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ENGINEERING TECHNOLOGY DIVISION
LONG-RANGE PLAN
1991-1995

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DIRECTOR'S OVERVIEW

This Engineering Technology Division Long-Range Plan is a departure from planning processes of the past. About a year ago we decided to approach our strategic planning in a very different way. With this plan we complete the first phase of a comprehensive process that has involved most of the Division staff. Through a series of "brainstorming" meetings, we have accumulated a wealth of ideas. By this process, we have been able to identify our perceived strengths and weaknesses and to propose very challenging goals for the future. The process itself has served as an excellent means to increase communication within the Division.

Planning by nature is a very difficult task because of the many uncertainties. However, by using our demonstrated strengths as the foundation of our plan, developing a consensus as to our direction, and acquiring the commitment of the management and staff, we feel that our strategy has an excellent chance of achieving our major objectives.

Early on in our planning, we selected two distinct areas where we desire changes. First, we want to pursue program development in a much more structured and dynamic manner: deciding what we want to do, developing plans, and providing the resources to follow through. Second, we want to change the way that we do business by developing more effective ways to work together within the Division and with the important groups that we interact with throughout Energy Systems. These initiatives are reflected in the plan and in related actions that the Division is implementing.

I am deeply appreciative of the effort of everyone who has contributed to this important plan and to the continuing planning process. The dedication, enthusiasm, and excellence of our staff convince me that we can turn plans and ideas into reality—and we will!

John E. Jones Jr.

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ENGINEERING TECHNOLOGY DIVISION LONG-RANGE PLAN 1991-1995

1. DIVISION MISSION

The Engineering Technology Division (ETD) has a rich history of technology development. From its beginning, the Division has been a leader in the development of nuclear power and other sources of energy. For the past several decades, ETD has been a national leader in structural engineering, thermal hydraulics, and systems analysis. Our technical staff has earned a reputation for the safe development and operation of large, complex, experimental systems. We desire to maintain a strong component of experimental engineering, and our plans emphasize this interest and ability to keep this important aspect of the Division viable.

The ETD mission is to perform research, development, conceptual design, analysis, fabrication, testing, and system demonstration of technology essential for

1. *nuclear reactor systems and related technologies,*
2. *space and defense systems,*
3. *advanced systems for energy conversion and utilization, and*
4. *water and waste management systems*

and to foster a vigorous program of technology transfer using the best available techniques of technical infusion into the marketplace. In meeting this mission, the Division will institute a documented pollution prevention program, ensure that environmental impact statements are prepared for the supporting program, and adhere to all environmental safety and health requirements.

2. PROGRAMMATIC THRUSTS

2.1 BUILDING ON STRENGTHS—CONTINUING THRUSTS

Sustained and directed growth is the foundation for the development of the Division's programs over the next 5 years. To direct this growth, we will seek opportunities that build upon our demonstrated strengths. Our strengths, perceived and/or real, are the technical capability and versatility of the staff and the potential of our research facilities. In general, the Division staff has a very strong background in most aspects of nuclear reactor technology. We have been leaders in the development of many advanced reactor concepts that reflect our strengths in thermal hydraulics, structural mechanics, and safety and systems analysis.

The Division has an unusually well-trained and experienced technical staff with expertise in the areas of structural mechanics and pressure vessel technology. Furthermore, it has experimental facilities for performing multiaxial inelastic response, pressure vessel fracture safety, and structural component tests. The Division also has experience and expertise in prestressed concrete reactor vessel and concrete materials technology, as well as in the

technology for steel reactor pressure vessels and components. The ETD staff has gained widespread recognition for its contributions to the development of high-temperature structural design methods and pressure vessel fracture safety criteria that are used around the world. Since the mid-1960s, the Division has had responsibility for the Nuclear Regulatory Commission (NRC)-sponsored Heavy-Section Steel Technology Program, a program acknowledged by the NRC to be one of its most successful research programs.

ETD has had a long history of thermal-hydraulic research and development (R&D). Traditionally the work has included a large component of basic engineering research and has grown primarily from the need for engineering data and correlations in support of the heat transport and thermal hydraulics of a variety of nuclear reactor systems and their associated power conversion systems. The Division has also led research in the development of thermal energy storage systems.

For over 25 years, ETD has been in the lead nationally in the collection, analysis, evaluation, and dissemination of information and data relating to the safe operation and maintenance of nuclear reactors and their associated fuel cycle facilities. Division personnel pioneered the use of probabilistic risk methodology to determine the quantitative significance of operational events.

Our systems analysis capabilities in certain areas are outstanding. These include the evaluation of nuclear reactor systems, especially in the areas of nuclear safety and accident analysis; evaluation of economics of nuclear and fossil power systems; evaluation and development of fuel combustion technology; evaluation of aging effects of power systems; evaluation of waste treatment technology; and general evaluation of energy technologies and their concomitant R&D needs.

It is clear that many of our research programs are very important not only to the Division but also to our sponsors and the nation. We intend to continue pursuing these programs with the same commitment and technical excellence as we have in the past and to expand these existing programs as appropriate opportunities arise.

2.2 MAJOR NEW PROGRAM THRUST AREAS

We have identified several new areas for which we would like to develop additional research programs. Six areas that appear to be technically exciting, nationally important, consistent with ETD's mission, and feasible for funding have been identified as our major new program thrust areas, and we will dedicate a significant effort to their development.

1. Nuclear Power
 - Advanced Neutron Source
 - Advanced Nuclear Reactor System
2. Power Plant Life Extension
3. Space Thermal Power Systems
4. Advanced Composites Design Methods and Manufacturing Science Centers
5. Advanced Diagnostic Engineering Center
6. Multilayer Kinetic Energy Shielding

In addition, we have identified other areas that are interesting but have lower probability for funding. We have designated these to be exploratory thrust areas with a modest commitment for development.

2.2.1 Nuclear Power

The Division remains committed to the development of nuclear power. We perceive it as one of the best means to solve many of the world's energy and environmental problems and an area where the Division is uniquely qualified to contribute. We will continue to conduct excellent research in our existing programs and will expand those areas where appropriate. We also intend to establish new thrusts in two nuclear areas.

Advanced Neutron Source (ANS) Project. The ANS is a new research reactor project that will provide the world's best capability for neutron scattering research, in addition to unique capabilities for neutron irradiation and isotope production. We intend to apply our expertise and the resources of the Division to support the design and construction of the ANS. The focus of our efforts will be the application of our expertise in structural mechanics, materials, thermal hydraulics, and severe accident analysis, although other capabilities (e.g., risk analysis) will also be utilized (see Fig. 1). This project is a natural complement to our strong capabilities and our desire to conduct more experimental activities.

Fig. 1. ANS corrosion test loop.

Advanced Nuclear Reactor System. The development of a more cost-competitive reactor system with inherent safety features is an attractive research area. The modular high-temperature gas-cooled reactor (MHTGR) has long been recognized as a technology with good inherent safety features and certain economic advantages, such as high thermal-to-electrical conversion efficiencies. However, some question this concept's economic competitiveness. The direct-cycle MHTGR combines the inherent safety advantages of the MHTGR with a promise for a simpler and even more efficient power conversion scheme, with concomitant savings in operating and capital costs.

We propose to conduct fundamental systems and economic studies to determine the potential of the direct-cycle MHTGR. These studies would include an evaluation of safety implications of higher power density and higher operating temperatures, thermodynamic cycle development and analysis to determine the best system configuration, and an evaluation of the R&D needs.

We have unique resources that can be used to develop this concept. For instance, the core flow test loop can be used for qualification of direct-cycle turbine design and performance, regenerator design and performance testing, graphite-structure characterization (i.e., strength, dimensional stability, corrosion by impurities, etc.) at the new operating conditions, and validation of proposed control schemes.

2.2.2 Power Plant Life Extension

For the most part, power plant life extension is an economic trade-off between increased maintenance costs and capital additions and the costs for a new block of power production. Between 1992 and 2030, operators of over 100 nuclear power plants will be submitting applications to the NRC to extend their operating permits for another 20 to 40 years. Each application will require a technical evaluation in two areas—safety and environmental impact. Although not officially licensed for a finite period of time, fossil-fueled power plants face similar economic and technical challenges. The technical challenge centers upon development of techniques to identify systems and components that limit long-term operation and development of maintenance procedures and other techniques to provide reliable operation through the extended operating period.

Oak Ridge National Laboratory (ORNL) is well positioned for a leadership role in this important research area. NRC has already placed the responsibility for a generic relicensing document at ORNL. With its experience in nuclear power plant aging research and accident analysis and its operations expertise, ETD should play a leading role in the overall technical evaluation of power plant relicense applications for NRC and apply our expertise to similar fossil plant evaluations.

2.2.3 Space Thermal Power Systems

In 1989, the President of the United States charted a new course for the human exploration of space. He proposed the Space Station Freedom, then a return to the Moon, followed by a manned mission to Mars. Space exploration and defense initiatives defined by the National Aeronautics and Space Administration (NASA) and the Strategic Defense Initiative Organization (SDIO) place increasingly demanding requirements (e.g., lightweight, survivable, high performance, etc.) on thermal systems associated with power, propulsion, and thermal control applications. This research area would build on current programs for NASA (development of thermal storage for solar dynamic power system) and use our applicable expertise in nuclear energy, heat transfer, thermal hydraulics, composite materials, and energy

storage technologies. Efforts in this area would focus on component development for nuclear and solar dynamic power sources, nuclear propulsion concepts, and heat transport and rejection systems. Space initiatives supported by this thrust area include lunar and Martian colonization missions, SDIO platforms, the national aerospace plane, and the space station.

2.2.4 Advanced Composites Design Methods and Manufacturing Science Centers

The U.S. Government [Department of Energy (DOE) and Department of Defense (DOD)] has designated "high-temperature/high-strength/lightweight composite materials" as one of 22 critical technologies that merit special consideration in government spending. We believe that the Division can make significant contributions in this technology area because it is uniquely qualified to do so. Our background in the development and validation of high-temperature structural design and fracture mechanics methods, coupled with the high-temperature materials development, characterization, and fabrication expertise that exists within ORNL and the Oak Ridge Energy Systems complex, will serve as the springboard for this thrust (see Fig. 2).

Fig. 2. Ultrahigh-temperature multiaxial test system for characterization of carbon-carbon and other composite material behavior.

As a first step, we envision establishment of a Design Methods and Structural Integrity Center for Advanced Materials. The center's primary mission would be to establish appropriate design and fracture assessment methodologies for emerging advanced materials, thus accelerating their application and transfer to U.S. industry. While the center would primarily address high-temperature composite materials (e.g., ceramic, carbon, and intermetallic matrix composites), design methods development and application for other composite materials (e.g., polymeric composites) would also be included if appropriate.

We believe that a triad of activities usually must be included in any successful efforts to develop and use advanced materials: (1) materials science, (2) design methods and structural integrity, and (3) manufacturing science. We envision the Division taking the lead role in completing this triad by forming a Manufacturing Science Team. The team would focus on increasing the performance of products made from advanced composites. Materials of interest would again include ceramic-ceramic, carbon-carbon, and ceramic-intermetallic composites. The team would interact closely with the Design Methods and Structural Integrity Center because design *of* and *with* composite materials must be done concurrently with a consideration of manufacturing and processing. ETD's ultimate goal would be to form a Manufacturing Science Center as a companion to the Design Methods and Structural Integrity Center.

Each of these advanced materials initiatives would emphasize networking across ORNL divisions, as well as across other Energy Systems organizations. Strategic relationships would be formed with industries, universities, and other government agencies. Target applications include aerospace vehicles and engines, space platforms, a variety of high-temperature process equipment, internal combustion engines, and lightweight "compositized" structures.

2.2.5 Advanced Diagnostic Engineering Center

Diagnostic monitoring methods measure and trend degradation of materials, components, systems, and structures such that corrective actions can be taken before failure. The resulting cost savings, safety enhancement, and availability improvement justify the use of diagnostic equipment in an increasingly large number of applications. In recent years, the application of diagnostic monitoring in nuclear and other industries, as part of predictive maintenance programs, has been growing. Diagnostic engineering generally involves the proper selection and use of sensors, signal processing equipment, and data management and analysis software to detect, process, and trend those parameters that are associated with the various degradation modes. Ideally, the sensors should be nonintrusive, reliable, and provide nonambiguous information on the degradation being monitored.

Research in advanced diagnostic engineering includes the development of new sensors, use of existing sensors for new applications, development of more powerful signal processing techniques to capture and exhibit the maximum information content from the sensors being used, and development of computer methods for data management and interpretation based on new computer techniques such as expert systems and neural network data analysis. Our current diagnostic engineering research includes work for the NRC and also a Director's R&D Fund project. As part of that effort, we have been successful in developing several sensors for use in monitoring the performance of motor-operated valves, solenoid-operated valves, and check valves used in nuclear power plants, and we are currently investigating new applications for these new sensors (see Fig. 3).

In addition to the obvious diagnostic needs of the utility industry, several other new research areas have been identified; these include diagnostic monitoring of airplane structures and machinery and bridge structures. Both have been the focus of safety concerns; but in both cases, appropriate diagnostic methods are not available.

Fig. 3. Development of new diagnostic techniques for motor-operated valves.

2.2.6 Multilayer Kinetic Energy Shielding

Continuous, passive protection of personnel and hardware is vital for certain types of military, commercial, and industrial activities. Satellites, aircraft, and automobiles can best be protected or shielded from damage by high-velocity projectiles (kinetic energy) and/or other forms of energy, such as lasers or x-rays, by the use of specifically designed multilayer shields.

This major thrust is to develop, optimize, and validate kinetic shields. Optimization of multilayer shields will involve a wide spectrum of ETD and ORNL expertise, including phenomenological and equation-of-state based modeling, component designing, testing, and failure analysis. It is envisioned that protection concepts will be developed to minimize the weight and/or volume for the given threat. Efforts will focus on optimizing the properties of each component in the shield to allow them to serve more than one function.

Development of shielding or passive protection programs, which are of critical significance to the United States, will involve wide-range application of the sound scientific background and experience of ETD and the Oak Ridge Reservation.

2.3 EXPLORATORY THRUST AREAS

Through our planning efforts, we have identified many areas of opportunity (see Appendix A). We have selected five areas to complement our major thrusts. Because these are more speculative, our development efforts will be modest in these areas:

1. Municipal Waste Disposal/Minimization,
2. Desalination Technology,
3. Development of a New Light Water Reactor (LWR) Fuel,
4. Human Biophysical Engineering, and
5. Combustion Enhancement.

2.3.1 Municipal Waste Disposal/Minimization

The treatment and disposal of waste material have become serious national problems. In two research areas, municipal waste disposal and waste minimization, we have the technical capability to make substantial contributions. As municipal landfills become saturated and new acceptable sites become scarce, an alternative disposal technique is inevitable. There seems to be a widespread lack of public acceptance for municipal waste incinerators because many people do not have confidence that proposed incineration systems will be environmentally acceptable. As a result, there is a need for an effective system that couples selective recycle with the most advanced forms of combustion technology. Because we have research staff members that are nationally recognized in the fields of combustion, fuels characterization, and emission control, we can make significant contributions.

Waste minimization is the process of evaluating processes and materials that generate waste streams and developing alternatives to eliminate the waste via recycle, reuse as feed to other processes, process modification, material substitution, etc. Most often, a single waste minimization project involves several of these strategies. Waste minimization is best defined as an initiative to reduce waste volume, disposal cost, effluent toxicity, etc., which is not "end of the pipe treatment." Waste minimization is a key issue throughout DOE, DOD, and industry. There are several incentives to minimize waste production. For instance, laws governing payment for environmental restoration make it clear that abiding by current laws or even adopting state-of-the-art waste disposal methods does not limit future liability. The cost of waste disposal is increasing rapidly. With real costs doubling every 3 to 4 years, waste disposal costs will someday impact our competitiveness to the same degree that high labor rates and budget deficits do today. Resources are limited, and wastes often contain valuable material. Finally, Congress has mandated that hazardous waste generators take steps to minimize waste generation [Resource Conservation & Recovery Act (RCRA) Reauthorization Act, 1984]. DOD and DOE have taken this as a mandate for action. Hazardous waste minimization seems to be a driver in obtaining funding for major capital projects at DOD and DOE production sites.

The technologies that contribute to a successful waste minimization project include chemical and physical separation, economic and process modeling, and a broad range of experience with chemical/physical processes. ETD, in conjunction with other Energy Systems organizations, could conduct bench-scale proof-of-principle tests, pilot-scale demonstration tests, process and life-cycle cost analysis, and technology transfer projects for DOE and DOD sponsors.

2.3.2 Desalination Technology

Desalination of seawater and brackish water is currently in large-scale use at only a few locations around the world. In general, it is an energy- and capital-intensive process that is economical only when alternative freshwater sources (e.g., pumping from underground aquifers and the transport of surface water and other natural freshwater sources via long distance aqueducts) are not available. Population pressures and the overpumping of aquifers are combining to suggest that existing freshwater sources for large urban areas may be limited in the next decade and that desalination may become the method of choice.

The construction of large desalination plants, both thermal (distillation and freezing) and membrane (reverse osmosis), peaked in the United States and worldwide during the 1960s to 1970s then virtually ended because of market saturation and the availability of lower cost alternatives in many parts of the world, such as the construction of long distance aqueducts (e.g., in California) or the increased pumping of aquifers (e.g., in Israel), coupled with the increased price of fossil fuels. Research funded by the U.S. Department of the Interior (DOI) also virtually ended in the early 1970s.

The DOI-funded research done in the United States was carried out primarily at ORNL, and much of that research was done in ETD. New processes for both distillation and membrane desalination technologies were developed and tested at ORNL. It appears to be a opportune time to revisit the desalination issue to determine the potential domestic and worldwide needs and to assess the technologies available. The potential funding sources include DOI, the U.S. Agency for International Development, the World Bank, and the United Nations.

2.3.3 Development of a New LWR Fuel

Development of an advanced nuclear fuel could serve as the basis for a potential line of new, safer, advanced LWRs and as a retrofit to improve the margin of safety for operating reactors. The proposed ceramic fuel system, based upon the same safety principles as the MHTGR fuel, would include coated particles, fuel rods, and grid structure. The inherent advantage is that such a fuel would serve as the principal fission product containment, relieving many of the safety concerns facing current LWRs.

As part of this thrust area, we could propose tasks to select candidate materials that have good neutronic economy, are stable under irradiation, are machinable, have high-melting temperatures, have good fission product retention, and are compatible with water/steam systems (Si_3N_4 reinforced with SiC whiskers might be a candidate). We might then propose a "neutronic" parametric analysis to ensure that an advanced core design with high thermal inertia and high-temperature coefficient is neutronically attractive. Then existing LWR severe accident computer codes would be adapted to assess a hypothetical operating LWR retrofitted with ceramic fuel (removal of all Zircaloy) to demonstrate the large safety benefits. Based on positive results, a full fuel development, characterization, and validation program would be proposed.

2.3.4 Human Biophysical Engineering

Recent advances in computing technology have had little effect on the practice of medicine in areas other than diagnostics. The use of computer simulation as a tool for improved understanding of human physiology, disease pathology, and treatment protocols has been hampered by lack of basic clinical knowledge, inadequate computer technology, and

medical tradition. The thrust of this effort is to develop a multidisciplinary center for the application of advanced computer hardware, software, and diagnostic techniques to provide an improved understanding of human physiology. The premiere tool to be developed and utilized by the center would be a highly advanced computer simulation of the entire human body. Potential applications and/or "products" include the investigation of disease pathology and treatment protocols and the development of advanced pharmaceuticals, treatment, and diagnostic technologies. Other consequences could be the design of artificial organs and components, improved survival suits and environmental control systems for spacecraft, and tools for the prediction of the biological impacts of radiological, toxic chemical, and other environmental stresses. Potential partners in this enterprise include several ORNL divisions, other national laboratories, universities, medical schools, the National Institutes of Health, DOD, DOE, NASA, pharmaceutical companies, the manufacturers of diagnostic and treatment equipment, manufacturers of artificial organs and components, and computer manufacturers.

2.3.5 Combustion Enhancement

Revolutionary approaches to combustion systems may be required to meet future expectations for emissions and fuel economy. The understanding of combustion processes has advanced considerably with the advent of laser diagnostics and new models. However, in actual practice, the control of combustion involves mostly macroscopic and rather dated technology. Continually increasing pressures for low-emission engines will likely surpass the emission reductions achievable with conventional approaches, such as fluid motions induced by combustion chamber geometry, stoichiometric operation with catalysts, and air-fuel ratio control via fuel injection. More extraordinary approaches may be required to achieve goals without resorting to impractical fuels. However, attractive alternative fuels can themselves be a means to achieve a desired combustion process and should be examined in that light, along with their role as petroleum substitutes. The fuel economy advantage of enhanced technologies has significant potential as well because lean-burn engines or various new forms of unthrottled engines might finally be made practicable.

Combustion enhancement is the influencing of combustion processes in engines to achieve optimal energy conversion (fuel economy) or to achieve specific goals in emissions. Our current understanding of combustion processes and fuels requires numerous compromises in engine and fuel design to control emissions or avoid abnormal engine operation. ETD's Fuels, Combustion, and Propulsion Technology Laboratory has extensive capabilities to pursue new combustion enhancement techniques (see Fig. 4). Our combustion enhancement initiative attempts to study and develop rather innovative or revolutionary methods to control combustion even at the molecular level. We believe that potential combustion enhancement technologies lie in the following categories:

1. catalysis and other surface phenomena,
2. fuel and oxidant chemistry,
3. energy fields or beams, and
4. advanced sensors and diagnostics.

2.4 PROGRAM DEVELOPMENT STRATEGY

An effective program development strategy is essential to the realization of our ETD goals and aspirations. Our strategy must consider that internal and external forces are

ORNL PHOTO 8043-90

Fig. 4. Examination of zirconia-coated piston insert after methanol utilization experiments in stratified charge engine.

continually changing, and therefore we must be flexible to adapt and take advantage of opportunities as they arise. Our strategy emphasizes (1) recruitment and maintenance of a highly trained and talented staff, (2) establishment of a viable program development organization that integrates existing Division and programmatic assets into an effective marketing unit, and (3) mechanisms to develop and implement tactical plans incorporating our given strengths into the opportunities as they arise.

We intend to establish a program development organization that is composed of two or more marketing specialists. These full-time program development experts will be responsible for monitoring the needs and program directions of our prospective sponsors. They will work closely with the existing ORNL program management to identify opportunities and to interact with potential sponsors. Development teams will be set up to represent each of the thrust areas outlined in this plan. The responsibility of these teams, with the support of Division management and marketing specialists, will be to construct and implement the development plans necessary to enable the Division to play a significant role in the specified thrust areas.

3. ORGANIZATIONAL THRUST AREAS

3.1 WORKING TOGETHER

During the course of our planning sessions, it was evident that there are significant opportunities to increase our effectiveness by developing better working relationships, both within the Division and with those outside the Division with whom we interact on a continuing basis. First, we intend to improve our communications within the Division and to communicate better with coworkers from outside the Division. For instance, we will better inform the Y-12 Research Services staff about the purpose and goals of our programs so that they will recognize that they are important components of our research team. In addition, we will search out ways to improve our working relationships with Information Resources and Administration (IRA), Central Engineering, Purchasing, Finance and Materials, Health Physics, Industrial Hygiene, and Y-12 Safety. It is our intention to establish thrust teams to seek out new methods to improve our working relationships. We want to enhance the teamwork atmosphere within the Division, tear down organizational lines, and work toward common goals. Many within the Division have taken our pledge:

I promise to take pride in what I do and to do my job in a way that makes the job of all those I interact with easier, more efficient, and more effective. I will go the extra mile and then ask what more I can do.

To emphasize this important philosophy, the Division has instituted (1) the "Extra Mile" Award to recognize those that exemplify the intent of the pledge, (2) a Division newsletter to inform employees of the activities of the Division, and (3) off-site Division quarterly meetings to give everyone an opportunity for questions and answers from the Division Director (who shares information about the ETD management and solicits questions from the staff).

3.2 ADMINISTRATION

We see an opportunity to increase our efficiency and productivity through an improved system of processing administrative tasks. A common complaint is the difficulty of processing many routine administrative tasks. The preparation of documents to satisfy many administrative requirements is extremely time-consuming and often involves duplication. Instructions are often unclear, incomplete, or nonexistent. To alleviate this problem we intend to institute a series of initiatives. One will be the development of a "Help" system that will involve the identification of ETD staff who are experienced in a particular area and can provide assistance in fulfilling the needed requirements. For instance, the budget preparation process is extremely complicated and laborious. We can significantly improve this system through examples and our Help system. We also intend to work closely with organizations both internal and external to the Division to ensure that instructions are made clearer and more available and that duplication is eliminated. We intend to establish a thrust team to outline a plan and execute this initiative.

3.3 CULTURAL DIVERSITY

The development of a Division that is culturally diverse is an important part of our long-range plan. We are committed to equal opportunity for all in staff recruitment, staff development, assignment of responsibilities, opportunities for advancement, performance reviews, and rewards. But beyond this, we desire to achieve a cultural diversity that more accurately reflects the cross section of the nation, seeking outstanding minority and female candidates that will enhance the capabilities of our technical and support staff. We will continue to search for qualified individuals through our association with Historically Black Colleges and Universities and through other recruitment resources. Our goal is to achieve a level of cultural diversity that will make affirmative action an unnecessary concept.

4. ENVIRONMENT, SAFETY, AND HEALTH (ES&H)

Over the past few years we have seen many changes in the way we do business, and one of the most significant is the way that we approach the safety and health of our employees and how we protect our local environment. While we are proud of our unprecedented safety record of over 40 years without a lost-time accident, we realize that we have significant shortcomings. We have recently completed an ETD self-assessment that points out our major weaknesses. Additionally, we have documented the Division's charter and the structure through which we conduct business.

We have a legacy of experimental equipment and buildings that have some radiation contamination or contain hazardous chemicals. We lack safety and hazard identification training, and we must upgrade our operating procedures. In addition, our self-assessment process identified hundreds of safety and environmental corrective actions. On a positive note, we have made significant progress in correcting our deficiencies. We have established an Office of Operational Readiness that focuses and coordinates our ES&H activities. We have taken action on most of our corrective measures. We have completed or are planning comprehensive radiation surveys of all of our major facilities, and we have removed surplus chemicals and equipment from our buildings. Most importantly, we have made a commitment to achieve excellence, not only in our R&D but also in meeting our responsibilities to health, safety, and protection of the environment, and we have developed a plan to achieve this objective.

Appendix A**STRATEGIC PLANNING PROCESS IN ETD**

The long-range plan described in this document is a result of planning activities that occurred during the first part of FY 1990. This document describes several parts of the plan. First, we define what we want to be as a division and how we view our mission. Next, we describe a series of new initiatives that we choose to call thrust areas. Last, we establish a plan by which we can develop and execute tactical plans and program development efforts to achieve our goals effectively.

During the winter of 1989 and spring of 1990, ETD embarked on a comprehensive planning process with the intent to involve all levels of the staff. The overall process is shown schematically in Fig. A.1. The process began with a series of offsite meetings that were coined "Brainstorming Sessions." Everyone in the Division was invited to participate, and over 110 staff members participated in the first series of meetings. The participants were asked to think about and discuss these questions:

1. What are the strengths of the Division?
2. What are the weaknesses?
3. What program areas offer the Division the best opportunities?

They were asked to rank our strengths and opportunities and suggest potential goals for the Division for the next 5 years.

A steering committee, composed of the Division senior management, reviewed the results of these deliberations. The steering committee selected 27 candidate programmatic areas to consider as new thrusts for the Division. Other nonprogrammatic issues were identified by the staff, and it was decided to address these separately. A second steering committee meeting, augmented with representatives of Y-12 Research Services, Central Engineering, Purchasing, ETD Support Services, IRA, ETD Office of Operational Readiness, Finance and Materials, and ETD Administrative Support, considered the issues and weaknesses brought forth in the previous sessions. This committee considered another series of thrusts to address the administrative problems and management weaknesses.

The original "brainstorming" groups were reconvened. During these sessions, the programmatic and administrative thrusts were reviewed. The programmatic thrusts were ranked by these groups using both objective and subjective criteria. The steering committee met once again, agreed upon a general mission statement for the Division, selected the thrusts that appear in this plan, and formulated the framework to execute this development effort.

Planning must be a dynamic and ongoing process to be effective. Thus, this plan will be reviewed and revised as often as appropriate to adjust the focus of the Division in light of new information. The next step in this process involves the establishment of teams to formulate the tactical plans and marketing strategies to implement the proposed programmatic and administrative thrusts. This ongoing activity is outlined in this plan.

Fig. A.1. ETD planning process.

Appendix B

DIVISION STAFF, FACILITIES, AND BUDGETS

B.1 STAFF

The ETD staff currently consists of about 190 members. Engineers and physical scientists make up two-thirds of the staff; their expertise lies primarily in the fields of mechanical, nuclear, and chemical engineering, but significant expertise lies in other areas such as optics and manufacturing science. The remaining one-third is composed of technical and administrative support staff (e.g., engineering technicians, computer specialists, secretaries, and other administrative support personnel). The past, present, and projected staffing for ETD are shown in Table B.1.

Table B.1. Comparison of staffing for FY 1989-1992

Staffing	Fiscal year			
	1989	1990	1991	1992
Professional	124	123	135	145
Technical support	18	23	24	26
Administrative support	<u>42</u>	<u>44</u>	<u>45</u>	<u>46</u>
Total	188	190	204	216

B.2 FACILITIES

ETD has offices and laboratories in ten buildings located at the Y-12 Plant (see Fig. B.1) and ORNL (X-10) site and a user facility at the K-25 Site. At Y-12, Building 9201-3 houses the administrative offices and the offices of approximately one-third of the staff. Experimental activities include the Optics MODIL Productivity Validation Test Bed and the Diagnostic Research Center. Building 9204-1 houses another one-third of the division staff. Experimental activities include the Multiaxial Materials Testing Laboratory, High-Temperature Structural Test Laboratory, ANS Test Loops, Ice Storage Test Facility, Thermal Shock Test Facility, and Concrete Testing Laboratory. Other buildings occupied by ETD staff include the following:

Building 9401-1	Fuels, Combustion, and Propulsion Laboratory
Building 9102-1	Office building
Building 9102-2	Office building
Building 9104-1	Office building
Building 9108	Office building
Building 9720-39	Equipment storage building

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Fig. B.1. ETD locations at Y-12 Plant.

At the X-10 site, Building 4508, Room 271, houses the Irradiation Engineering Capsule Assembly Area, which is used for assembly of irradiation capsules for experiments conducted in the High Flux Isotope Reactor (HFIR). The Division also has a facility at the HFIR (Building 7900) to control and collect data from the irradiation experiments. A facility at the K-25 Site, the Pressure Vessel Research Users' Facility, is a pressurized-water reactor pressure vessel used to conduct structural examinations and tests.

B.3 Budget

Over the past decade, there has been a substantial restructuring of our funding sources. Traditionally the research conducted in the Division was sponsored by DOE and NRC (>90%). About 10 years ago we made a conscious decision (documented in previous long-range plans) to seek funding from the DOD and other nontraditional sources; in 1986 those sources amounted to 40% of the budget. With what we view as a renewed interest in nuclear power and a decreased emphasis on national defense, we are once again preparing for a change. In FY 1990 our DOE funding was at the highest level in 8 years, and the NRC and DOE combination approached 80% (Table B.2). In the immediate future, we envision that our defense programs will stabilize, while we see modest growth in both the DOE and NRC programs. One area where we expect new program support is in cooperative research with industry as part of DOE's technology transfer initiatives.

Table B.2. Actual costs for FY 1988-1990 and estimated budgets for FY 1991 and 1992 (\$ millions)

Sponsor/Program	Actual			Budget	
	1988	1989	1990	1991	1992
DOE					
Nuclear Energy	2.7	1.8	2.6	2.6	3.2
Conservation	2.6	2.8	3.5	4.6	4.0
Fossil Energy	0.1	0.2	0.1	0.1	0.3
Energy Research	3.7	3.0	3.9	3.7	3.9
Defense/new production reactor	0.7	1.0	3.2	2.6	3.0
Other	<u>1.6</u>	<u>1.2</u>	<u>1.8</u>	<u>1.3</u>	<u>1.5</u>
Total DOE	11.4	10.0	15.1	14.9	15.9
NRC	8.6	8.9	9.2	9.8	10.3
DOD	9.0	7.0	6.3	6.8	6.5
Other	<u>1.4</u>	<u>0.9</u>	<u>0.8</u>	<u>0.7</u>	<u>2.0</u>
Total non-DOE	19.0	16.8	16.3	17.3	18.8
Total	30.4	26.8	31.4	32.2	34.7
Subcontract costs	5.5	4.0	4.6	4.0	4.0

Appendix C

LIST OF ACRONYMS

ANS	Advanced Neutron Source
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
ES&H	Environment, Safety, and Health
ETD	Engineering Technology Division
HFIR	High Flux Isotope Reactor
IRA	Information Resources and Administration
LWR	light water reactor
MHTGR	modular high-temperature gas-cooled reactor
NASA	National Aeronautics and Space Administration
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
R&D	research and development
SDIO	Strategic Defense Initiative Organization

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