.1		17.4		18.1		17.2	
Construction	9.8		9.1		16.7		34.8		92.4		73.9		92.1	
Total	397.5		420.0		461.1		504.9		560.7		538.2		552.4	
Technical personnel	2025.2		2133.5		2193.7		2261.4		2217.1		2196.9		2189.1	
Other direct personnel	215.0		223.2		229.0		246.9		245.9		231.7		228.9	
Total direct personnel	2240.2		2356.7		2422.7		2508.3		2463.0		2428.6		2418.0	

[a]Escalation factors from FY 1986 to FY 1987 and from FY 1987 to FY 1988 are both 5.5%. Figures for FY 1989 through FY 1992 are in constant FY 1988 dollars.
[b]Program AF ended in FY 1986. Continuing activities are included in Program AF.
[c]For FY 1986 through FY 1988, amounts shown for budget obligations exceed budget authorization because DOE Headquarters decreased forward financing requirements.
[d]Subcontracts and direct FTEs at other sites are reported in the *Institutional Plan* for work for others.



Oak Ridge National Laboratory organization chart.

Acknowledgments

The Program Planning and Analysis Office gratefully acknowledges the help of many ORNL staff members in the preparation of this Institutional Plan. In particular, we would like to thank those persons who have contributed greatly to the production of this document: for editing, J. M. Dole; for secretarial assistance, B. W. Shelton and P. F. Wright; for budget compilation assistance, the Finance and Materials Division; for the services of the Technical Publications Department's Composition Unit, especially L. J. Jeffers, N. C. Smith, and S. C. West, and Makeup Unit, R. A. Eldridge; and for the services of the Graphic Arts Department, V. L. Conner.

M. L. Sollenberger
J. W. Terry

CRL