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DEPARTMENT OF ENERGY

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INFORMATION TECHNOLOGY RESOURCES LONG-RANGE PLAN

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U.S. Department of Energy
Assistant Secretary, Management and Administration
Deputy Assistant Secretary for Administration,
Information, and Facilities Management
Directorate of Administration

SECTION 4: STRATEGIES FOR THE EFFICIENT USE OF INFORMATION TECHNOLOGY RESOURCES

SECTION 5: INFORMATION TECHNOLOGY RESOURCES, REQUIREMENTS, AND PLANS

SECTION 6: PROGRAMMATIC USES OF COMPUTERS

APPENDICES

SECTION 1: OVERVIEW

The Department of Energy has consolidated its plans for Information Systems, Computing Resources, and Telecommunications into a single document, the Information Technology Resources Long-Range Plan. The consolidation was done as a joint effort by the Office of ADP Management and the Office of Computer Services and Telecommunications Management under the Deputy Assistant Secretary for Administration, Information, and Facilities Management. This Plan is the product of a long-range planning process used to project both future information technology requirements and the resources necessary to meet those requirements. It encompasses the plans of the various organizational components within the Department and its management and operating contractors over the next 5 fiscal years, 1991 through 1995.

This section describes the Plan contents, objectives, and scope and concludes with an executive summary.

1.1 PLAN CONTENTS

The Plan is organized into six sections. A brief description of each of the sections is presented below:

- SECTION 2: PLANNING AND MANAGEMENT OF INFORMATION TECHNOLOGY RESOURCES merges the planning and management process of the three Information Technology Resources (ITR) areas (information systems, computing resources, and telecommunications) and describes how the Department manages the unclassified computer security program as an integral part of the information resources management function.

- SECTION 3: INFORMATION TECHNOLOGY RESOURCES COSTS contains the total ITR costs of the Department categorized into four major categories: equipment, personnel, commercial services, and other related costs.

- SECTION 4: INFORMATION TECHNOLOGY RESOURCES STRATEGIES describes the strategies employed by the Department to promote the efficient use of ITR and initiatives to further enhance the unclassified computer security program.

- SECTION 5: INFORMATION TECHNOLOGY RESOURCES, REQUIREMENTS, AND PLANS includes a section for each of the three major functional components-- information systems, computing resources, and telecommunications -- and describes the significant development projects currently underway, current resources, the types of program activities that are planned to meet future requirements of the Department, and planned major acquisitions.

- SECTION 6: PROGRAMMATIC USES describes how information technology resources are used by the Department to meet programmatic missions.

At the end of this Plan, there are six supplementary appendices. A brief description of each appendix is listed below:

- APPENDIX A: SITE PROFILES synopsizes, for each of the sites included in the planning process, the site's major function(s), program(s) supported, and their primary information systems, computer and telecommunications resources.

- APPENDIX B: PROGRAM PROFILE includes a Department organization chart and a brief description of the major program areas within the Department.

- APPENDIX C: INFORMATION TECHNOLOGY RESOURCES ASSESSMENT addresses the current trends and the future directions in information technology.

- APPENDIX D: ACRONYMS AND GLOSSARY includes special acronyms and defines terms related to information technology resources that are used in this Plan.

- APPENDIX E: RELATIVE CAPACITY UNIT discusses the current relative unit of measure used within the Department to report and aggregate computing capacity, capability, and requirements. It also includes the relative computing capacity ratings of installed Departmental computers.

- APPENDIX F: INDEX OF TABLES AND FIGURES lists, in their order of appearance, the identifying number, title, and page reference of each table and figure.

1.2 OBJECTIVES

The principle objective of this Plan is to describe the information technology resources and capabilities of the Department, the future requirements, and the strategies and plans to satisfy the identified requirements. The long-range planning process provides the systematic means to meet this objective and assists the Department in assuring that information technology support is provided in an efficient, effective, and timely manner so that the programmatic missions can be accomplished. Another important objective of the Plan is to promote better understanding, both within and external to the Department, of its information technology environment, requirements, issues, and recommended solutions, and to identify how the Department manages the unclassified computer security program as an integral part of the information resource management function.

1.3 SCOPE

The Information Technology Resources Plan covers the 5-year period from fiscal year 1991 through 1995. It takes into consideration the information technology resource requirements of more than 53 different Departmental components and contractors.

1.4 EXECUTIVE SUMMARY

DOE is composed of organizations which encompass many diverse programmatic missions such as the design, development, and production of nuclear weapons, energy research and development, nuclear research and development, uranium enrichment, management of radioactive wastes, and marketing of hydroelectric power. Thus, the information technology requirements are diversified. Additionally, these requirements are continually changing to reflect changes in technology, policy, and program mission. The long-range planning for information technology resources (ITR) has been developed to assure that adequate support is available for cost-effective accomplishment of mission objectives.

These resources are vital to the successful accomplishment of the programmatic missions in the Department. This is evidenced by the fact that the estimated ITR cost for fiscal year 1990, approximately $1.3 billion, was about 9.3 percent of the total Departmental budget request, while the total estimated ITR cost for the entire Federal Government was less than 2 percent of the total Federal budget request for the same time period.

1.4.1 Long-Range Planning Process

The annual long-range planning cycle for supporting this Plan is shown in Figure 2.1-1 on page 2-2. It was initiated by a Headquarters Call in August 1988 for site ITR plans to be submitted in February 1989 by those Departmental components and contractors with major ITR requirements. The site plans were reviewed by the appropriate operations offices, program offices, Office of ADP Management, Office of Computer Services and Telecommunications Management, and other senior management officials. During this review process, consideration was given to the validity of the programmatic requirement , the reasonableness of funding estimates, identification and resolution of any issues, and other alternatives available. The planning process culminated with the publishing of this Plan.

1.4.2 Information Systems

The IS planning process is only the beginning of the information system (IS) life cycle methodology which DOE organizations are expected to follow. Due to the diversity of missions and related IS requirements, each DOE component is expected to establish their own specific procedures and management practices governing IS development, documentation, and ongoing maintenance and operation. These must, however, be in line with policies and guidelines set forth by DOE management orders. To assure compliance with policies and guidelines, the Office of ADP Management conducts periodic reviews of selected IS management programs and recommends improvements or changes as necessary.

Automated IS are required by virtually all DOE components to support a broad range of programmatic and administrative functions. IS range from small, stand-alone systems used within a single organization to large, integrated, major systems which affect every DOE and DOE contractor organization. During calendar year 1988, 164 new IS became operational, giving DOE a total of 509 operational IS. Nine enhancements to existing operational systems were also implemented this past year. The Department spent almost $43 million to operate and maintain its IS.

The functional category into which the largest number of IS fall is the administrative one. Of the 509 operational IS, 198 perform administrative activities. The finance and accounting area is the functional category with the second largest number of systems, 57, and the procurement area has the third largest number of IS, 46.

Over the last 3 years, there has not been any significant change in the distribution of IS with impact on organizations other than the system sponsor. An analysis of the operational IS inventory indicates that the number of systems not exchanging data with any other IS has increased from 351 to 358 over the past 2 years, but the percentage they comprise of the total inventory has increased slightly from 68.9 percent to 71.1 percent.

As of October 1, 1989, DOE organizations had plans to develop 37 new IS, redesign 3 IS, and make 17 enhancements to 12 already operational systems. These Departmental components were also in the process of developing 70 new IS, redesigning 3 IS, and making 18 enhancements to 13 existing operational ones. This totals 148 IS projects which are either planned or under development. A year ago, there were 207 such projects either being planned or underway. Most of the information system development activity relates to microcomputer-based IS although most enhancement and redesign activities are associated with mainframe-based IS.

1.4.3 Computing Resources

At the beginning of FY 1989, the Department had 3,391 installed computers with an initial purchase value of over $50,000 each. Including peripheral equipment, these resources were valued at almost $1.3 billion. These computers establish the base upon which plans are made for providing future computing support to meet the computational requirements of Departmental programs. Based upon projections, the dependency on computing resources to accomplish the varied program missions of the Department is increasing. Requirements are projected to grow at an average annual rate of approximately 31 percent between FY 1990 and FY 1995, which is consistent with projections in last year's Departmental ITR Long-Range Plan. Defense Programs will continue to be the primary user of computing resources throughout the planning period, followed by Energy Research and Nuclear Energy, respectively.

To meet the increased demands for computing support, the Department has established plans for 150 major ADP equipment acquisitions, each with a purchase equivalent value of $1 million or more, between FY 1991 and FY 1995. The total projected purchase value of these acquisitions is approximately $921 million. When compared to the 5-year planning period in last year's Departmental Plan, FY 1990 through FY 1994, the number of total acquisitions planned during the period covering FY 1991 through FY 1995 declined by approximately 7 percent. The decline when compared to the prior 5-year Plan, FY 1989 through FY 1993, was even more dramatic showing a 26 percent decrease in the total number of acquisitions. This can be attributed to numerous factors; i.e., changes in Departmental priorities, phase-out of programs and projects that were previously planned as ongoing throughout the planning period, delays and cancellations of previously-planned acquisitions due to budgetary constraints, advances in state of the art computational resources and techniques providing additional capability and capacity with fewer systems, and changes in site strategies for meeting computational requirements. When comparing total projected costs for the same periods (FY 1991 - FY 1995 to FY 1990 - FY 1994 and FY 1989 - FY 1993), the decreases were less significant; i.e., 4.5 percent and 7 percent, respectively. The primary reason for the smaller decline in costs versus total quantity of acquisitions is due mainly to planned out-year acquisitions of costly high-performance supercomputers to meet research and development programmatic requirements.

1.4.4 Telecommunications

The Department uses all forms of telecommunications equipment and media to distribute the vast amounts of information generated by people and computers. Sophisticated systems, networks, equipment, and schemes are in place or planned at all major facilities that provide the support required by the dynamic user community of DOE. These resources provide connectivity within the agency as well as access to worldwide networks for shared information and technology.

The basic DOE strategy is to improve telecommunications services while concurrently reducing costs and, based on estimates received from DOE sites, this will be achieved. The ITR budget for FY 1991 is $1.4 billion. Telecommunications will account for approximately 25 percent of that total, or $350 million. However, by FY 1995, the planned resources for telecommunications will account for only 20 percent of the total estimated $1.5 billion ITR budget. Effective telecommunications planning is successfully supporting the basic strategy.

Supporting the Department's research, administrative, operational, and manufacturing functions by implementing the extensive DOE corporate and shared systems in an efficient, reliable, and cost-effective manner will require the use of structured and proven methodologies rather than reactive, system by system solutions. In the data communications area, more than others, top-down strategies will be imperative if the telecommunications managers are expected to quickly respond to requirements to implement, test, operate, and maintain the diverse IS currently under development. More interaction between data communications and IS personnel during the system development process will also be required to ensure network access, availability, and compatibility. Upfront funding will be required to have hardware, software, and personnel resources in place and ready to respond to DOE user requirements.

Due to the nature of the DOE activities, facilities are very often remotely located. In addition, several DOE-wide programs function almost entirely in a mobile environment (e.g., the Nuclear Emergency Search Team, the Radiological Assistance Program and the transportation of Sensitive Nuclear Materials). Overcoming these geographic barriers, maintaining required security, dealing with the ever changing regulatory and standards environment, and achieving the technological proficiency required to accomplish the Department's missions require a cooperative effort by both the Headquarters and field telecommunications managers. Therefore, Headquarters and field telecommunications managers are working together to plan and implement efficient top-down strategies that will establish short-, mid-, and long-term goals for their communications support activities and initiatives. These strategies support DOE management goals as well as the specific goals of the facilities.

The advent of deregulation and competition within the telecommunications industry has increasingly complicated the task of planning and managing effective telecommunications systems. The complex and diverse programs of the Department require that telecommunications managers be flexible and highly responsive. They must also conform to various national directives, regulations, and public laws governing the procurement, deployment, and management of telecommunications resources. DOE's capability to manage its resources depends upon the capabilities of these managers at all levels. This is particularly important in view of the DOE strategy to achieve some measure of self-sufficiency and control at each site. Equally important is avoiding the risks of incompatibility, inefficiency, and technological isolation.

Two basic and ongoing activities support Departmental telecommunications strategies. First is the constant evaluation of existing circuitry and service arrangements which produces numerous opportunities to contain costs and improve operational efficiency. This includes common use of the satellite backbone transmission system, shared-use T-1 collector facilities to eliminate the proliferation of multi-DOE communications links between similar locations, integration and consolidation of site services, and conversion to least-cost service offerings. Second is the use of the competitive procurement process to acquire services and equipment. Improved technology at lower cost is stimulated by this process. Since more sophisticated telecommunications capability will be required to support high-level computer processing over the 5-year planning period, DOE will continue to pursue this course of action to take advantage of increased competition in the marketplace and technological advances, both locally and through nationwide policy initiatives.

The basic goals for achieving the telecommunications strategies are ongoing. Below is a synopsis of activities, in progress and planned, that will achieve these goals.

- Commitment to National Priorities - Throughout DOE, strategic direction must be tempered with national priorities, such as standards policies like the Government Open Systems Interconnection Profile (GOSIP), security policies, national security emergency preparedness (NSEP), radio frequency spectrum conservation, use of Governmentwide common-user services, and public safety.

- End-To-End Digital Connectivity - In order to achieve end-to-end digital connectivity, the development and implementation of national and international standards will be closely monitored. Adherence to these standards will preclude DOE isolation from commercially available services upon which continuing, reliable telecommunications are dependent.

- Containment of Costs - As in all other components of ITR, cost containment is a major objective of the telecommunications resource management strategy. It takes many forms, depending on the type of activity and timing within the life cycle of resources.

- Control of Telecommunications Resources - As stated earlier, the Department actively advocates a level of self-sufficiency and control at individual locations. This decentralized approach allows delegation of management responsibility to the appropriate level to effectively provide and manage local services. Management of the resources at this level allows more efficient operation and more effectively prevents abuse or misuse of telecommunications facilities.

These above goals have been firmly set and will continue as the basis for the development of strategies and of the initiatives necessary to carry out the strategies. The initial steps for accomplishing the Department's goals have already been taken. However, national initiatives and issues as well as emerging technologies and standards continually affect direction and initiate new actions for the Department. Several intensive DOE-wide initiatives that are currently being pursued to accomplish the telecommunications mission follow. In addition, 64 major site initiatives, planned to achieve the common DOE goals as well as improve telecommunications capabilities at the sites, are presented in subsection 5.3. Successfully accomplishing all planned telecommunications activities will ensure that the Department meets its telecommunications mission to provide the best telecommunications services and facilities available, while cost-effectively procuring and managing the technology.

- Transition to FTS 2000 - FTS 2000 is currently being implemented at DOE locations to provide an efficient, low-cost carrier for long-distance communications. DOE intends to use FTS 2000 as the dominant source for all administrative telecommunications services.

- Enhancement of the Department of Energy Nationwide Telecommunications Service (DOENTS) - During the past year, several enhancements were accomplished that provided greater capacity and connectivity. More cost-effective solutions for high-speed data and video teleconferencing requirements are now permitted as well. DOENTS will continue to evolve to meet the requirements for telecommunications services and to support the emergency requirements of DOE.

- Implementation of the Government Open System Interconnect Profile (GOSIP) - GOSIP defines a common set of protocols and protocol options to be used by Federal agencies as they implement OSI networking products. The adoption of GOSIP protocols by August 15, 1990, is mandated by FIPS PUB 146 and the Brooks Act (as amended by the Computer Security Act of 1987).

- Telecommunications Improvement Program (TIP) - Providing assistance to sites with regard to procurement and regulatory affairs will continue through this Headquarters-based program. TIP provides economic, regulatory, and policy analysis as well as assistance with all stages of the competitive procurement process.

- Secure Video Conferencing - A short-term demonstration of video conferencing equipment was established to determine demand for secure video teleconferencing between Headquarters and DOE field locations. Defense Programs has since determined that the video teleconferencing capability should be implemented on a permanent basis at Headquarters with additional locations currently under consideration.

- Expansion of Secure Voice and Data Communications Capability - Secure Telephone Unit (STU-III) equipment is the fastest growing cryptographic program in the Department. The newer technology provides a lower cost system with more features than the STU-II system, which, with the exception of a few special applications, was phased out in FY 1989. In addition, the availability of

NSA-approved devices for protection of voice and data communications, radio systems, and backbone networks will be expanded. The use of embedded COMSEC devices, which began in FY 1988, will continue into the 1990s.

- Telecommunications Services Priorities (TSP) Program - With the recent Federal Communications Commission (FCC) approval of the three major documents associated with the system, the TSP system will now supersede the current restoration priority system. Initial operational capability is scheduled for September 10, 1990. At Headquarters, a Departmental TSP point-of-contact and a procedural structure will be established to manage both DOE internal requests for TSP assignments and the requests from the power utilities for DOE sponsorship of TSP assignments.

- National Emergency Telecommunications System (NETS) Access Plan - NETS will expand the limited routing capability of the public switched networks to provide additional connectivity for NSEP traffic; however, it will not enhance the access circuit survivability between the network and the user. DOE will therefore be required to produce a Departmental plan to access NETS that will include additional routing requirements that will assure required connectivity for DOE sites during emergency situations.

SECTION 2: PLANNING AND MANAGEMENT OF INFORMATION TECHNOLOGY RESOURCES

This section of the ITR Long-Range Plan synopsizes the planning and management process used by the Department of Energy.

2.1 PLANNING

The dependency on information technology resources in accomplishing many of the program missions within the Department is increasing. To ensure that programmatic requirements are met efficiently, effectively, and economically, the Department established a long-range planning process for the acquisition and development of these resources.

In addition to meeting internal Departmental information technology resources management and control objectives, the long-range planning process is designed to decrease the reporting burden of the Departmental components and contractors. The plans provide a base of information to use in responding to requests for special reports and inquiries from within the Department and to satisfy applicable policy, budgeting, and reporting requirements set forth by other Government organizations such as the Office of Management and Budget (OMB), and the General Services Administration (GSA). The ITR long-range planning process at DOE is continually being refined and, as necessary, revised to reflect changes in technology, policy, programmatic missions, congressional legislation, and requirements from OMB, GSA, and other Government organizations.

The long-range planning process has been established to estimate future ITR requirements and to project plans for the acquisition and use of ITR resources to meet projected programmatic requirements. This process helps assure each DOE organization that information systems, computing resources, and telecommunications required to support that organization's mission and objectives will be available when needed. The process provides information necessary to support and improve Departmental decision making with respect to planning, budgets, requirements identification, design, engineering, acquisition/development of systems and services, resource sharing, and reutilization of computing resources equipment.

The current long-range planning cycle (shown in Figure 2.1-1) for producing this Departmental Plan began in August 1988 with the issuance of a Call for FY 1991 Information Technology Resources Long-Range Site Plans from the Director of Administration. This Call also included planning requirements from the Office of the Deputy Assistant Secretary for Financial Management and Controller for automated financial management systems (FMS) planning information. The Call was issued to all Departmental sites who significantly use ITR to assure that their future needs are anticipated and met. Because the Department of Energy supports a diversity of programs ranging from state of the art nuclear weapons design and development to the marketing of hydroelectric power, the sites program requirements and their supporting ITR needs are diversified. Each site prepares its own long-range plan according to the format and reporting requirements contained in the Call.

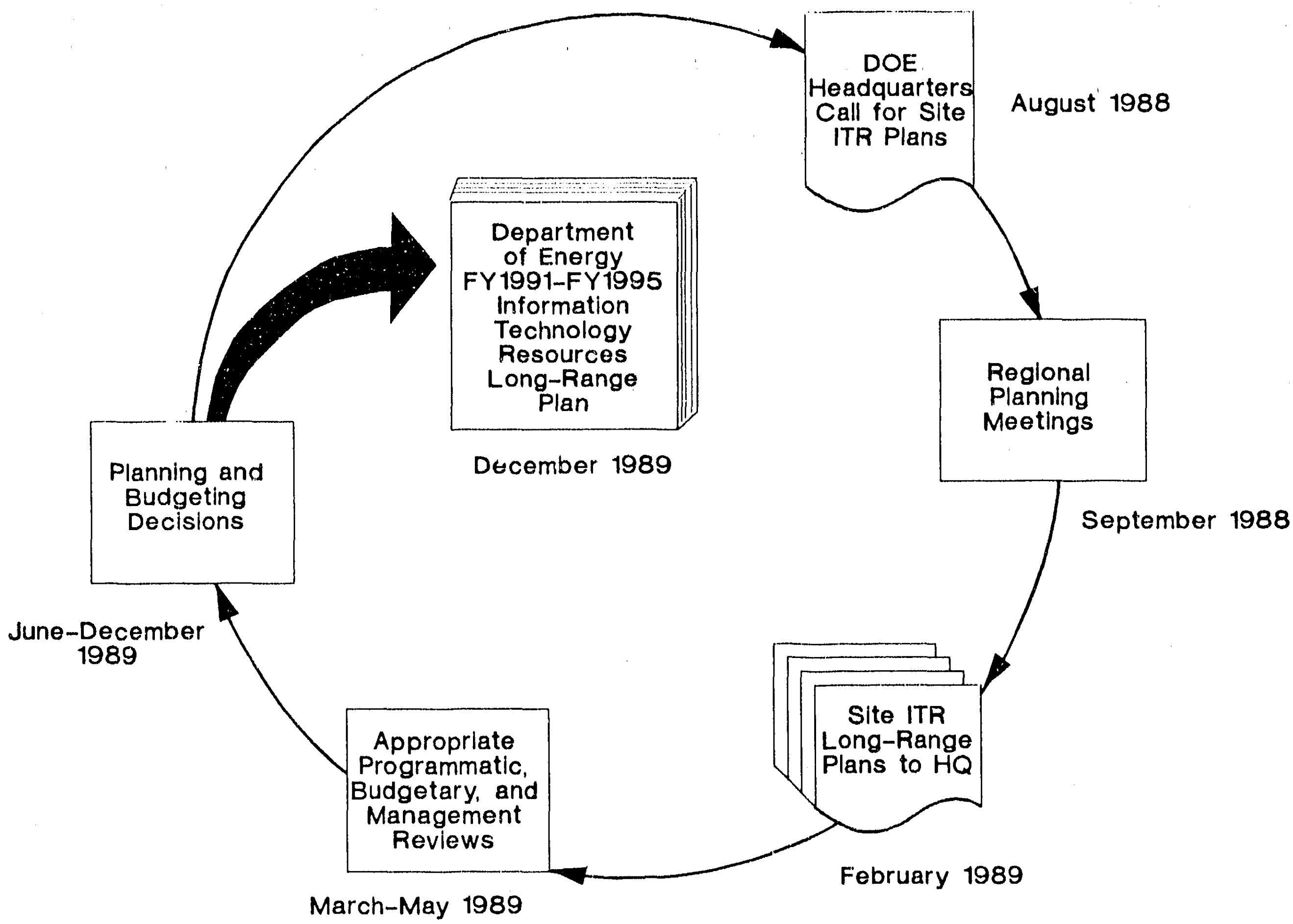


FIGURE 2.1-1 INFORMATION TECHNOLOGY RESOURCES LONG-RANGE PLANNING CYCLE, FY 1991

In order to provide a long-range perspective of a site's programmatic requirements and planned ITR resources, the planning data reported in a site plan spans an 8-year period beginning with the actual data for the previous fiscal year. For this planning cycle, the period began with FY 1988 data. This approach provides for identification and review of a site's requirement for additional major ITR resources during as many as five annual planning cycles before an ITR acquisition must be included in the budget. This allows for enough time to confirm the validity of the requirement and to investigate and evaluate all of the alternative methods of acquiring/developing the needed resources before actual budgetary decisions are required.

Each site plan includes a description of the site's current ITR environment, projection of future requirements, and strategies and plans to satisfy the requirements along with their projected costs and major accomplishments of the previous year that supported these goals. Each site develops a plan using site-specific planning tools plus those included in the Call. The basic data for describing the actual and projected ITR needs of the site are derived by the scientists, engineers, and other technical and management personnel who are responsible for achieving the Departmental missions and programs at that site. These ITR program support requirements are then compared to the ITR available at the site. Plans and strategies are then developed by the site to provide additional information technology resources to meet the requirements, if needed.

Each year, the review cycle of individual long-range site plans begins with review and approval by their own site management. Where appropriate, the site-approved long-range plans are forwarded to the cognizant operations office for review and comment. The site plans are then forwarded to Headquarters along with any applicable operations office comments and/or recommendations. Sites that do not report to an operations office forward their plans directly to Headquarters.

At Headquarters, both programmatic and ITR management reviews of site plans are made. The plans are provided to the cognizant program offices for their evaluation of the estimated programmatic requirements among all pertinent sites, both individually and collectively. This assists the program in making overall planning decisions as well as establishing their priorities in making budgetary allocations.

The ITR management review of site plans examines the justification for the requirements and the projected costs for providing the estimated resources, as well as the plan's consistency, completeness, and consideration of technical alternatives. As the information presented in the individual site plans is examined, issues (or potential issues) are identified and resolved. The results of these reviews are provided to the sites for appropriate consideration in the formulation of their next site plan.

The final phase in the planning cycle is the preparation of the Department of Energy Information Technology Resources Long-Range Plan which consolidates individual plans with appropriate adjustments to reflect the revisions made during the various planning and budgeting reviews and presents overall strategies and directions. This Plan is distributed throughout the Department and, upon request, to industry and other Government organizations. Experiences gained during each planning and management process will be reflected in changes to subsequent planning cycles.

2.2 MANAGEMENT PROGRAM

To assure that DOE organizations are adhering to basic policies and procedures for planning, development, implementation, and operation, as well as to assess the effectiveness of DOE policy, the Department utilizes a management review program to oversee the activities and practices of each DOE organization. The Office of ADP Management, whose responsibilities include computing resources, information systems, and unclassified computer security conducts these reviews on a 2-year cycle, whereas the Office of Computer Services and Telecommunications Management conducts telecommunications management reviews on a 3-year cycle. The operations offices, in turn, conduct similar reviews of the management and operating contractor sites under their cognizance. Field organizations and Departmental Elements not reporting through operations offices are generally reviewed on a 3-year cycle with selected sites on a shorter basis. The primary objectives of the review program are:

- o improve the process by which the Departmental Elements execute their ITR management responsibilities;
- o test the guidance and policy issued by Headquarters for quality and effectiveness;
- o provide feedback to Headquarters when new or better guidance is needed; and,
- o facilitate the transfer among Departmental Elements of innovative practices and techniques.

Based on the results of a management review, a formal report of findings and recommendations is prepared and sent to the organization reviewed. This organization then responds by describing specific actions which will be taken to correct any problem areas identified. These are in turn examined during the next review to ensure that all previously identified problems have been fully addressed.

The management review process is continually being refined and revised to reflect changes in technology, policy, and programmatic missions. In addition to the management review program, the management process utilizes other mechanisms for each area of information technology resources which are described below.

2.2.1 Information Systems

The Department has established policy, responsibilities, and authorities for the management of information system activities. Through the administration of this policy, Headquarter's organizations and field elements are held responsible for using effective life cycle methodologies and controls when developing, acquiring, enhancing, redesigning, and implementing software in support of their organization, The methodologies provide a structure similar to the one contained in the Federal Information Processing Standard Publications (FIPS PUBS) 38 and 64 where specific activities are performed and actual deliverables are produced. The deliverables are in the form of documents which serve as a vehicle for communication throughout system's life cycle. The number and complexity of these documents vary according to the size and critically of the project. The documents generally produced include a problem/requirement definition paper, a project work and cost plan, a system development request, a preliminary study, feasibility study, an analysis of benefits and costs, a functional requirements and data requirements document, a set of system/subsystem specifications, user's manuals, an operations manual, and a program/software maintenance manual. With the production of these documents, written communication is established among the original requestor of the software, the actual software users, and the maintainers of the software.

As stated earlier, the Office of ADP Management conducts biennial management reviews of the Departmental ADP activities. During these reviews, the IS portion is directed at ensuring compliance with Departmental-established policy, responsibilities, and authorities governing the use of effective life cycle methodologies in the management of information system activities. These reviews provide findings and recommendations which are provided to the reviewed organizations management and to senior Departmental management.

Department procedures require, that at the problem/requirements definition stage in the life cycle, that the Office of ADP Management receive notification for a planned IS development. This document is prepared and submitted by the user organization. This notification is used to inform all potentially interested parties within the Department of the start a development activity and to update the Departmentwide IS inventory data base. In addition, should this IS impact most organizations within the Department, conceptual approval to proceed with development must be obtained from the Director of Administration.

Software maintenance and development are controlled as a by-product of conducting the Department's annual information technology resources long-range planning process. Each year, all DOE elements and contractors are called upon to identify their plans for new information systems or major enhancements to existing IS. This information is used to update the Departmental inventory of information system software. The inventory is used to notify Departmental elements of those IS which will impact their organizations, reduce duplicative and/or overlapping systems, and also, to influence organizations to buy software or reuse existing software from other sources thereby reducing IS development and overall maintenance costs.

DOE procedures specify that all operational IS should be reviewed by user organizations at least once every three years, unless such systems have been designated for review by an external organization. The purpose of these reviews is to determine the extent to which the IS continues to meet intended objectives, to assure that appropriate security controls are in place, and to assess the efficiency and cost-effectiveness of the IS. The Office of ADP Management is responsible for reviewing Departmental major IS. These reviews are conducted triennially and a report of findings and recommendations to correct deficiencies is prepared and fowarded to the user organization and DOE management personnel.

An integral part of the overall IS planning and management process is the updating of the Departmental inventory of information system software. The System Review Inventory System (SRIS) contains basic descriptive information on DOE IS and their enhancements which are operational, under development, planned, or undergoing redesign. The SRIS, which is operated by the Office of ADP Management, was created to provide information needed by the Department to properly monitor and manage its IS activities.

2.2.2 Computing Resources

Long-range planning of computing resources is supportive of the budget formulation process by ensuring that the ADP budgeting information is tied to the program and mission requirements of the Department. Identification of the computing requirements in the plan's out-years helps to improve the budgetary process by providing descriptions of the requirements from the time when the needs are first identified to the time when, all other alternatives having been considered, the acquisition of ADP equipment becomes part of the budget year submission. This process better ensures that each item will have been fully justified and reviewed within the overall computing resource allocation priorities of the Department. As a result, funding for computing support is contained within each program's budget. In the budget formulation process relating to computing resources, special attention is given to major items of ADP equipment acquisitions. A major item of ADP equipment is defined, for budgetary purposes, as an ADP equipment component or group of components having a total estimated purchase equivalent cost of $1 million or more, regardless of the actual method of acquisition. All planned acquisitions of major items of ADP equipment supported by the Department are identified and justified in the Departmental budget submitted to both OMB and Congress. In addition, several crosscut exhibits related to computing resource acquisitions and overall ADP costs are prepared from data contained in the site long-range plans and submitted to OMB.

The acquisition process is managed by the Department through the review and approval of implementation plans and clearance documents. Following approval of the DOE budget by Congress, procedures require that an implementation plan be prepared by the site that plans to acquire the ADP equipment. The implementation plan provides for a reconfirmation of the computing requirement by the cognizant program office based upon latest programmatic information. The implementation plan includes a summary of all major factors affecting the proposed acquisition and identification of the important milestones involved. Preparation and review of implementation plans also help to ensure that an appropriate level of competition exists; that specifications for meeting the requirement have been clearly stated; that the selection criteria are clear and fair; that adequate facilities, trained personnel, etc., will be in place when the equipment is installed; and that computer performance evaluations have been conducted, where appropriate, and that the results are documented along with the validation of requirements and an analysis of alternatives. Approval authority for implementation plans for the acquisition of ADP equipment costing less than a major item of ADP equipment is normally delegated to the operations offices. Major items of ADP equipment are normally approved by Headquarters, unless such authority has been specifically delegated to the operations office.

The acquisition itself is conducted by the site and includes solicitation of proposals, receipt of vendor responses, evaluation of those responses, selection of the winning proposal based on solicitation criteria, and selection of the method of acquisition (purchase, lease, etc.). Certain acquisitions are selected for more extensive and detailed review by the operations office or Headquarters and require the approval of a clearance document prior to contract award.

2.2.3 Telecommunications

The Department continues to pursue a course of action to take advantage of increased competition in the marketplace and technological advances, both locally and through nationwide policy initiatives. The ultimate goal is to improve services while concurrently reducing costs.

Within DOE, responsibilities for telecommunications management have been assigned to the Office of Computer Services and Telecommunications Management at Headquarters. These responsibilities include integration of Departmental activities within the national telecommunications framework, provision of centralized guidance for common-user national and regional DOE networks, telecommunications policy direction, oversight management, cost containment, and interoperability and compatibility assurance within DOE and the larger framework of national objectives.

DOE Order 5300.1B, Telecommunications, outlines policies and directions regarding requirements identification, design, engineering, planning and acquisition of telecommunications systems and services. It is supplemented by procedural guides and manuals that specifically address carrying out the directive.

Directives and guides are complemented by a continuing dialogue between Headquarters and field staffs to provide managers and telecommunications personnel with information regarding the changing technology, regulations management, and economic aspects of the telecommunications world. A new information vehicle was issued by Headquarters in September 1989: teletalk. This publication will be used to track major regulatory events and provide a forum for the exchange of ideas and information that is vital to successful telecommunications management. The articles contained will present timely, informative articles that hopefully will provoke thought, stimulate dialogue, encourage creativity, and promote exchange of ideas among the DOE teams responsible for telecommunications. Additionally, seminars, conferences, and working groups are held to provide a cross-section of Government and private industry outlooks on the nature and evolution of telecommunications.

Telecommunications management policy is predicated on the concept that field locations are in the best position to determine and manage their local telecommunications needs. However, this policy of local determination should not be construed as a statement of total field autonomy, as we must all adhere to national rules, regulations, public laws, Departmental budget constraints, and initiatives. Within these common constraints, the Headquarters policy is to provide the field sites with telecommunications guidance and mediation support to ensure the application of available, proven technology in cost-effective ways to satisfy valid requirements.

This policy of decentralization best suits the diverse missions, programs, and locations comprising DOE, and enables Headquarters to function as the single point-of-contact on matters involving Departmental telecommunications. This concept of decentralization can be further delineated by describing responsibilities for the planning process and procurement of goods and services necessary to satisfy telecommunications requirements. Individual sites within DOE are responsible for determining local telecommunications requirements and for producing a plan to satisfy those needs. Local telecommunications are defined as equipment and services assembled in a manner that satisfies local requirements and provides for interconnection to other sites and locations comprising DOE and to the outside world.

DOE policy advocates that, where feasible, local telecommunications services be provided through a single vendor contract at each location and obtained through a competitive bidding process. Procurement responsibility associated with obtaining and maintaining a local telecommunications configuration resides with local managers. This policy raises the question of operational and technical compatibility of each individual site and its ability to freely interconnect to other locations and common-user networks. Headquarters addresses this issue by providing strategic direction to local planning and procurement and ensures compliance with that direction. Headquarters also provides technical and operational guidelines that specify the terms and conditions of interconnection to national and regional common-user networks to facilitate uniformity.

Planning for requirements between sites or among DOE-wide locations requires a different approach and is heavily influenced by the type of mission and programs in place at each site. It is also influenced by common telecommunications requirements, such as providing security and adhering to directives governing intercity acquisition. The scope of this process exceeds requirements for local site planning and is best performed by a centralized body which gathers local intercity requirements, combines them with common telecommunications needs, produces a common-user solution, procures the required system or services, and provides operational management. Throughout the process, Headquarters has the responsibility of providing direction to ensure a fully compatible and interconnectable system of communication; however, responsibility for developing, procuring, implementing, and operating the system is delegated to an appropriate field site. An example of this is the Western Area T-1 Network (also known as INTRANET), which is a major part of DOENTS. While network activities are coordinated with Headquarters, INTRANET is managed and operated by the Albuquerque Operations Office.

From a broader perspective, the DOE must conform to various national directives, regulations, and public laws governing the procurement, deployment, and management of telecommunications resources. Headquarters serves as the single telecommunications point-of-contact for General Services Administration, Federal Communications Commission, National Telecommunications Information Administration, National Communications System, Office of Management and Budget, Department of Defense, National Security Agency, and the Institute for Computer Science and Technology. Headquarters also has Departmental oversight responsibilities for telecommunications management to ensure DOE compliance with regulations and public law and to carry out the Governmentwide directives of other agencies. It follows that the concept of decentralization must be implemented within the broader framework which establishes the limits within which Headquarters and the field locations may decide upon a decentralization procedure.

2.2.4 Unclassified Computer Security Program

DOE represents one of the largest, most diverse, and highly decentralized computer environments in the Federal Government. These conditions could normally be expected to add to the complexity and length of time necessary to implement an effective unclassified computer security (UCS) program. However, the Department is widely recognized as having one of the most advanced and successful UCS programs in the Federal sector. The success of the Departmental UCS program is attributed to a fundamental policy statement, an appropriate organizational structure, and an effective compliance review process.

Due to rapid advances in computer and telecommunications technology, OMB issued Circular A-130 entitled "Management of Federal Information Resources" on December 12, 1985. Appendix III to Circular A-130 specifically addresses UCS requirements. The Department analyzed the requirements of the new Circular and revised Departmental policy to reflect additional OMB concerns. The basic computer security management principles established in the original Departmental policy issued in 1979 were retained. However, additional emphasis was placed on: integrating UCS requirements into the system planning and development phases; assigning information systems, data owner, and end-user responsibilities; establishing significant incident reporting procedures; and requiring the conduct of continuous computer security awareness and training. These new policy enhancements also met the requirements of the Computer Security Act of 1987.

Departmental policy requires that a Computer Protection Plan (CPP) be formulated and maintained at each site. The CPP must be kept current and should include elements that are relative to the specific computer environment(s) of the site. Appropriate approving and reviewing authorities are to judge the comprehensiveness and effectiveness of the UCS program at a particular site. In cases where multiple computer installations, computer systems, or program-area applications exist at a site, multiple plans may be formulated and maintained. The policy of the Department will continue to rely on Computer Protection Plans as the cornerstone to a sound UCS program.

UCS is managed as an integral part of the Departmental information resource management function in the Office of ADP Management. Headquarters issues general policy and guidelines and assures compliance at the operations office level by conducting periodic on-site management reviews, as previously discussed, to assess the sustained effectiveness of their management oversight of the UCS programs established by sites under their cognizance. The Director of ADP Management also serves as a Departmental point of contact on the UCS program and coordinates the review and dissemination of significant UCS information.

Findings and recommendations resulting from the management reviews have helped the Department improve the UCS program by identifying good management techniques and by identifying areas in the program which need additional guidance. Through these ADP management reviews, the field elements are also made aware of new requirements, which will be emphasized in future review activities, and what procedures and guidance the Department will be providing to assist in complying with new requirements.

On at least a 3-year cycle, the operations offices conduct compliance and management assistance reviews at sites under their cognizance. As part of their program, the Office of ADP Management at DOE Headquarters conducts similar compliance reviews at sites not reporting through an operations office. These reviews, which are more detailed and comprehensive in nature than general management reviews conducted at the operations offices, assess the degree to which each sight has continued to comply with Departmental unclassified computer security policy.

SECTION 3: INFORMATION TECHNOLOGY RESOURCES COSTS

This section of the ITR Long-Range Plan describes the current and projected ITR costs for the Department.

3.1 DEPARTMENTAL INFORMATION TECHNOLOGY RESOURCES COSTS

Total ITR costs for the Department include purchase and lease of ADP and telecommunications equipment, personnel costs, commercial services costs, and other costs. The projected costs throughout this section for FY 1991 through FY 1995 are based on planning data and are subject to change during the budget process.

As shown in Figure 3.1-1, Departmental planned ITR costs are projected to grow from $1,229 million in FY 1989 to $1,465 million in FY 1995. The average annual increase during the period is 3.0 percent. From FY 1989 through FY 1991, Departmental ITR costs are projected to increase about 6.6 percent per year. Current plans call for the projected growth to slow to an average 1.2 percent annually between FY 1991 and FY 1995 as budget constraints continue being implemented and computing and telecommunications technology advances provide improved cost performance. ITR costs are projected to be approximately 9.3 percent of the Departmental FY 1990 budget request. The variations in the total ITR costs from FY 1992 through FY 1995 are a result of the timing of planned acquisitions of ITR.

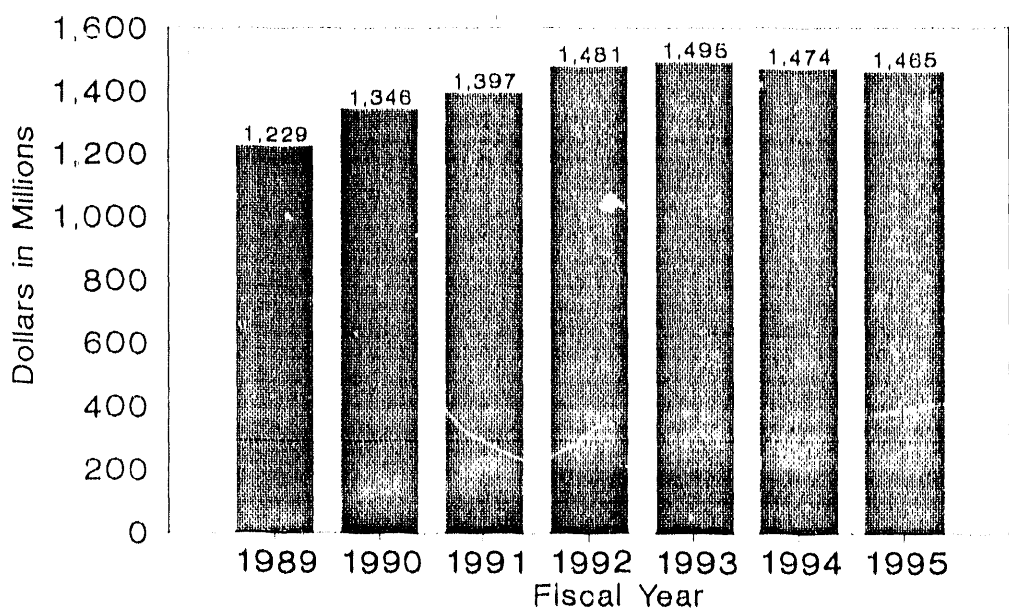


FIGURE 3.1-1 TOTAL DEPARTMENTAL ITR COSTS BY FISCAL YEAR

3.2 ITR COSTS BY CATEGORY

The ITR costs of the Department have been categorized into four major categories: equipment, personnel, commercial services, and other costs. Table 3.2-1 shows the costs for FY 1989 through FY 1991 broken down into these categories. The average annual growth rate during this period for these categories is as follows: personnel - 6.2 percent; equipment - 9.5 percent; commercial services - 7.1 percent; and other costs - negative 2.8 percent. The detailed items which comprise these four categories are described later in this subsection.

Category	FY 1989	FY 1990	FY 1991
Personnel	$459	$488	$518
Equipment	395	470	474
Commercial Services	250	267	287
Other Costs	125	121	118
TOTAL	$1,229	$1,346	$1,397

TABLE 3.2-1 ITR COSTS BY CATEGORY
(DOLLARS IN MILLIONS)

Figure 3.2-1 displays the percentage distribution of the projected FY 1991 ITR costs by category. Software costs are included within the personnel and commercial services categories and are addressed in subsections 3.2.2 and 3.2.3.

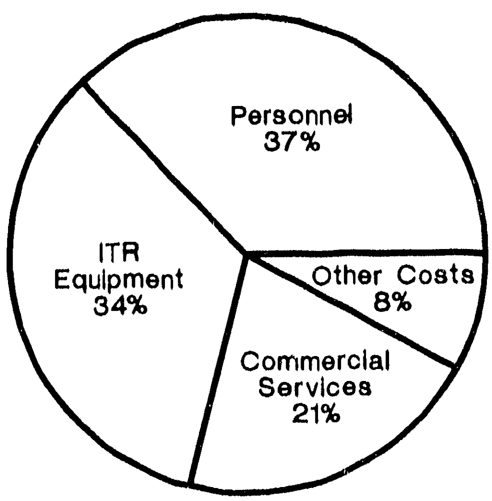


FIGURE 3.2-1 PERCENT OF FY 1991 TOTAL ITR COSTS BY CATEGORY

3.2.1 ITR Equipment Costs

As shown previously in Table 3.2-1, the Department projects to spend about $474 million for ITR equipment during FY 1991. This figure includes the amounts to purchase or lease both major and non-major items of ADP equipment and telecommunications equipment. A major item of ADP equipment refers to the acquisition of an ADPE component or group of ADPE components that have a purchase equivalent value of $1,000,000 or more irrespective of the method of acquisition.

Of the $474 million projected for FY 1991 ITR equipment costs, $174 million (37 percent) are estimated for major items of ADPE, $179 million (38 percent) for non-major items of ADPE, and $121 million (25 percent) for telecommunications equipment.

3.2.2 Personnel Costs

For purposes of this section, ITR personnel are defined as those personnel whose primary functions are directly related to ITR activities. This category also includes personnel in user organizations who are principally assigned to ITR support functions.

The Department projects to spend approximately $518 million in FY 1991 for ITR personnel. This amount can be subdivided into the following areas:

Personnel Subcategory	Amount	Percent
Software Development and Maintenance	$211	41%
Telecommunications	106	21%
Computer Operations	100	19%
In-house Computer Equipment Maintenance	23	4%
Other Areas	78	15%
TOTAL	$518	100%

TABLE 3.2-2 FY 1991 DISTRIBUTION OF PERSONNEL COSTS
(DOLLARS IN MILLIONS)

3.2.3 Commercial Services Costs

In FY 1991, the Department projects to spend $287 million for commercial services. These costs will be distributed as follows:

Commercial Services Subcategory	Amount	Percent
Software Acquisitions/Development	$113	39%
ITR Equipment Maintenance	108	38%
Operation of ITR Facilities	36	12%
Acquisition of Computer Time	5	2%
Other Commercial Services	25	6%
TOTAL	$287	100%

TABLE 3.2-3 FY 1991 DISTRIBUTION OF COMMERCIAL SERVICES COSTS
(DOLLARS IN MILLIONS)

3.2.4 Supplies, Other Operating Costs, and Space

The Department projects to spend approximately $118 million for supplies, other operating costs, and space during FY 1991. The costs will be distributed as follows:

Other Operating Cost Subcategory	Amount	Percent
Supplies and Other Operating Costs	$ 94	80%
Lease or Rental of Space for ITR Operations and Office Space	24	20%
	$118	100%

TABLE 3.2-4 FY 1991 DISTRIBUTION OF OTHER COSTS
(DOLLARS IN MILLIONS)

SECTION 4: STRATEGIES FOR THE EFFICIENT USE OF INFORMATION TECHNOLOGY RESOURCES

The Department of Energy strives to manage, implement, and protect its information technology resources in an efficient and effective manner. This section describes the strategies, and the initiatives to meet these strategies, which the Department has implemented to accomplish this goal and thereby contribute to the overall Departmental information technology resources management program.

4.1 REUSE OF EXISTING SOFTWARE

Objective

The Department wants to reuse as much already operational software as is feasible and cost effective. The reuse of such software not only increases personnel productivity by shortening the time required to implement new automated information systems, but it also improves their reliability and thereby reduces the time and cost of maintaining existing systems.

Current Situation

The Department of Energy, as is the case with most large organizations today, has experienced increasingly complex problems, such as insufficient definition of requirements and specifications for new systems and rapidly rising costs associated with the development and maintenance of its automated information systems. The primary methods being used in the industry today to bring some control to this situation have been the automation of as many parts of the process as cost effective and the bringing of as much discipline to the process as possible. These methods, however, require a long time period before they begin to show results. An approach which brings about a much more immediate payoff is the reuse of already operational software.

Strategic Initiatives

The Department has the following three specific strategic initiatives underway in order to successfully achieve this objective:

- o reusing of automated information systems which were originally developed for one component organization but were capable of satisfying the needs of other organizations within the Department.

- o circularizing to all Departmental components a listing of every Departmental automated information system which is under development or already operational. This allows a site to appropriately consider the alternative of reusing existing software rather than in-house automated information system development for new systems or enhancements to existing ones.

- collecting and exchanging evaluations and experiences concerning the capabilities of commercially available applications packages and automated information systems developed by DOE organizations.

4.2 SOFTWARE MANAGEMENT PROGRAM EXPANSION

Objective

The primary objective of the Software Management Program is to sensitize DOE and DOE contractor management to the importance of managing software as a valuable corporate resource and asset and to stimulate management into improving software management programs at their local sites.

Current Situation

DOE is like most other large and complex organizations today using information technology resources to carry out its vital daily operations. Software is becoming a major element of the overall information technology resources budget and is drawing more and more attention from central management and oversight agencies primarily because the costs of planning, developing, maintaining, and enhancing software have grown tremendously over the last several years. Additionally, there is no indication that this rate of growth will be slowing at any time. Given this situation, it is imperative that Departmental management has in place the appropriate management policies and procedures which will guide the use of software as a means to accomplishing important missions and responsibilities in the most efficient and effective manner possible.

Strategic Initiatives

The Departmental software management program strategies continue to change as the program itself matures. New policies are being developed and existing policies are being revised to address the management of all computer software maintained and operated by DOE organizations. The following strategic initiatives will be further developed and progress made on their implementation during the planning period addressed by this Long-Range Plan.

- Update software management program appraisal and management review functions to incorporate new software approaches when implemented.

- Require the use of software life cycle management methodologies throughout DOE and its associated contractor community, and develop a DOE standard for the content and coverage of system management methodologies.

- Explore alternative methods for improving quality control over software development, acquisition, implementation, and maintenance which would be effective in the DOE and DOE contractor environments.

- Encourage the use of automated software tools, engineering practices, and environments that have the potential for increasing software planning, development, acquisition, and/or maintenance productivity.

- Explore the possible implementation of selected national and international standards by DOE and its contractors which would facilitate information exchange among all sites.

4.3 MEETING FUTURE SUPERCOMPUTING NEEDS

Objective

The strategic objective of the Department of Energy for meeting future supercomputing needs is to ensure that state of the art computational techniques are developed and available to support programmatic missions in the most cost-effective and efficient manner.

Current Situation

The Department has long recognized the need to utilize the latest computational techniques available to perform many of its missions. Currently, the Defense and Energy Research Programs are the primary users of the latest computational hardware and software approaches. Often, progress and scientific breakthroughs in these programs has been, and is expected to continue to be, related to the availability of the latest state-of-the-art supercomputers and other computational approaches, which provide needed capacity and capabilities to researchers, scientists and engineers. Over the years, the Department has found the use of advanced computational techniques to be very cost effective. In many instances through computer simulation, the Department has saved many times a computer's cost by eliminating the number of very expensive prototype devices that need to be built, by reducing the number of tests or experiments that need to be run, etc. The Department expects its need to utilize the latest advanced computational techniques to continue and, in fact, due to the likelihood of tighter budgets, the need to maximize expenditures will increase the need for these items. The Department will continue, as it has in the past, to work in a cooperative manner with computer hardware and software vendors to obtain the latest needed technology to help assure the continuing accomplishment of its programmatic missions and goals.

There is general agreement that supercomputer speeds are nearing their fundamental physical limitations (the speed of light) and that the only way that substantial increases in computational speed and capability may be obtained is to exploit computational parallelism, where more than one processor is used at the same time to work on a single problem. The direction of supercomputer technology development beyond the currently available and announced machines is not clear.

Over the last several years, various vendors have developed new computational techniques using the latest technological developments in hardware and/or software. However, these advances are usually characterized as new leading edge technology, having little or no software, difficult to predict when they will be available from the vendors, and not always being able to fit into the normal Departmental annual budget process. The Department has become aware of a number of new computational techniques which warrant investigation and evaluation to determine their potential applicability to many of the computational operational requirements of its programs.

Strategic Initiatives

To attain the objective for providing for future supercomputing needs through the most cost-effective and efficient manner, the Department is conducting basic research in new computational techniques. To exploit the parallel capability that is emerging from U.S. supercomputer manufacturers, the Department is investigating methodologies such as restructuring compilers to allow accurate and immediate identification of sections in existing vector codes that are suitable for parallelism.

Longer-term research projects have been initiated to gain an understanding of how to effectively utilize systems with hundreds to thousands of parallel processors. Basic research into new software methodologies has been initiated which focuses on programming languages and environments, compiler techniques, algorithms, and operating systems. Such work is essential to obtain optimal performance when using these inherently more complex parallel systems.

To facilitate the acquisition of state of the art computers for computational research, the Department plans to evaluate and implement those budgetary procedures that will encourage Departmental sites to continue working with vendors to evaluate and/or develop new computational techniques. This will assist the cooperation between the Department and industry by allowing the timely testing and/or acquisition of new leading edge hardware and/or software in order to evaluate its potential applicability to support the advanced computational operational requirements of the Department. The Department needs to position itself to be able to react quickly to new technological breakthroughs and the opportunity to evaluate and potentially exploit these computational devices/techniques. An important aspect to being in a proactive posture in the 1990's is implementing changes to budgetary procedures, as necessary, to allow the timely availability of funding for the acquisition of bonafide computational research items or activities.

As necessary, budgeting procedures will be modified to place the Department in a position to be able to more quickly make funding available when computational technological breakthroughs take place. These budgeting changes will be coordinated among the cognizant Departmental elements and external oversight organizations, as appropriate, to assure that the revised procedures are consistent with good management practices and applicable regulations and laws.

4.4 CONDUCTING ANALYSES OF BENEFITS AND COSTS

Objective

The strategic objective of conducting analyses of benefits and costs (ABCs) is to provide managers and analysts with economic analyses of alternatives for acquiring or developing information technology resources and selecting the most cost-effective alternative which meets the missions and goals of the Department.

Current Situation

Early in FY 1987, DOE recognized the usefulness of analyzing benefits and costs as a management tool in making effective and informed ITR management decisions. Based upon a lack of effective guidance in this area, DOE undertook the development of guidelines for conducting these analyses. The guidelines were issued in two volumes during June 1988. The first volume is a manager's guide to ABCs, which explains how the structured ABC process can assist in making decisions regarding the expenditure of scarce resources for ITR acquisitions or development activities. Its principle purpose is to explain the usefulness of ABCs in making choices among competing ITR alternatives. The second volume is an analyst's handbook for conducting ABCs, which assists information technology personnel with little or no previous experience in ABCs to understand the essential concepts and procedures necessary to conduct an ABC. It also explains the use of ABCs to support decisions related to ITR acquisitions or development as well as suggested items to consider when conducting the ABC, including formats for displaying the results.

Strategic Initiatives

To meet its strategic objective, the Department is incorporating ABCs as a component of its ITR acquisitions and/or development activities. A draft policy Order has been reviewed and concurred in by the appropriate DOE organizations. When officially issued, the Order will fully implement ABC policy throughout the Department.

Once the Department has more experience in using the ABC guidelines and the ABC policy Order has been fully implemented, the Department plans to include ABCs in its ADP management and site review procedures to assess the effectiveness of the ABC guidelines in the ITR decision-making process. As experience is gained, the ABC guidelines and policy will be revised as appropriate to enhance their usefulness in conducting ABCs.

4.5 COMBATING COMPUTING RESOURCES OBSOLESCENCE

Objective

The strategic objective of the DOE initiative to combat obsolescence in the ADP equipment inventory is to assure that installed computing resources are performing the functions for which they were originally acquired in the most cost-effective and efficient manner to meet Departmental missions and goals.

Current Situation

Rapid technological development in the ADP industry is attributed as a major force in making ADP equipment obsolete. With continuing user requirements for better products, growing opportunities to develop systems due to advances in component technology, and increasing competition within the computer industry, vendors have accelerated the introduction of state of the art products. During the 1960's and early 1970's, many products were marketed for 6 to 10 years. In the late 1970's and early 1980's marketing time was cut to 3 to 5 years for many products, especially those in the plug-compatible field. As technological advances accelerate, life cycles most likely will continue to grow shorter. Figure 4.5-1 on the next page compares the average age by size of equipment for the DOE ADP inventory against the Federal Government average for FY 1989.

The major contributors to DOE's Very Large system obsolescence are the CDC 7600's, the IBM 3033's, and the Cray 1S'. These systems are scheduled for retirement by 1992. DOE's obsolete equipment in the Large systems is the Honeywell DPS 8/54 and the Unisys 1100/82. All of these systems are planned to be retired by 1993. The eldest Medium systems are the IBM 4341's and the Modular Computer System MODCOM IV. These systems account for over 89 percent of the obsolete Medium systems. Small systems remain an area of concern because they are over the obsolete threshold of 8 years and are the primary contributor to the Departmental overall average age of 10.6 years. When the equipment in this category ceases to fulfill programmatic missions in a cost effective manner, they will be replaced.

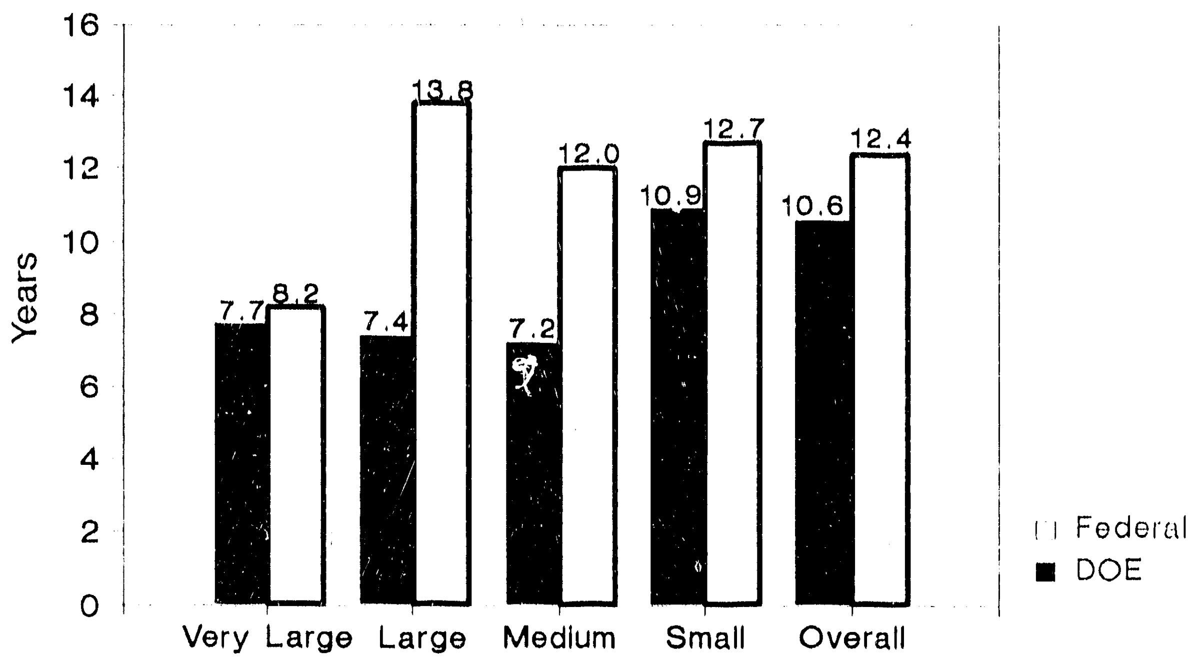


FIGURE 4.5-1 COMPARISON OF AVERAGE AGE BY SIZE IN DOE AND GOVERNMENTWIDE

Strategic Initiatives

To attain the DOE objective for combating obsolescence in the ADP equipment inventory, the following strategic initiatives have been established:

- continue to identify obsolete computing resources through the planning process and ADP management reviews to allow a systematic disciplined approach towards retirement and/or replacement of targeted obsolete systems;

- continue to coordinate programmatic needs requiring capability and capacity with state of the art computing technology; and

- continue to replace obsolete ADP equipment subject to availability of programmatic funding and appropriate oversight and management approvals.

4.6 COMPUTER SECURITY ASSURANCE REVIEW

Objective

The strategic objective of the Computer Security Assurance Review (CSAR) is to assure computer security effectiveness within the Department. The Department expects that this review will provide additional insight into the Unclassified Computer Security program at each site. As a direct result, the Department will be assured of an effective UCS program or will recommend corrective action for improving the protection of unclassified computer systems and the sensitive unclassified automated information processed on those systems.

Current Situation

Each operations office must insure that sites under their cognizance establish, implement, and sustain a computer protection program in accordance with the requirements of DOE policy. Currently, unclassified computer security compliance reviews are performed by the operations office having cognizant oversight authority of the site. Headquarters is responsible for assessing the sustained effectiveness of the program established and managed by the operations office. Although site compliance reviews provide a measure of fundamental conformity with DOE policy, **compliance** does not necessarily equate to computer security **effectiveness**.

Strategic Initiatives

This initiative will begin in FY 1990. The Department will develop a methodology and then test and evaluate this methodology at various sites. In the development of the CSAR program, the Department will identify the security areas to be evaluated and will describe the measures or tests to be performed to evaluate each of these security areas. The CSAR program will be developed with input provided by each operations office. Once the methodology and procedures are finalized, the Department plans to perform CSARs at DOE sites on a cyclical basis. CSAR will provide an in-depth UCS program effectiveness review of the implemented computer security measures at DOE sites. The results of the CSAR will assure the Department that computer security is functionally effective.

4.7 HANDLING OF COMPUTER SECURITY INCIDENTS

Objective

The Department of Energy needs to establish an advisory capability which can be called upon by all DOE and DOE contractor sites when they experience computer security-related incidents such as hacker attacks, viruses, worms, "Trojan horses," and time bombs. This advisory capability will provide assistance by analyzing incidents, coordinating technical solutions, providing necessary information to the DOE community, and training others to deal with incidents. Ultimately, the activities of this organization will result in further enhancement of computer security programs at all sites.

Current Situation

Until recently, most computer security-related incidents affecting Department of Energy computer systems could be described as either hacker incidents or incidents resulting from some kind of internal sabotage. However, in the past 2 years, there is evidence that hacker attacks are becoming more sophisticated and disruptive through perpetration of viruses, worms, "Trojan horses," and time bombs. The "Internet worm" of November 1988 received national attention and raised the awareness of computer security experts to the potential damage which could be caused by what was previously considered a non-traditional and unlikely form of attack. All computer systems, whether stand-alone or networked, are susceptible to subversion in one way or another. As the number and complexity of computer security-related incidents grows, DOE's need to respond quickly, efficiently, and effectively becomes greater.

DOE Headquarters Office of ADP Management (OADPM), responsible for policy and management oversight of the DOE Unclassified Computer Security Program, and the Office of Safeguards and Security, responsible for classified computer security policy and management oversight, jointly initiated an incident handling capability project in April 1989. Located at Lawrence Livermore National Laboratory, the project has been titled the Computer Incident Advisory Capability (CIAC).

During the first 6 months of operation, CIAC provided assistance to numerous DOE sites, made several training presentations, and established a 24-hour computer security incident handling capability. In addition, CIAC has been cooperating with, and in some cases providing guidance to, other organizations interested in establishing similar response capabilities.

Strategic Initiatives

Strategy for the CIAC project is twofold: (1) create a capability which can provide immediate technical advice and assistance to the DOE community when computer security-related incidents occur; (2) use the knowledge gained from these experiences to develop guidelines, software tools, and demonstrations to be used in workshops and other awareness sessions designed for improving management of the DOE computer security programs. Specific initiatives identified for this project are:

- provide 24-hour analysis and advisory capability;
- establish communication capabilities and procedures;

- develop cooperative procedures with other Federal agencies and vendors;
- develop computer security incident handling guidelines;
- develop and conduct training and awareness workshops; and
- develop software tools for incident handling.

4.8 USE OF RISK ASSESSMENTS

Objective

A key element in any computer security program is determining how to manage the risks associated with a particular computer installation. Risk assessments are important as the basis for making informed management decisions related to accepting identified risk exposures or implementing appropriate cost-effective protection measures to reduce them. When used appropriately, they can be a very effective management tool. When used inappropriately, risk assessments can be costly and ineffective for all involved.

Current Situation

Due to the lack of governmental guidance for appropriately conducting risk assessments for all types of computer installations, the Department prepared and issued the "DOE Risk Assessment Guideline" to all DOE sites in October of 1989. This guideline enables site-level organizations to continue to have the flexibility of selecting methodologies and implementing risk assessment programs that are most appropriate to their individual computer environment. This guideline includes an important final step in the risk assessment process, the development of an Executive Summary. The purpose of this last step is to obtain accountability for the decisions and choices made throughout the process, to provide a mechanism for briefing, reviewing, and discussing the risk assessment results with management, and to provide for sign-off and acceptance of the risk profile.

Strategic Initiative

After this guideline has been in place for several months, the Department, through its various review processes, will more closely examine the risk assessment methods used at the various sites to determine how effectively they are being used as management tools in the planning process.

4.9 MEETING CURRENT AND FUTURE TELECOMMUNICATIONS NEEDS

Objective

The current and long-range strategies for telecommunications within DOE follow:

- o Commitment to the national priorities that affect the telecommunications community through continued representation on national level committees, and by participation in the development of standards and policies, especially where energy-related issues and resources are concerned.

- o Provide end-to-end digital connectivity within and between DOE facilities to effectively support all existing and planned telecommunications requirements.

- o Contain the costs required to provide telecommunications. This will be effected through strategic planning, continuous evaluation of existing systems and services, and efficient management of resources.

- o Control telecommunications resources by owning, managing, operating, and maintaining telecommunications systems and services at the site level as well as nationwide.

Current Situation

The Department of Energy uses all forms of telecommunications equipment and media to distribute the vast amounts of information generated by people and computers. Integration of services and systems within the DOE community is, therefore, a major area of focus for the telecommunications managers. Communications networks that support DOE-wide requirements, as well as individual site requirements, are undergoing major changes in terms of architecture, equipment, and service offerings. The technology available is dynamic; however, it is not always compatible. Therefore, Headquarters and field telecommunications managers are working together to plan and implement efficient top-down strategies that will establish short-, mid-, and long-term goals for their communications support activities and initiatives. These strategies support DOE management goals as well as the specific goals of the facilities and assure:

- o mission requirements are met;

- o regulations, policies, and standards are followed;

- o available technology is efficiently used;

- o solutions are cost-effective;

- integrated systems are effectively managed;
- systems are compatible;
- systems and services are supportable; and
- flexibility is provided to allow enhancement with future technologies.

A smooth and steady transition to integrated systems is occurring. In most cases, incremental approaches are being used to effect manageable system integration. This incremental approach reduces costs and allows flexibility to meet changing mission requirements and budgets.

Telecommunications resources currently account for approximately 25 percent of the estimated ITR budget. Although more sophisticated telecommunications capability will be required to support higher level computer processing and the extensive information systems being developed, strategic planning and procurement approaches on the part of the telecommunications managers will contain costs. Based on estimates received in the site plans, the telecommunications costs will drop to approximately 20 percent of the total ITR estimate by FY 1995.

The advent of deregulation and competition within the telecommunications industry has increasingly complicated the task of planning and managing effective telecommunications systems. The complex and diverse programs of the Department require that the telecommunications manager be flexible and highly responsive. The manager must also conform to various national directives, regulations, and public laws governing the procurement, deployment, and management of telecommunications resources. DOE's capability to manage its resources depends upon the capabilities of these managers at all levels. This is particularly important in view of the DOE strategy to achieve some measure of self-sufficiency and control at each site. Equally important is avoiding the risks of incompatibility, inefficiency, and technological isolation.

Headquarters provides strategic direction, leadership, guidance, and oversight to ensure compliance with regulations, directives, and national initiatives. It is also responsible for ensuring technological compatibility and interoperability for all locations comprising DOE. Generally, field offices are responsible for the planning, acquisition, and operation of local telecommunications resources required to support the missions of their sites. Responsibility for regional and national networks may vary according to type of network, mission being supported, and locations interconnected. Headquarters may choose to delegate responsibility for certain network configurations to a field location or assume planning, acquisition, and operational duties for others.

Strategic Initiatives

The Department has the following four strategic initiatives.

- Commitment to National Priorities - Strategic direction must be tempered with national priorities, such as security policies, standards policies such as GOSIP, national security emergency preparedness (NSEP), radio frequency spectrum conservation, use of Governmentwide common-user services, and public safety. DOE constantly examines all national policies and, when necessary, makes appropriate adjustments to its telecommunications policies and direction. Through continued representation on national level committees and participation in the development of standards and policies, the Department will continue to influence national direction, especially where energy-related issues and resources are concerned.

- End-To-End Digital Connectivity - In order to achieve end-to-end digital connectivity, the development and implementation of national and international standards must be closely monitored. Adherence to these standards will preclude DOE isolation from commercially available services upon which continuing, reliable telecommunications are dependent. Configuring existing systems to meet new standards through the use of interface devices, while carefully considering all new system procurements in this light, is required and must be applied to the three major components of a telecommunications system: the local distribution system at each DOE location, the switching device serving local and network connection functions, and the network of facilities interconnecting discrete DOE locations. This natural partitioning permits phased improvements of digital capability in each component and presents a maximum of opportunities and alternatives for achieving end-to-end digital connectivity while avoiding proprietary systems.

  The Department has taken the initial steps to provide high-speed digital pipelines that are accessible to nearly every DOE facility. An important element of these pipelines is the Department of Energy Nationwide Telecommunications Service (DOENTS). DOENTS provides up to 60 Mpbs satellite and terrestrial service and has been configured in such a way as to allow further expansion and connectivity if requirements justify those actions. Most major sites have furthered the end-to-end digital connectivity concept by implementing modern digital switching systems to support their local activities and provide access to worldwide information sources and transport media. The remaining step in this process is the implementation of the extensive DOE corporate and shared systems in an efficient, reliable, and cost-effective manner using structured and proven methodologies rather than reactive, system-by-system solutions.

To accomplish this final step, DOE will need to change the way data communications are currently implemented and managed. More upfront funding will be required to have hardware, software, and personnel resources in place and ready to respond to user requirements. In the data communications area, more than others, top-down strategies are imperative if the data communications managers are expected to quickly respond to requirements to implement, test, operate, and maintain the diverse IS currently under development. More interaction between data communications and IS personnel during the system development process will also be required to ensure network access, availability, and compatibility.

o Containment of Costs - As in all other components of ITR, cost containment is a major objective of the telecommunications resource management strategy. It takes many forms, depending on the type of activity and timing within the life cycle of resources. In this area as well, top-down strategies are necessary if the Department is to accomplish this goal. Constant evaluation of existing circuitry and service arrangements produces numerous opportunities to contain costs and improve operational efficiency. This includes common use of the satellite backbone transmission system, shared-use T-1 collector facilities to eliminate the proliferation of multi-DOE communications links between similar locations, conversion to least-cost service offerings, and competitive circuit acquisition. Telecommunications planning requires that complex econometric techniques be used in developing alternatives, determining comparative cost/benefit ratios, and analyzing cash flow.

  Cost containment is also being achieved through the competitive procurement process which is mandated for most resource acquisitions. This is the most effective means of procurement as it keeps down the cost of services while stimulating the development of newer and better technologies. However, if the procurement process is driven only by specific existing needs rather than rationally anticipated future requirements, the results may not be as cost-effective as first perceived. Therefore, strategically planned systems and resources must be in place that are ready to address the needs of the diverse DOE user community and their associated computing resources as they occur. This will allow efficient system implementation and integration in the most cost-effective manner. It will also eliminate the occurrence of crisis situations that often develop when the telecommunications manager is called on to meet an urgent program requirement without adequate resources.

- Control of Telecommunications Resources - With the advent of deregulation, DOE facilities are in a much better position to control and effectively manage their telecommunications activities. The Department is actively advocating a level of self-sufficiency and control at individual locations for provision of local services. The impetus for this goal and its accompanying strategy is provided, in part, by public law governing procurement competition and the continuing necessity to effectively manage such resources. Serving the letter of the law while maintaining a common interface with the local and/or interexchange carriers is a complex task for DOE as it regains control of plant and facilities installed on DOE property. However, DOE is moving to eliminate obstacles by providing expert resources to assist DOE field locations in finding solutions.

  Sites are currently avoiding contracts for installing, operating, and maintaining their on-site switching equipment. This action provides the telecommunications manager with current and detailed information on system usage and allows better planning of available resources to meet future needs. Management of the resources also prevents abuse or misuse of the telecommunications facilities as well as inefficient operation.

SECTION 5: INFORMATION TECHNOLOGY RESOURCES, REQUIREMENTS, AND PLANS

This section of the ITR Long-Range Plan presents a brief description of all of the ITR being operated by the Department and highlights the requirements and planned activities which will affect one or more of the components. The Departmental operational automated information systems (IS) are described, along with plans for new IS and enhancements to already operational systems. This section also describes the computing resources within the Department, the estimated future computing requirements of the programs, and the plans to satisfy the computing needs. Subsection 5.3, Telecommunications, has been developed using input received from the reporting sites described in Appendix A with attention focused on both technological and management issues. Existing telecommunications resources, estimated future requirements in each of the functional areas, and the plans to satisfy the telecommunications needs of the Department are described in this section.

5.1 INFORMATION SYSTEMS

This subsection presents the results of the most recent information system planning cycle. It describes the current information systems environment, including major Departmental systems, and the plans for information system development activities described by the various Headquarters and field organizations. This information was derived from the materials submitted in response to the annual DOE information technology resources planning process.

5.1.1 Current Information System Environment

The use of automated IS within DOE has become extensive, with every DOE component and organization using them in some way. Automated IS are used to support the many diverse missions of the various DOE organizations at Headquarters and in the many field locations. As of the end of FY 1989, DOE had an inventory of 503 operational automated IS. The total costs for operating and maintaining those IS were nearly $43 million, and average annual operating and maintenance costs were about $102,000. This average was derived by excluding 84 microcomputer-based IS whose costs over the last year were negligible.

While the uses of automated IS within DOE are diverse and varied, there are certain characteristics which are common among groups of systems. By observing these common traits, it is easier to examine and understand the purposes served by automated IS within the Department. The observations which follow are based on an analysis of these groupings and the trends which have been identified.

5.1.1.1 Information Systems by Primary Functions Performed

As a means of categorizing IS within the Department, each is categorized using 11 primary functions. In certain instances, IS have been categorized as having multiple primary functions. IS with multiple primary functions are usually those IS which are integrated, allowing for the sharing of common information. Table 5.1-1 summarizes the IS population relative to the primary functions performed.

Over the last 3 years, there has been significant increases with primary functions related to operations and program management. Other primary functions have remained relatively stable over these years.

	PRIMARY FUNCTION	NO. OF IS WITH THIS PRIMARY FUNCTION FY 1987	FY 1988	FY 1989
1.	Administration	186	198	198
2.	Budgeting	40	41	35
3.	Executive	3	1	2
4.	Finance and Accounting	61	60	57
5.	Operations	18	24	27
6.	Planning	24	25	26
7.	Procurement	42	42	46
8.	Program Management	25	40	41
9.	Project Management	26	25	26
10.	Safeguards and Security	32	30	28
11.	Special Purpose	29	31	28

TABLE 5.1-1 INFORMATION SYSTEMS BY FUNCTION SUPPORTED

5.1.1.2 Information Systems by Organizational Impact

Information systems are also classified according to the type of impact they have on organizations other than their sponsors, as shown in Table 5.1.2 below. Three classifications are used to describe this impact. These categories are:

- DOE-Wide Impact - Any IS which provides output to most DOE organizations or which requires input from most DOE organizations is classified as a DOE-wide IS.

- External impact - Any IS which requires input from one or more DOE or DOE contractor organizations external to the users' organization but not extensive enough to be DOE-wide. User organization is defined to include any DOE Headquarters secretariat level organization or any DOE field organization.

- No Impact - Any IS which is not DOE-wide and which has no external impact.

	FY 1987		FY 1988		FY 1989	
	No. of IS	Percent of Total	No. of IS	Percent of Total	No. of IS	Percent of Total
DOE-wide	40	8	59	12	63	12
External	91	19	99	19	82	16
None	351	73	351	69	358	72
Total IS	482	100	509	100	503	100

TABLE 5.1-2 INFORMATION SYSTEMS BY IMPACT

Observations relating to the total IS universe indicate that the percentage of IS have remained relatively constant.

5.1.1.3 Information Systems by Interface Type

Another classification method used to analyze the automated information system inventory indicates the kind of interface, if any, an IS has with other information systems. IS are differentiated by whether they provide data to other IS, receive data from other IS, neither, both, or where the respective sponsoring organization of the specific IS are within the Department. The distribution of operational IS by type of interface are listed in Table 5.1-3 on the next page.

Description of Interface	FY 1987	FY 1988	FY 1989
Does not receive or provide data to another IS	319	322	308
Provides data to another IS			
In user organization	22	33	32
External to user organization	17	17	19
Receives data from another IS			
In user organization	40	44	37
External to user organization	17	17	15
Both provides data and receives data from another IS			
In user organization	40	30	42
External to user organization	6	7	9
Provides and/or receives data from another IS in the user organization as well as another IS external to user organization	36	39	41
Total Information Systems	482	509	503

TABLE 5.1-3 INFORMATION SYSTEMS BY TYPE OF INTERFACE

The above table provides a summary of the number of operational IS in each interface classification for each DOE organization for FY 1987 through FY 1989. An analysis of the inventory suggests that there has not been a significant deviation in the number of IS characterized by interface type for this time period.

5.1.1.4 Information Systems by Criticality and Complexity

Another classification method used by DOE to allow observations of the IS inventory is to classify the systems as being either key DOE IS, supporting IS, or stand-alone IS. Definitions of these classifications are provided below.

- o Key DOE IS - Any DOE automated IS which requires input from two or more other DOE or DOE contractor organizations and meets at least one of the following criteria:
  - System is critical to the accomplishment of a major segment of the overall DOE mission.

- System captures and provides information essential to DOE top management including the Secretariat level of DOE.

- System costs of $250,000 per year to operate.

- System is critical to the successful operation and mission accomplishment of one of the major DOE operating programs, i.e., Conservation and Renewable Energy; Defense Programs; Energy Research; Fossil Energy; Nuclear Energy; Power Marketing; General Administration; Civilian Radioactive Waste; or Environment, Safety, and Health.

o Supporting IS - Any IS operated by a DOE organization which provides input to and/or receives output from a key DOE IS. The providing of input to or receiving of output from a key DOE IS need not be the main reason that the IS is in use. If providing input or receiving output is part of the function performed by the IS, the IS is categorized as a supporting IS.

o Stand-alone IS - Any IS operated by a DOE organization which is not characterized as a key DOE IS or supporting IS.

	FY 1987		FY 1988		FY 1989	
	No. of IS	%	No. of IS	%	No. of IS	%
Key DOE IS	40	8	44	9	44	9
Support IS	54	11	53	10	62	12
Stand-alone IS	388	81	412	81	397	79
Total IS	482	100	509	100	503	100

TABLE 5.1-4 INFORMATION SYSTEMS BY CRITICALITY AND COMPLEXITY

Table 5.1-4 summarizes the IS population relative to complexity and criticality. It is of particular interest to note that the percentages for each category have remained relatively stable regardless of the change in the number of IS for each category.

5.1.1.5 Major DOE Information Systems

The final category into which an IS may be classified indicates whether or not the information system is considered to be a major IS. A major DOE IS is any system which has been classified as both a DOE-wide IS and a key DOE IS and has annual operating costs of over $250,000. DOE has 13 IS that fulfill all of the criteria of being major DOE IS. These systems are listed and described below.

Approved Funding Program System (AFPS)

AFPS provides the means for the distribution of all obligational authority made available to DOE for the fiscal year. This system transmits the funding authority levels of DOE programs for all Departmental Elements, both in the field and at Headquarters. AFPS is used to establish and maintain controls at the Departmental level to insure that legal, Congressional, OMB, and internal ceilings and limitations are not exceeded. The system restricts obligations and expenditures in each appropriation to the amount apportioned by OMB. It is the means by which the Department assigns responsibility under the administrative control of funds provision of Section 3679 of the Revised Statutes, enabling the Secretary to fix responsibility for creation of any obligation or making of any expenditure in excess of an apportionment. The system provides the basis for the annual execution of programs as approved by Congress, for the programmatic detail of allotted funds and cost ceilings to the organizations that have administrative or technical responsibility for the execution of a program and for a control to insure that funds are not distributed in excess of stated limitations.

The DOE AFPS is a time-tested, responsive, and flexible method for the nationwide distribution of funds for a broad range of programs conducted through a large number of field offices and industrial contractors. This process has been in place for a number of years and meets reporting requirements of Congress, OMB, and the Department. Additionally, this system has adapted readily to large-scale changes in program size and organizational structure while maintaining control of the distribution of funds.

The AFPS is installed on a Data General C-330 which is located in the Budget Execution Branch area at Germantown. Both the system and the hardware are operated by members of this branch for all users in the Department. Numerous reports are produced summarizing approved funding program data at different levels for use by DOE management and AFPS recipients.

Budget Table System (BTS)

The Department's Budget Table System (BTS) provides an automated capability to assist in the formulation of the DOE budget. The BTS is comprised of a proprietary software package called All Purpose Table (APT) which is provided through a time-sharing license agreement with Business Information Services, a subsidiary of Control Data Corporation. The software resides on IBM 3033, 3082, and 3081 hardware owned by Business Information Systems, Inc., and located in Cleveland, Ohio.

The BTS has the following features:

- Spreadsheet format made up of approximately 5,000 rows and 200 columns.

- Direct access data base.

- Self-contained data base maintenance and reporting system.

- Flexibility to allow specially designed budget tables and reports including the ability to reformat the data base from an appropriation structure to organizational structure without rekeying data.

- Accommodates "what if" analyses.

The system is designed to provide a quick response to management throughout the budget process through the use of summary, decision-unit reports, and provides detailed reports at the sub-activity level at critical points in the annual process. The system provides budgetary controls at all phases of budget formulation and tracks funding decisions throughout the process including Congressional action.

Departmental Integrated Security System (DISS)

The Office of Safeguards and Security uses DISS to process and track security clearance investigations from the initial request through disposition as well as the clearance status of individuals for up to 10 years after employment by DOE or DOE contractors. Records that have remained inactive for a period of 10 years are then removed from the system and stored on microfiche. Once the clearance has been obtained, the system stores the data on a data base that is used by DOE Headquarters (both Germantown, MD, and Washington, DC, offices) and field offices to check the clearance status of any individual. This central depository of information holds clearance data on approximately 1,285,000 active and inactive DOE and support contractor employees. The DISS data base contains unclassified information, but data is sensitive and subject to the Privacy Act of 1974.

DOE initiates approximately 30,000 full field investigations and 18,000 National agency checks per year. An applicant applying for a security clearance or reinvestigation has to complete a Personal Security Questionnaire unless the person is a member of the U.S. Congress. Once the questionnaire is completed, it is forwarded to the cognizant Office of Safeguards and Security, either at one of the DOE field locations or Headquarters. The Secured Access Communications Network (SACNET) is used to transmit batch input to DISS. This feature can be used by field offices supporting their own automated systems capable of producing transactions in the formats required for entry into DISS.

The primary objective of DISS is to provide a responsive, processing support tool. The on-line system provides fast access to accurate data for all users.

DISS output consists of responses to on-line inquiries, preformatted reports, and ad hoc reports. Users are able to interactively query the data base for specific data needed. Query information displayed on the CRT screen is also produced on hard copy terminals located in each office. A series of daily, weekly, monthly, and annual reports are provided to support activity as well as the tracking of security clearance processing. DISS has been interfaced but not integrated with the Security Badge Control System (SBCS) and the Central Personnel Clearance Index (CPCI) at Headquarters. Interfacing DISS with independent field office automated systems is also being explored.

DOE Integrated Payroll/Personnel System (PAY/PERS)

PAY/PERS provides full automated data processing and management information support for both personnel and payroll functions throughout DOE in compliance with appropriate laws and regulations issued by OPM, OMB, GAO, Treasury, and the Federal Retirement Thrift Investment Board. This includes data entry and editing, file maintenance, query, report generation, generation of check tapes (for payroll), and generation of Federally-required reports to the regulating agencies. The system was developed at the U.S. Department of the Interior, then tailored and enhanced to meet DOE requirements.

Since PAY/PERS is an integrated system, both payroll and personnel offices utilize the same master file and the same data base edit/update mechanism. The advantages of an integrated system are realized in eliminating data redundancy, ensuring consistency between data used in payroll and personnel reporting and processing, and highlighting the interdependence of those functions. All required payroll and personnel reports are available from PAY/PERS; labor cost and other interfaces also provide input for accounting and other systems for each user. Updating the master file requires the assignment of responsibility for updating data elements on the employee master record to either payroll or personnel based on functional responsibility within the organization and/or accessibility to information required to update the data base. Personnel offices have been assigned the responsibility for all Standard Form (SF) 50 data, position data, and establishing and inactivating master records. The payroll offices are responsible for other earnings, tax information, deductions, bonds, allotments, check mailing, adjustments for pay, leave and allowances, processing time and attendance reports, and certification of the payment of biweekly payroll. Regardless of the assignment of update responsibility, the information stored in the PAY/PERS data base is available for use by authorized payroll and personnel users through standard and ad hoc reports and query.

The PAY/PERS Management Group (PPMG) directs all operations, maintenance, enhancement, and development activities associated with PAY/PERS with its own resources or resources provided by appropriate support staffs. The group also provides support to system users, as well as local and Departmental management, and responds directly to user-identified requirements. PPMG receives day-to-day payroll and personnel policy direction from the Deputy Assistant Secretary for Financial Management and Controller and the Deputy Assistant Secretary for Procurement and Human Resource Management, respectively. Payroll, personnel, and timekeeper user manuals are centrally maintained together with full system documentation.

Energy Manpower Personnel Resource Information System (EMPRIS)

EMPRIS is an information system supporting DOE human resource management and manpower resource planning, budgeting, accounting, and productivity management. EMPRIS provides user-friendly access to human resources-related management information via menu selection of a number of preformatted reports. The system provides a powerful and responsive query and report writer capability for requirements not satisfied by menu reports.

EMPRIS is designed to provide management information support to organizational management and supervisors and Departmental and organizational administrative staff who are not directly involved in personnel, payroll, and related operational activities, but still have a valid need for access to accurate and timely human resources information.

The system is extensively interfaced with other systems in order to obtain essential data and eliminate duplicative data entry. User data entry to EMPRIS is required when the necessary data does not exist in other Departmental systems. This condition is generally limited to manpower resource planning and budgeting functions.

EMPRIS supports a wide range of administrative functions which are completely or partially dependent on human resource management data, both at the organizational and Departmental levels. These functions include:

- Manpower resources planning and budgeting;
- Manpower resource allocation, ceiling control, and full-time equivalency accounting;
- Productivity measurement;
- Nuclear Waste Fund support;
- Equal opportunity employment;
- Financial disclosure/conflict of interest monitoring;
- Organization planning and management;
- Position management; and
- Local applications unique to the user organization.

Financial Information System (FIS)

FIS is the official source of financial information for DOE. FIS is a reporting system rather than an accounting system in that its major functions are to collect, edit, update, consolidate, and report financial information for the entire Department at various management and working levels. It provides Departmental external reports to Congress, OMB, Treasury, and other Federal agencies and provides the Deputy Assistant Secretary for Financial Management and Controller with the necessary information to financially manage the Department. The system maintains the widely used budget and reporting codes, the obligation and cost plan/estimate file from budget, and several other edit/report files.

The actual accounting data is supplied to FIS from field offices, laboratories, integrated contractors, power marketing administrations, energy technology centers, regional offices, Office of Headquarters Accounting Operations, and Departmental control accounts.

The obligation and cost plan data is obtained from Budget and used by FIS for reporting purposes. The FIS also interfaces with the Procurement and Assistance Data System for contractor information and the Departmental Integrated Standardized Core Accounting System for allotment data at the Departmental level. The budget and reporting classification code file and various other edit files are loaded and maintained from internal documents creating the data requirements. The integrated contractors and laboratories report through their respective field offices.

After the FIS master file is updated, FIS interfaces with the budget and PADS data to produce report files and hard copy reports. Reports are distributed via SACNET and by mail. The small amount of classified data is kept separate and processed after the monthly reports are completed.

Nuclear Materials Management and Safeguards Systems (NMMSS)

NMMSS is the national nuclear materials accountability data base and information system operating under joint DOE and Nuclear Regulatory Commission (NRC) sponsorship. NMMSS provides information about inventories and flows of nuclear materials within the United States and also serves international interests in the programs for the peaceful application of nuclear energy and in the nonproliferation of nuclear weapons. The purpose of NMMSS is to provide quality nuclear data in a timely manner to support both domestic and international nuclear programs. Within the scope of NMMSS are found all nuclear materials applied and controlled under United States law and related international agreements including nuclear materials production programs and private nuclear industrial activities within the United States.

NMMSS is responsible for maintaining and providing information regarding nuclear materials safeguards, production and materials management, physical accountability, financial and cost accounting, military applications and other information involving the utilization of nuclear materials for DOE, and for providing NRC with information concerning nuclear materials control and accountability. NMMSS serves both agencies in support of reporting commitments under two types of international treaties and agreements: (1) the Agreement between the United States of America and the International Atomic Energy Agency (IAEA) for the Application of Safeguards in the United States of America; and (2) the bilateral agreements for cooperation with other nations concerning the peaceful uses of nuclear energy. In addition, its national and international scope enables it to provide services to other organizations like the Arms Control and Disarmament Agency (ACDA), the Department of State, and the Congress.

NMMSS is a series of application programs and supporting data that reside on a central network of computers at Martin Marietta Energy Systems, Inc., in Oak Ridge, Tennessee. NMMSS software consists of approximately 300 programs (about 800,000 statements of source code) written primarily in COBOL in conjunction with some FORTRAN and Assembler language programs. These application programs provide input processing, data base manipulation, and report generation.

The 957 megabyte NMMSS data base is designed around logical information categories which provide the timely response capabilities necessary for servicing safeguards and related national security information requests.

The data base consists of primary and background subsystems. The primary subsystem consists of the actual data reported by, or generated for, individual facilities and is divided into three main categories: inventory, transaction, and material balance data. The primary subsystem is supported by background subsystems which are used to provide auxiliary reference information for rapid data retrieval, interaction, and edit controls. The background libraries include information on: nuclear materials, contracts, transportation, projects, organizations, import/export/retransfer, country control information, material balance categories, and financial correlations.

The largest volume of requests for services originates quite logically through DOE and NRC. The entire organizational hierarchy, from Headquarters to the operations and regional offices down to their associated facilities use NMMSS services. Other agencies, such as the Department of State, the General Accounting Office, foreign governments, state and municipal jurisdictions, Congress, and the public use information supplied by NMMSS based on authorized approval by the DOE and NRC. Requests for information from the system can be made on either a standard distribution schedule or on the basis of a special information request depending on the individual user's needs.

Procurement and Assistance Data System (PADS)

PADS provides the Procurement and Assistance Management Directorate with the ability to track and report on procurement and assistance actions throughout the Department.

The data contained in PADS enables a day-by-day monitoring of the procurement and assistance processes, contract administration, and the establishment of procurement lead times. The system contains data which is sent to the Congress, the Office of Management and Budget (OMB), and the public. Specifically, PADS contains data relating to the following:

- Synopsis requirements of Public Law 98-72, Amendments to the Small Business Act.
- Subcontracting requirements of Public Law 95-907, Amendments to the Small Business Investment Act.
- Research and Development funding requirements of Public Law 97-219, Small Business Innovation Development Act of 1982.
- Competition requirements of Public Law 98-369, the Competition in Contracting Act.

This system allows for data collection and data entry in several different ways. The most commonly used method of data entry is via cathode ray tube (CRT) terminals using the DOE-developed data collection software package called OMEGA. Several awarding offices submit data to PADS via their computer system. The data in PADS is available for all DOE initiating and awarding offices.

Other systems use PADS data through automated interfaces. These are:

- Active Instrument Review System (AIRS) - Basic award information is obtained from PADS on the 20th of each month.

- Automated Contractor Capability and Experience Source System (ACCESS) - the PADS Miscellaneous Tables are used as an edit source for ACCESS.

- Contract Closeout Management Information System (CLOSE) - Basic award information is obtained from PADS on a daily basis.

- Contract Management Information System (CMIS) - Chicago Operations Office submits data to PADS via their CMIS.

- Federal Assistance Award Data System (FAADS) - DOE is responsible to report selected assistance actions to the FAADS. Data is extracted from the PADS data base on a quarterly basis and sent to FAADS via magnetic tape.

- Federal Procurement Data System (FPDS) - DOE is required to report selected procurements to the FPDS. Data is extracted from the PADS data base on a quarterly basis and sent to FPDS via magnetic tape.

- Financial Information System (FIS) - FIS provides PADS financial information on a monthly basis. Awardee data is passed from PADS to FIS. These interfaces are used to improve the data quality in both systems.

- Field Management System (FMS) - provides assistance data to PADS.

- Funds Tracking System (FUNTS) - provides data on funds availability to PADS.

- Material Management System (MMS) - Bonneville Power Administration submits data to PADS via the procurement module of their MMS.

- Procurement Invoice Tracking System (PITS) - The initial entry of an invoice to PITS causes the OMEGA program to "fetch" data about the contract from PADS.

- Property Information Monitoring System (PIMS) - Basic award data is provided to PIMS via weekly extracts from PADS. This data establishes records in PIMS.

- o Technical Information Management System (TIMS) - The Office of Scientific and Technical Information (OSTI) in Oak Ridge, Tennessee, uses selected elements from the award records in PADS. OSTI then applies the data from PADS to its TIMS data base. Thus, the elements supplied by PADS become the basic record for the award actions in TIMS. To those basic records, OSTI adds additional data to support its needs. TIMS supplies PADS information on awardee names.

- o Subcontracting Reporting System (SCORS) - Basic award information is obtained from PADS on a daily basis.

Real Property Inventory System (RPIS)

The Assistant Secretary, Management and Administration, has the responsibility to ensure that DOE is properly planning, constructing, and maintaining the physical plant assets assigned to the Department. Part of these responsibilities include managing and reporting on real property to ensure that the Government retains the most efficient and effective plant to perform its assigned missions.

Real property is defined as land and improvements to land, including buildings, structures, roads, parking lots, etc. The RPIS provides the capability to track detailed data for all DOE real property, both leased and owned. The system contains all data elements necessary to:

- o Provide the Assistant Secretary, Management and Administration, with the capability to exercise Departmentwide oversight of the management of real property.

- o Respond to external requests from Congressional committees; OMB; and others regarding the ownership, disposition, condition, and costs of real property assets.

- o Provide an inventory of all real property owned and leased by DOE for internal management requirements.

- o Provide automated production of the annual reports to GSA for owned and leased property.

- o Provide an annual history file capability to be utilized for statistical analysis of yearly data.

- o Provide reconciliation interface with DOE financial systems.

The exchange of real property information currently flows between the Headquarters Office of Projects and Facilities Management (OPFM) and the DOE field offices. The data which is transmitted, however, originates in approximately 50 DOE field and area offices which provide real property information to the system. The transmission of input data to RPIS occurs through input via CRT directly by the field office. DOE field offices are only able to update and query their own data base. Headquarters OPFM has access to all field offices data. The system interfaces with the GSA system in the form of tape transmittal of information for the specific GSA reports.

Departmental Integrated Standardized Core Accounting System (DISCAS)

DISCAS is the Department of Energy's standardized system for accounting and financial reporting applications. It became operational in all operations offices (Albuquerque, Chicago, Idaho, Oak Ridge, Nevada, Richland, San Francisco, and Savannah River); the Pittsburgh Energy Technology Center; and the Office of Headquarters Accounting Operations by December 31, 1985. The system utilizes common hardware (HP 3000 Series) and common software, and is centrally managed by the Departmental Accounting and Financial Systems Development Division, Office of the Deputy Assistant Secretary for Financial Management and Controller.

The system provides the capability to perform accounting and financial reporting functions consistent with the accounting policy and procedures contained in the DOE Accounting Practices and Procedures Handbook. DISCAS applications accept allotment data, process all types of accounting transactions, issue payments and billings, produce internal and external financial reports, and provide monthly data for Departmental consolidation to the Financial Information System.

The DISCAS Software Configuration Management Plan provides procedures for monitoring and controlling software modifications. The purpose of these procedures is to assure management of the continued integrity and standardization of the system. Site modifications are limited to local interface and reporting needs and must be implemented to comply with the DISCAS "Core" Definition.

National Energy Information System (NEIS)

The purpose of NEIS is to directly support the mission of the Energy Information Administration (EIA). The mission of EIA, an integral yet independent agency in the Department of Energy, is to provide meaningful, timely, objective, and accurate energy information to the Executive Branch, Congress, State Governments, industry, and the public so that those who make decisions about energy in all sectors of society have the tools to make those decisions wisely. To accomplish this, EIA collects, processes, and interprets energy data and exercises independent judgment in gathering, analyzing, and disseminating information.

In 1989, NEIS consisted of 37 computer-driven models, 75 data gathering surveys, plus associated planning and control applications. The results of NEIS statistical and analytical efforts are published in periodicals and special one-time reports. NEIS periodicals are grouped into families based on fuel types and appear weekly, monthly, quarterly, and annually. During 1989, approximately 250 issues of 83 titles of data analysis and interpretative reports were prepared. In addition, about 25 one-time special reports and publications were completed.

DOE Waste Information Network (WIN)

A major component of the Hazardous Waste Remedial Actions Program (HAZWRAP) is the development of a specialized information system encompassing all aspects of hazardous chemical and mixed radioactive waste technology. The emphasis of the effort to date has been on identifying, collecting, analyzing, and automating waste stream data for U.S. Department of Energy installations. As a result of this, the WIN data base has been developed for retrieval and analysis of data through the use of IBM-compatible personal computers. A variety of related data bases focusing on technology adaptation and application and environmental restoration activities were also developed. Site visits were made to 25 DOE installations where information was collected on each site's hazardous and mixed waste management practices and problems, technology activities, and information systems needs and interest. Specific waste stream data for 41 DOE sites has been extracted and entered into the information system. The national WIN was established to manage this diversity of information systems and communication features under development by the HAZWRAP. WIN provides a state of the art resource of information exchange and data analysis mechanisms for use by DOE Headquarters, DOE operations offices and their contractors, and HAZWRAP staff. Future plans include continued development of the data bases, quantifying the waste stream data, conducting further data analysis, expansion of the network system, responding to information requests, and continued close interaction with site representatives.

The major data bases currently under development and/or planned for the HAZWRAP cover the following topics:

1. Hazardous and Mixed Waste Streams
2. Technology Adaptation/Application
3. Environmental Restoration Activities
4. Hazardous Chemical Waste Treatment, Storage, Disposal, and Transportation Vendors
5. Legislative and Regulatory Issues
6. Principle Contact Directory

Additional data bases will be developed as new needs and interests are identified within the DOE waste activity area. All the data bases are being designed for retrieval in a user-friendly environment and will be cross-indexed to allow a more efficient and precise means of retrieval. So that the process of retrieving general or specific information can be manipulated easily, the data bases have been structured into a relational format. The software package used to accomplish this on a personal computer is Dbase III, a relational data base management system. The data bases will primarily consist of unclassified data for ease of application on personal computers. However, procedures have been formulated to computerize any classified data received on a dedicated secured system at the Oak Ridge National Laboratory (ORNL). Electronic transfer of this data can be handled through a separate procedure available within the DOE community. Satellite communications will also be utilized where feasible.

Licensing Support System (LSS)

The Office of Civilian Radioactive Waste Management (OCRWM) is responsible for the siting, design, construction, operation, and closure of geological repositories for the disposal of spent nuclear fuel and high-level nuclear wastes as authorized by the Nuclear Waste Policy Act (NWPA) of 1982 (PL 97-425). In order to fulfill this responsibility, OCRWM must demonstrate compliance with all applicable Federal, State, and local regulations and obtain the necessary licenses and permits associated with these regulations. Also, OCRWM staff must be able to demonstrate that they have the required records to support their request for a license, as well as coordinating and documenting licensing interactions, and commitments such as for meetings and exchanges of materials.

LSS will create and maintain an on-line data base of all pertinent licensing information generated by DOE, NRC, or any other party to the licensing process. The data base records created will contain both document and non-document information. Document information records will be retrieved using bibliographic information, or by full text searches. The system will display the text of the record(s) on the terminal screen, both in ASCII and image form, and printed output will be provided upon request.

Non-document information records will be retrieved by using bibliographic information. The system will display a written summary of the non-document record and its location on the terminal screen. Instructions on how to access the information will also be furnished, upon request.

The system will also provide DOE and NRC licensing personnel with access to the latest versions of the laws and regulations with which the repository must comply. Although DOE is developing an issues and commitment tracking system, the NRC rule that is being negotiated probably will not require it to be part of the LSS.

5.1.2 **Information System Development Activities**

5.1.2.1 Managing Information System Development Activities

Automated information system planning within the Department is based upon the utilization of a life cycle management methodology which follows information systems from initial conception through their eventual retirement.

DOE policy requires that all Departmental components utilize a life cycle methodology which, in general, provides for the performance of specific activities and the preparation of certain deliverable documents. Due to the diversity of individual organization mission assignments and associated data processing requirements, it is not possible to uniformly require that each activity be performed and each document be prepared for every IS development. The specific activities performed and the documents prepared are intended to be commensurate with the mission priority and sensitivity, as well as the impact, scope, life cycle costs, and complexity of the information system project.

5.1.2.2 Information System Development Activities

As with most large organizations, DOE initially developed stand-alone IS which performed a single function. These systems did not transfer information to other stand-alone IS nor receive any data from other systems. Additionally, similar IS were often developed several times by several different organizations. Using the area of payroll as an example, DOE organizations developed several different payroll systems to serve the needs of the various operations offices and other field locations and utilized another payroll system at Headquarters. Information needed by management from several functional areas were either not available or had to be compiled manually.

Over the last several years, significant changes have occurred concerning the development and use of IS. The Department has tended to develop highly integrated systems which avoid the duplication of data entry, allow common information sharing, and ensure data integrity. Examples of such integrated systems are the Departmental Integrated Standardized Core Accounting System and the DOE Integrated Payroll/Personnel System which are described in subsection 5.1.1.5.

Standard DOE-wide systems are developed when several major functions are found to be common to all DOE organizations. In most situations where a commonality has been found, standard Departmentwide systems have been developed to replace individual IS being used by various DOE organizations. Examples of such standard Departmentwide systems are the Nuclear Materials Management and Safeguards System and the DOE Waste Information Network which are described in subsection 5.1.1.5.

In many instances, several organizations have the same or similar need for information. In such situations, rather than developing a new IS for each of the organizations, a standard IS is developed for the use of several organizations. Usually, this type of IS will require slight modifications so that it can be used by other organizations. Most times, this type of IS will usually have a low development cost and often times is a microcomputer-based IS. In general, this type of IS usually is an administrative tracking type system such as those which track project-type budgets, foreign travel, and local personnel action activities.

DOE, like other Government and private organizations, has experienced a rapid growth in the use of microcomputers. In the initial stages of this growth, much of the effort was devoted primarily to the concept of office automation. In office automation, organizations tended to focus on activities such as text processing and electronic mail. Currently, since users have been become very proficient with the use of this technology, an impact on the IS area has taken place. Many applications are being developed using the microcomputer environment. Programming tools have been developed so that applications can be prototyped and modeled on microcomputers. Over the last three reporting cycles, several IS have been moved from mainframe to minicomputers or microcomputers. It is anticipated that this trend will continue and that it will actually accelerate with the technological advances in relational data bases, programming languages, storage devices, and networks for the transmission of information.

5.1.2.3 Sources of Information System Requirements

The basic intent of IS planning by DOE organizations is to assure that needs for information within each organization are met in a timely and efficient manner. In reviewing their information needs, each organization focuses on three primary areas which serve to generate the requirements for new or enhanced IS. These are discussed below.

- Policy, Program, and Technology Changes - Organizations and the environment within which they operate are dynamic and subject to continuous changes from many varied sources. New laws may mandate major changes to the IS within an organization. Programs may change the focus of their activities, expanding or decreasing to satisfy the requirements of the legislation. Changes in technology may present new methods for securing or manipulating needed information requiring changes to an organization's automated IS base. Based on all of these possible changes within the general environment, organizations must attempt to assess the impact these changes will require on the IS which they use. This assessment is, in turn, translated into requirements for modifications to the automated IS being used. These are then incorporated into the organization's IS long-range site plan.

- o <u>New Information Needs</u> - Even in the absence of changes in policy, program, or technology, management often wants information which is not currently available or which would be even more useful if automated. During the planning cycle, each organization also attempts to identify any information needs not being met by the current automated IS base. Depending upon resource availability and the criticality of these needs, efforts to fill them will be included in the long-range site plan.

- o <u>Improvements in Support</u> - A final source of requirements for a new IS or an enhancement to an existing system is the need for improved support. This essentially deals with questions about the timeliness and accuracy of information, capacity, and maintenance difficulties due to software inadequacy, extensive use of computer resources, procedural difficulties affecting IS, and other similar problems. These needs for improvement are generally determined from ongoing reviews of IS by the organization itself or by other outside groups.

5.1.2.4 Summary of DOE Information System Plans

DOE organizations have a continuing need to develop new or enhance existing IS to meet their requirements for information. Based on IS site plans submitted during FY 1989, Table 5.1-5 provides a distribution of these projects based on estimated costs. Most of the IS activity is on small IS costing less than $50,000.

Cost Category	Planned	Under Development	Total No. of IS	Percent
Cost under $50,000	42	42	84	57
Cost $50,000-$100,000	7	20	27	18
Cost $100,000-$250,000	5	17	22	15
Cost $250,000-$500,000	2	4	6	4
Cost $500,000-$1,000,000	1	4	5	3
Cost over $1,000,000	1	3	4	3
Total	58	90	148	100

TABLE 5.1-5 NEW OPERATIONAL INFORMATION SYSTEMS BY DEVELOPMENT COST CATEGORY

Another method of classifying IS is by the type of impact the information system has on DOE organizations external to the IS owner's organization. This is especially important to DOE and contractor organizations since their organizations may be required to provide input to the impacting information system. The external impact of the 148 projects is provided in Table 5.1-6.

	Planned Initiatives			Initiatives Under Development				
Impact	New IS	Enhancements	Redesign	New IS	Enhancements	Redesign	Total No.	%
Major DOE-Wide	0	6	0	1	2	0	9	6
DOE-Wide	3	0	0	12	2	0	17	12
IS has some external	5	4	0	18	4	1	31	21
No external	26	10	3	40	10	1	91	61
Total	34	20	3	71	18	2	148	100

TABLE 5.1-6 NEW INFORMATION SYSTEMS AND ENHANCEMENTS BY TYPE OF IMPACT

As the above two paragraphs indicate, while the Department has many new IS developments and enhancements either planned or in the process of being developed, most of these projects are not large scale efforts and do not have DOE-wide or external impact to DOE and DOE contractor organizations.

5.1.2.5 New Major DOE-Wide IS Planned or Under Development

At this time, only one major DOE-wide IS is being developed and none are in the planning stages. The Licensing Support System which is described in subsection 5.1.1.5 is being developed for the Office of Civilian Radioactive Waste Management.

It is also important to indicate that several DOE-wide IS are in the planning or development stages but these IS are not considered major IS. These initiatives are identified in Table 5.1-6 above.

5.1.2.6 Planned Enhancements to Major DOE-Wide IS

There are 6 planned enhancements to 2 different operational major DOE-wide systems. These systems are listed below with a short description of the enhancements.

DOE Integrated Payroll/Personnel System (PAY/PERS)

There are five enhancements planned for this system. The first will provide an acceptable method of training personnel and payroll users on the proper use of the system. This training will be accomplished using a computer-assisted instruction approach. The second enhancement will provide for the use of microfilm to store payroll source documents. The third enhancement will expand personal computer download capabilities to accommodate a diversified user community. The fourth enhancement will provide a screen for users to document system problems and/or deficiencies to the best of their ability. The last enhancement will establish review procedures of the overall operational aspect of the system.

Energy Manpower and Personnel Resource Information System (EMPRIS)

This enhancement will provide for the acquisition of off-the-shelf, user-friendly data collection software and for an interactive editing system.

5.1.2.7 Enhancements Under Development to Major IS

There are two enhancements currently under development for a major DOE-wide IS. The system is listed below with a short description of the enhancements.

DOE Integrated Payroll/Personnel System (PAY/PERS)

The first enhancement will permit an audit trail of changes made to the SF 52 and will also maintain a log of activities. The second enhancement will replace the OMEGA based payroll data entry function with a Customer Information Central System (CICS) based payroll source document entry function.

5.2 COMPUTING RESOURCES

This subsection describes the computing resources within the Department. It includes information by cost and manufacturer, the relative computing capacity available from the larger multipurpose systems, capacity growth, and capacity distribution by program and site. In view of the vital role microcomputers play in today's office environment, this section also discusses the microcomputer resources of the Department.

5.2.1 Profile of Computing Resources

As of September 30, 1989, the Department had 3,391 computers installed with a purchase value of approximately $795 million. Including peripheral equipment, these computing resources were valued at nearly $1.3 billion.

These figures are based upon data submitted into the General Services Administration (GSA) Governmentwide ADP Equipment Data System. Only computer systems with a purchase equivalent of $50,000 or more are being reported. In Table 5.2-1 below, the computers have been aggregated according to their initial purchase price.

The computers originally valued at a million dollars or more account for only 2 percent of the total number of installed computers. However, they had an original purchase value of over $490 million, approximately 62 percent of the total inventory.

The 3,391 computers in use by the Department are supplied by over 107 different vendors. As indicated in Table 5.2-2 on the next page, 48 percent of the computers installed as of September 30, 1989, were provided by Digital Equipment Corporation, a leading vendor of small computers. However, Cray Research, Inc., the leading vendor of supercomputers, accounts for about 45 percent of the total value of installed computers.

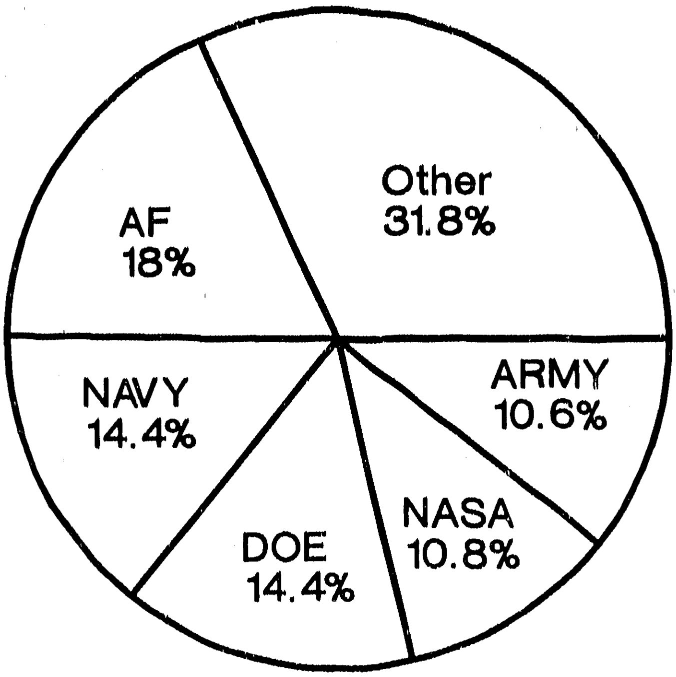
Price Range of Computer (Without Peripherals)	Computers: Number	Computers: Percent	Original Purchase Value: Amount	Original Purchase Value: Percent
Less than $100,000	2,448	73%	$ 91	11%
$100,000 to $500,000	811	24%	182	23%
$500,000 to $1,000,000	52	1%	33	4%
$1,000,000 to $5,000,000	45	1%	111	14%
Greater than $5,000,000	35	1%	378	48%
TOTAL	3,391	100%	$ 795	100%

TABLE 5.2-1 DEPARTMENTAL COMPUTERS AGGREGATED BY PRICE RANGE, FY 1989
(DOLLARS IN MILLIONS)

Vendor Name	Computers Number	Computers Percent	Original Purchase Value Amount	Original Purchase Value Percent
Cray Research, Inc.	32	1%	$ 358	45%
Digital Equipment Corp.	1,643	48%	170	22%
International Business Machines Corp.	141	4%	98	12%
Control Data Corporation	39	1%	48	6%
Hewlett Packard Co.	361	10%	16	1%
Data General Corp.	176	5%	11	1%
Amdahl	6	1%	10	1%
Computervision Corp.	69	2%	9	1%
National Advanced Systems	6	1%	7	1%
Modular Computer Systems, Inc.	126	3%	6	1%
Other Vendors	79 ~~822~~	24%	62	9%
TOTAL	3,391	100%	$ 795	100%

TABLE 5.2-2 DISTRIBUTION OF DOE COMPUTERS BY MANUFACTURER, FY 1989
(DOLLARS IN MILLIONS)

Departmental computing resources account for approximately 14.4 percent of the total U.S. Government ADP equipment value. This figure was extracted from the third and fourth quarters of the FY 1988 summary report, prepared by GSA. As shown in Figure 5.2-1 on the next page, DOE computer resources along with Navy rank second among both civilian and military agencies, with only the Air Force having more computer resources.



Total ADP Equipment Value: $8 Billion

AF - Department of the Air Force

ARMY - Department of the Army

NAVY - Department of the Navy

DOE - Department of Energy

NASA - National Aeronautics and Space Administration

FIGURE 5.2-1 DISTRIBUTION OF ADP EQUIPMENT DOLLAR VALUE BY FEDERAL AGENCY, FY 1988

5.2.1.1 Computing Capacity Distribution

Figure 5.2-2 identifies the computing capacity available to the Department for the period FY 1980 through FY 1990. For comparative purposes, a common denominator, the Nominal Service Unit (NSU), was used to calculate total capacity. In FY 1986, the Department converted to a more detailed metric for measuring various categories of capacity (more detailed information related to the Relative Capacity Unit (RCU) can be found in Appendix F). Therefore, FY 1986 through FY 1990 indicates total capacity in NSUs and the categories of capacity by supercomputers, mainframes, and minicomputers. As indicated, by the end of FY 1990 the available computing capacity will have grown from 560,000 NSUs in FY 1980 to approximately 9.7 million NSUs. This increase is attributable to a number of factors, but the primary factor has been the increased utilization of supercomputer capabilities within the Department. These supercomputers account for approximately 67 percent of the total capacity in FY 1990, compared to the mainframes which will provide approximately 15 percent and the minicomputers at approximately 18 percent.

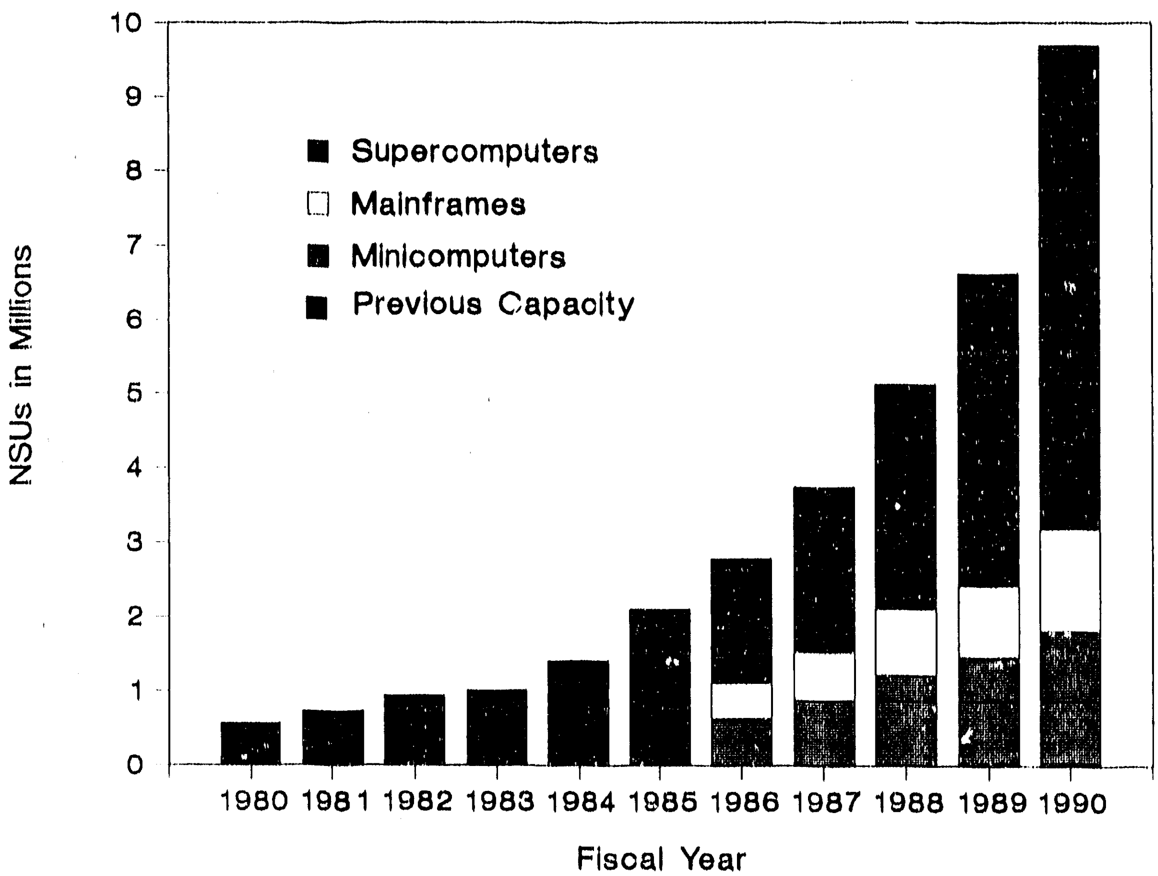


FIGURE 5.2-2 DOE COMPUTING CAPACITY GROWTH

ADP Costs by Program

As would be expected in FY 1990, the projected costs to acquire, maintain, and run the computer resources used by the various programs correlate rather well to the use of computer resources by the programs. Figure 5.2-3 displays the percentage distribution of projected FY 1990 ADP costs by major program areas.

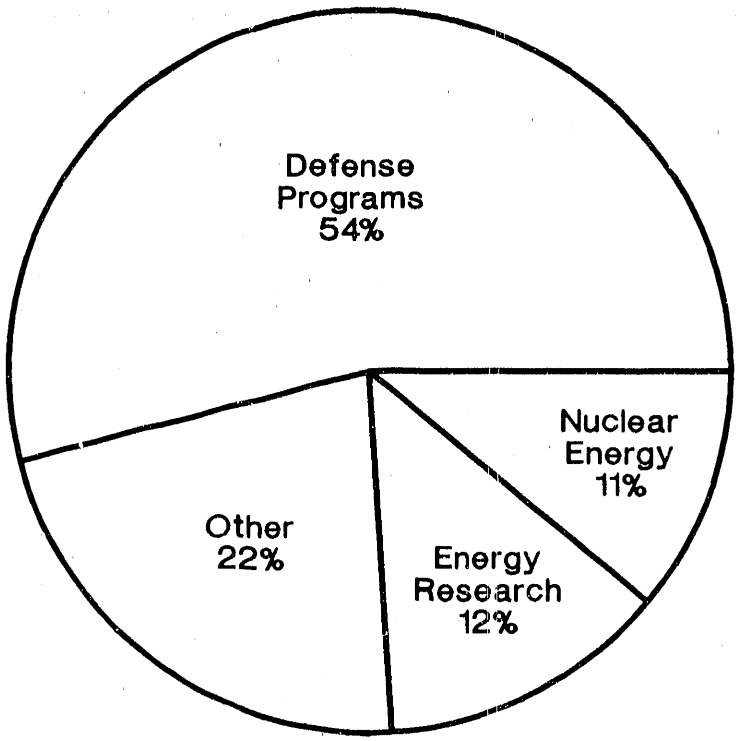


FIGURE 5.2-3 PERCENT OF FY 1990 TOTAL ADP COSTS BY MAJOR PROGRAM AREA

Resources by Program

Use of Departmental capacity has been grouped by the following major program areas: Defense Programs, Energy Research, Nuclear Energy, and Other Program Activities. Included in Other Program Activities are: Energy Information; General Administration; Conservation and Renewable Energy; Fossil Energy; Civilian Radioactive Waste; Power Marketing; Environment, Safety, and Health; and other program areas.

There are considerable differences in the level of use of the existing computer resources by the various DOE programs, as indicated in Figure 5.2-4. Ninety-three percent of the resources will be used during FY 1990 to meet the programmatic requirements of Defense Programs, Energy Research, and Nuclear Energy. Specific examples of the current programmatic uses of the computing resources are presented in Section 6.

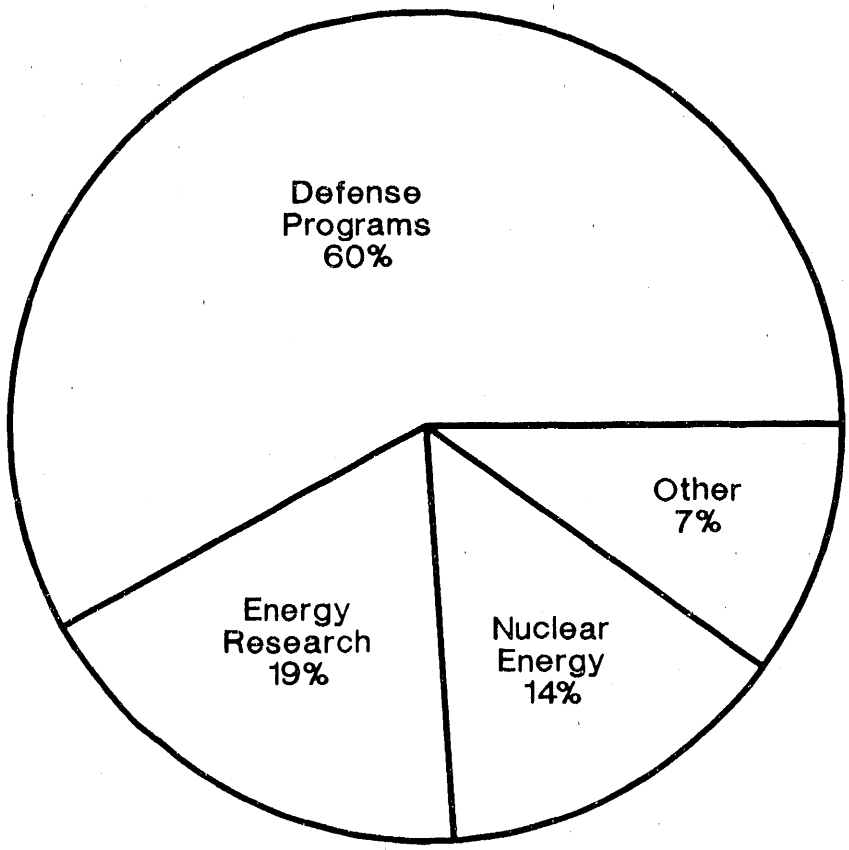


FIGURE 5.2-4 USE OF COMPUTER RESOURCES BY MAJOR PROGRAM AREA, FY 1990

Resources by Site

The computing capacity available at the sites included in this Plan varies considerably, as shown in Figure 5.2-5. Based on data for FY 1990, the top 3 sites, which primarily support Defense Programs, account for approximately 57 percent of the computer capacity with the top 15 sites accounting for approximately 89 percent. The computing capacity at each site naturally differs according to the amount of programmatic requirements for computational support.

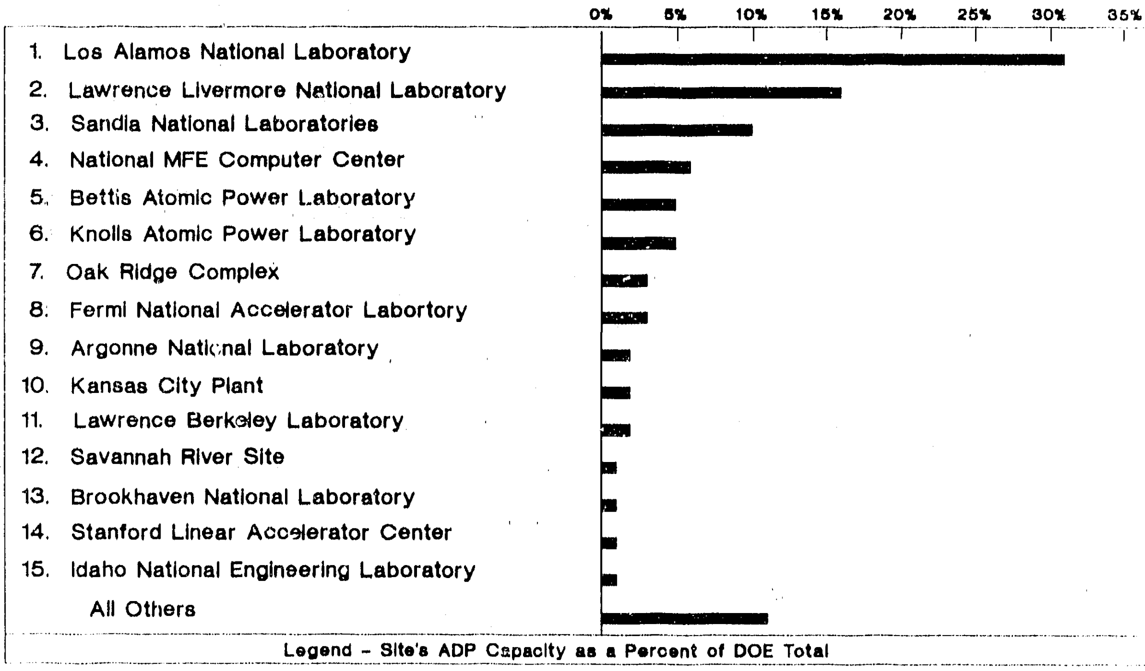


FIGURE 5.2-5 FY 1990 COMPUTING CAPACITY DISTRIBUTION BY SITE

Program Support By Site

Computing systems have been acquired and used in nearly all facets of the operation of the Department. They provide a cost-effective means of accomplishing a substantial segment of the programmatic work load. In addition, certain types of programmatic work are possible only because of the existence of computers.

The number of programs receiving computational support varies considerably by site, as shown in Figure 5.2-6 on the next page. Twenty-seven sites are primarily dedicated to the support of one program and/or administrative work, 8 sites support two to three programs, and the remaining 11 sites provide computational support to many programs. Defense Programs receive support from 20 sites, Energy Research from 17 sites, Nuclear Energy from 12 sites, and other program activities from 28 sites.

Sites		Weapons Activities	Verification & Control Tech.	Nuc. Sfgd. & Sec.	Materials Production	Defense Waste & Envr. Restoration	Magnetic Fusion	Biol. & Envt. Res. (Envt. R&D)	High Energy Physics	Nuclear Physics	Basic Energy Sciences	Nuclear Energy Research & Development	Remedial Action & Waste Tech.	Naval Reactors	Uranium Enrichment	Power Marketing	Conservation & Renewable Energy	General Administration	Fossil Energy	Environment, Safety, and Health	Energy Information	Civilian Radioactive Waste	
		Defense Programs					Energy Research					Nuclear Energy				Other							
Albuquerque Operations Office	1	●																●					1
Ames Laboratory	2								●		●												2
Argonne National Laboratory	3						●	●	●	●	●	●							●				3
Bettis Atomic Power Lab.	4													●									4
Bonneville Power Admin.	5															●							5
Brookhaven Natl. Laboratory	6							●	●	●	●												6
Chicago Operations Office	7			●				●										●					7
Fermi Natl. Accelerator Lab.	8								●														8
GA Technologies, Inc.	9						●																9
Grand Junction Project Office	10					●							●									●	10
Hanford Complex	11		●		●	●	●	●			●	●	●				●	●		●		●	11
Hdqrs Comp. Serv. & Tele. Mgmt	12																	●					12
Hdqrs. Energy Info. Admin.	13																				●		13
Hdqrs. Off. of Civ. Rad. Waste Mgt.	14																					●	14
Idaho Natl. Engineering Lab.	15			●	●	●						●	●	●						●			15
Idaho Operations Office	16																	●					16
Kansas City Plant	17	●																					17
Knolls Atomic Power Lab.	18													●									18
KMS Fusion, Inc.	19	●																					19
Lawrence Berkeley Lab.	20						●	●	●	●	●						●					●	20
Lawrence Livermore Natl. Lab.	21	●	●		●		●	●							●		●					●	21
Los Alamos National Lab.	22	●	●	●	●		●			●	●	●					●					●	22
Massachusetts Inst. of Tech.	23								●	●													23
Morgantown Energy Tech. Ctr.	24																		●				24
Mound Facility	25	●				●																	25
National MFE Computer Ctr.	26						●				●												26
Naval Petroleum Res. in CA	27																		●				27
Nevada Complex	28	●				●												●				●	28
Oak Ridge Complex	29	●		●				●			●	●			●					●			29
Oak Ridge Operations Office	30					●									●			●					30
Ofc. Scientific & Tech. Info.	31																	●					31
Pantex (Amarillo) Plant	32	●																					32
Pinellas Plant	33	●																					33
Pittsburgh Energy Tech. Ctr.	34																		●				34
Portsmouth Gaseous Diffusion Plant	35														●								35
Princeton Plasma Physics Lab.	36						●																36
Rocky Flats Plant	37	●																					37
Sandia National Laboratories	38	●	●	●		●	●				●						●		●			●	38
San Francisco Ops. Office	39	●																●					39
Savannah River Complex	40	●			●	●								●									40
Savannah River Ops. Office	41				●													●					41
Solar Energy Research Institute	42										●						●						42
Southwestern Power Admin.	43															●							43
Stanford Linear Accelerator Ctr.	44								●														44
Strategic Petroleum Reserves	45																		●				45
Western Area Power Admin.	46															●							46

FIGURE 5.2-6 MAJOR PROGRAM SUPPORT BY SITE

5.2.1.2 Microcomputer Resources

In recent years we have seen major advances in the price/performance of microcomputer related technology, an explosion of product offerings, and a growing interest in this technology and resource. These developments have had a significant impact on the accessibility of computer resources. What was once available only through the central computer center, is now readily available on the user's desk. The effective and innovative utilization of this technology has presented considerable opportunities to increase the productivity and efficiency of the office environment.

DOE, as other Federal agencies, has recognized the potential of this technology, as evidenced by the number of current and projected installed units. DOE has been exploiting this technology and has instituted a strategic, disciplined approach to the management, acquisition, and utilization of microcomputer resources within the Department.

Installed Microcomputers

By the end of FY 1988, approximately 79,000 microcomputers had been acquired at an approximate cost of $314 million. Figure 5.2-7 represents the cumulative microcomputer hardware costs associated with FY 1985 through FY 1990. Actual costs are provided through FY 1988 with estimates for FY 1989 and FY 1990.

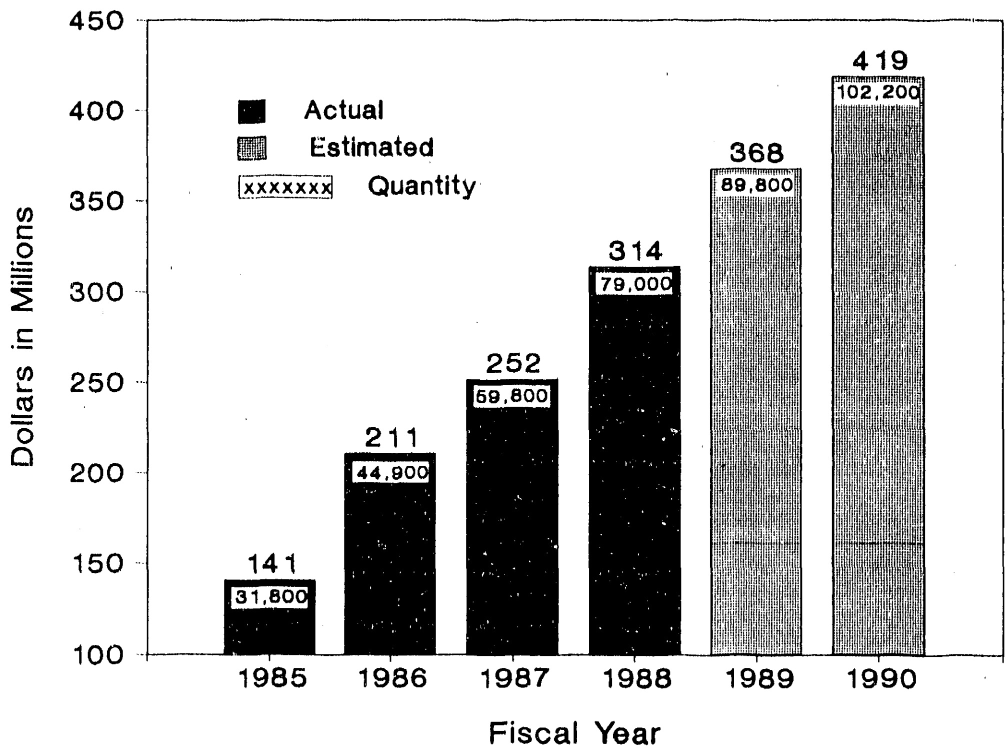


FIGURE 5.2-7 CUMULATIVE MICROCOMPUTER HARDWARE COSTS BY FISCAL YEAR

Microcomputers by Manufacturer

By the end of FY 1988, 79 percent of the installed microcomputers had been procured from 5 different manufacturers. Table 5.2-3 identifies the relative percentages of units by manufacturer.

Manufacturer	Number	Percent of Total
IBM	42,000	53%
APPLE	11,900	15%
COMPAQ	3,000	4%
HP	2,900	4%
DEC	2,700	3%
OTHER	16,500	21%
TOTAL	79,000	100%

TABLE 5.2-3 MANUFACTURER DISTRIBUTION OF INSTALLED MICROCOMPUTERS, FY 1988

Microcomputer Software

The proliferation of microcomputer hardware has been accompanied by a corresponding increase in the number of software packages acquired by the agency. This increase is due to the fact that a myriad of applications can now be satisfied with off-the-shelf microcomputer software. Whereas word processing and spreadsheets were the primary packages purchased, today's packages encompass a wide variety of applications. These include: graphics, project management, data base, communications, system utilities, desktop utilities, statistical analysis, etc.

As of September 30, 1988, DOE sites reported an inventory of PC software with a total estimated purchase value of $65 million. Table 5.2-4 identifies the most frequently acquired packages within the Department.

LOTUS	VTERM	EXCEL	ENABLE
DBASE	SMARTERM	MAC WRITE	WORD MARC
WORD PERFECT	WORD	SYMPONY	DISPLAYWRITE
MULTIMATE	WORDSTAR	MAC DRAW	MAC PAINT
			VERSATERM

TABLE 5.2-4 MOST COMMONLY USED MICROCOMPUTER APPLICATION SOFTWARE PACKAGES, FY 1988

Figure 5.2-8 illustrates the cumulative microcomputer software costs for the period FY 1985 to FY 1988. Actual software costs are provided through FY 1988 with estimates for FY 1989 and FY 1990.

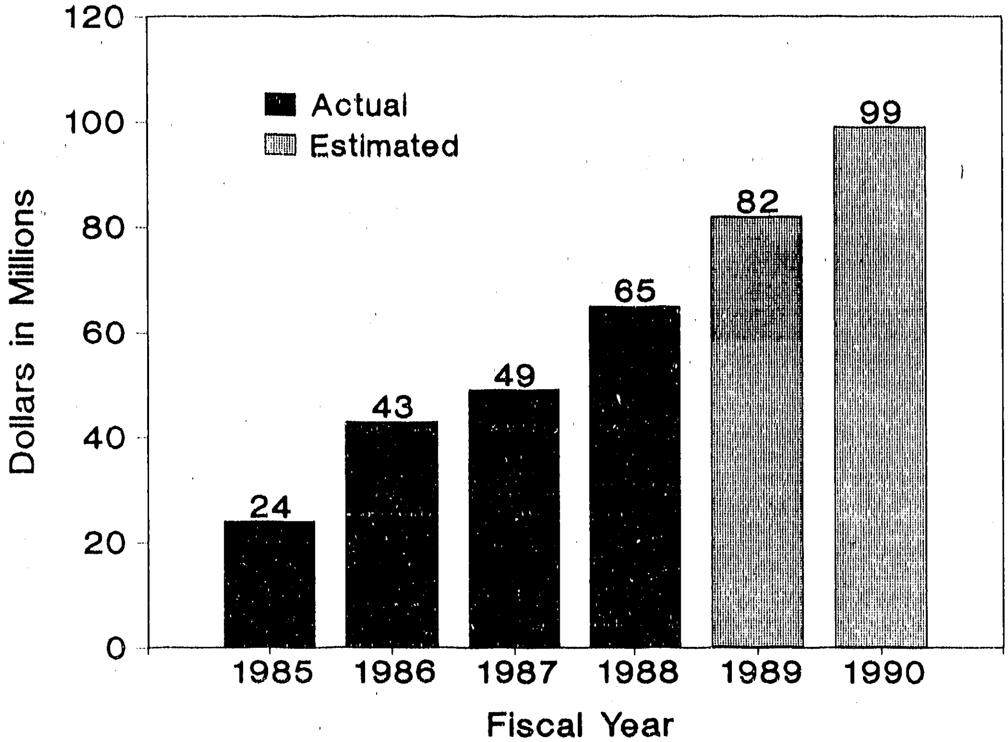


FIGURE 5.2-8 CUMULATIVE MICROCOMPUTER SOFTWARE COSTS BY FISCAL YEAR

5.2.2 Computing Requirements

This subsection addresses the overall need for computing resources within the Department based on the requirements submitted by reporting sites and approved by the responsible program organizations. It includes a summary of the Departmental long-range computing resource requirements, the distribution of these requirements by program, and their classification into categories of computing system needs.

Computing resources requirements are defined as needed capacity and/or capability which are projected given constraints on funding, the state of the art of the technology available or anticipated, and a realistic assessment of the likelihood for realizing acquisitions which may have been planned and budgeted. All sites are expected to satisfy requirements for computing resources throughout the planning cycle either by installed on-site capacity, resource sharing, commercial services, or through the acquisition of new capacity and/or capability.

Departmental requirements are stated in terms of the Nominal Service Unit (NSU), which has been retained as a gross aggregate total of the Relative Capacity Unit (RCU) used by DOE sites in reporting requirements, installed capacity, and computing capability. The RCU is an extension of the NSU in that it introduces three categories of computing capability instead of treating all computing resources as essentially equivalent. Three fundamental units of capability (minicomputers, mainframe computers, and supercomputers) have been identified. The supercomputing category has been subdivided into requirements which can reasonably be accomplished on current technology machines and those that necessitate development of future technology systems in the out-years. Future technology requirements include applications such as quantum mechanical or relativistic problems requiring computational capabilities beyond what is now or anticipated to be available in the current generation of supercomputer hardware or software. More detailed information related to the RCU can be found in Appendix E.

5.2.2.1 Departmental Computing Requirements

The planned computing resource requirements for the Department are shown in Figure 5.2-9. These forecasted programmatic requirements indicate the aggregate level of computing support that needs to be provided for the successful accomplishment of major programmatic missions.

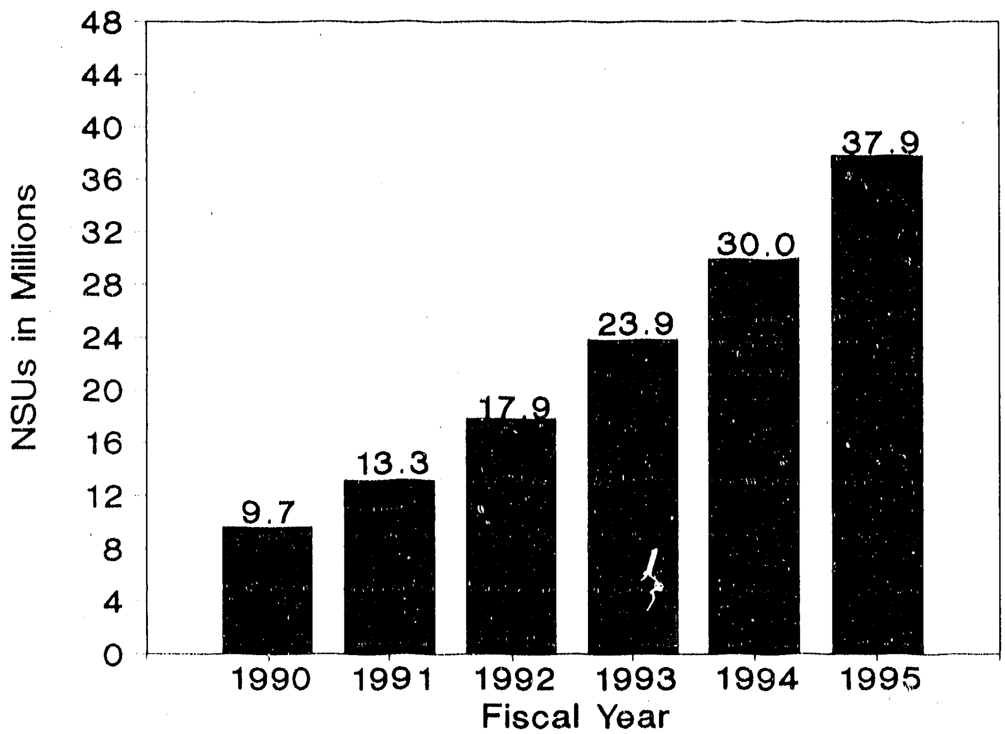


FIGURE 5.2-9 DEPARTMENTAL COMPUTING REQUIREMENTS BY FISCAL YEAR

Based upon current projections, Departmental requirements will grow from approximately 9.7 million NSUs in FY 1990, the baseline year, to over 37 million NSUs in FY 1995. The increase represents an average annual growth rate of approximately 31 percent, which is consistent with projections in last year's Information Technology Resources Long-Range Plan.

As depicted in Figure 5.2-10, the principle growth in computing requirements will occur in Defense Programs. This programmatic area currently accounts for 60 percent of the Departmental requirement and is projected to grow over 18 million NSUs during the planning period. Energy Research is the next largest user with Nuclear Energy third. Although these two programmatic areas currently share a substantial portion of the computing requirements in the Department, at 19 and 14 percent, respectively, Defense Programs is now and is projected to continue to be the major computing user in DOE throughout the planning period.

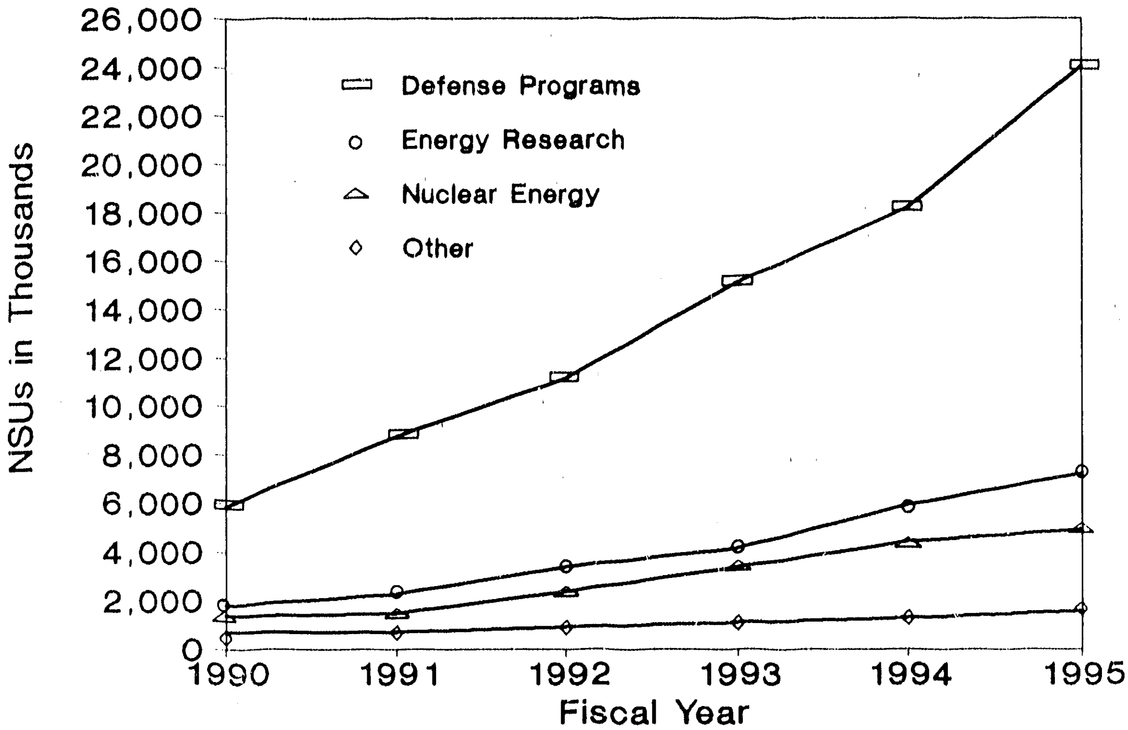


FIGURE 5.2-10 COMPUTING REQUIREMENTS BY MAJOR PROGRAM AREA

In Figure 5.2-11 on the next page, requirements are classified by computing system category. Since this Plan focuses primarily on larger, multipurpose general management systems within the Department, microcomputer requirements and the requirements for special management systems, such as data acquisition and control systems, are not included.

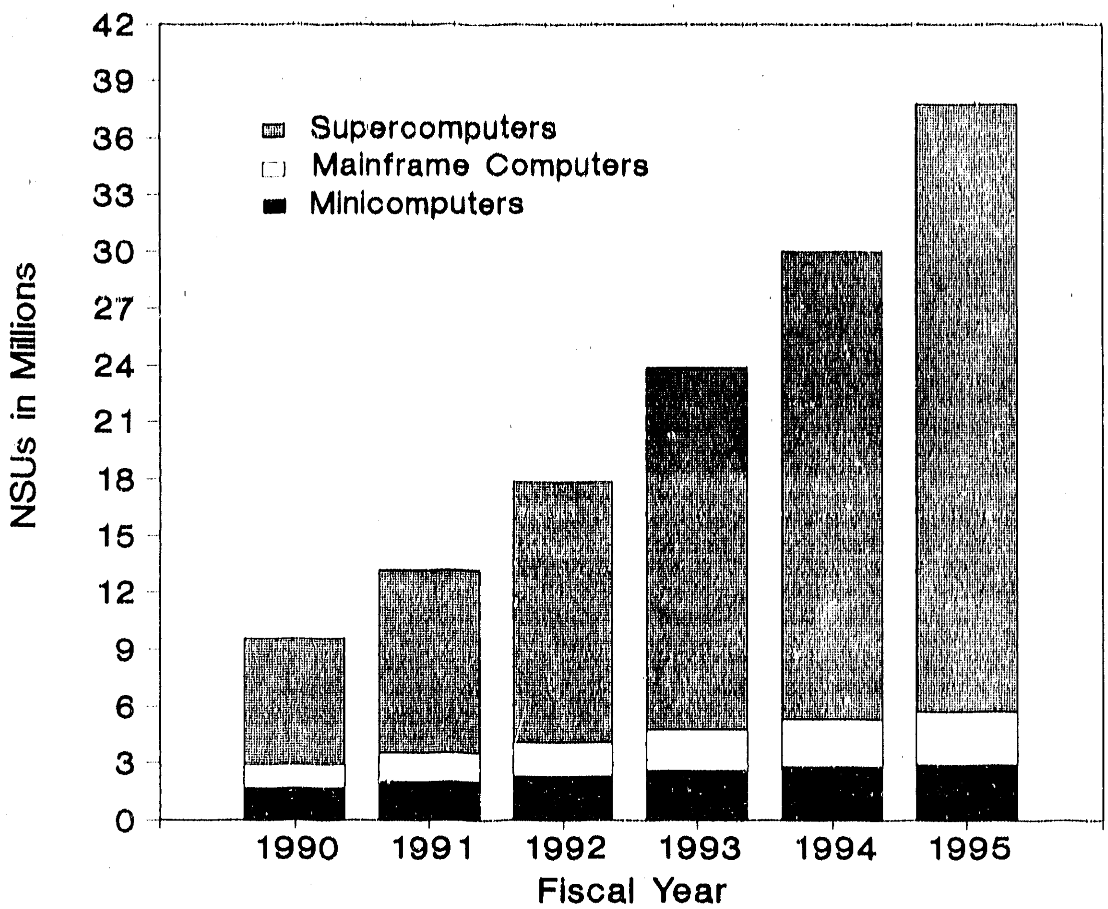


FIGURE 5.2-11 REQUIREMENTS BY COMPUTING SYSTEM CATEGORY

Minicomputer and mainframe needs for general management computing functions are projected to grow at an average annual rate of 11 and 17 percent, respectively, during the period covering FY 1990 through FY 1995. However, the portion of the total Departmental computing requirements met by combined minicomputers and mainframes is expected to decrease from 31 percent in FY 1990 to 15 percent in FY 1995. The decline is due to the increased need for supercomputing capability throughout the Department. In FY 1990, supercomputers will satisfy 69 percent of the Departmental computing needs; by FY 1995, these requirements are projected to increase to the point where they will account for 85 percent of total requirements. Departmental supercomputing requirements have been broken down between those that can reasonably be accomplished with current generation supercomputer technology (Classes VI/VI enhanced), which also includes near-term announced technology systems that are not yet available (Class VII), and those that must be satisfied on future technology supercomputers (Class VIII and beyond). Further information is provided in Appendix E.

5.2.2.2 Computing Requirements by Program

Computing requirements have been grouped into the following major areas which relate to overall Departmental missions: Defense Programs, Energy Research, Nuclear Energy, and Other Activities. A detailed explanation of the programs that compose these groupings follows.

Defense Programs

The Assistant Secretary for Defense Programs is the principal advisor to the Secretary on national security matters and is the manager of the nuclear weapons program and the weapons complex. The Assistant Secretary is also responsible for planning, directing, and executing programs of materials production, nuclear safeguards and security, verification and control technology, weapons activities, and defense waste and environmental restoration. The planned computing requirements for Defense Programs are shown below in Figure 5.2-12. In FY 1990, the Defense Programs portion of the total Departmental computing requirement is the largest at 60 percent and is expected to remain relatively constant throughout the planning period. The annual growth rate is projected to be approximately 33 percent. The predominance of this requirement supports Weapons Activities for Research, Development, and Testing, as well as Production and Surveillance.

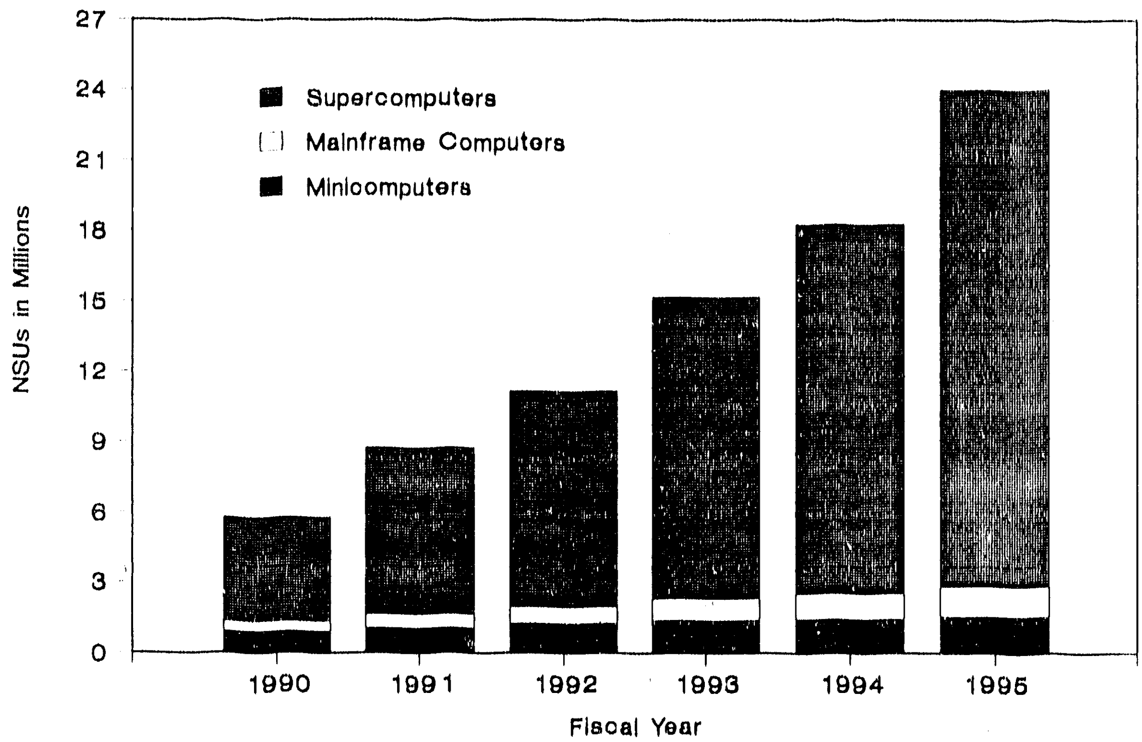


FIGURE 5.2-12 PLANNED DEFENSE PROGRAMS COMPUTING REQUIREMENTS

Defense Programs minicomputer and mainframe combined requirements currently account for 23 percent of total programmatic needs; supercomputing capability accounts for the remaining 77 percent. While minicomputer and mainframe growth is projected at 12 and 23 percent, respectively, supercomputing requirements are projected to increase at an annual rate of 36 percent. As a result, combined minicomputer and mainframe requirements will decline to 12 percent by 1995, while supercomputer requirements to support research and development projects increase to 88 percent of total Defense Programs needs.

Energy Research

The Director of Energy Research serves as principal science advisor to the Secretary in formulating the basic research policy of the Department. In this capacity, the Director provides independent reviews, analyses, and recommendations to the Secretary concerning a wide range of Departmental activities which require scientific counsel. These activities include, for example: national research and development strategies, plans and policies, budgetary priorities for energy research and development programs, the development and management of Departmental technology programs, and policy issues related to determining the best use of the multipurpose laboratories assigned to Energy Research. The principle program areas are Nuclear and High Energy Physics, Biological and Environmental Research, Magnetic Fusion, and Basic Energy Sciences which includes the nuclear, material, chemical, engineering, applied mathematical, and geological sciences.

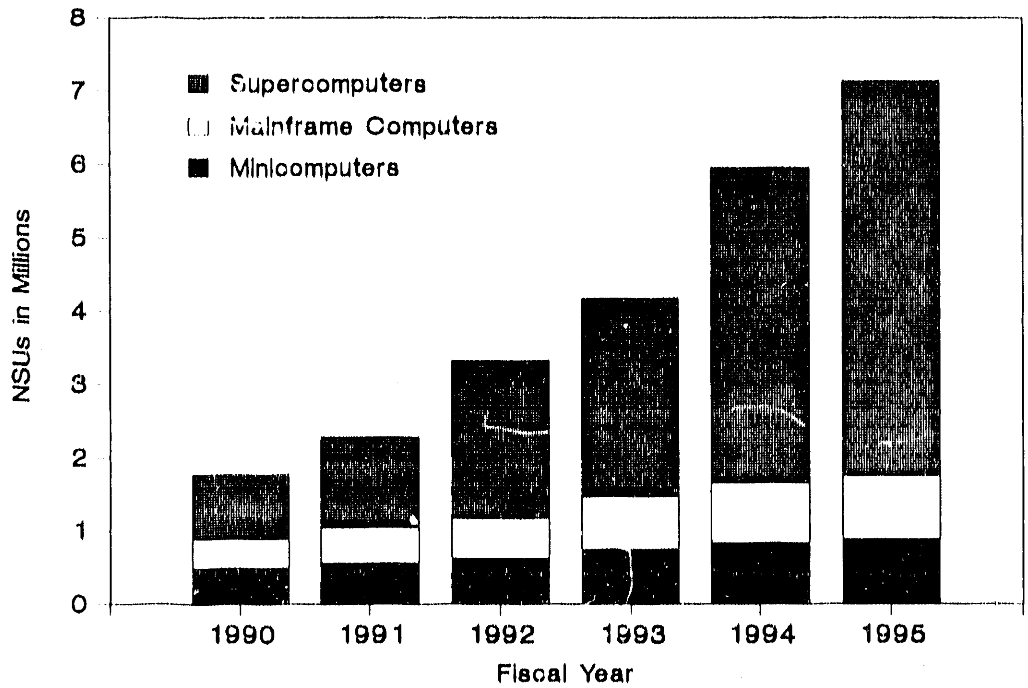


FIGURE 5.2-13 PLANNED ENERGY RESEARCH COMPUTING REQUIREMENTS

The planned computing requirements for Energy Research Programs are shown in Figure 5.2-13 on the previous page. Energy Research, the second largest user of computer resources in the Department, currently accounts for 19 percent of Departmental programmatic requirements. The Energy Research annual growth rate is estimated at approximately 32 percent. These requirements are constrained by the limited amount of supercomputer computing capacity that is available due to the budgetary constraints of the programs. Approximately 50 percent of the current Energy Research requirement is at the supercomputer level and is met by the centralized supercomputing center at the Lawrence Livermore National Laboratory.

The Energy Research computing requirements are projected to increase from approximately 1.8 million NSUs in FY 1990 to slightly over 7.2 million in FY 1995. Although combined minicomputer and mainframe requirements will almost double during the planning period, supercomputer requirements alone are projected to increase more than four times to meet scientific research and development programmatic needs.

Nuclear Energy

The Assistant Secretary for Nuclear Energy is the principal advisor to the Secretary concerning nuclear fission energy. The Assistant Secretary is responsible for planning, developing, and executing Departmental programs for nuclear energy research and development, advanced nuclear systems, remedial action and waste technology, naval reactors, and for uranium enrichment. Nuclear Energy also includes computing support for the programmatic work of the Nuclear Regulatory Commission at DOE facilities.

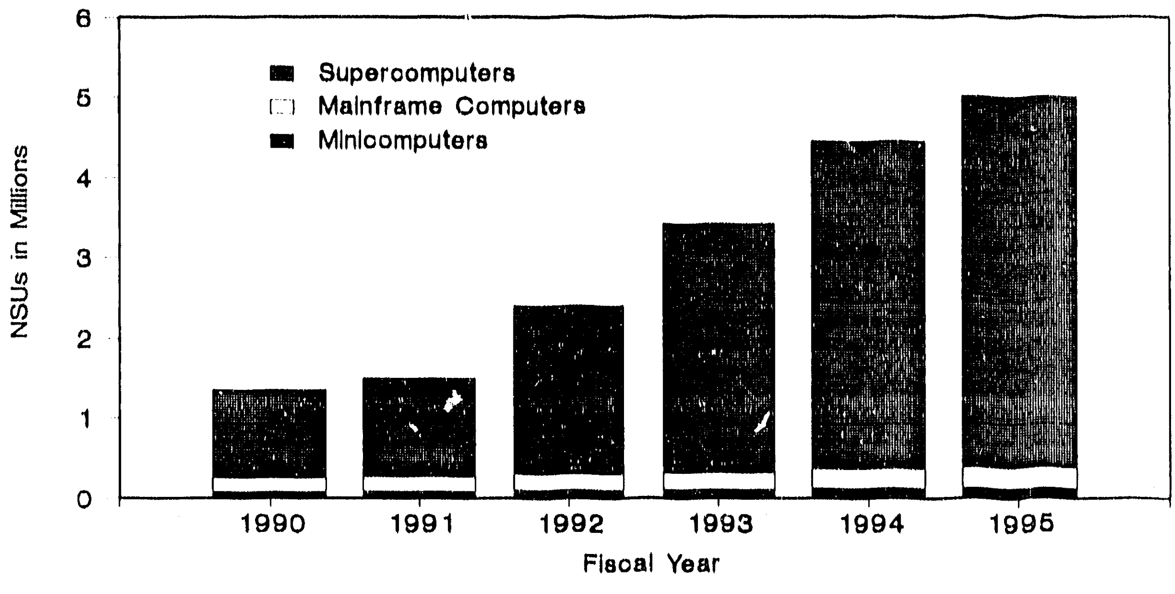


FIGURE 5.2-14 PLANNED NUCLEAR ENERGY COMPUTING REQUIREMENTS

The planned computing requirements for Nuclear Energy programs are shown in Figure 5.2-14 on the previous page. The Nuclear Energy requirements currently represent approximately 14 percent of the overall Departmental requirements and are expected to remain stable throughout the planning period. Nuclear Energy requirements are growing at an annual rate of approximately 30 percent. This increase can mainly be attributed to the need for increased supercomputer power by the nuclear research and development projects of the Naval Reactors program. This program currently makes up 85 percent of the Nuclear Energy computing requirement and is projected to grow to 87 percent by the end of FY 1995.

Other Programs

Other program activities include General Administration, the administrative support area of the Department; Energy Information; Conservation and Renewable Energy; Fossil Energy; Environment, Safety, and Health; Civilian Radioactive Waste; and Power Marketing.

The planned computing requirements for other activities are shown below in Figure 5.2-15. The computing requirement of these other programs account for 7 percent of the Departmental requirement. Their total average annual growth rate is approximately 18 percent. Overall, no single programmatic activity dominates this area. As with the major programmatic areas highlighted earlier in this section (i.e., Defense, Energy Research, and Nuclear Energy), supercomputing requirements for other programs will increase the most during the planning period. While these requirements are relatively small, compared to the major programs, they will rise by 46 percent from FY 1990 through FY 1995.

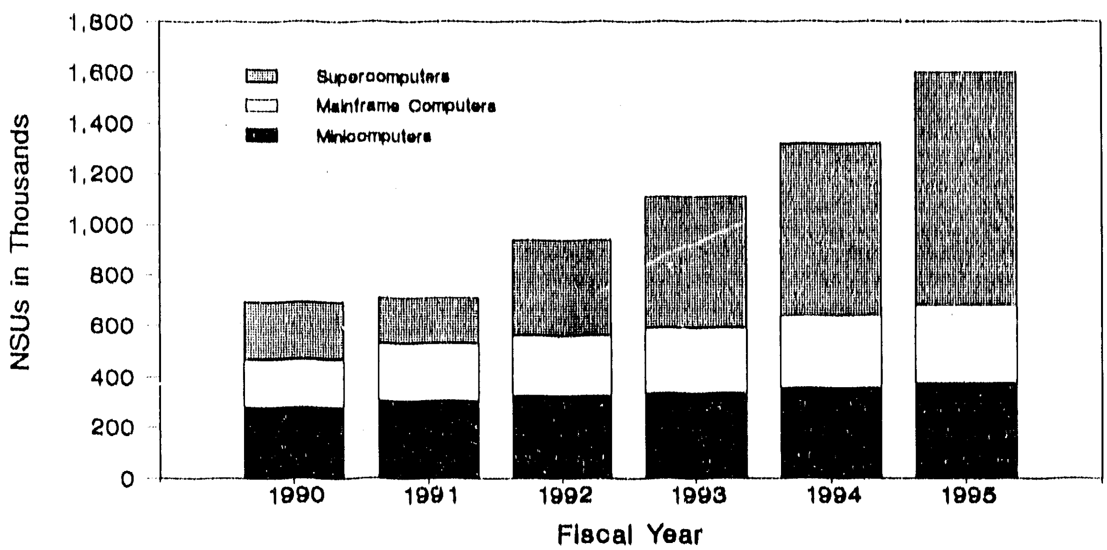


FIGURE 5.2-15 PLANNED OTHER PROGRAMS COMPUTING REQUIREMENTS

5.2.2.3 Computing Requirements by Category of Computing System

Departmental programmatic computing requirements are satisfied on computer systems that vary significantly in both capacity and capability. A crucial step in effective planning of computing resources is matching the requirement to the appropriate computer system to ensure that requirements are satisfied in the most effective, efficient, and economical way possible. When making this determination, consideration must be given to the needs of the program (e.g., required turnaround time), the availability of suitable software, and the necessary financial factors. Although there are many computing requirements that can be reasonably accomplished on any system, there are also others that are well suited only to a specific level of system.

The various levels of computing systems within the Department have been characterized as follows: microcomputers, minicomputers, mainframe computers, and supercomputers. This generic nomenclature and the further categorization of classes at the supercomputer level provides a medium by which the Department can uniformly describe the level of the required computing capacity and capability in general terms, thus promoting better communication within and external to the Department. Due to the continuous stream of technological advancements made in the computing world, the boundaries between these designated levels of computing are becoming less distinguishable.

Microcomputers/Workstations

Microcomputers, the smallest of computer systems, are typically single user desktop machines that use microprocessors as their central processing units. They provide a computing capability that is user friendly and cost-effective within the actual work environment of the end user enabling the user to have direct control and easy access. Typical microcomputer applications include data base manipulation, electronic spreadsheet work, interoffice communications, and word processing. However, with the increase in computing power of these machines, some advanced applications such as graphics and engineering tasks are now capable of being performed on microcomputers.

Depending on the computational capabilities and, in some cases, the operating system utilized, some small computing systems may be categorized as workstations rather than microcomputers. These units are increasingly becoming the preferred interface to large scale systems used by scientists and engineers to generate sophisticated 2-D, 3-D, or 4-D visualization (i.e., graphics). High-powered workstations can also be used for some applications as a dedicated computational resource rather than using a mainframe or minicomputer. The primary benefit of this approach is the ability to download information for processing on the workstation, thereby releasing the host resources for other tasks.

Since this Plan focuses primarily on larger, multipurpose general management systems within the Department, microcomputer and workstation requirements and the requirements for special management systems, such as data acquisition and control systems, are not included.

Minicomputer Systems

A major portion of minicomputers within DOE are used for dedicated special functions. Controlling, monitoring, analyzing a process, or serving as an integral part (i.e., front-end) of larger computer systems, are typical uses. With such uses, these minicomputers are generally unavailable for independent general management computing. However, some of the newer minicomputers are able to provide computing at a lower cost per instruction executed, for a limited range of applications and capabilities, than the larger computer systems. In some cases, minicomputers absorb some of the work load from larger computers; in other cases, they become replacements for larger, obsolescent computers. The HP 3000 series, DEC VAX 6000 series, IBM 4300 series, and Prime 9955 are typical minicomputer systems.

	FISCAL YEAR						
	1990	1991	1992	1993	1994	1995	Total
Defense Programs	885	1,045	1,238	1,347	1,444	1,545	7,504
Energy Research	490	582	638	754	842	900	4,206
Nuclear Energy	75	79	100	114	119	121	608
Other	279	304	325	337	355	372	1,972
	1,729	2,010	2,301	2,552	2,760	2,938	14,290

TABLE 5.2-5 PLANNED MINICOMPUTER REQUIREMENTS BY PROGRAM
(NSUs IN THOUSANDS)

Table 5.2-5 illustrates planned minicomputer requirements by Departmental major program area. Departmental planned minicomputer requirements are projected to increase approximately 70 percent at slightly more than 11 percent annually from FY 1990 through FY 1995. Defense Programs will increase 12 percent annually from 885 to 1,545 thousand NSUs, while Energy Research will grow from 490 to 900 thousand NSUs at approximately 13 percent annually during the same period. Nuclear Energy will increase from 75 to 121 thousand NSUs at approximately 10 percent annually during the planning period. Other Programs will grow from 279 to 372 thousand NSUs at approximately 6 percent annually during the planning period.

Mainframe Computer Systems

Uses of mainframe computer systems include scientific research and engineering processing, weapons production support, and administrative processing such as personnel, accounting, and management information. These computers are usually capable of accommodating a large number of on-line users with time-sharing and/or transaction processing applications while concurrently processing several batch-type programs. They usually have word sizes of 32 to 60 bits, sophisticated operating systems, large main memories, and the capability to control and concurrently operate large numbers of disk files, magnetic tape drives, printers, terminals, and other devices. Typically, these systems are designed to allow for upward migration. The lower end of computer systems within this level is comparable to a super minicomputer; but, through additions of central processing units, memory, and channels, etc., the system capability/capacity can be doubled and even quadrupled. Some computers on the high end of this computer spectrum that provide vector capability border on the supercomputer category. Examples of mainframe computing systems are IBM 3000 series, NAS 9000 series, and CDC 180 series machines. A list of typical mainframe systems installed at DOE sites can be found in Appendix E, Figure E-1.

	FISCAL YEAR						
	1990	1991	1992	1993	1994	1995	Total
Defense Programs	477	623	766	990	1,138	1,344	5,338
Energy Research	411	482	554	737	822	896	3,902
Nuclear Energy	200	215	218	224	262	279	1,398
Other	190	227	236	257	285	310	1,505
	1,278	1,547	1,774	2,208	2,507	2,829	12,143

TABLE 5.2-6 PLANNED MAINFRAME REQUIREMENTS BY PROGRAM
(NSUs IN THOUSANDS)

Defense Programs mainframe requirements are projected to increase 23 percent annually and grow from 37 percent of the current Departmental mainframe requirements in FY 1990 to 48 percent in FY 1995. Energy Research requirements will remain constant at 32 percent throughout the planning period.

Supercomputer Systems

DOE uses the term "supercomputer" to refer to the largest, most powerful, scientific computers available. Four of the most important characteristics of supercomputers relative to mainframe computers are faster speed in executing computer operations (add, subtract, multiply, and divide), larger main memories, finer precision (number of digits) used in calculations, and better price/performance ratios. The current supercomputers within DOE typically provide 64 bit word lengths, high-speed arithmetic/logic units, multi-million byte main memories, and the capability to work with massive arrays of scientific data.

Due to the wide range of overall cost and performance, DOE has further classified supercomputers in terms of classes. The class designations vary according to capability/capacity and technology of the system. Current generation supercomputers are termed Class VI/VI enhanced systems; near-term announced technology machines that are not yet available are referred to as Class VII systems; and future generation machines to be developed from as yet undetermined technology are Class VIII systems. Typical Class VI computers are the Cray 1, Cray X-MP/1, and the CDC Cyber 205. Enhanced Class VI computers include the Cray X-MP/2 and 4 and the Cray 2. A more complete list of Class VI/VI enhanced systems currently installed at DOE sites can be found in Appendix E, Figure E-1.

DOE computing paces the entire Federal effort in the application of supercomputers. Departmental users have defined computing needs that are on the leading edge of supercomputer capability. For example, as the fields of physics advance, theoretical investigations naturally evolve from a stage where the most important problems can be solved analytically, to where numerical solutions become essential. The ever present need for increased computational capability can be directly attributable to the increases in complexity of the area of scientific interest. Complexity shows up in the form of increases in dimensionality of models, in moving from ordinary differential equations to partial differential equations for the solution of critical problems, from the impetus to move from low order to high order expansions, and in moving from scalar to vector systems and from linear to nonlinear systems.

While mainframe computers are the workhorses in computing, supercomputers are needed to satisfy an increase in scientific/engineering applications including the growing need to model complex systems, the solution of which is impossible without the capacity and capability of supercomputers. DOE scientists and engineers are continually seeking better tools in the form of increased computing capability as a means for solving more difficult computational problems. Some scientific and engineering problems cannot be solved with the most capable supercomputers of today either because memory limitations do not permit the desired parameter refinement or because execution speed would require an unreasonably long run time to produce a result.

Computers with greater capability are not always available in the marketplace when they are needed. When greater computer capability does not exist, scientists are forced to scale down their problems to fit the size and speed of the available computers. In many instances, only approximate representations with coarse resolutions and lower dimensionality can be attempted. However, trends in technology indicate that industry will be able to offer a computer meeting DOE's immediate near-term needs for a Class VII in the late FY 1991-1992 timeframe which will be approximately 4 to 10 times the capability of the current Class VI enhanced supercomputers. Future supercomputer technology (Class VIII and beyond) is anticipated to have significantly more power and will potentially be available in the early to mid-1990's timeframe.

Computing knowledge, techniques, and capability must advance along with the technical advancement in the energy programs to enable adequate computing to support Departmental programs in the future. This is necessary for all types of computing, but, because of the highly complex nature of the research and development programs, it is particularly important that more advanced technology be developed to meet the computing needs of the Department. Current hardware and software limitations are constraining the rate of advancement in the scientific and engineering programs.

Analysis of requirements by computing system categories indicates a continuing need for supercomputers. To meet the Departmental needs for computers with significantly increased capacity and capability, development by industry of more innovative improvements in architecture, parallel processing, and easy-to-use software will be needed.

	FISCAL YEAR						
	1990	1991	1992	1993	1994	1995	Total
Defense Programs	4,467	7,092	9,160	12,820	15,678	21,162	70,379
Energy Research	897	1,255	2,163	2,698	4,278	5,461	16,752
Nuclear Energy	1,089	1,208	2,093	3,100	4,069	4,581	16,140
Other	226	183	381	519	680	922	2,911
	6,679	9,738	13,797	19,137	24,705	32,126	106,182

TABLE 5.2-7 PLANNED SUPERCOMPUTING REQUIREMENTS BY PROGRAM
(NSUs IN THOUSANDS)

Table 5.2-7 on the previous page shows total current and future technology supercomputing requirements by program within DOE. These requirements, which support programmatic scientific research and development projects, far exceed the other computing category requirements (i.e., minicomputer and mainframe) of the Department.

Defense Programs, as with the other computing categories, continues to represent the largest need for computing capacity and capability with 66 percent of the total supercomputing requirements for the planning period. Energy Research follows with 16 percent, and Nuclear Energy and Other Programs require 15 and 3 percent, respectively, of total supercomputing requirements between FY 1990 and FY 1995.

Defense Programs, Nuclear Energy, and Other Programs supercomputing requirements all increase at an average annual rate of around 34 percent from FY 1990 though FY 1995. Energy Research requirements, however, are projected to increase an average of 43 percent annually during the same period. This is primarily due to planned increases in support of National Magnetic Fusion Energy Computer Center development projects.

As shown in Table 5.2-7, when future technology requirements are introduced and begin to impact growth in FY 1992, current generation supercomputing requirements level off. This is an indication of the increasing need for the larger, more powerful next generation supercomputers required to meet Departmental programmatic missions and goals.

5.2.3 <u>Computing Resource Plans</u>

This subsection describes Departmental plans for providing general management computing resources required to satisfy mission needs during the period covering FY 1991 through FY 1995.

5.2.3.1 Planned Major Acquisitions

To meet growing programmatic general management computing requirements, the Department has developed plans for 150 major acquisitions during the FY 1991 through FY 1995 planning period. These major acquisitions each have a total purchase equivalent value of $1 million or more and collectively have a total purchase value of approximately $921 million. The 150 planned acquisitions are categorized as:

- o computer acquisitions and upgrades and
- o enhancements to computer systems.

Summarized in Table 5.2-8 are the planned computer acquisitions/upgrades and enhancements to installed computer systems showing the quantity and purchase equivalent value projected during the FY 1991 through FY 1995 planning period.

Planned Acquisitions		FISCAL YEAR 1991	1992	1993	1994	1995	TOTAL
Computer Acquisitions/Upgrades	**No.**	**24**	**27**	**20**	**23**	**14**	**108**
	Value	$145	$184	$151	$189	$141	$810
Enhancements to Computer Systems	**No.**	**8**	**11**	**6**	**13**	**4**	**42**
	Value	$19	$24	$17	$41	$10	$111
Total Acquisitions	**No.**	**32**	**38**	**26**	**36**	**18**	**150**
	Value	$164	$208	$168	$230	$151	$921

TABLE 5.2-8 NUMBER AND PURCHASE VALUE OF PLANNED MAJOR ACQUISITIONS
(DOLLARS IN MILLIONS)

When compared to the 5-year planning period in last year's Departmental Plan, FY 1990 through FY 1994, the number of total acquisitions planned during the period covering FY 1991 through FY 1995 declined by approximately 7 percent. The decline when compared to the prior 5-year Plan, FY 1988 through FY 1993, was even more dramatic showing a 26 percent decrease in the total number of acquisitions. This can be attributed to numerous factors; i.e., changes in Departmental priorities, phase-out of programs and projects that were previously planned as ongoing throughout the planning period, delays and cancellations of previously-planned acquisitions due to budgetary contraints, advances in state of the art computational resources and techniques providing additional capability and capacity with fewer systems, and changes in site strategies for meeting computational requirements. When comparing total projected costs for the same periods (FY 1991 - FY 1995 to FY 1990 - FY 1994 and FY 1989 - FY 1993), the decreases were less significant; i.e., 4.5 percent and 7 percent, respectively. The primary reason for the smaller decline in costs versus total quantity of acquisitions is due mainly to planned out-year acquisitions of costly high-performance supercomputers to meet research and development programmatic requirements.

The remainder of this subsection provides a more detailed perspective of the planned future acquisitions and is organized as follows on the next page.

- o computer acquisitions and upgrades
  - by system category and class
  - by type, i.e., new computer, replacement, or upgrade
- o enhancements to computer systems

Computer Acquisitions and Upgrades

The Department has planned 108 major computer acquisitions and upgrades with a projected purchase value of $810 million. These acquisitions include increases in the central processing power and commensurate increases in secondary storage devices (i.e., disks, tapes, terminals, input/output devices, etc.). Tables 5.2-9 and 5.2-10 show these acquisitions by category and class of system and by type (i.e., new, replacement, or system upgrade), respectively.

Computer Acquisition and Upgrade by System Category and Class

The 108 computer acquisitions and upgrades have been categorized in Table 5.2-9 on the next page. Plans provide for acquiring 80 new mini and mainframe computers and upgrades. The remaining 28 planned computer acquisitions and upgrades will be supercomputers. Eleven of the supercomputers are current generation supercomputers (Class VI/VI enhanced), eleven are near-term announced technology systems that are not yet available (Class VII), and six acquisitions are planned in the out-years for machines to be developed from future, as yet undetermined, technology.

The enhanced current generation technology and future technology supercomputers are required to process increasingly complex work loads, as well as to manage and control the larger data storage systems. These processing requirements exceed the capability of the current technology machines. Availability of the Class VII supercomputers has been anticipated for the past 2 years. However, based upon current forecasts, the Department is now anticipating that this urgently needed enhanced supercomputing capability will not be available until FY 1991. If the enhanced and future generation technology supercomputers do not become available when expected, other alternatives, including acquiring additional current technology supercomputers, will have to be selected as an interim measure to meet programmatic processing requirements.

Category/Class of Computer Acquisitions and Upgrades		FISCAL YEAR 1991	1992	1993	1994	1995	TOTAL
Minis and Mainframes	**No.**	**19**	**19**	**16**	**15**	**11**	**80**
	Value	$52	$64	$51	$69	$55	$291
Current Supercomputers	**No.**	**2**	**5**		**4**		**11**
(Class VI/VI enhanced)	Value	$14	$39		$20		$73
Near-term Announced Supercomputer Technology	**No.**	**3**	**3**	**3**	**2**		**11**
(Class VII)	Value	$79	$81	$72	$40		$272
Future Supercomputer	**No.**			**1**	**2**	**3**	**6**
Technology	Value			$28	$60	$86	$174
Total	**No.**	**24**	**27**	**20**	**23**	**14**	**108**
Acquisitions	Value	$145	$184	$151	$189	$141	$810

TABLE 5.2-9 NUMBER AND PURCHASE VALUE OF PLANNED COMPUTER ACQUISITIONS AND UPGRADES BY SYSTEM CATEGORY AND CLASS
(DOLLARS IN MILLIONS)

Computer Acquisitions and Upgrades by Type

The 108 computer acquisitions and upgrades have also been categorized by new systems, replacements, and upgrades as shown in Table 5.2-10 on the next page. The Department plans to acquire 38 new additional computers valued at approximately $457 million. Fifty-three percent of these new additional systems will be mini and mainframe systems, while the remaining will be supercomputers.

In addition to the new computer systems, the Department plans to acquire 30 computers to replace existing Department computers during the planning period. The total projected purchase equivalent value of the replacement systems is approximately $191 million. Two primary reasons for replacing computer systems are to reduce obsolescence or to increase computing capability and/or capacity to meet projected increases in programmatic work load. As discussed in subsection 4.7, Combating Obsolescence in the ADP Equipment Inventory, the cost-effectiveness of computers as they become older eventually drops to the point where replacements must be planned due to their high operating costs, excessive requirements for power and space, inability to support current technology hardware or software, and/or poor reliability. Replacement computer systems are sized according to the magnitude and nature of current and future anticipated computing requirements and the technological capabilities expected to be available at the time of acquisition. In the majority of the replacements where the primary emphasis was obsolescence, the site will also acquire additional capability and/or capacity to meet long-term needs.

Categories of Computer Acquisitions/Upgrades		FISCAL YEAR 1991	1992	1993	1994	1995	TOTAL
New Computers	**No.**	**7**	**12**	**6**	**12**	**1**	**38**
	Value	$89	$128	$65	$147	$28	$457
Replacements	**No.**	**11**	**5**	**7**	**2**	**5**	**30**
	Value	$42	$21	$48	$8	$72	$191
Upgrades	**No.**	**6**	**10**	**7**	**9**	**8**	**40**
	Value	$14	$35	$38	$34	$41	$162
Total Acquisitions	**No.**	**24**	**27**	**20**	**23**	**14**	**108**
	Value	$145	$184	$151	$189	$141	$810

TABLE 5.2-10 NUMBER AND PURCHASE VALUE OF PLANNED COMPUTER ACQUISITIONS BY TYPE
(DOLLARS IN MILLIONS)

As shown in Table 5.2-10 above, the Department also plans to acquire 40 upgrades to installed computer systems from FY 1991 through FY 1995. The purchase equivalent value of these upgrades is projected to be approximately $162 million. Increases in a computer system's capacity and/or capability can be achieved in a cost-effective manner by upgrading its central processing unit(s). This can be accomplished in various ways: upgrading the power of the existing central processor(s), increasing the memory size and/or number of input/output channels, and/or adding more central processing units. These type of improvements in capacity and/or capability help meet the increases in programmatic computing requirements while causing minimum disruption to users.

Enhancements to Computer Systems

Considerable improvements to installed computer systems can also be obtained in a cost-effective manner by enhancing or changing other equipment components in the existing configuration. The Department has planned 42 acquisitions to enhance existing computing system configurations, with a projected total purchase equivalent cost of $111 million during the period covering FY 1991 through FY 1995. These planned acquisitions improvements include:

- o storage devices, which are used to provide access to data; this may include processors to serve as file managers, fast access disk drives, tape drives, and mass storage devices.

- o other peripheral upgrades such as back-end processors, input/output devices, and network communication devices.

As shown in Table 5.2-11, the Department has planned 23 storage device and 19 other peripheral upgrades, additions, or replacements with projected total purchase equivalent costs for the planning period of $68 and $43 million, respectively.

Categories of Planned Enhancements		FISCAL YEAR 1991	1992	1993	1994	1995	TOTAL
Storage Devices	No.	4	6	4	6	3	23
	Value	$9	$15	$14	$22	$8	$68
Other Peripheral Upgrades	No.	4	5	2	7	1	19
	Value	$10	$9	$3	$19	$2	$43
Total Acquisitions	No.	8	11	6	13	4	42
	Value	$19	$24	$17	$41	$10	$111

TABLE 5.2-11 NUMBER AND PURCHASE VALUE OF PLANNED ENHANCEMENTS TO COMPUTER SYSTEMS
(DOLLARS IN MILLIONS)

5.2.3.2 Planned Major Acquisitions by Program

The number and purchase value of all major acquisitions planned during the FY 1991 through FY 1995 planning period have been summarized by program area below.

As shown in Table 5.2-12 on the next page, current plans call for Defense Programs to acquire computing resources with a projected purchase equivalent value of $600 million. These acquisitions represent about 76 percent of the total acquisitions for the Department over the planning period. Energy Research and Nuclear Energy plan to acquire 12 and 8 percent, respectively, Other Programs will acquire the fewest computing resources at about 4 percent of the total. This distribution is commensurate with the growth projected in computing capacity and capability needed to meet future programmatic computing requirements.

Program Area		FISCAL YEAR 1991	1992	1993	1994	1995	TOTAL
Defense Programs	**No.**	**27**	**28**	**19**	**24**	**16**	**114**
	Value	$129	$130	$97	$151	$93	$600
Energy Research	**No.**	**2**	**5**	**4**	**6**	**1**	**18**
	Value	$5	$25	$51	$35	$33	$149
Nuclear Energy	**No.**	**2**	**1**	**3**	**5**	**1**	**12**
	Value	$27	$25	$20	$24	$25	$121
Other Program Activities	**No.**	**1**	**4**		**1**		**6**
	Value	$3	$28		$20		$51
Total Acquisitions	**No.**	**32**	**38**	**26**	**36**	**18**	**150**
	Value	$164	$208	$168	$230	$151	$921

TABLE 5.2-12 NUMBER AND PURCHASE VALUE OF PLANNED MAJOR ACQUISITIONS BY PROGRAM AREA
(DOLLARS IN MILLIONS)

5.2.3.3 Planned Departmental Capacity Versus Programmatic Requirements

As discussed in subsection 5.2.2.1, programmatic requirements for computing resources will increase by more than 3.6 times between FY 1990 and FY 1995. To meet this growth in demand, the Department has developed plans, as described in this subsection, for the acquisition of 150 major items of ADP equipment (108 computer acquisitions and upgrades, and 42 enhancements to computer systems) over the planning period. These acquisitions will significantly increase installed Departmental computing capacity from 9.7 million NSUs to 41 million NSUs during the planning period.

5.3 TELECOMMUNICATIONS

This subsection presents the various telecommunications services, equipment, and media used within the Department to distribute the vast amounts of information generated by people and computers in support of program missions. Described are the sophisticated systems, networks, equipment, and schemes that are in place or planned at all major facilities to provide the support required by the dynamic user community of DOE. These resources provide connectivity within the agency as well as access to worldwide networks for shared information and technology.

Telecommunications resources include routine administrative telephone systems as well as sophisticated high-speed data transport networks that connect the numerous facilities located throughout the United States. Due to the nature of the DOE activities, facilities are very often remotely located. Overcoming these geographic barriers, dealing with the ever changing regulatory and standards environment, and achieving the technological proficiency required to accomplish the Department's missions require a cooperative effort by both the Headquarters and field telecommunications managers. Therefore, Headquarters and field telecommunications managers are working together to plan and implement efficient top-down strategies that will establish short-, mid-, and long-term goals for their communications support activities and initiatives. These strategies support DOE management goals as well as the specific goals of the facilities.

Two basic and ongoing activities support these strategies. First is the constant evaluation of existing circuitry and service arrangements which produces numerous opportunities to contain costs and improve operational efficiency. This includes common use of the satellite backbone transmission system, shared-use T-1 collector facilities to eliminate the proliferation of multi-DOE communications links between similar locations, integration and consolidation of site services, and conversion to least-cost service offerings. Second is the use of the competitive procurement process to acquire services and equipment. Improved technology at lower cost is stimulated by this process; and, since more sophisticated telecommunications capability will be required to support high-level computer processing over the 5-year planning period, DOE will continue to pursue this course of action to take advantage of increased competition in the marketplace and technological advances, both locally and through nationwide policy initiatives.

The 5-year total resource estimate for telecommunications is $1.52 billion. This amount includes resources necessary to carry out continuing telecommunications support functions as well as planned telecommunications initiatives. Telecommunications resources remain fairly constant over the planning period; however, when compared to the total estimated resources for ITR over the period, they progressively decline from 25 percent of the total in FY 1991 to 20 percent of the total in FY 1995. In addition, telecommunications services will be used to save money or avoid costs in many other areas within DOE, such as protecting the Government's investment in facilities, technology, research, and other ITR. Some other examples follow.

- o High-speed access and retrieval of shared Government and public information has reduced the data storage burden at individual facilities.

- o Audio and video conferencing is reducing travel and training costs. Time lost while travelling is also being eliminated with these services.

- o Transmitting data between computer systems and images via communications equipment, such as facsimile machines, reduces shipping and mailing costs. It also eliminates time lost waiting for the information to be delivered.

With proper planning and effective management, DOE telecommunications will continue to provide required support as well as introduce new savings opportunities.

The economy and environment of areas surrounding DOE installations are also benefiting from telecommunications activities and support. Being in touch with the needs and concerns of surrounding communities is a commitment of all DOE facilities. To illustrate, spectrum resources at the Bonneville Power Administration are being used to provide assistance to the local fishing industry to help determine the cause for lower salmon fishing harvests since the building of the Bonneville Dam. The local industry is tagging fish in the hatcheries and monitoring the migration patterns to determine where the losses are occurring in their routes up the Columbia River. Through this effort, the environment will be preserved and enhanced. In addition, the fishing industry, which is one of the primary sources of revenue to the communities along the Columbia, will benefit from this increased yield and flourish once again.

5.3.1 Profile of Departmental Telecommunications Resources

Three basic functional areas provide telecommunications within the Department. These are voice communications, data communications, and frequency spectrum-dependent communications. The three areas account for more than 93 percent of the total telecommunications resource estimate. During the FY 1991 through FY 1995 planning period, voice services will account for slightly more than half (51 percent) of all DOE projected telecommunications resource expenditures, while data communications will account for 32 percent. However, this picture of percentages is becoming more clouded due primarily to integration of voice and data communications activities through shared digital switching systems and cable plants. Eighteen facilities reported major initiatives for integrated voice/data systems during the planning period with most of these being reported as voice communications initiatives. Therefore, the percentage stated for voice communications may be somewhat overstated.

Resources for spectrum-dependent communications are approximately 10 percent of the total planned telecommunications resources, and the remaining 7 percent includes resource estimates for teleconferencing activities; COMSEC devices, systems, and facilities that provide for the protection of telecommunications; and systems and services that support the NSEP Program. The following figure presents the above discussion graphically.

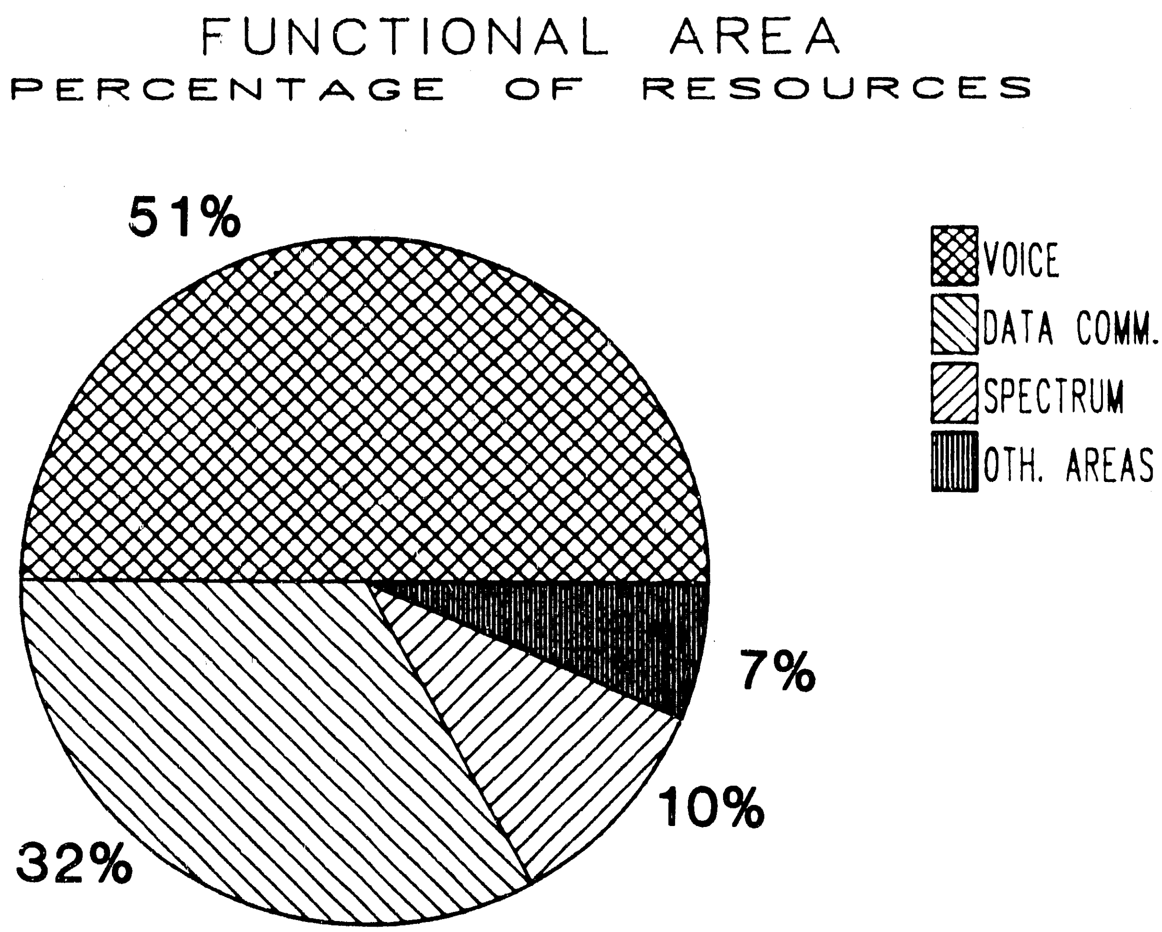


FIGURE 5.3-1 FUNCTIONAL AREA PERCENTAGE OF RESOURCES

The following subsections present a synopsis of telecommunications activities within each of the main functional areas.

5.3.1.1 <u>Voice Communications Services</u>

Voice services within the Department essentially encompass the provision of administrative telephone service to employees and direct support contractor organizations at Headquarters and field organizations. This service is for conducting Government business on a continuing basis. Voice services are considered to be primarily administrative in nature as the telephone continues to be an essential tool in all activities connected with day-to-day handling of routine, as well as mission-oriented, functions.

The Headquarters and field locations are served by Departmental voice systems that range in size from 40 lines to more than 20,000. The escalating costs for providing even routine basic service since deregulation has forced DOE facilities to conduct studies and identify alternative solutions to the traditional common-carrier telephone services. Substantial savings have resulted from these studies and subsequent actions.

The availability of digital switching equipment has provided the telecommunications managers with a valuable resource for dealing with the dual effects of the deregulated world and the increasing demands for data services. The new generation machines are superior for voice handling and can use existing twisted-pair cable systems. They offer high reliability with a guaranteed access configuration. At speeds up to 64 Kbps, they offer equivalent capabilities of dedicated broadband local area networks and have a lower attachment cost.

Consolidation of services and cost control are being accomplished through acquisition of onsite switching, cabling, and equipment facilities; renegotiation of fixed price leasing arrangements; and, on a limited basis, diversion of long distance offnet telephone calling to competitively acquired commercial service. In the case of the latter strategy, short-term arrangements have been negotiated pending the full implementation of the FTS 2000 program.

Major Accomplishments in the Voice Communications Area

Major Departmental accomplishments in this area as well as some representative site accomplishments are summarized below.

- FTS 2000 Network Activities:

  - Intensive support has been provided to the General Services Administration (GSA) acquisition of the FTS 2000 Network. Representation has been supplied to the FTS Interagency Management Council, its various subcommittees, the FTS 2000 Advisory Committee, and the FTS 2000 Source Evaluation Board.

  - The contract, awarded to American Telephone & Telegraph (AT&T) and U.S. Sprint, will reduce FTS per minute costs from approximately 40 cents per minute to between 15 and 20 cents per minute. The potential savings to DOE could be $20 million annually.

  - An FTS 2000 Coordinator and Designated Agency Representative to manage the DOE-wide transition to the new network was appointed.

- The Off-Net FTS Program was completed in 1988 and reduced the DOE FTS bill by approximately $13 million. This was a 33 percent reduction. The net savings to DOE, after paying the commercial vendor for the toll service, was $6 million annually.

- Department of Energy Nationwide Telecommunications Service (DOENTS) satellite network voice-related activities:

  - Voice services were converted from analog to digital.

  - The Call Ticketing System was enhanced to provide near real-time call detail data for voice calls. This improved troubleshooting and system management capabilities.

  - Network Number Exchange routing was implemented to provide the capability to route calls to particular trunk groups based on the first three digits of the number dialed. This permits the DOENTS satellite system to connect to the three different telephone systems at Albuquerque, Los Alamos National Laboratory, and Kirtland Air Force Base.

- Technical assistance and guidance was provided by Headquarters to field activities in the procurement of new telecommunications systems. With assistance provided through the Telecommunications Improvement Program (TIP) over the past year, 13 Operations Offices and field locations have competitively acquired, or are in the process of acquiring, telecommunications services. Economic analysis assistance was also provided to the Oak Ridge, Richland, and Savannah River Operations Offices, Lawrence Livermore National Laboratory, and Los Alamos National Laboratory. Based on a 10-year life cycle, a cost avoidance of approximately 40 percent is anticipated from telecommunications systems procured competitively compared to telephone company Centrex type service.

- A DOE Notice was developed to establish policy and provide guidance to all DOE activities regarding control of costs associated with cellular telephone use in privately-owned vehicles.

- At Idaho National Engineering Laboratory, the installation and cutover of the INEL Communications System (ICS) was successfully completed during the past year. This new system, in conjunction with the Fiber Transmission Network (FTN) at the site, will now provide increased high-speed data communications capability. Access to worldwide networks supporting mail systems and high-speed interactive connection to a variety of host computers is now possible, including: Because It's Time Network (BITNET) and National Science Foundation Network (NSFNET). A more detailed description of this system and a supporting diagram appear in Section 5.3.2.4.

- The Mound Facility anticipates that their current telephone system can support their facility's needs until FY 1994. Until that time, retrofitting and enhancing the current system will continue in order to provide new services for the Mound user community. One recently implemented enhancement was the installation of a new Telephone Answering, Messaging, and Information system, which was successfully pilot tested and placed into operation. The system serves more than 650 employees and provides telephone answering, messaging, information services, and the capability to interface to transaction processing systems.

Voice Communications Resources

Summarized in Table 5.3-1 are planned telecommunications resource estimates for voice communications services over the planning period. The total resources planned in this functional area over the 5-year period increased from the $749 million reported in the FY 1990 plan to $766 million this year. This increase is reflected almost entirely in the planned operating costs category. Planned operating costs for the 5-year period, which total approximately $180 million, have risen by nearly $24 million over last year's planned resources, which was $156 million. This is a result of planned system implementation over the period with resulting onsite operations and maintenance. This represents a significant change in the allocation of voice communications resources and a trend that will continue in the future as more planned systems and system enhancements become operational.

Commercial services also had a dynamic increase. The more than $46 million increase planned for the period reflects planned commercial leasing agreements for equipment and services. This planned increase is offset, however, by planned interagency costs decreasing by more than $45 million for the period.

EXPENDITURE CATEGORY	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	TOTAL
Capital Investments	$ 12,207	$ 16,227	$ 22,046	$ 23,261	$ 18,075	$ 91,816
Government Personnel	1,451	1,484	1,509	1,638	1,778	7,860
Operating Costs	37,954	38,320	38,866	36,613	28,010	179,763
Commercial Services	64,570	67,378	67,738	63,214	64,135	327,035
Interagency Services	31,193	30,500	31,215	32,852	33,370	159,130
TOTAL	$147,375	$153,909	$161,374	$157,578	$145,368	$765,604

TABLE 5.3-1 VOICE COMMUNICATIONS RESOURCE ESTIMATES (IN THOUSANDS)

Figure 5.3-2 graphically displays these planned resources and illustrates resources planned by expenditure category for each year.

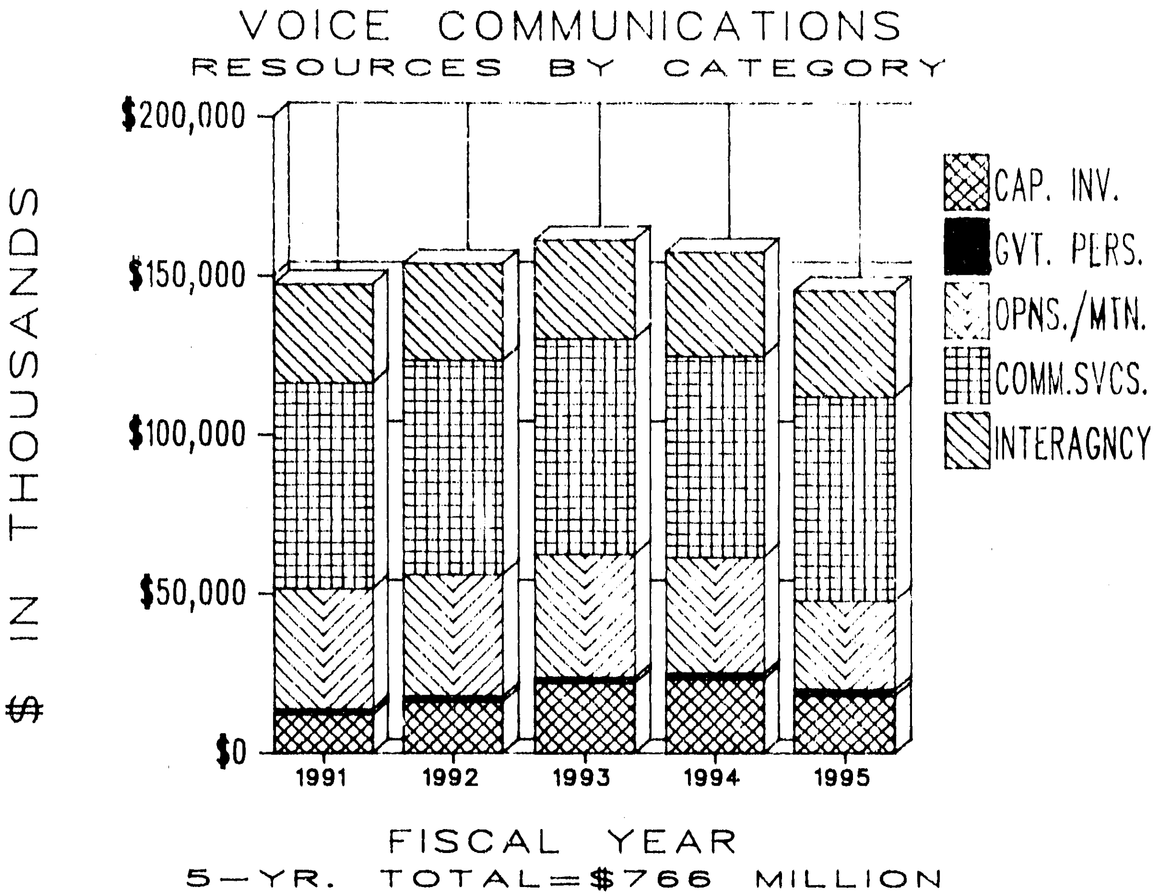


FIGURE 5.3-2 VOICE COMMUNICATIONS RESOURCES

Major Voice Communications Acquisitions

The budget tightening process has shown its impact on planned initiatives. In some cases, already planned initiatives have been deferred until outyears, and in others, requirements are being restudied to determine priority ranking for new or expanded services. To illustrate, in last year's planning for the FY 1991 timeframe, an estimate of $35 million was planned for capital investments associated with the voice communications area. Reporting estimates for the FY 1991 timeframe submitted with this year's site plans decreased to $12 million, with the bulk of the difference being spread to the outyears.

Twenty-two major voice communications acquisitions are planned during the 5-year period. An obligation profile of these acquisitions, along with descriptions, are presented in this subsection. These acquisitions account for 42 percent of the $766 million reported in this functional area. Figure 5.3-3 illustrates the resources forecasted for major voice communications acquisitions.

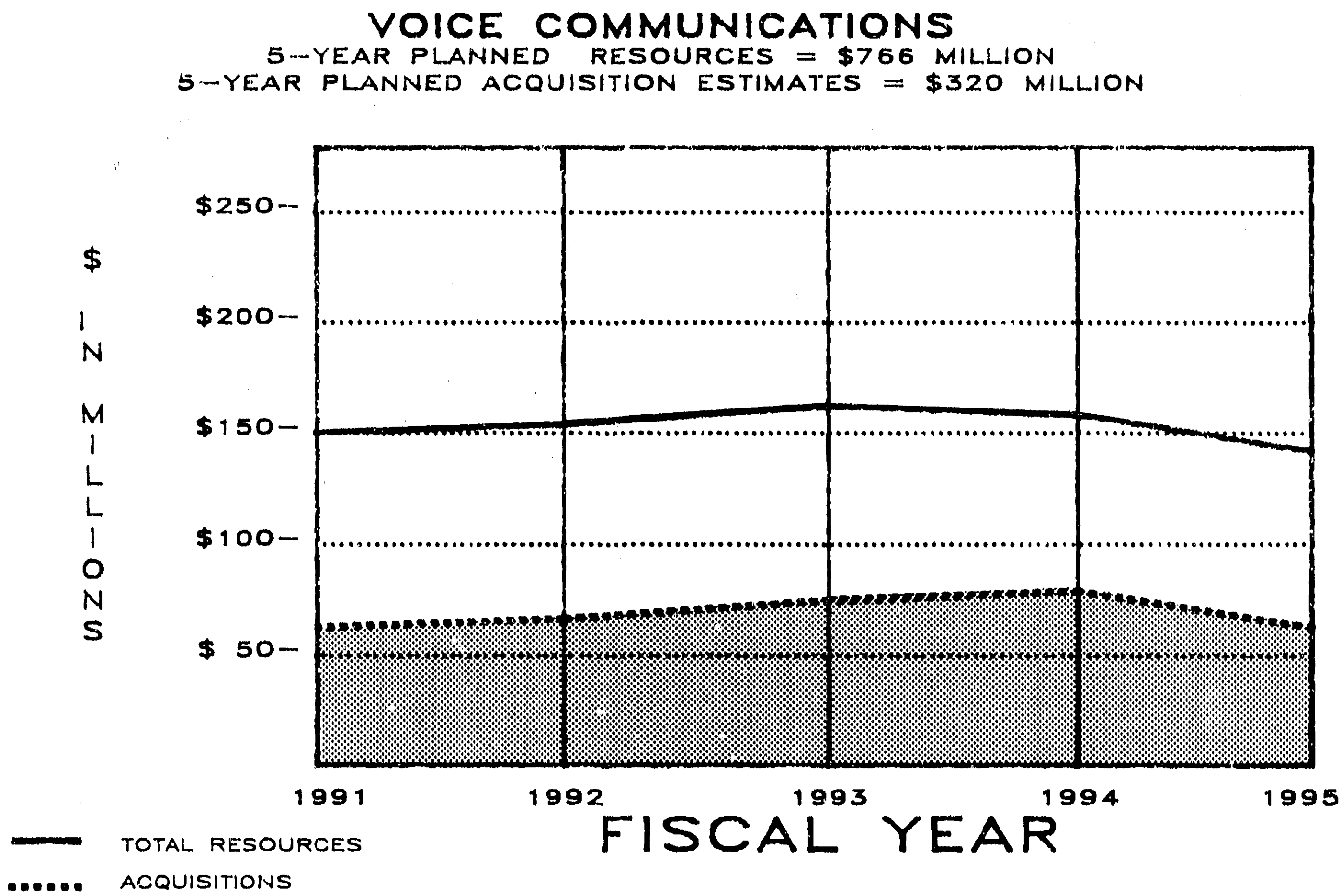


FIGURE 5.3-3 PLANNED MAJOR VOICE COMMUNICATIONS ACQUISITIONS

lbuquerque Sites

Electronically Supervised Plant Emergency Notification System - The Kansas City Plant will install an Underwriters Laboratory (UL) listed electronically supervised plant emergency notification system. The current system is not electronically supervised nor is it UL listed for fire alarm indicating applications. Planned 5-year resources = $6.3 million.

Los Alamos Integrated Communications System (LAICS) - The LAICS acquisition will provide switched and dedicated voice, data, and imagery teleservices over common high-speed fiber-optic transmission facilities. LAICS will increase user productivity and reduce per-unit service costs through advanced technology. Onsite switching will provide improved security, management, and control. Planned 5-year resources = $45.2 million.

Digital Telephone System - Mound will replace the Dimension 2000 PBX currently in use with a new system. It will be an all digital switch supporting both voice and unclassified data requirements. The replacement is required due to lack of maintenance support capability. Planned 5-year resources = $8.3 million.

Integrated Systems Digital Network (ISDN)-Compatible Digital Private Branch Exchange (PBX) - The Pantex Plant will acquire an ISDN-compatible digital PBX and the necessary cable upgrade to support it. The system will replace the Dimension 2000 PBX, which has become obsolete. Planned 5-year resources = $2.6 million.

ISDN-Compatible Digital PBX - At Rocky Flats Plant, an ISDN-compatible digital PBX, handling 5,000 individual lines and 200 trunk lines, was acquired. The new PBX replaced an obsolete analog PBX. The new system provides digital switching capabilities, additional voice capacity, and new capabilities for managing both voice and data communications. Planned 5-year resources = $3.3 million.

Replacement for Life Safety/Disaster Warning System - The scope of this project at the Rocky Flats Plant involves replacing all equipment associated with the Production Annunciation Utilities and providing for segregated critical alarm systems in fissile material handling buildings. The project is needed to ensure a reliable, functioning system for broadcasting alarms and disseminating emergency and production-related information to plant personnel. Planned 5-year resources = $21.8 million.

Voice and Open Data-Switching System - Sandia National Laboratories, Albuquerque (SNLA) will install this system with a capacity of 12,000 voice and 4,000 data lines. Included in this project is the rerouting and rehoming of interbuilding cable to the locations of the switches. Planned 5-year resources = $11.0 million.

Voice Cable System - SNLA will install a Voice Cable System that will replace the existing system. The new system will use fiber-optic and twisted-pair cables in a new duct system. The present system, which is 20-40 years old, is inadequate for transmission of voice and open data between and within buildings and does not meet current SNLA and national standards. It also does not have the capacity to handle the current traffic requirements. Planned 5-year resources = $6.0 million.

Chicago Sites

Digital PBX - A digital PBX was acquired in September 1987, at Argonne National Laboratory, through a 10-year lease-to-purchase initiative. The system was installed by Bell Atlanticom and includes a digital switch, new wire and cable plant, and all station equipment other than single line telephones previously purchased from AT&T. The system provides switched data communications up to 56 Kbps. The resources shown below indicate estimated lease costs for the current planning period. Planned 5-year resources = $9.5 million.

ISDN-Capable Switch - An ISDN-capable switch with 4,500 lines and 168 trunks is planned at Brookhaven National Laboratory to replace the current switch, which will be more than 10 years old chronologically and 12 years old technologically when it is replaced in FY 1991. This initiative supports migration to ISDN capability. Planned 5-Year resources = $1.9 million.

Digital Voice/Data PBX - A digital voice/data PBX will be procured by Fermi National Laboratory through a lease-with-option-to-purchase initiative over a 10-year period. Planned 5-year resources = $1.5 million.

Digital Switching Telephone System - At the Princeton Plasma Physics Laboratory, a system that will cut over with 2,000 lines and a capacity for 4,000 lines is planned. It will replace the current Centrex III service. The system will have stored program control. The contract will be a 5-year lease-to-purchase agreement. Planned 5-year resources = $2.8 million.

Oak Ridge Sites

Oak Ridge Operations Integrated Communications Network (ORO-ICN) - The ORO-ICN is planned for the Oak Ridge Complex. Procurement will be through a lease-with-option-to-purchase contract. It will provide unclassified voice and data communications on-premises switching and will include a complete new cable plant and telecommunications management system. Planned 5-year resources = $23.0 million.

Telephone Cable System Procurement - The Portsmouth Gaseous Diffusion Plant will procure the cable system which is now leased from General Telephone Company. This is the first step at deregulated telephone service for the facility and will allow more flexibility in assignment and control of the network. Planned 5-year resources = $1.8 million.

Integrated Cable Plant and PBX - At the Westinghouse Materials Company of Ohio site, a new integrated cable plant and PBX to support sitewide voice and data communications requirements will be installed. The rapid growth in data communications requirements has exceeded the capacity of the present cable plant, which was installed in the 1950s. Planned 5-year resources = $3.0 million.

Power Marketing Administration

Private Branch Exchange (PBX) - A 1,200-line PBX system for voice and data communications is planned at the Western Area Power Administration. The facility will be relocating in FY 1990 and will no longer share a telephone system with the Solar Energy Research Institute. Planned 5-year resources = $0.9 million.

Richland Sites

Integrated Voice/Data Telephone System (IVDTS) - A new telephone system is planned for the Hanford Complex that will support voice and data communications. The planned FY 1991 installation would result in a termination liability charge in the amount of $7.5 million, which is included in the resources shown. If installation occurs after FY 1991, this amount would be reduced. Planned 5-year resources = $31.9 million.

San Francisco Sites

Integrated Communications System (ICS) - Purchase and installation of the ICS is a current initiative at Lawrence Berkeley Laboratory. This system will support voice and data communications and is based upon an Intecom IBX S/80 PBX. The system will be acquired under a 7-year lease-to-purchase subcontract. Installation is now in progress. Planned 5-year resources = $7.8 million.

Livermore Laboratories Information Exchange (LLIX) - The current Lawrence Livermore National Laboratory/Sandia National Laboratories, Livermore (LLNL/SNLL) Centrex system is to be replaced by a multiple node, digital PBX system capable of handling current and anticipated traffic levels. Both circuit-switched services and high-speed packet-switched services are to be provided. The system will utilize new interbuilding and intrabuilding wiring services. Acquisition is by lease-to-purchase contract. Planned 5-year resources = $82.2 million.

Savannah River Sites

Telecommunications Services - At the Savannah River Plant, telecommunications services will be competitively acquired through a lease-to-ownership arrangement. The scope will include replacement of 11 exchanges and installation of a new exchange, intercommunicating through a fiber optic network with route diversity. Planned 5-year resources = $47.5 million.

Other Facilities

Digital PBX - A digital PBX is planned at the Morgantown Energy Technology Center that will reduce lease line and equipment costs. The site will obtain greater control of equipment features and combine voice and data systems. Planned 5-year resources = $0.9 million.

Naval Reactors Facility (NRF) Intrasite Telephone System - At the Bettis Atomic Power Laboratory, existing wiring for the NRF intrasite telephone system will be replaced and capacity added. In addition, telephone handsets will be replaced with those capable of using new features. Both handsets and wiring at NRF are no longer capable of providing sufficient voice service for NRF operations. Planned 5-year resources = $0.7 million.

5.3.1.2 Data Communications Services

The service philosophy of the Department dictates that information will be shared as a corporate resource to the extent security and policy will allow. Accumulating, storing, transferring, retrieving, consolidating, and processing the huge volume of energy information available to DOE sites requires many sophisticated methods of data communications to fulfill the intricate and complex requirements of the ADP community.

The goals of the Department in the data communications area for the FY 1991 through FY 1995 period are as follow:

- o Support the goal of end-to-end digital connectivity in the manner most reliable and cost effective.
- o Improve the Departmental ability to acquire expeditiously, and on a competitive basis, data communications services as the needs arise.
- o Ensure interconnectivity and compatibility between networks and equipment, optimal sizing of networks, and system redundancy.

Energy data is made available to the facilities through a variety of transport media from coaxial cabling to satellite transmission. Systems and networks that carry the burden of transporting this multitude of information are developed at each facility based on their individual data communications needs. Basic requirements of these systems are that they be technically sound, flexible, supportable, upgradeable, and capable of responding to changing program or facilit requirements.

Adoption of standards such as Fiber Distributed Data Interface (FDDI), and concepts such as the Government Open Systems Interconnection Profile (GOSIP), ensure the ability of all DOE computer systems to speak a common language. This, in turn, allows a free flow of information driven entirely by users needs, eliminating the need to solve protocol problems on the communications networks.

The two major technologies currently having the most influence on data communications are fiber optics and satellite. Fiber optics is being widely implemented in the commercial sector and is expected to replace much of the copper and, to an extent, microwave radio services. It offers broad bandwidth, small size, immunity from electromagnetic and radio interference, and an inherent degree of security. Major advances in this area forecast improved traffic flow capability, lower costs, and wider area coverage. However, its traffic concentration makes services vulnerable to interruptions.

The availability of satellite technology with its wide band access provides an alternative to the terrestrial-based facilities. Therefore, satellite services will continue to be a valuable resource due to its high reliability, particularly during times of emergency or system stress.

Major Accomplishments in Data Communications Area

Major Departmental accomplishments in this area as well as some representative site accomplishments are summarized below.

- For DOENTS, enhancements were accomplished that provided greater capacity and connectivity. More cost-effective solutions for high-speed data and video teleconferencing requirements are now permitted as well.
  - The satellite network was upgraded to 60 Mbps.
  - New high capacity trunks for the Eastern Area T-1 Network were accepted for service in July.
  - Implementation of an Eastern Area T-1 Network between the Savannah River and Oak Ridge Operations Offices and Germantown began.
  - In the Western Area T-1 Network, high-capacity terrestrial trunks were upgraded by having AT&T provide the same basic timing used throughout the entire AT&T network. This makes the Western Area T-1 fully compatible with commercial networks.
  - Two 2.048 Mbps circuits were implemented on the DOENTS satellite network for open computer-to-computer communications between the Sandia National Laboratories.
  - Usage-based billing to DOENTS satellite locations was implemented October 1, 1989.
- For GOSIP:
  - The DOE GOSIP Migration Working Group was established to develop a strategy for implementing GOSIP within DOE.
  - A plan/program for integrating GOSIP into DOE's networking efforts was developed.
  - Designation as the DOE telecommunications addressing authority for GOSIP was obtained.
- For the Secure Automatic Communications Network (SACNET) Replacement Project:
  - The SACNET Switch Replacement System design document was completed. This document describes in detail how the replacement system is to perform. It is being used during the implementation phases to ensure that the system will function as required.
  - The SACNET Replacement Terminals (SRTs) were implemented on the SACNET System. This has improved reliability and reduced operating costs for the system. A savings of $200K was realized in FY 1989 and projected annual savings of $400K are anticipated.

- A SACNET Users meeting was held to discuss various issues regarding the SRT, crypto replacement, teletypewriter replacement, and switch replacement.

- Training classes on the SRT were given for field office personnel.

- o Communications for the Nuclear Energy nationwide electronic mail and data communications requirements were implemented.

- o A strategy for the integration of DOE's electronic mail requirements and systems was developed.

- o The TYMNET connection was expanded at Headquarters in Germantown, MD, to handle the increased traffic from the field.

- o A secure circuit between a Defense Programs user in Germantown, MD, and the Albuquerque Operations Office was established for a classified application.

- o The data communications required to serve the Central Personnel Clearance Index (CPCI) and PAY/PERS requirements were completed. This entailed various TYMNET options available for field site network access to CPCI and PAY/PERS on the Headquarters host system.

- o At Lawrence Berkeley Laboratory (LBL), Ethernet bridges have allowed partitioning of the LBL Network (LBLnet) into a collection of interconnected subnets. More than 500 systems are now interconnected through this complex of LANs using three major network protocol families. Connection to LBLnet also provides access to several external networks. The demand for increased capacity and interconnectivity is fueled by a shift to the use of single-user workstations supported by file servers as well as by the expansion in the number of workstations. LBLnet has also started the transition from being a totally bridged network to being a routed network of subnets. This has been necessitated by a growth in Internet nodes beyond the capacity of a single subnet, and the need to isolate broadcast traffic by establishing smaller subnetworks. The first router was installed during the past fiscal year. In addition to Ethernet-to-Ethernet routing, LBL has also begun the installation of Kinetics *Fastpath* routers to effect the connection of Macintosh AppleTalk Twisted-pair networks to the LBLnet. More than 20 of these routers were installed. A more detailed description of LBLnet with a graphic illustration is found in Section 5.3.2.4.

- o At the Pinellas Plant, a pilot program was initiated using a software package called ISTAR. This software allows DEC Ethernet interfaces to communicate with Ungermann-Bass devices over the LAN using XNS protocol. ISTAR supports Ungermann-Bass terminal servers and also allows the VAX computer to be a resource and file server to PCs. This project overcame limitations identified during the implementation of the pilot project for PC NETwork Services.

A pilot project using TCP/IP protocol was also conducted that allowed SUN/UNIX workstations, PCs, and VAX hosts to communicate using various TCP/IP user-level services. This project was initiated as a result of requirements to provide network services, such as file transfer and terminal emulation, in a multi-vendor environment.

Data Communications Resources

The increasing demand for faster, more sophisticated data communications support by a steadily increasing user population is evident this reporting period. Plans for installing, expanding, and upgrading resources used to support this steadily growing area are discussed in nearly every site plan.

Summarized in Table 5.3-2 are planned telecommunications resource estimates for data communications services over the 5-year planning period. These planned resources represent 32 percent of the total planned telecommunications expenditures of the Department, or $493 million. Cost projections for data communications show a more significant increase than any other functional area, with a projected increase of 21 percent over the $406 million reported in last year's plan. The increased costs are spread fairly evenly over the period, with about $20 million per year being added to last year's estimates. The rise in costs is basically due to increased leasing costs for equipment and telecommunications services along with a parallel rise in costs for operations and maintenance of leased systems.

Planned resources for access to wide area networks (WANs) will continue as sites upgrade service to achieve higher transmission rates required for scientific, research, and development activities. A significant increase is also shown in the area of system design and engineering, which would be expected with such a dynamic environment. Another area showing an increase is planned resources for Government personnel. Approximately 12 workyears have been added each year in this area.

EXPENDITURE CATEGORY	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	TOTAL
Capital Investments	$ 37,153	$ 45,382	$ 43,978	$ 33,456	$ 27,572	$187,541
Government Personnel	3,682	3,906	4,148	4,357	4,544	20,637
Operating Costs	17,422	17,440	18,186	18,108	18,293	89,749
Commercial Services	31,083	32,194	34,233	34,909	34,847	167,266
Interagency Services	4,550	4,991	5,523	6,058	6,599	27,721
TOTAL	$ 93,890	$104,213	$106,068	$ 96,888	$ 91,855	$492,914

TABLE 5.3-2 DATA COMMUNICATIONS RESOURCE ESTIMATES (IN THOUSANDS)

Figure 5.3-4 graphically displays these planned resources and illustrates resources planned by expenditure category for each year.

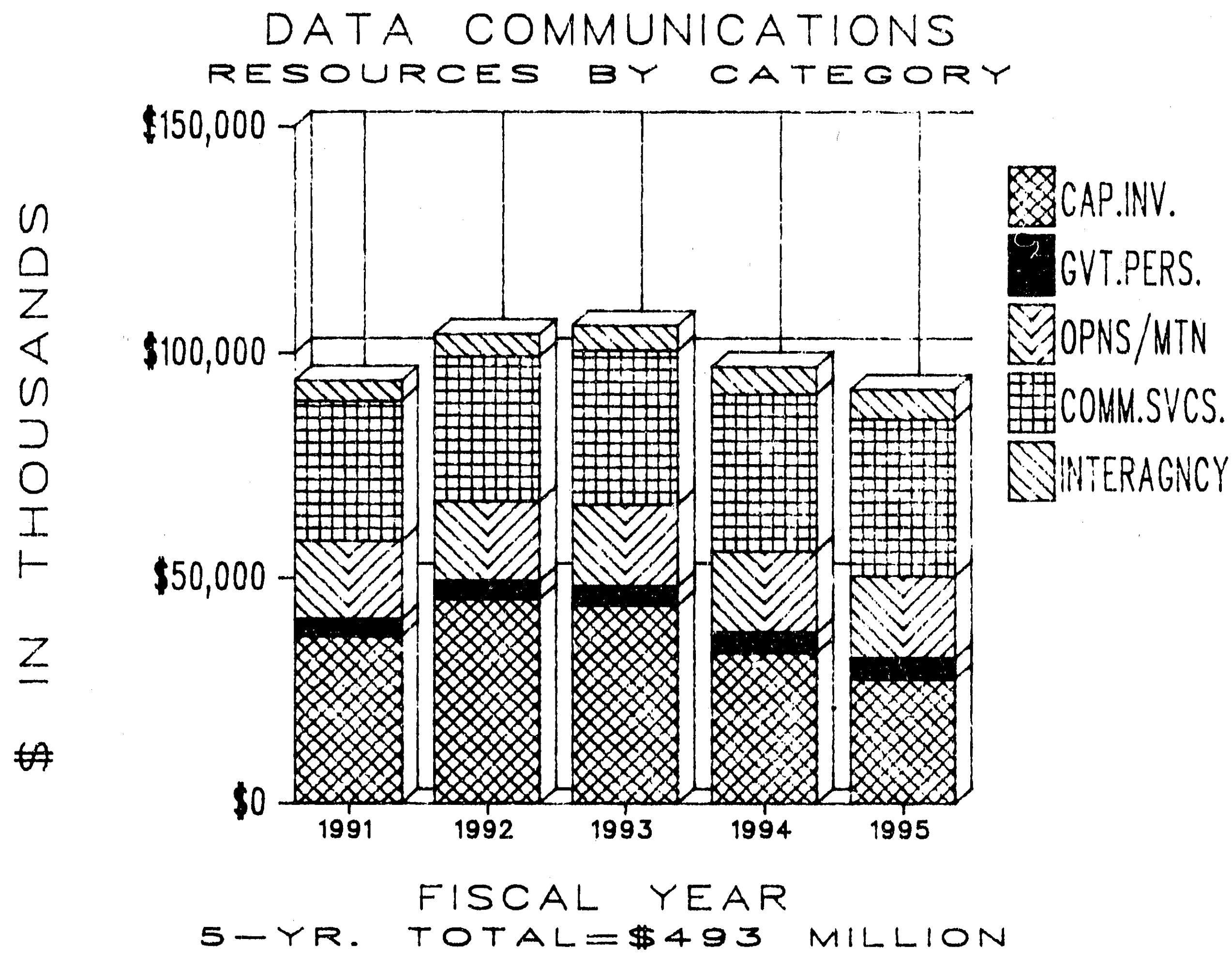


FIGURE 5.3-4 DATA COMMUNICATIONS RESOURCES

Major Data Communications Acquisitions

Twenty-seven acquisitions, amounting to $134 million, are planned in this area. This amount represents 27 percent of all planned data communications resources for the period. There has been no significant increase in planned major initiatives from last year's reporting. An obligation profile of these acquisitions, along with descriptions, are presented in this subsection. Figure 5.3-5 illustrates the resources forecasted for major acquisitions in this area.

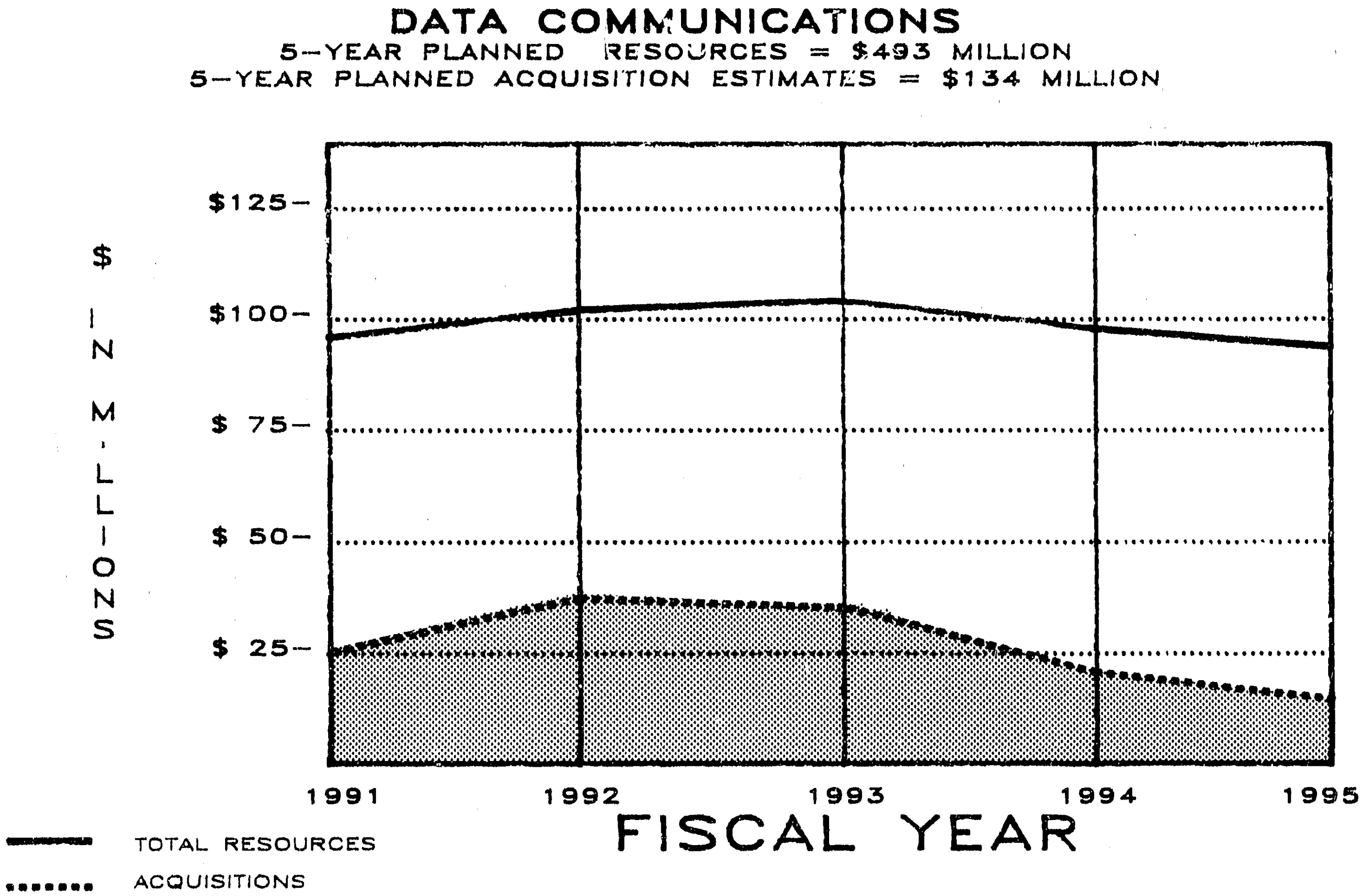


FIGURE 5.3-5 PLANNED MAJOR DATA COMMUNICATIONS ACQUISITIONS

Albuquerque Sites

Field Direct Digital Control (DDC) Microprocessing Units - At the Kansas City Plant, a new central minicomputer control system will be acquired. Two hundred and twenty field DDC microprocessing units will be installed on the existing air handling units. The new central control system will be computer-based to provide task flexibility and accurate control strategies. The existing control system is not capable of providing increasingly critical control strategies required by production departments. The central control system will monitor substation and main switchgear for plant project design. Planned 5-year resources = $4.1 million.

Multi-Use Distribution System (MDS) - The Kansas City Plant MDS will create a plantwide fiber-optic and twisted-pair communications utility. It will be used principally for data communications but will be made available for voice, video, fire, safety, and security alarms. MDS will provide quick, convenient access to a variety of protocols, reducing the average wait for new service from approximately 1 year to 2 working days. It will also simplify system maintenance and restoration. Planned 5-Year resources = $2.8 million.

Government Open System Interconnection Profile (GOSIP) Migration GOSIP will require technical and administrative training and support for DOE-wide facilities to maximize GOSIP benefits and minimize costs and delays. GOSIP will link existing incompatible networks with standard hardware and software modules. This will provide the capability to perform rigorous control testing and certification of purchased vendor standards components as requested by the DOE. Planned 5-year resources = $2.2 million.

GOSIP-Based Standard Communication Network - Kansas City Plant will be migrating to a GOSIP-based standard communications network to increase efficiency in data sharing between existing isolated networks. This will result in a reduction of delays and data management costs for weapons production. GOSIP vendor-supplied components will increase the flow of automation and data management in the focused electronic factory and support other initiatives requiring more efficient data communication. Planned 5-year resources = $1.8 million.

Mound Local Area Network (MOLAN) Enhancements - The MOLAN, which was installed at the Mound Facility in FY 1986, is a combination of broadband and baseband technologies. Additional buildings have been added to the network yearly. The network provides a broad range of communications options and end user services for Mound. Terminal-to-computer connections can be accomplished using MOLAN at a considerable savings over conventional point-to-point methods. It also provides greatly enhanced connectivity. Planned 5-year resources = $1.3 million.

Security Enhancement - At the Pantex Plant, new data cabling and fiber optics systems will be installed with appropriate field interface devices and multiplexers to provide data and video communications to the primary and secondary security alarm centers. Increased interest in security necessitates more sophisticated systems to enhance the Plant's security posture. Planned 5-year resources = $6.3 million.

Pantex Fire Protection Upgrade Project - This upgrade project will replace all buried and in-ramp data transmission cabling and associated hardware. A Class "A" loop configuration in critical areas will provide solid state digital transmission methods to be incorporated. Much of the system is not arranged in a physical class "A" loop; therefore, it is very vulnerable to accidental cutting or damage beyond use due to storms, fire, or other incident. Also, present systems do not have the capacity recommended by the plant's Fire Protection Engineer. During the design phase, fiber optics may be investigated. Planned 5-Year resources = $1.3 million.

Local Area Network (LAN) - This equipment, being procured at the Rocky Flats Plant, is an expansion of the plantwide LAN. It is an augmentation of the present protected distribution system (PDS) wireline. The LAN provides end-user connection to computer resources, processor-to-processor communications for interbuilding applications, and video distribution. This project represents expansion of the LAN services to support applications such as CIM, material requirements planning (MRP), and other weapons program applications requiring access to computer resources and information distribution facilities. Planned 5-year resources = $4.7 million.

Data Collection Network (DCN) - The plantwide DCN at the Rocky Flats Plant supports multiple applications for gathering data from the shop floor. The network will handle routing of transactions to appropriate computer hosts for processing and queuing of transactions for resources that are overloaded or inoperative. Planned 5-year resources = $2.3 million.

Personnel Access Control System (PACS) - At the Rocky Flats Plant, PACS consists of a dedicated host computer connected to Distributed Access Control System (DACS) minicomputers. The system is an online interactive system connected via the LAN and telephone lines to remote locations. PACS is being installed to improve control over people and materials entering or leaving the Plant. Improved control is required to meet directives for controlling access to critical materials and to enhance personnel health, safety, and security. Planned 5-year resources = $17.2 million.

Data Acquisition System - This system provides instrumentation, data collection, and data processing equipment and software for more effective operation of utilities at the Rocky Flats Plant. The system will allow better control of utilities equipment with constant online monitoring of operating perimeters. Planned 5-year resources = $4.4 million.

Open Data System - Installation of a digital data system in an open environment is planned at SNLA. The system includes an advanced digital data PBX, interbuilding fiber optic cable network, and intrabuilding cable and riser system. Planned 5-year resources = $8.5 million.

Area III/V Tech Control Center - This activity is a modification of the present tech control facility at SNLA to serve Tech Area III/V until the new facility is constructed in FY 1994. Planned 5-year resources = $1.7 million.

Installation of T-3 Link Between SNLA and SNLL - Installation of a T-3, 45 Mbps link between the two Sandia National Laboratories will connect supercomputers at both locations. The system includes bandwidth obtained from commercial carriers or DOENTS. Termination hardware is also included. Planned 5-year resources = $16.5 million.

Satellite Link - SNLA plans a satellite link using a small-aperture antenna between SNLA and the Tonopah Test Range to provide a 2.048 Mbps link for the transmission of secure CAD/CAM, secure data, and secure compressed video signals. High-capacity data links are required for data and video transmissions to support the test operations. An alternate routing capability is also required in case the DOE INTRANET facility fails. Planned 5-year resources = $9.0 million.

Chicago Sites

Site Wide Energy Management and Control System - Installation of this system in 11 buildings is planned at Brookhaven National Laboratory. The system optimizes operation of HVAC systems to conserve energy. Planned 5-year resources = $2.2 million.

Communications and Networking - Procurement of communications and networking items for additional installation of fiber-optic cable to experimental areas at Fermi National Laboratory is planned. This will expand the fiber optic communications backbone. Planned 5-year resources = $2.0 million.

Headquarters Sites

Secure Automatic Communications Network (SACNET) Upgrade - Headquarters will upgrade the secure communications network interconnecting 22 DOE field sites and the Headquarters. The replacement system is expected to recover initial costs within 4 years. Planned 5-year resources = $5.7 million.

Nevada Sites

Holmes and Narver Data System (HANDS) - HANDS is a wide area network consisting of interconnected Ethernet LANs in several geographical areas within Nevada. HANDS was developed to support the interconnection of all major Holmes and Narver computer systems and their associated peripherals by a technique which would allow a relatively simple migration to proposed GOSIP standards. Planned 5-year resources = $2.3 million.

Information Management System Bridge Program (IMSBP) - The IMSBP will link DOE/HQ with the Yucca Mountain Project. The link, supporting image retrieval purposes, is required since Office of Civilian Radioactive Waste Management and Office of Geologic Repository personnel will be early users of retrieval capabilities. Planned 5-year resources = $1.0 million.

Oak Ridge Sites

Fiber Optic Network - An intrasite fiber optic network serving the Y-12 Plant, Oak Ridge National Laboratory, and the Oak Ridge Gaseous Diffusion Plant is proposed for host-to-host, terminal-to-host, and point-to-point data services. The network will have provisions for future interconnections to the planned ORO-ICN. This network will provide higher speed data service, increased capacity, and intersite trunking capability. Planned 5-year resources = $3.0 million.

Richland Sites

Environmental and Molecular Sciences Laboratory (EMSL) Communications - High-speed data communications will be required among the computers and workstations in the EMSL to support about 200 scientists and engineers supporting the Richland Operations Office. Planned 5-year resources = $2.9 million.

Inter-Area Communication Network - At the Hanford Site, a 5-phase project to assure that all required buildings are wired for LAN communication is planned. The project is phased to permit changing program requirements and to eliminate some of the cabling work. Planned 5-year resources = $2.7 million.

Data Network Expansion Telecommunications Equipment - At the Hanford Site, central site data communications port upgrade, LAN expansion, and maintenance funding is used to maintain the data communications interface with the Hanford Site operating community. Multiplexers, modems, and packet address devices will be replaced or added to the system. Hyperchannel adapters have to be added or replaced. Planned 5-year resources = $2.0 million.

San Francisco Sites

Very High Speed Data Communications Project - This is a second phase prototyping effort at LLNL to investigate the applicability of circuit switch technology to the problem of very high speed data transfer. The proposal will initially provide a switch capable of switching 32 inputs at a data rate of 200 Mbps. The switch will be tied into the 800 Mbps Cray X-MP HSC channel of the LCC. Planned 5-year resources = $24.3 million.

Security and Safeguards System Upgrade - This is a set of actions at LLNL to upgrade the physical security systems, including the Secure Interactive Alarm Systems. The existing systems are obsolete and are not fault tolerant. In light of today's world situation, DOE is upgrading security at its weapons facilities. Planned 5-year resources = $1.0 million.

Other Sites

Pittsburgh Energy Technology Center (PETC) Onsite Communications Network - This network consists of multiplexed asynchronous lines and Ethernet segments providing data paths between buildings. The network handles all communication between users and computers as well as computer-to-computer data transfers. This initiative will provide communications capability to users who do not currently have communication to the Central Computer Facility nor access to the sitewide Ethernet. Planned 5-year resources = $1.0 million.

5.3.1.3 Frequency Spectrum-Dependent Communications

Spectrum-dependent services are defined as those services that involve the use of frequencies within the radio portion of the electromagnetic spectrum for both communications and noncommunications functions. DOE, with its multi-faceted role of research, development, production, protection, and distribution in the energy and weapons areas, is ranked seventh as a major user of these services in the Federal Government and is dependent upon radio systems to provide the required voice communications and data transmissions essential to mission accomplishment. Area coverage, terrain, and distances involved are all considerations that dictate the use of radio systems and networks within the Department.

Frequency spectrum-dependent activities are perhaps the most varied and vital of all DOE telecommunications services. Without exception, all major field sites depend upon radio-based communications links for administrative operations. Mobile, portable, and hand-held radio sets for security patrols, maintenance, testing, operations, and construction activities are in place at every major DOE location. Due to the nature of DOE programs, many of the larger facilities are remotely located and encompass large geographical areas. Since hardwiring of these facilities is not practical from either the technical or economic aspect, extensive microwave systems are employed to interconnect outlying areas for central control, voice/data communications, and environmental monitoring.

The Power Marketing Administrations are particularly dependent upon spectrum-based facilities for system monitoring and control. This includes not only microwave, but also power line carrier systems. These latter systems have served well for many years, but, unfortunately, have not been afforded the necessary interference protection that other Government spectrum allocations have employed. Therefore, migration to microwave technology is the strategy in this area.

With its statutory-mandated responsibilities for Nuclear Emergency Search Team (NEST) operations, the Radiological Assistance Program (RAP), and the transportation of Sensitive Nuclear Materials (SNM) with the support of the Secure Communications (SECOM) Network, DOE is vitally dependent upon spectrum allocations. Additionally, with the threat of hostile intervention with these programs and to physical locations, protection of critical radio links has become mandatory.

Congress and the Department of Commerce have recognized the need for the Federal Government to review its current policy for management and use of the radio frequency spectrum. Accordingly, Commerce initiated a program to assure that the public and private sectors are involved in this comprehensive review. In addition, Congress introduced in the House of Representatives the "Emerging Telecommunications Technologies Act of 1989," the purpose of which is to release 200 MHz of Federal Government spectrum resources for commercial assignment in order to promote the development and use of new telecommunications technologies, and to promote global marketplace requirements. An analysis is being performed on DOE's frequency spectrum use to assure that it represents the most effective and efficient use of these resources and to preclude loss of essential resources. In conjunction with this activity, the field sites have been advised to coordinate with local authorities to consolidate some of the public safety systems currently in use at the facilities. The Federal Communications Commission (FCC) has set aside 6 MHz in the 800 MHz band for regions to use for public safety.

Many sites are studying newer methods of operation. This is evidenced by the increased funds being set aside for system design and engineering in this area and the major initiatives presented to implement computer-controlled trunked radio systems. These systems will alleviate congestion and conserve the scarce frequency allocations available. The National Communications System (NCS) is currently developing a trunked radio standard which may impact planning in this area. Therefore, Headquarters is keeping sites advised of the progress of this development.

<u>Major Accomplishments in the Spectrum-Dependent Area</u>

Major Departmental accomplishments in this area, as well as some representative site accomplishments, are summarized below.

- Performance specifications for a new Frequency Management System (FMS) and Frequency Management Bulletin Board System were completed. Implementation and initial operational capability began in FY 1990 for both systems.

- A 3-day conference was sponsored to discuss mobile satellite service and to set the framework for economic and efficient satisfaction of required capabilities within the DOE. A wide variety of satellite-based requirements exist ranging from shipments of radioactive waste to supplementing Power Marketing Administration telecommunications.

- The application of new and emerging technology for spectrum-dependent programs was successfully promoted. National Telecommunications Information Administration (NTIA) spectrum certification was obtained for a new Albuquerque Operations Office $5 million trunked radio system.

- Spectrum-dependent programs were satisfied by processing 2,482 radio frequency assignment requests. Of these, 745 were for new radio systems. Nearly 54,000 requests from other agencies were reviewed and more than 1,600 Canadian requests were coordinated to ensure spectrum-compatible operation domestically and along the Canadian border.

- NTIA will finalize an agreement with the FCC for release of new radio spectrum to satisfy urgent requirements of the Power Marketing Administrations. This has already resulted in the receipt of approximately 350 requests from the Western Area Power Administration for new power system controls and monitoring capabilities.

- Active participation in the Interdepartment Radio Advisory Committee (IRAC) and the NCS Committee of Principals and Council of Representatives ensured that the DOE spectrum-dependent programs and NSEP requirements were presented, defended, and accommodated at the national level. This effort also included providing Departmental input to the NTIA and NCS long-range planning process.

- At the Savannah River Plant, a procurement strategy for a trunked radio system is in progress. Until that system can be implemented, several interim projects have been completed to enhance the radiocommunications capability at the site:

  - New repeaters were installed to provide better coverage of the plant

  - An automated computer-controlled radio analyzer was purchased to track current radio equipment

  - A project that will replace the outdated radio control console in the Emergency Operating Center was approved and started.

Frequency Spectrum-Dependent Resources

Table 5.3-3 shows the 5-year resource estimates forecasted for frequency spectrum-dependent resources. The 5-year total is $158 million, which is a $52 million increase over last year's 5-year estimate of $106 million. This total 5-year estimate accounts for 10 percent of the total $1.52 billion planned telecommunications costs for the Department over the 5-year period.

EXPENDITURE CATEGORY	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	TOTAL
Capital Investments	$ 21,400	$ 18,113	$ 13,257	$ 10,375	$ 11,534	$ 74,679
Government Personnel	5,587	5,815	6,041	6,277	6,522	30,242
Operating Costs	2,867	2,891	2,944	3,025	3,111	14,838
Commercial Services	8,371	8,134	6,755	7,049	7,359	37,688
Interagency Services	17	17	17	17	17	85
TOTAL	$ 38,242	$ 34,970	$ 29,014	$ 26,743	$ 28,543	$157,512

TABLE 5.3-3 FREQUENCY SPECTRUM-DEPENDENT RESOURCE ESTIMATES (IN THOUSANDS)

This 49 percent increase in planned resources is primarily due to the first reporting by one site in this functional area. The planned resources submitted by this site amounted to $41 million over the 5-year period and were reflected in the following categories: Government personnel, capital investments, and operating costs. The remaining portion of the increase was due to seven sites reporting planned initiatives that will implement computer-controlled trunking systems that will relieve frequency congestion at the sites. Figure 5.3-6 graphically displays these planned resources and illustrates them by expenditure category for each year.

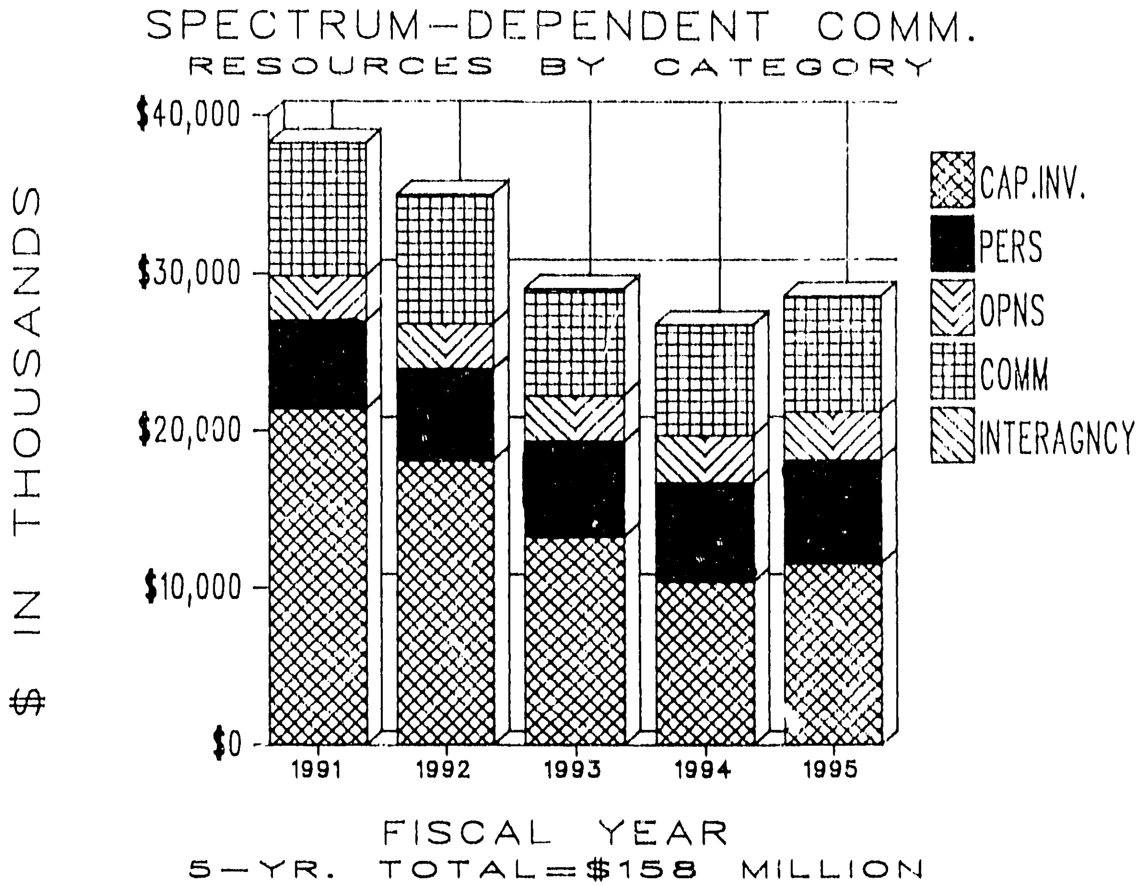


FIGURE 5.3-6 FREQUENCY SPECTRUM-DEPENDENT RESOURCES

<u>Major Frequency Spectrum-Dependent Acquisitions</u>

Eleven major acquisitions, amounting to $46 million, are planned in the spectrum area over the period. This amount accounts for 29 percent of the planned resources in this area. There is very little change in direction for acquisitions; resources are very similar to those planned last year. An obligation profile of these acquisitions, along with descriptions, are presented in this subsection. Figure 5.3-7 displays the planned major acquisitions.

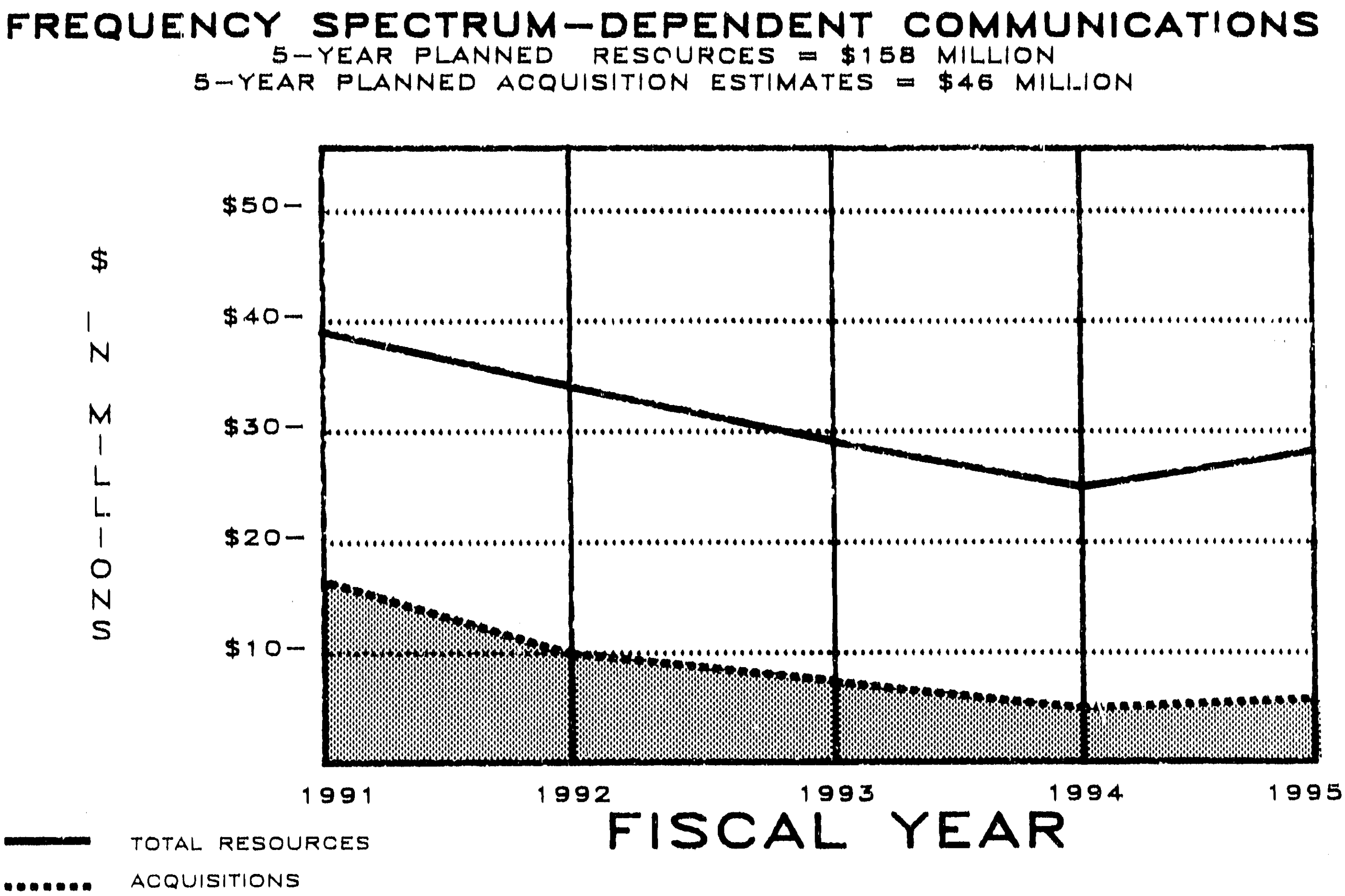


FIGURE 5.3-7 PLANNED MAJOR FREQUENCY SPECTRUM-DEPENDENT SERVICES ACQUISITIONS

Albuquerque Sites

Computer-Controlled Trunked Radio Repeater System - LANL is planning the acquisition of a computer-controlled trunked radio repeater system. The system will reduce the overall number of discrete radio frequencies; provide state-of-the-art radio communications that can be expanded to meet future needs; and provide emergency intercommunications between remaining discrete networks. Planned 5-year resources = $3.1 million.

Pantex Security, Transportation, Safety, and EOC Communications Systems Replacement Project - This project will replace the Security, Transportation, Safety, and EOC Communications systems, including the main control consoles with the latest encrypted radio equipment. Each guard unit will have identification and duress built into system. Planned 5-year resources = $0.6 million

Trunked Radio System - A 400 MHz, 6-repeater radio trunking system will replace the current VHF system at the Rocky Flats Plant. The new system will provide additional capabilities and enhanced security, and will significantly reduce maintenance costs. Planned 5-year resources = $1.5 million.

Idaho Sites

Trunked Simulcast Radio Network - This network is planned at the Idaho National Engineering Laboratory and will include multiple repeater locations controlled by a central station. The system will provide better area coverage, better use of bandwidth, and enhanced, more reliable secure radio transmissions. Planned 5-year resources = $10.4 million.

Nevada Sites

Trunked Radio System - A trunked radio system at the Nevada Test Site will reduce the number of radio frequencies required in the existing system and offer a degree of privacy. The first increment of the 5-year project begins in FY 1990. Planned 5-year resources = $2.5 million.

Oak Ridge Sites

Trunked Radio System - Installation of a new radio trunking system serving the Y-12 Plant, Oak Ridge National Laboratory, and the Oak Ridge Gaseous Diffusion Plant; and migration of users from existing networks to this new system is planned. Increased demand for radio service and lack of frequencies in the Government's portion of the VHF frequency band created the need for an easily expandable, high capacity radio system. To meet this need, a new radio system utilizing trunking technology will be implemented. Planned 5-year resources = $2.2 million.

Power Marketing Administration

Microwave Radio Network - This initiative will replace the microwave RF hardware and associated multiplex equipment at the Bonneville Power Administration (BPA). This equipment is used to provide critical control, protection, and monitoring of the BPA transmission system. Planned 5-year resources = $11.6 million.

VHF Radio Equipment Upgrade - BPA is planning an upgrade to the VHF mobile radio system that will replace radios, antennas, and repeater controls at selected VHF radio stations. No new functions are being added; this initiative is strictly to replace aging radios and associated equipment. Planned 5-year resources = $3.5 million.

Richland Sites

DES Microwave Encryption (Phases 1 and 2) - Phase 1 provides for the procurement and installation of T-1 and T-2 NSA-approved commercial encryption on selected microwave tail circuits. Phase 2 provides for the procurement and installation of T-3 NSA-approved commercial encryption equipment for the T-3 backbone circuits. The project provides bulk encryption of the Hanford Site Microwave System data in accordance with National Security Decision Directive (NSDD) 145. Planned 5-year resources = $0.7 million.

Savannah River Sites

Trunked Radio System - Starting in FY 1989 and continuing through FY 1993, the Savannah River Plant plans to implement a trunked radio system to provide the mobile service required as a result of project expansions. The existing networks cannot handle traffic due to congestion and inefficient channel assignment. Channel sharing causes confusion between groups and sometimes causes safety problems. The need to encrypt all plant radiocommunications is crucial. Planned 5-year resources = $5.5 million.

Other Sites

Trunked Radio System - A new radio trunking system is to be installed at all seven remote Strategic Petroleum Reserve (SPR) sites and New Orleans. All new mobiles, bases, and portables are included. The system will be computer-controlled and monitored by a system manager terminal in New Orleans. Implementation of this system will provide SPR with improved radiocommuncations reliability, flexibility, and operational effectiveness. Planned 5-year resources = $4.5 million.

5.3.1.4 Other Teleservices Activities and Programs

This subsection discusses specific telecommunications activities and programs that may utilize one or all of the three basic functional areas of communications discussed previously. Included are:

- o Teleconferencing activities;
- o Communications Security (COMSEC) Program activities; and
- o National Security Emergency Preparedness (NSEP) Program activities.

They are presented in a separate area to more concisely present the overall strategy and planning approaches being employed for these specific activities.

Summarized in Table 5.3-4 are planned telecommunications resource estimates for these communications areas over the planning period. The total planned in this consolidated area is $101 million, which is approximately 7 percent of the total DOE telecommunications resource estimates.

EXPENDITURE CATEGORY	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	TOTAL
Capital Investments	$ 13,187	$ 8,689	$ 7,607	$ 7,252	$ 7,487	$ 44,222
Government Personnel	907	941	942	949	998	4,737
Operating Costs	2,794	2,826	2,866	2,900	2,925	14,311
Commercial Services	4,514	4,535	4,623	4,349	4,859	22,880
Interagency Services	2,997	2,891	2,944	2,983	2,743	14,558
TOTAL	$24,399	$ 19,882	$ 18,982	$ 18,433	$ 19,012	$100,708

TABLE 5.3-4 OTHER TELESERVICES ACTIVITIES AND PROGRAMS RESOURCE ESTIMATES (IN THOUSANDS)

An analysis or comparison with FY 1990 planning figures is not possible in this area, since NSEP costs have been added this year. They account for costs in several categories, but their most significant impact was in Interagency Services where the "fair share" funding for the NCS National Level NSEP Telecommunications Program was reported. Figure 5.3-8 graphically displays these planned resources and illustrates them by expenditure category for each year.

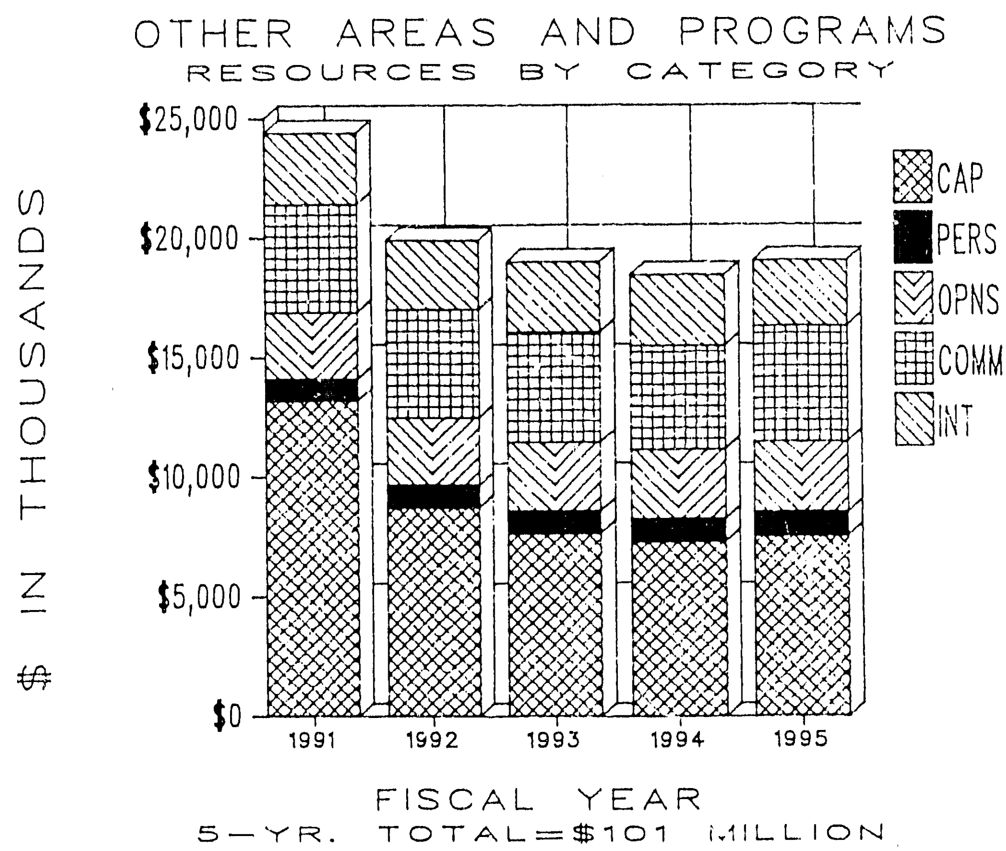


FIGURE 5.3-8 OTHER TELESERVICES ACTIVITIES AND PROGRAMS RESOURCES

Four major acquisitions are included in these estimates. These acquisitions account for 11 percent of the planned resources in this area, which is approximately the same as last year. Figure 5.3-9 illustrates the resources forecasted for major acquisitions in this area.

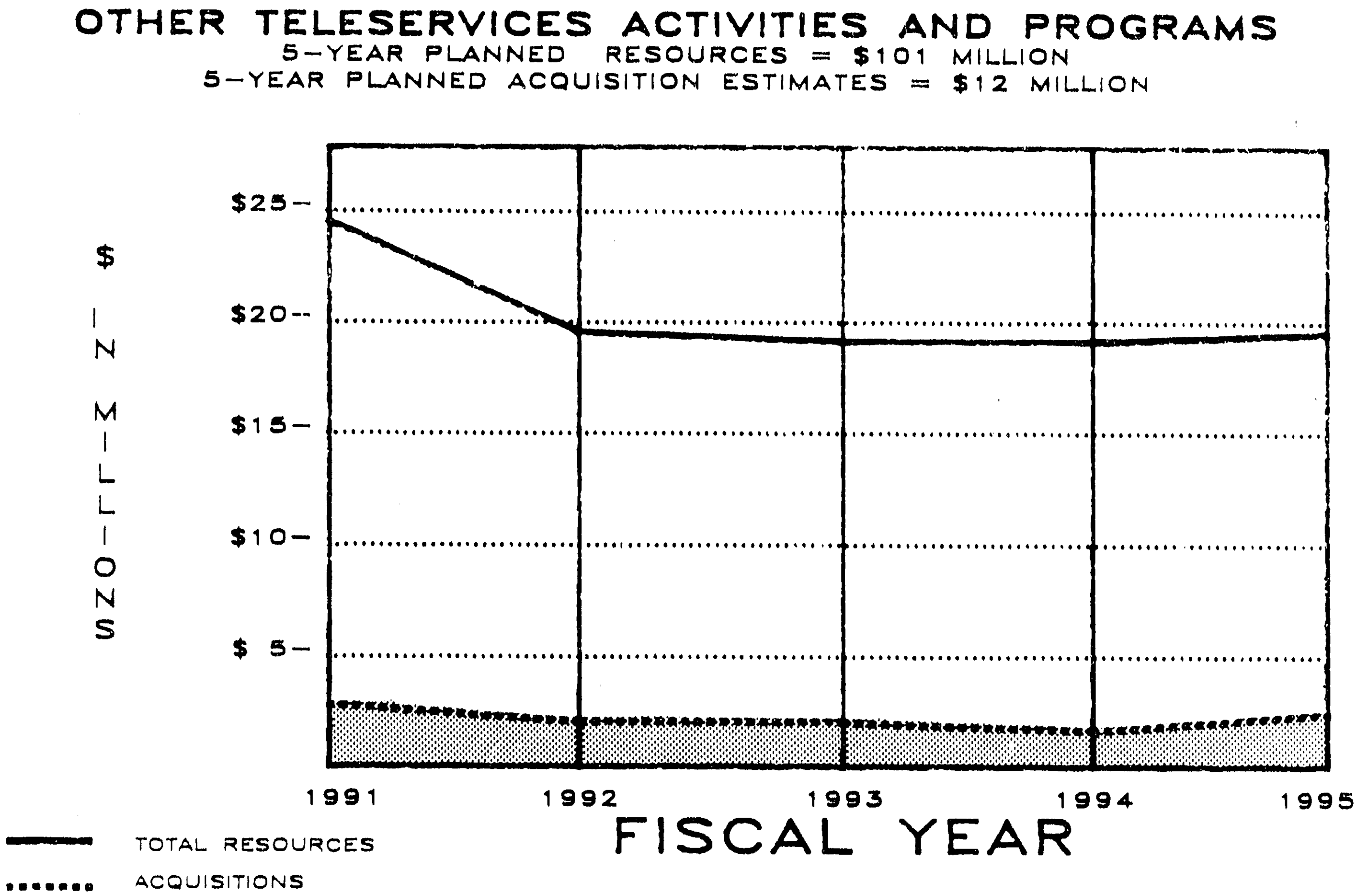


FIGURE 5.3-9 PLANNED MAJOR ACQUISITIONS FOR OTHER TELESERVICES ACTIVITIES AND PROGRAMS

5.3.1.4.1 Teleconferencing Services

Teleconferencing, or electronic conferencing, has traditionally been considered an exchange between participants. Currently, more and more facilities are being utilized, especially in the laboratory and university environments supporting the Department, to provide training and sharing of technical knowledge. Many sites are taking advantage of teleconferencing capability to save on travel costs and loss of time associated with travel, where feasible.

With the availability of video compression techniques and wideband transmission capabilities, conferencing is being employed to broadcast video coverage of training material, live coverage of seminars, and technically oriented material. In some limited cases, two-way video is available; while in others, one-way video and two-way audio is employed.

At almost all Department locations, some form of audio (telephone) conferencing is available. It is provided either via portable conferencing equipment, add-on features and conferencing bridges, or operator-assisted conference arrangements. At facilities where new voice/data systems are being planned, installed, or implemented, some form of teleconferencing service is almost always included as part of the integrated package.

Major Accomplishments in the Teleconferencing Area

A short-term demonstration of video teleconferencing equipment began in October 1989 between the two Headquarters facilities and Albuquerque Operations Office. The demonstration was a cooperative venture between the Offices of Defense Programs and Management and Administration and the Albuquerque Operations Office. It was established to determine demand for secure video teleconferencing between Headquarters and DOE field locations. Defense Programs has since determined that the video teleconferencing system should be implemented on a permanent basis. The two Headquarters locations and the Albuquerque Operations Office will now join the Sandia National Laboratories in Albuquerque and Livermore and the Kansas City Plant in a secure video teleconferencing network which uses the DOENTS satellite transmission services. Los Alamos National Laboratory is actively pursuing compatibility with the network, and other DOE field sites are expected to follow suit.

Major Teleconferencing Services Acquisitions

Three major teleconferencing acquisitions are planned by sites during the period. A description of the initiatives along with an obligation profile follow in this subsection.

Headquarters Sites

Video Teleconferencing - Headquarters is planning video teleconferencing to be utilized as a common user facility within DOE. This will allow video conferencing interaction between Headquarters and field sites that currently have this capability. Planned 5-year resources = $1.6 million.

Oak Ridge Sites

Teleconferencing - CATV System - The Portsmouth Gaseous Diffusion Plant plans a CATV system for display of essential emergency and administrative information. Monitors will be installed in strategic areas on the site. Planned 5-year resources = $1.2 million.

Richland Sites

Hanford Site Video Teleconferencing - This system will initially consist of three non-secure video teleconferencing rooms, video compression equipment, and transmission facilities. The backbone microwave system will provide interarea connections from 56 Kbps to 1.544 Mbps. Planned 5-year resources = $1.9 million.

5.3.1.4.2 Communications Security (COMSEC)

The COMSEC area is an intricate, centrally-directed mechanism that provides a full range of managerial, operational, and technical solutions for the protection of information. The COMSEC program provides policy development and program oversight to assure that DOE adequately protects classified and sensitive information during telecommunications and automated information processing. Support services include emission security (TEMPEST) testing; installation standards development and publication; cryptographic equipment acquisition, and control; and a full range of managerial, operational, and technical assistance.

National attention on control and protection of the communications systems has significantly increased in recent years due in part to terrorism and computer security vulnerabilities. The overall strategy and resultant planning in the COMSEC area continues to be directed towards provision of approved devices for the protection of both classified and sensitive information threat assessment, and TEMPEST type equipment and facility testing. In the latter case, DOE has pursued the policy of following national directives, while making decisions based on threat data to achieve a rational and affordable TEMPEST countermeasure posture.

The Department continues to actively participate in the development of national information security policy under NSDD-145. This participation serves to influence national policies and to accommodate unique Departmental interests. Training and familiarization programs have been implemented, and the technical expertise and necessary equipment have been put in place. Radio systems are being upgraded to provide a minimum of data encryption standard (DES) protection for unclassified sensitive information. Some radio systems are being upgraded to full period cryptographic protection for transmission of classified information.

Included in this area of telecommunications are all COMSEC devices, systems, and facilities providing for the protection of telecommunications. It not only covers those devices dedicated to fully secure systems, but also use of DES, PDS, and TEMPEST requirements and services. Resources planned in this area include cryptographic and protection equipment, employed or planned, as well as engineering efforts for system design. Resources for inspections are also included.

A cryptologic revolution is underway at the National Security Agency (NSA). Private vendors are being approved for manufacture and direct sale of information processing equipment that will embody encryption protection. While this will ultimately mean increased availability of crypto-equipment, adequate safeguards must be implemented to assure system security is achieved.

New generations of cryptographic equipment and techniques to replace obsolete and less reliable devices are continuing. Recently, older cryptographic equipment has been replaced with less costly and more reliable devices at a number of DOE facilities. Replacement with KG-84 equipment began in FY 1987 and continues through FY 1990. The conversion and expansion of the Departmental secure voice system started with the delivery of Secure Telephone Unit (STU-III) equipment in FY 1988 and continues today. The newer technology provides a lower cost system with more features than the STU-II system which, except for a few special applications, was phased out in FY 1989. This is the fastest growing cryptographic program in the Department. The availability of NSA-approved devices for protection of voice and data communications, radio systems, and backbone networks will be expanded. An example is the use of embedded COMSEC devices. The use of embedded COMSEC devices began in FY 1988 and will continue into the 1990s. For example, hand-held radios are currently available that include cryptographic protection installed by the manufacturer. Also available are other devices, which can be directly inserted into existing equipment (personal computers, radios, etc.), that provide COMSEC protection at low cost and decrease the need for expensive PDS.

TEMPEST testing resources, such as shielded laboratories, receivers, antennas, spectrum analyzers, and vehicles, are included in the planning for this area. Also included are existing and planned PDS which permit the transmission of unencrypted classified information through areas with lower levels of security.

Additional resources will be applied in the area of technical support, design, inspection, testing, and evaluation of facilities that process classified information. Regular revisions and issuances of the necessary directives and procedural documents to assure implementation of operational and technical developments in the COMSEC field will be provided to all facilities within the Department.

Major Accomplishments in the COMSEC Area

The primary initiative in this area has been the expansion of the secure voice program through the installation of STU-III. The objective of the program is to provide secure telephone accessibility to DOE and DOE contractor personnel who need such service. Additional attention will be devoted to the secure application of the data port capability of the STU-III.

A continuing initiative is the constant technical upgrading of the TEMPEST program to improve effectiveness and reduce the cost of providing protection. Headquarters, Oak Ridge, and Albuquerque have the necessary technical personnel and equipment to provide a full range of testing and certification.

Radio systems are being constantly upgraded to provide a minimum of DES protection and, in some cases, full term cryptographic protection. This is in line with new technical advances in true digital radio equipment which lends itself more readily to this level of protection.

Protected distribution systems provide secure, unencrypted data communications paths. Systems are being installed and/or upgraded to provide enhanced security for data transmissions and are being migrated to the growing number of broadband networks being installed after all security criteria have been met. To maintain security and control of PDS, some sites, such as Los Alamos National Laboratory, have completed detailed documentation packages of all existing PDS at the facility including location of all physical structures, type of transmission media contained within the structure, and location and type of all outlets connected to the transmission media. It is expensive to install, inspect, and maintain PDS in a manner that will assure security provisions. Embedded crypto and secure optics may provide alternatives to PDS installations in the future.

A rational technical criteria for classified information processing systems based on new TEMPEST criteria will be developed. New direction for the implementation of TEMPEST countermeasures will also be issued. New classified information processing systems will be tested for compliance with TEMPEST criteria.

Major Acquisitions Planned in the COMSEC Area

Following is a description and obligation profile of the single major acquisition planned in this area during the period.

Headquarters Sites

STU-III Secure Telephone Units - This initiative will provide STU-III to be used primarily in the DOE Nuclear Weapons Program. Two thousand four hundred telephones in the Washington, D.C. area will be replaced with STU-IIIs by 1992. These are secure voice/data telephone terminals that will provide classified communications over the public telephone network. Planned 5-Year resources = $6.9 million.

5.3.1.4.3 National Security Emergency Preparedness (NSEP) Program

Continued emphasis at the national level and the accelerating tempo of NSEP planning are requiring increased attention to the Department's emergency telecommunications and information management posture. NSEP planning applies to any telecommunications system that supports a program that by Public Law or Executive Order involves national security or public safety.

Telecommunications resources are essential elements to an effective NSEP posture and response capability. The DOE is classified as a Category A agency by the Federal Emergency Plan (classified, title unclassified), Annex C-XI, Telecommunications. As a result, DOE must have telecommunications resources that are capable of providing essential and emergency telecommunications to support Departmental statutory functions in war emergencies, operational emergencies, or energy emergencies.

NSEP planning is applicable for any system or service that supports programs involving national security or public safety. NSEP plans cover a wide range of emergency support and reaction activities, from shutting down and securing a facility to deploying highly sophisticated mobile laboratories to assist in emergency or hostile situations. Nearly all NSEP activities are coordinated through the site Emergency Operations Centers (EOC), where special equipment is installed for voice, data, radio, and image transmission in emergencies. While all sites do not have specific NSEP programs or plans in place, most of the telecommunications services that are used can and do support EOC and NSEP functions. Nearly all sites have, or are acquiring, a backup voice system for use during any primary system failure.

Many systems are also in place that coordinate activities with local authorities, fire departments, and hospitals. Procedures have been established for many possible crisis scenarios. Facilities and teams have been established to specifically deal with hostage/terrorist situations, or with nuclear accidents.

Guidance for developing budgets for NSEP programs and planning for telecommunications during emergencies is currently being developed within the Department. Headquarters is working closely with the NCS and the Department of Commerce regarding assignment of restoration priorities for wire and radiocommunications circuits during times of emergency. Headquarters and field sites are also working closely on a day-to-day basis to ensure that all requirements from national authorities are met.

An NSEP Telecommunications Procedural Guide is being developed to assure that all sites are kept fully informed on NSEP requirements and directives.

<u>Major Accomplishments in the NSEP Area</u>

Following are major accomplishments made in the NSEP area during FY 1989.

- One of the DOE's principal accomplishments in this area has been its continued ability to influence Federal Government NSEP telecommunications policies and planning through its representation on the NCS Committee of Principals and Council of Representatives. Exercising this influence will continue to be one of the major objectives of DOE to ensure that DOE NSEP telecommunication interests are recognized and provided for at the national level.

- Revalidated and submitted to NCS the DOE nationwide emergency telecommunications services requirements for the late trans-/early post-attack periods.

- Translated functional NSEP communications requirements of the Department for the peacetime and crisis mobilization period into specific NSEP telecommunications requirements and forwarded this information to the NCS.

- Identified and consolidated DOE peacetime and crisis NSEP telecommunications requirements and forwarded same to NCS.

- Published and distributed two Instructions:

  - "Department of Energy Major Telecommunications-Related Incident/ Service Interruption Reporting Instructions," that provides guidance for establishing a management and reporting channel between the telecommunications managers and the Departmental telecommunications emergency manager during major emergencies or incidents.

  - "Department of Energy National Security Emergency Preparedness Telecommunications Instructions," that provides guidelines for identifying NSEP telecommunications services and invoking NSEP procedures to obtain priority provisioning and restoration of these services.

- Successfully obtained NCS recognition and approval for the Department to sponsor private and public interstate power utility requests for Telecommunications Services Priority (TSP) assignments. The DOE request has been included in a proposed NCS TSP Directive 3-1, which is now in the process of being forwarded to the White House for approval.

- Provided assistance and NSEP telecommunications input to the Office of Safeguards and Security in preparation of the Department's Annual Report to the President on Domestic Safeguards and Security. Arranged and participated in a briefing for the Director of Telecommunications, National Security Council, on the DOE Security and NSEP telecommunications programs.

- Updated Headquarters and field office EOC procedures to include EOC notification of telecommunications management personnel of emergency situations that could potentially affect local voice and data communications services. This action was a result of the lessons learned from the fire that destroyed the AT&T Hinsdale telephone facility serving the Chicago Operations Office.

- The NSEP Telecommunications Service Procedural Guide is being expanded to include additional requirements of Headquarters and NCS, such as the NCS TSP system, and procedures for DOE sponsorship of interstate public and private electric utility requests for NCS TSP assignments.

- Completed a survey of field offices and requested their assistance in the development of an Essential Services Protection Program to provide priority end-office dial tone for local telephone service during emergency situations.

- Numerous sites expanded and upgraded their EOC facilities.

<u>Major Acquisitions Planned in the NSEP Area</u>

There are no specific major initiatives planned that totally support NSEP activities. Many of the initiatives and activities discussed in the other functional areas include planned resources that will support the NSEP program.

5.3.2 Major Networks and Systems Utilized by the Department

Described in Sections 5.1 and 5.2 are the vast and sophisticated information systems and computing resources used within the DOE ITR community. To provide fast, efficient, and cost-effective telecommunications support to connect these resources requires equally sophisticated networking schemes. Telecommunications managers must be able to provide state-of-the-art communications equipment and technology that can meet the requirements of the highly technical DOE research and production community as well as support ongoing administrative and operational requirements. Providing high-speed reliable connectivity between DOE facilities and between DOE facilities and other Government agencies, universities, or the private sector is perhaps the greatest challenge facing the telecommunications manager.

Following is an overview of networks and systems used by DOE facilities. They are grouped into four different categories to allow presentation of a variety of complex and simple networks which use all forms of transmission media. The first group of systems are major DOE networks that can provide telecommunications support to virtually all facilities within the agency. The second and third groups describe other Government networks and the private sector networks that are accessed by DOE users. The final group depicts several randomly selected facility networks that support site-specific requirements.

5.3.2.1 DOE-wide Networks

Department of Energy Nationwide Telecommunications Service (DOENTS)

This extensive and exclusive DOE-wide network currently provides high-speed, protected, digital transmission for all types of information. It handles voice, data, text, video, and computer-to-computer traffic equally well. DOENTS satellite service will be used to support NSEP requirements after the implementation of FTS 2000 at DOE facilities.

The system began as a circuit bundling program which was initiated in FY 1986 to consolidate nationwide circuits into wide band carrier systems. These efforts were initially implemented between locations where the Department's satellite backbone system was not yet available and to support requirements not tolerant of satellite service. These wide band carrier systems were then combined with the satellite system to create DOENTS.

The present DOENTS configuration provides 60 Mbps service and consists of six nodes in the following locations:

Germantown, MD	Kansas City, MO	Albuquerque, NM
Oak Ridge, TN	Mercury, NV	Livermore, CA

Complementing the satellite links are two terrestrial T-1 networks: the Eastern T-1 Network, connecting the Germantown and Oak Ridge satellite nodes to the Savannah River Plant in Aiken, SC; and the Western T-1 Network connecting the Albuquerque, Mercury, and Livermore satellite nodes with Los Alamos National Laboratory and Pleasanton, CA. The Western T-1 Network is also known as INTRANET. Enhancements recently made to the system provide more flexibility in extending the DOENTS to other facilities through local telephone switches.

For the DOE community, DOENTS provides a large telecommunications pipeline that supports Hyperchannel connectivity, dedicated data service, video teleconferencing, and switched traffic such as voice and dialup data. DOENTS is transparent to the user and identical to similar services offered by commercial carriers. An important point is that DOENTS provides digital service to DOE locations where such services may not necessarily be available from commercial carriers.

In addition, DOENTS provides technical advantages to the ADP network user. The bit error rate performance for individual DOENTS nodes exceeds commercial carrier standards. In general, DOENTS can provide a data service that is more reliable and accurate than commercial services. Systemwide availability for the past 2 years has been maintained at 99.8 percent. Finally, DOENTS provides the user a dedicated, private, and secure network with full network management support. DOENTS is managed by Headquarters with the DOE nodal sites providing operational and customer support.

Cost-benefit analyses have shown that significant savings can be realized and costs can be avoided by maximizing the use of satellite nodes and T-1/multiplexing technology. The initial circuit bundling analysis indicated annual benefits rising from $0.5 million in FY 1987 to more than $5 million in FY 1995. In order for DOENTS to provide the benefits and cost savings that are projected, support and cooperation will be required from the field organizations. In this regard, Headquarters will continue to prescribe the policy and procedures for field identification and submission of telecommunications requirements for approval and implementation. The DOENTS will be given first consideration for each submission and, if possible, the necessary allocations and assignments will be made. Figure 5.3-10 shows the DOENTS configuration.

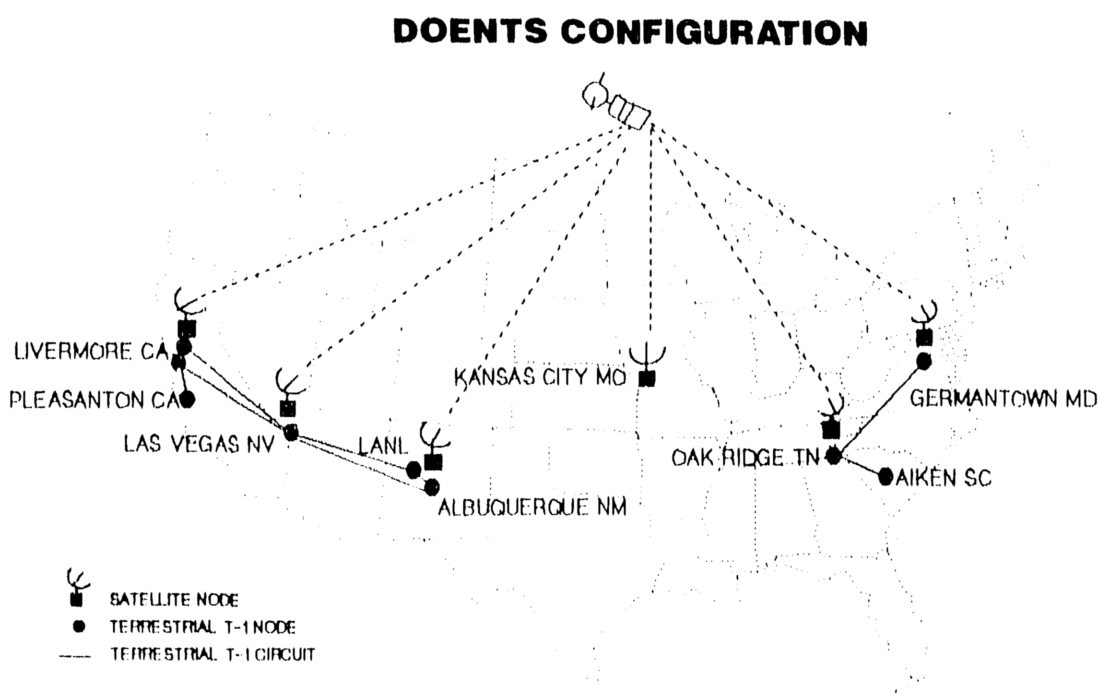


FIGURE 5.3-10 DOENTS CONFIGURATION (April 1990)

Secure Automatic Communications Network (SACNET)

The SACNET System was originally designed in 1969 and began operation in 1974. The system is a store-and-forward message switching system in a star configuration. The SACNET Replacement Project, which is nearing completion, involves the following:

- o Message switch being replaced with a VAX-based system;
- o Twenty-two Mohawk Data Sciences programmable terminals being replaced with PC-based terminals; and
- o Twenty-one facsimile terminals being replaced.

The DOENTS satellite backbone transmission system is used for the replacement system, providing secure electronic communications services directly to 23 DOE locations, including DOE offices, major laboratories, and production facilities, throughout the United States. A diagram of the system is shown in Figure 5.3-11.

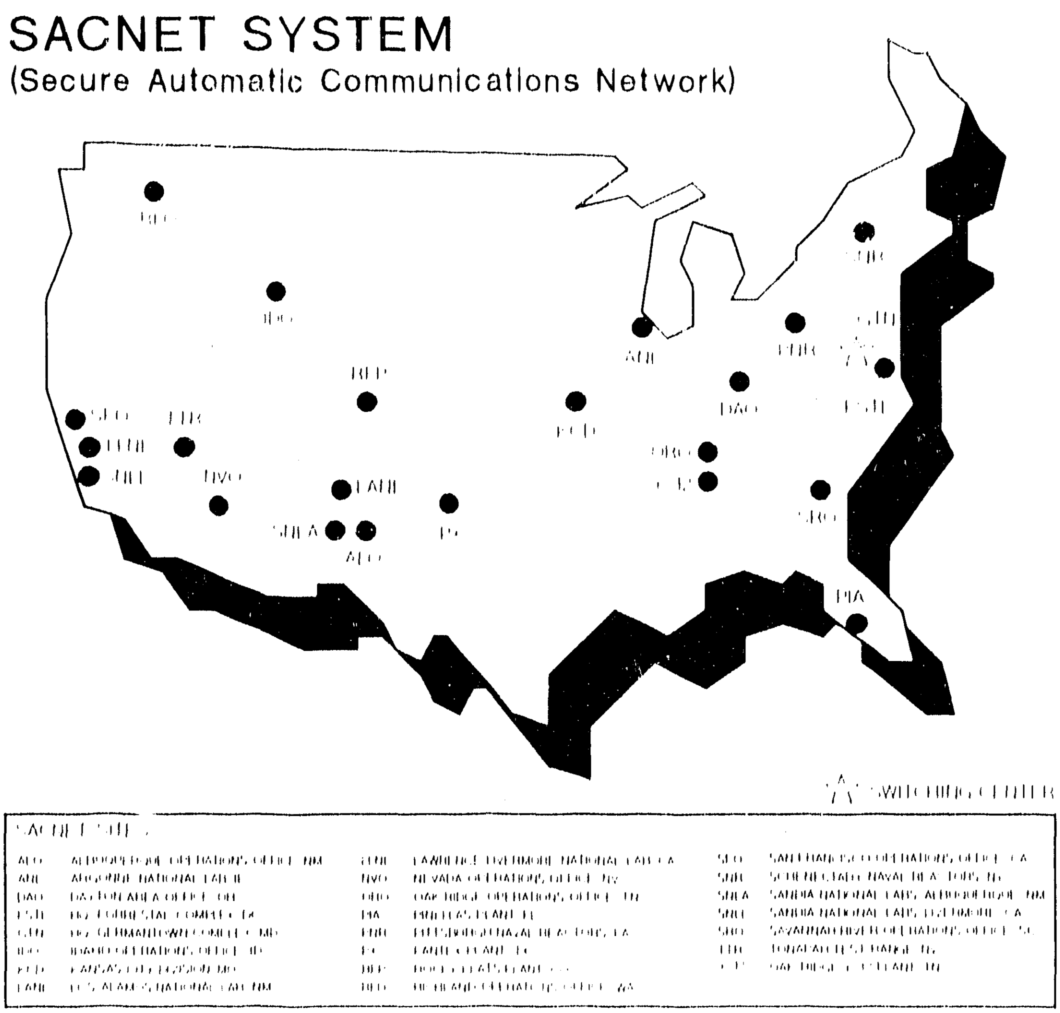


FIGURE 5.3-11 SACNET SYSTEM

Wide Band Communications Network (WBCN)

The WBCN project is an example of implementation and management by an appropriate field organization that is strategically placed to accomplish network objectives. It is a DOE-sponsored network linking the DOE national laboratories and weapons production sites to provide data transmission services between them. The WBCN uses 56 Kbps and 9.6 Kbps bandwidth obtained from the transport providers. It is a value-added packet-switched network using DECNET protocol and allows file push process only. All links in the network are protected by NSA-approved encryption devices. Computer networks at the local sites are connected only by tape transfers. The primary application in the network is Computer Integrated Manufacturing (CIM) and other file transfers. The Nuclear Weapons Complex Network (NWCNET) uses the WBCN as a transport medium.

The Albuquerque Operations Office continues design work on the secure WBCN which may ultimately serve up to 12 locations, including design laboratories, production facilities, and DOE administrative offices. In addition to the communications channels, a gateway computer will be located at each site to provide an interface between the WBCN and the site's local computing resources. A related project will develop an approach to interconnect sites with a multilevel secure computer network, requiring the design and implementation of a universal communications security controller. The DOENTS satellite backbone transmission system is being utilized wherever possible. Figure 5.3-12 portrays the WBCN.

WIDE BAND COMMUNICATIONS NETWORK

FIGURE 5.3-12 WIDE BAND COMMUNICATIONS NETWORK

Energy Sciences Network (ESNET)

Within the DOE, an effort was initiated in data communications networking which was designated the Energy Sciences Network. The ESNET concept is intended to bring together the various data communications efforts of the different research programs funded by the Office of Energy Research (ER) into a single network that would use protocols being developed for OSI. ESNET will be implemented from three components: Magnetic Fusion Energy Network (MFENET)/MFENET II, High Energy Physics Network (HEPNET), and the NASA Space Network (SPAN). The system will evolve from the current 56 Kbps MFENET II and provide enhanced T-1 service capable of supporting the high-speed, high-volume requirements of the growing user community. The transition to ESNET is planned to occur without disruption in current service or capability. This will take place in three phases:

- o construction of the major backbone loop;
- o movement of major sites to the ESNET backbone; and
- o movement of secondary sites to the ESNET backbone.

Additional considerations include planned connections to Japan, Germany, and Switzerland. Figure 5.3-13 displays the ESNET backbone.

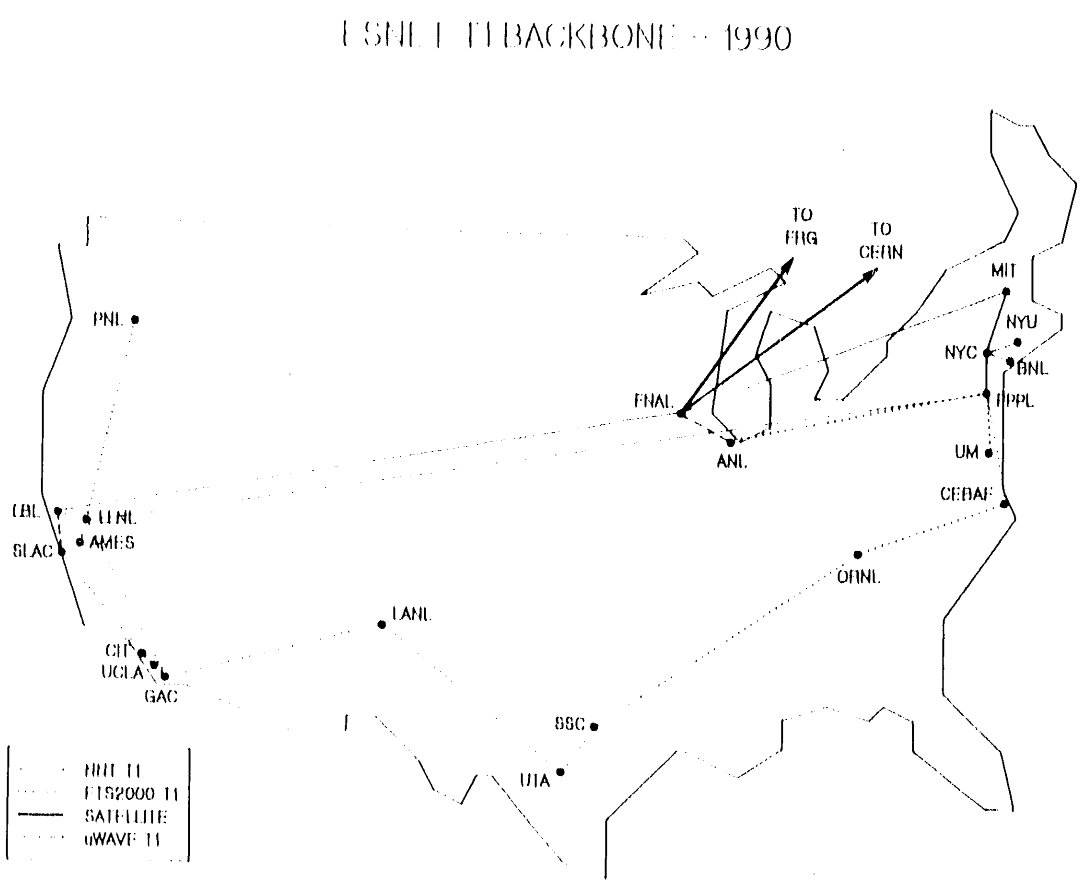


FIGURE 5.3-13 ENERGY SCIENCES NETWORK (ESNET)

Atmospheric Release Advisory Capability (ARAC) Network

The DOE ARAC Center is operated by Lawrence Livermore National Laboratory and provides emergency response for the accidental release of radioactive or toxic substances into the atmosphere by nuclear reactors or other sources. In the event of an accident or exercise, the ARAC Center retrieves accident information from the site. The Center also receives routine and on-demand emergency data from the Air Force Global Weather Center and from numerous other sites around the country where meteorological towers have been placed. This data is processed at the Laboratory with a large computer code designed to forecast the transport and diffusion of the substances.

The Center and its associated network support DOE and other agencies, such as the Department of Defense, the Nuclear Regulatory Commission, the Federal Aviation Administration, and state and local governments. Future ARAC plans call for ARAC to service sites outside the continental United States. Satellite communications and the Defense Data Network (DDN) are being evaluated for that purpose. These services are also being considered as alternatives and/or backups to the switched network. The Integrated Services Digital Network (ISDN) is being considered for the long term (mid-1990s).

Node-to-Node Network

The Node-to-Node Network, sponsored by Headquarters, is an SNA architected network used for data transfer and interactive sessions. Computers at cooperating agencies can join this network to enhance their transmission capabilities. The network was once limited to only IBM mainframes; however, protocol enhancements have now made it possible to communicate with various computing systems. The Amdahl computer at Headquarters is a participating node on this network.

5.3.2.2 Other Government Networks Used by DOE

FTS 2000 Network

GSA has awarded the FTS 2000 contract jointly to American Telephone & Telegraph (AT&T) and U.S. Sprint to provide modern, low-cost telecommunications to the Federal Government. FTS 2000 is a universal telecommunications capability, providing voice, circuit- and packet-switched data service, video, and dedicated services. The service offerings will provide agencies with the capability to match their applications with the appropriate telecommunications services of the system. DOE intends to use FTS 2000 as the dominant source for all administrative telecommunications services. Locations served by DOENTS will transition the on-net voice traffic to FTS 2000 with the exception of services required for operational and NSEP support.

Implementation of FTS 2000 is currently progressing in phases until July 1990, when the system will be fully operational. This is a usage-based network that will provide six basic services.

- Switched voice service is a dialup service for the transmission of voice and data at data speeds up to 4.8 Kbps. These services are available with the current FTS; however, FTS 2000 has higher quality, better performance, more features, and lower costs.

- Switched data service gives agencies spontaneous, on-demand access for the high-speed transfer of data at cost-effective prices. Charges are user sensitive, based on time of use and distance between access areas. This service allows utilization of high-speed fax, bulk data transfer, and downloading files. It gives access to remote locations and centralized processors, and has features for disaster recovery and secure data transfer.

- Packet-switched service is a fully integrated digital data transfer service designed for communications between geographically dispersed terminals and computers. It is the most cost-effective means of data transfer when many terminals are communicating with different computers and transmission occurs when the average data rate is low.

- Dedicated transmission service provides users a cost-effective alternative for sending large amounts of data between two locations on a continuous basis. It can be used for voice, high volume data, and terminal-to-mainframe communications. Analog services will be provided for voice or data with speeds up to 9.6 Kbps. Digital data transmission will be provided at 9.6 Kbps, 56 Kbps, and 1.544 Mbps.

- Compressed and wide band video transmission service gives users the ability to send video and audio from one location to another. This service will provide inexpensive conferencing capability using two-way video as well as broadcast video for training, announcements, etc.

- Switched Digital Integrated Service (SDIS) is fully integrated to provide voice, image, and video capability. The benefits of this service are providing users with various integrated access methodologies and minimizing the cost and service disruption associated with facility changes that are required to take advantage of ISDN applications. Also, the SDIS function of aggregating traffic at a service delivery point allows users to claim volume discounts. The two types of service available are T-1 and ISDN.

DOE intends to participate wherever the FTS 2000 network provides the best economic alternative and furthers its goal for end-to-end digital connectivity or where dictated by National priorities. The success of the new system will be measured by reductions in cost for the service and other factors that will guarantee success of the system, such as the vendors' ability to provide a smooth transition with efficient ordering and billing procedures; the return of former FTS users to the new network; and significant use of the various data communications capabilities available. DOE will utilize Network A of the FTS 2000 Network which is provided by AT&T. Figure 5.3-14 illustrates this network.

AT&T's FTS2000
Integrated Custom Network

FTS2000 Network Facility Route Connectivity

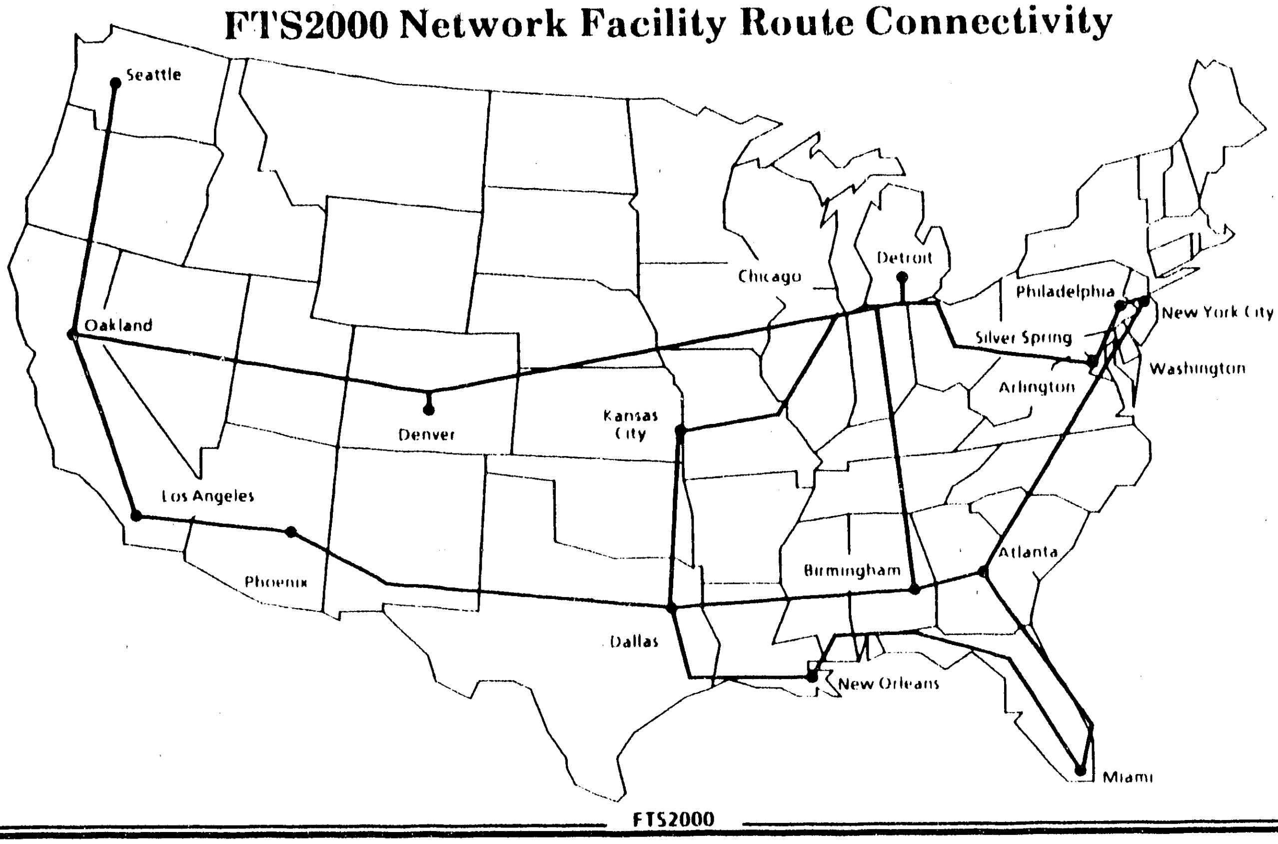


FIGURE 5.3-14 FTS 2000 INTEGRATED CUSTOM NETWORK

Automated Digital Network (AUTODIN)

AUTODIN is a worldwide store-and-forward data communications system. It is owned and operated by the Department of Defense. The network interfaces with many Government systems providing access to numerous agencies. The SACNET switching center at Germantown is a node on the AUTODIN network. This provides access to AUTODIN to DOE facilities connected to SACNET.

5.3.2.3 Commercial Networks

Because It's Time Network (BITNET)

BITNET provides access to about 1,600 computers in the academic and non-profit research communities in the United States, Canada, and overseas. The system does not permit remote login; it only provides message- and file-transmission services via the IBM Remote Spooling Communications Subsystem (RSCS) protocols.

Internet

Internet consists of the global set of TCP/IP networks that are interconnected and share a common address space. This network has also been known as ARPA Internet, DARPA Internet, and TCP/IP Internet. The Internet is a logical network connecting over 700 networks including wide area networks, such as the ARPANET, NSFNET, and Milnet; and mid-level and regional networks, such as NYSERNet and BARRNet. It also connects many local area networks.

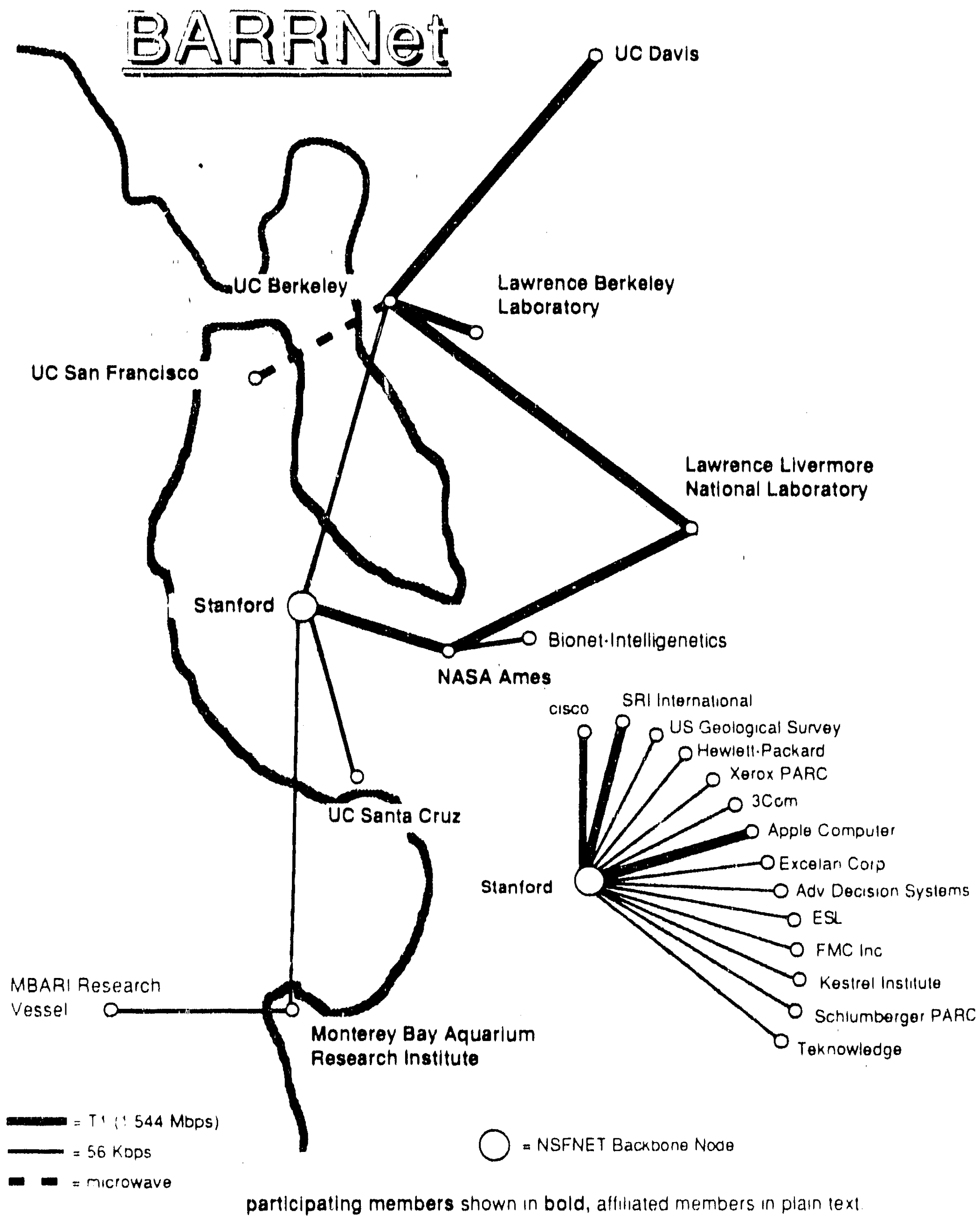
While the largest number of participating networks are in the United States, the Internet connects TCP/IP networks in Canada, Mexico, Japan, Europe, New Zealand, Australia, and Asia. It is not known exactly how many computers communicate via the Internet. Most estimates are well over 100,000.

TYMNET AND TELENET

These are value added networks that provide remote dialup communications access through regional facilities. These services are either contracted for directly from the vendor or included in the commercial timesharing services offered to DOE facilities by approximately 48 vendors who provide commercial information services.

Bay Area Regional Research Network (BARRNet)

This is a network within the National Science Foundation (NSF) Internet. BARRNet connects universities and research organizations in the Northern California area. Its purpose is facilitating inter-institution communication and collaboration, and providing researchers and educators with access to remote computing facilities such as the NSF supercomputer centers and the ever-expanding realm of online libraries, data bases, and other network-accessible services. BARRNet is expected to include 40 member networks by the end of 1989, and to exceed 60 by the end of 1990. Any non-profit educational or research organization in the northern California area, plus Nevada and Hawaii, is eligible for membership in BARRNet. Figure 5.3-15 illustrates this network.



Sites added 6/89: DEC WRL, Lucid Systems, MIPS, mt Xinu, Rockwell PAL, Sun Microsystems, Tandem Computers, VLSI Technology

FIGURE 5.3-15 BAY AREA REGIONAL NETWORK (BARRNet)

5.3.2.4 DOE Site Networks

Every DOE site has one or more networks serving the facility. The networks within DOE range from small local PC-to-PC communications to large diversified local area networks that handle onsite data communications as well as connectivity to national and international networks. Integrated voice/data solutions are used wherever appropriate. This shared use of information exchange switching facilities is expanding with the acquisition of integrated digital switches.

In many cases, separate data networks are appropriate due to security or other requirements. In every instance, emphasis is placed on the most cost-effective method of providing the quality of required service to support the mission or programs.

Presenting a description of every system within the DOE facilities would require volumes; therefore, descriptions of several typical installations will be discussed. The following are examples of an integrated digital system, small and large LANs, a wide area network, a radio network, and a teleconferencing system.

INEL Communications System (ICS)

This system has just been implemented at the Idaho National Engineering Laboratory (INEL). It consists of 11 Northern Telecom Meridian SL-1 switches and 1 remote peripheral unit. Each major campus at both the Idaho Falls and site locations will house a standalone switch. Network connections will be accomplished using the site's fiber transmission network. A Network Management Center provides monitoring of switch traffic and performance, collection of call and traffic data, and centralized maintenance and configuration control. Figure 5.3-16 shows the network configuration.

INEL COMMUNICATION SYSTEM (ICS)

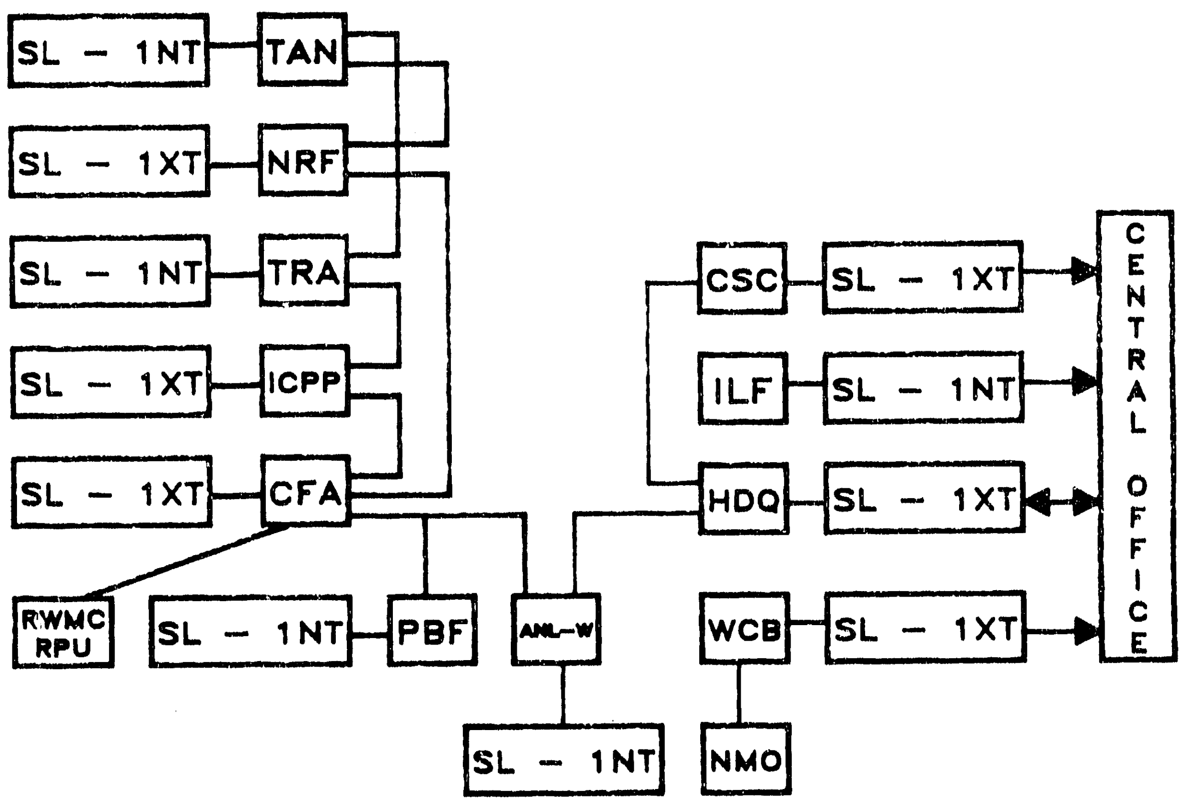
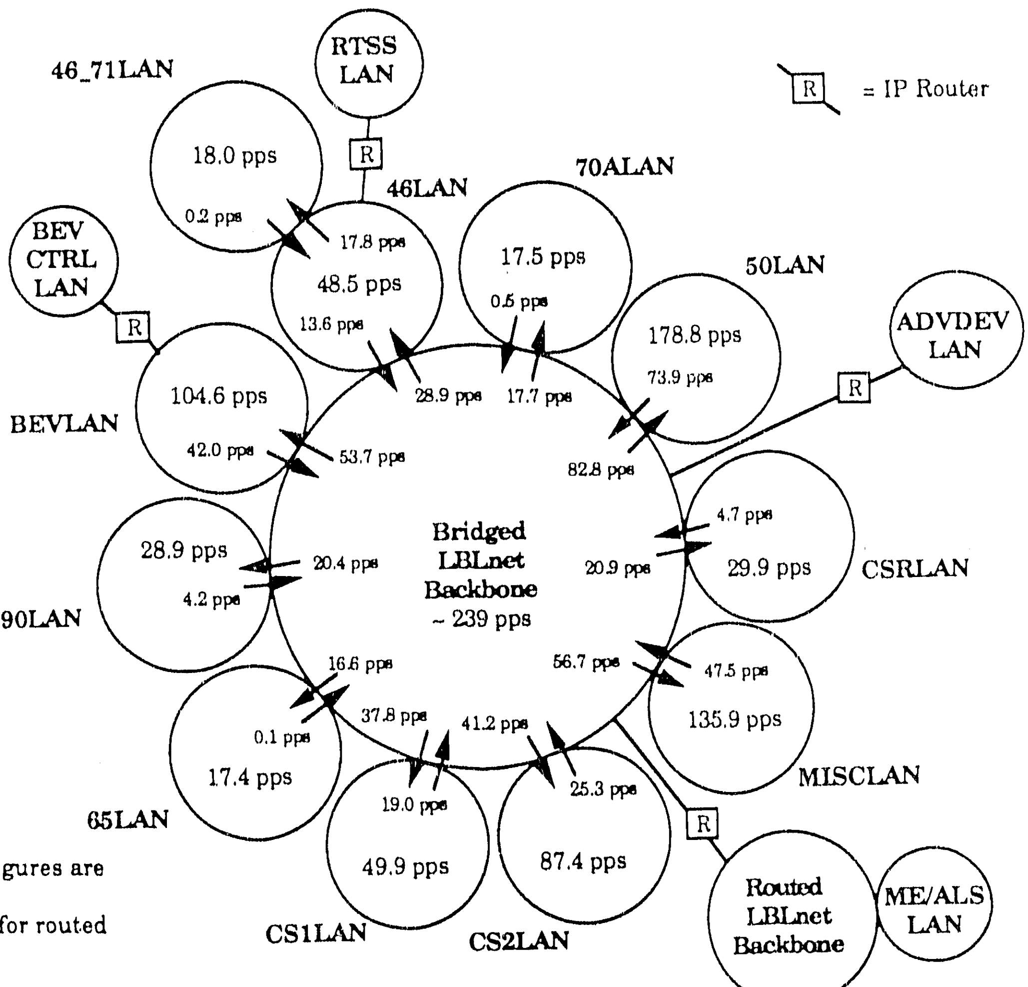


FIGURE 5.3-16 INEL COMMUNICATIONS SYSTEM (ICS)

Lawrence Berkeley Laboratory Network (LBLnet)

At Lawrence Berkeley Laboratory (LBL), the implementation of the Laboratory-wide Ethernet began in FY 1984 and continues to expand. Ethernet bridges allow LBL to partition LBLnet into a collection of interconnected subnets. More than 500 systems are now interconnected through this complex of LANs using three major network protocol families: DECNET, TCP/IP, and XNS. Connection to LBLnet also provides access to several external networks. LBL has started the transition from being a totally bridged network to being a routed network of subnets. This has been necessitated by a growth in Internet nodes beyond the capacity of a single subnet and the need to isolate broadcast traffic by establishing smaller subnetworks.

In addition to Ethernet-to-Ethernet routing, LBL has also begun the installation of Kinetics *Fastpath* routers to effect the connection of Macintosh AppleTalk twisted-pair networks to the LBLnet. Figure 5.3-17 displays the LBLnet configuration as of December 1988.



pps = packets per second; all figures are monthly averages (no figures are available for routed subnets at this time)

Each circle is a separate Ethernet.
Interconnections are bridges or routers, as indicated.
Arrows indicate packet flow through a bridge from one LAN to another.

FIGURE 5.3-17 LBLnet

Oak Ridge National Laboratory (ORNL) Unclassified Interfacility IBM Network

This network provides intersite file transfer, interactive terminal sessions, and network job entry for interactive graphics systems, IBM systems support functions, program development, and other functions using IBM host computers. The network uses the Intersite Broadband Network and leased DDS lines at 56 Kbps. The wide dispersion of Engineering, Financial, and Computing and Telecommunications Department personnel and the large applications to be run require high-speed T-1 connections to effectively and efficiently use these large mainframe computers; therefore, an upgrade of the system is currently planned. Figures 5.3-18A and B show the current and planned configurations of the system.

PRESENT INTERFACILITY UNCLASSIFIED SNA AND NJE CONNECTIONS FOR HIGH SPEED COMMUNICATIONS

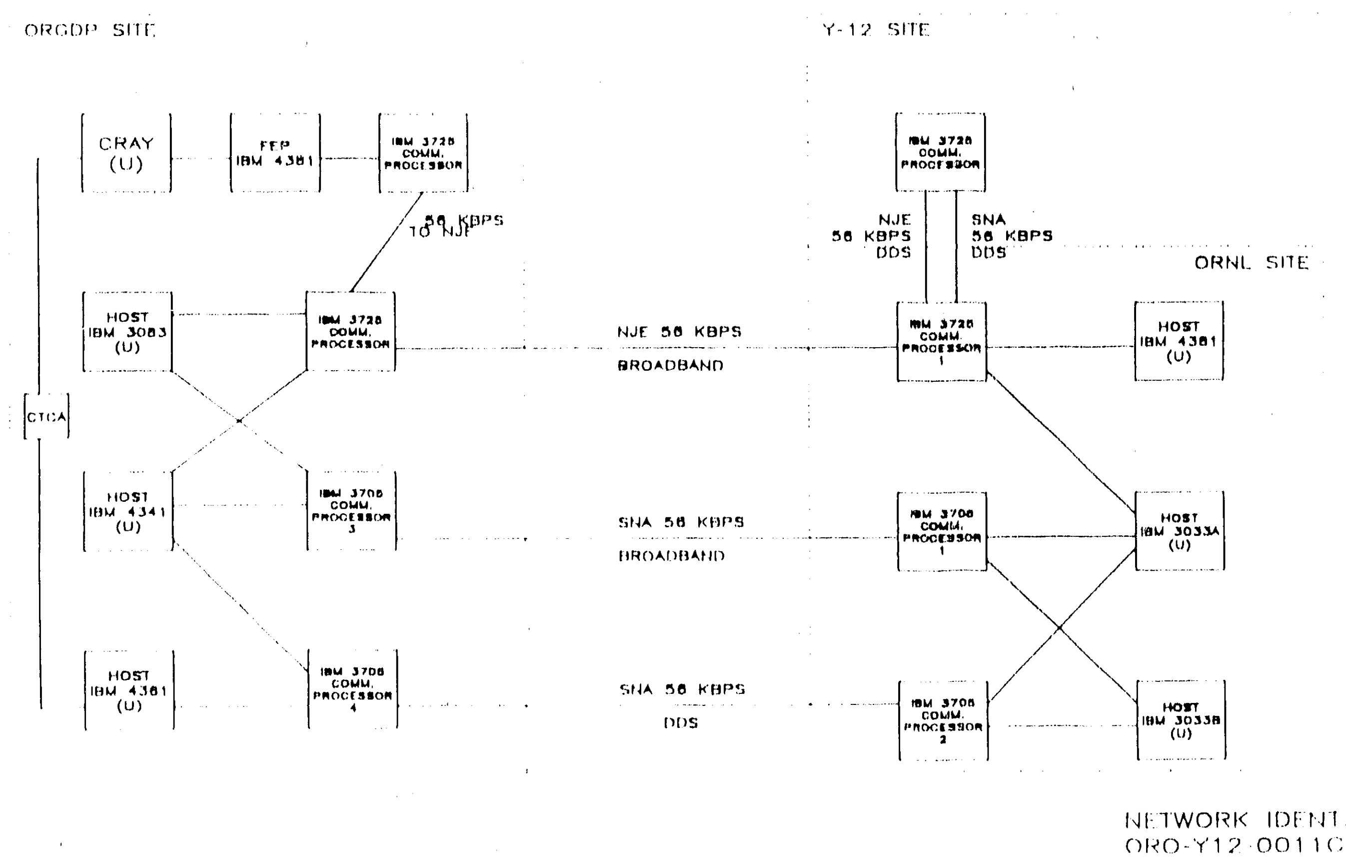


FIGURE 5.3-18A CURRENT ORNL UNCLASSIFIED INTERFACILITY IBM NETWORK

PLANNED INTERFACILITY UNCLASSIFIED SNA AND NJE CONNECTIONS FOR HIGH-SPEED COMMUNICATIONS

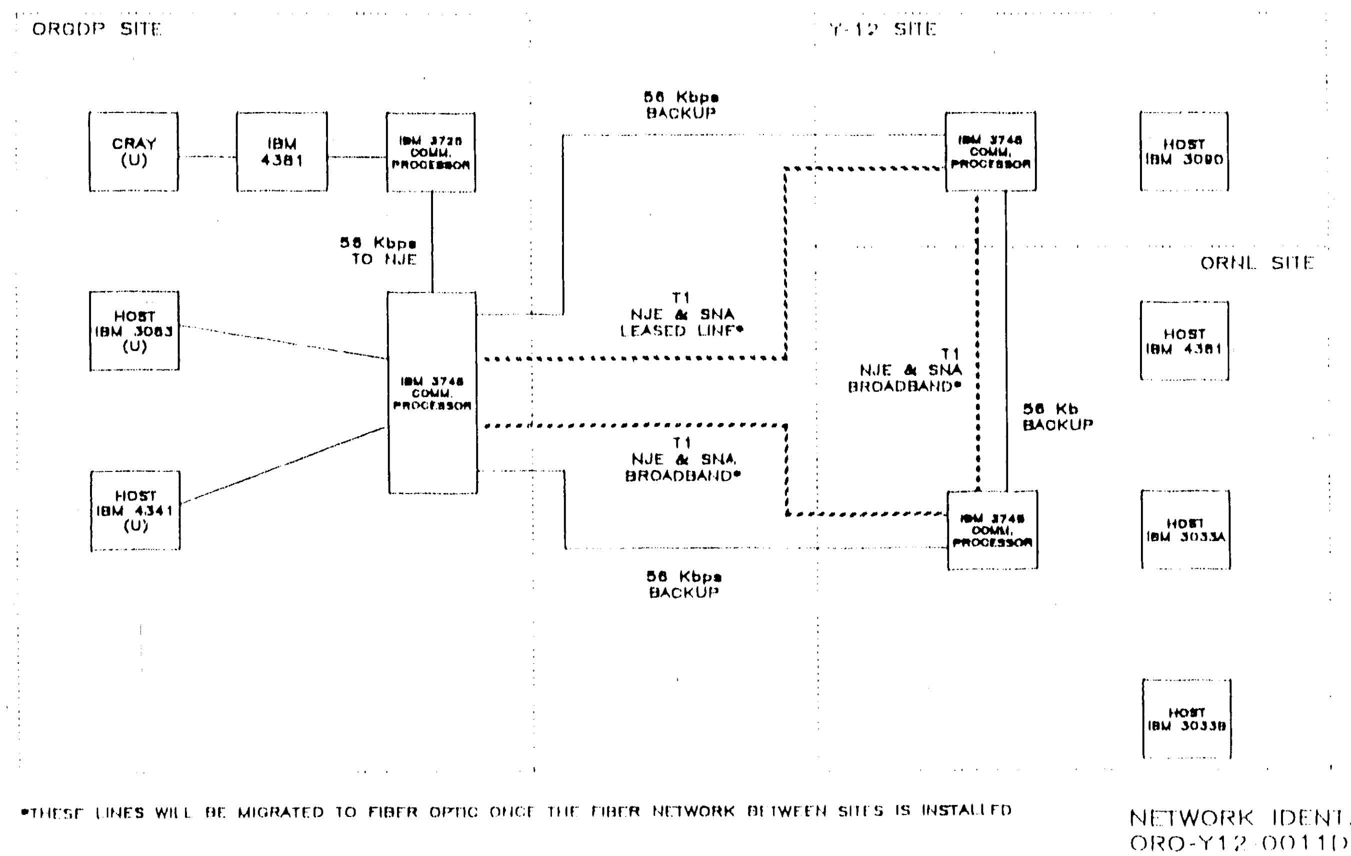
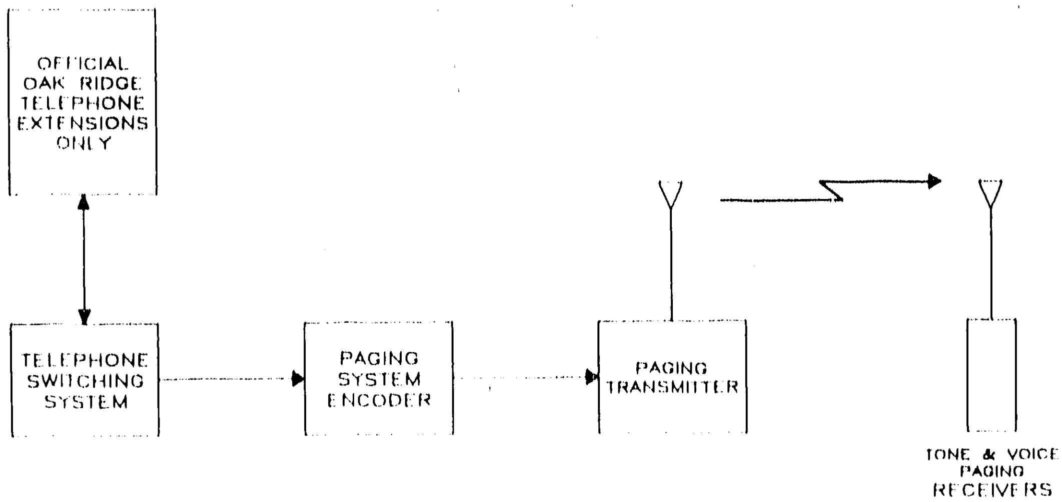


FIGURE 5.3-18B PLANNED ORNL UNCLASSIFIED INTERFACILITY IBM NETWORK

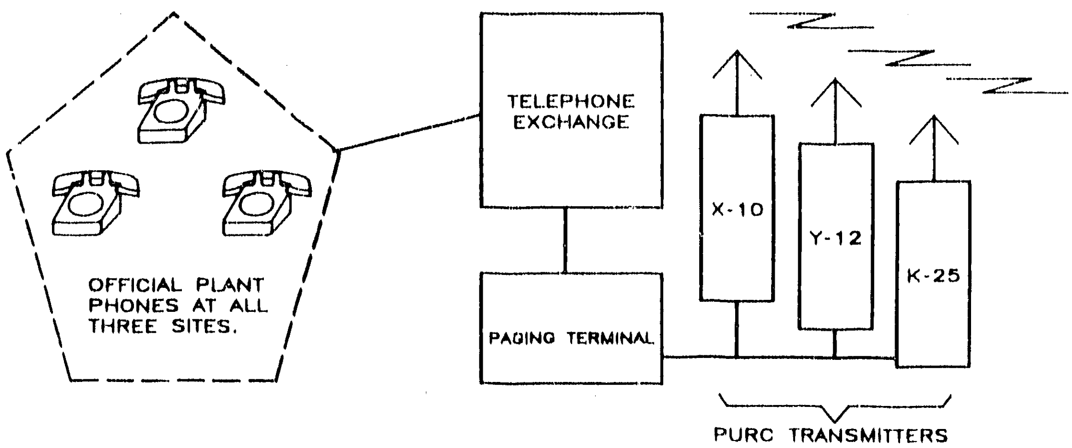
Oak Ridge Gaseous Diffusion Plant (ORGDP) Radio Paging Network

This network is used by all divisions within ORGDP and shared by all Oak Ridge installations for a direct telephone to radio paging system. Network assets include fixed and portable units. Studies recently performed resulted in a report summarizing the existing services, the problem areas, and future requirements for this service at the three Oak Ridge facilities. A new three plantwide paging system was recommended that will include voice store-and-forward capability. The recommended system is currently in the procurement process. Diagrams of the current system and the prcposed system follow as Figure 5.3-19.

CURRENT IN-PLANT RADIO PAGING SYSTEMS



PROPOSED IN-PLANT PAGING SYSTEM



NOTE: ALL PAGES ARE TRANSMITTED AT EACH SITE SIMULTANEOUSLY. PAGERS MAY BE TONE AND VOICE OR NUMERICAL DISPLAY.

FIGURE 5.3-19 CURRENT AND PLANNED ORGDP RADIO PAGING NETWORK

SNLA Instructional Television System

This system is operated by SNLA to provide educational telecasts for its employees. The system uses receive-only satellite and microwave antennas to receive telecasts from national technological universities, the Institute of Electrical and Electronics Engineers, and the University of New Mexico. The telecasts are switched to classrooms throughout the laboratories via fiber and coaxial cable. The system design is presented in Figure 5.3-20.

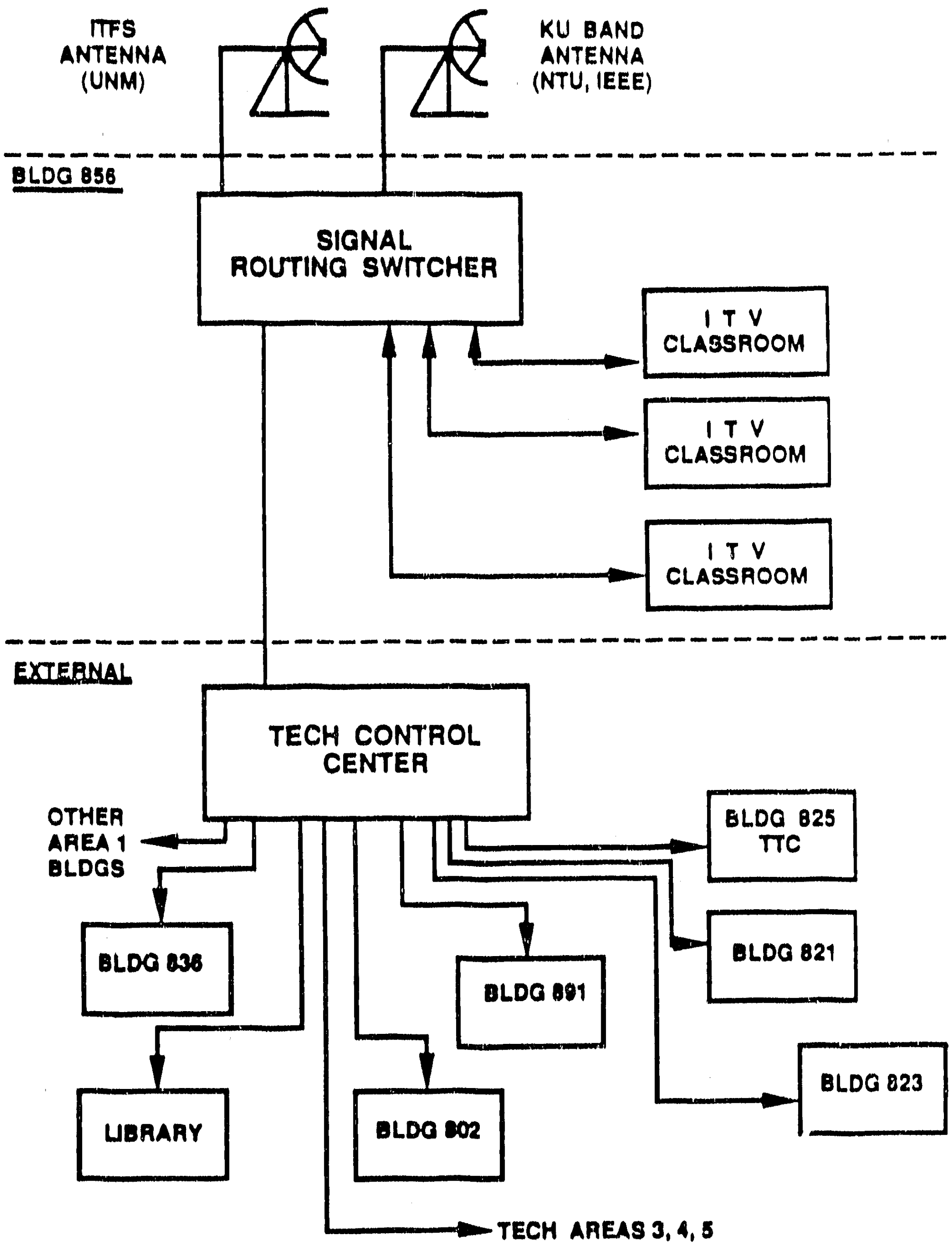


FIGURE 5.3-20 SNLA INSTRUCTIONAL TELEVISION SYSTEM

5.3.3 Current and Planned Activities

The basic goals for telecommunications have been firmly set and will continue as the basis for the development of strategies and of initiatives necessary to carry out these strategies. There are many factors that affect and influence the strategies and initiatives. These include, but are not limited to, urgent national priorities, changes in mission direction, short- and long-term funding issues, competition, operational considerations, and expanding technological growth and demand.

The initial steps for accomplishing the DOE goals are already being taken. Following are activities currently underway within the Department that are effecting the telecommunications goals.

5.3.3.1 Current Activities

FTS 2000 - FTS 2000 is currently being implemented at DOE locations to provide an efficient, low-cost carrier for long-distance communications. DOE intends to use FTS 2000 as the dominant source for all administrative telecommunications services. Since the network offers six basic services that can accomplish nearly all intercity telecommunications requirements, users can order the appropriate telecommunications service of the system that matches their applications.

DOENTS - DOENTS will continue to evolve to meet the requirement for telecommunications services and to support the emergency requirements of DOE.

Integration of Technology - Integration technologies will continually be pursued. Eighteen major initiatives described earlier in this section exemplify the move towards integrated systems and capabilities at DOE sites.

TIP - This Headquarters-based program will continue to provide assistance to sites during the planning and procurement process for new telecommunications systems or services. This program provides economic, regulatory, and policy analysis as well as assistance with the competitive procurement process.

Secure Video Conferencing - Secure video conferencing was demonstrated and evaluated at Headquarters. Based on the success of the demonstrations, Defense Programs, the supporter of this venture, requested that the system be retained. Plans for establishing secure connectivity with additional facilities are currently underway.

5.3.3.2 Planned Activities

GOSIP - The Open Systems Interconnection (OSI) protocols have been under development as international standards for over 10 years. GOSIP defines a common set of protocols and protocol options to be used by Federal agencies as they implement OSI networking products.

The adoption of GOSIP protocols by August 15, 1990, is mandated by FIPS PUB 146 and the Brooks Act (as amended by the Computer Security Act of 1987). GOSIP applies only to new purchases and major enhancements to existing systems. Existing contracts will not be affected.

Recognizing the wide diversity of hardware and software in use throughout DOE, a major objective of GOSIP is to provide interconnection capability for existing DOE networks without negatively impacting the functionality of the existing networks. Transition to GOSIP by DOE will, therefore, be a well planned, multi-step process. It is estimated that, in 5 years, GOSIP networks with diverse equipment will interoperate on a routine basis.

Anticipating the requirement for compliance with FIPS PUB 146, DOE created a GOSIP Migration Working Group in April 1989, with the following charter:

> "The Department of Energy GOSIP Migration Working Group has the responsibility to identify and recommend solutions to issues related to the specification, design, implementation and development of operational networks which conform to the Government Open Systems Interconnection Profile (GOSIP)."

The GOSIP Migration Working Group is composed of both technical and managerial telecommunications representatives from the Department. Working within its charter, the group has been tasked with the development of a DOE GOSIP Transition Strategy and Implementation Plan.

The near-term goal at the onset of the transition will be the development of a small OSI network (OSInet) for testing purposes. In the 5-year timeframe, the transition from current networking protocols to those specified by the GOSIP model will have demonstrated increased interoperability and application-based functionality. GOSIP products will have been developed through cooperation and interaction among vendors and their Government buyers. Testing procedures will have been fully developed and demonstrated to ensure product compliance to the GOSIP standards and interoperability between products of different vendors. General Services Administration (GSA) schedules will include a number of products certified as GOSIP-compliant by agencies other than DOE available at reduced cost from those initially developed in the beginning of the transition.

Longer term development of GOSIP will be a process similar to the evolution of the Transmission Control Protocol/Internet Protocol (TCP/IP). It will be realized through life-cycle attrition of systems and the gradual procurement of GOSIP products. Compliance with GOSIP by DOE will enhance the ability to accurately and efficiently transfer information between DOE sites.

Telecommunications Spectrum Policy-Making Infrastructure Review - The President and Congress have initiated separate actions to review the telecommunications spectrum policy-making infrastructure. This action is designed to improve national competitiveness in the international marketplace, to establish an Advanced Civilian Technology Agency, and to expand the National Security Council to include Cabinet members who deal with trade issues, policy issues, and promote the application of technology to commerce. DOE will work through the NTIA/IRAC forum and provide comments and suggestions. Resource management modeling techniques will be applied to ensure the most effective and efficient infrastructure for the Federal Government and the Department.

Resource Sharing - Congress has directed the reduction of telecommunications cost through consolidation, integration, and sharing of telecommunications services, systems, and spectrum resources by Government and non-Government entities. One initiative to support resource sharing is in the area of public safety and emergency services provided by land mobile radio systems and high frequency radio systems.

A Departmental strategy will be developed to sensitize the FCC to the fact that a technical standard for trunking is required. Failure to do so will result in (1) public safety authorities and the Federal Government not being able to interoperate, (2) adjacent regions not being able to interoperate, or (3) all regions being forced to procure equipment from the same manufacturer. This situation is contrary to the aims of deregulation.

Land Mobile Radio Systems - The bulk of the Department spectrum-dependent telecommunications resources are for land mobile purposes. Because of increased demands for land mobile radio, NTIA has directed IRAC to review the 162-174 MHz and 406-420 MHz bands in order to accommodate mobile service expansion. The goal is to implement changes in the 1990s. The Department will develop a Departmentwide Master Plan for the identification and acquisition of land mobile systems to support the diverse missions and programmatic requirements of DOE. A cost-savings benefit is possible by this initiative.

Frequency Management System (FMS) - The FMS was developed to expedite the processing of frequency application requests. To maximize the benefits of this automated system, all frequency management officers will be linked via the dialup telephone network in FY 1990. Once the Headquarters and field sites are linked, a review process will commence to access additional capabilities along with new developments in order to identify future enhancements to the system.

Radiocommunications Services Bulletin Board System This system will be implemented allowing the unofficial electronic exchange of information between frequency management officers.

Mobile Satellite Telecommunications Service Planning - This is an area of increased activity on the part of the field organizations, and some degree of coordination and consolidation of requirements is needed. Headquarters has approved the establishment of a Satellite Technical Advisory Council (STAC) to provide guidance and recommendations on transportable and mobile satellite service offerings for possible application throughout the Department. Departmentwide meetings will begin on a periodic basis, starting in December 1989.

Communications Security - COMSEC activities include the following:

- o Issue a new directive for the implementation of emission security (TEMPEST) countermeasures.
- o Develop a rational technical criteria for classified information processing systems based on new TEMPEST criteria.

- o Test new classified information processing systems for compliance with TEMPEST criteria.

Telecommunications Services Priority (TSP) System - TSP has moved closer to realization. After FCC approval of the three major documents associated with the system, the TSP system will supersede the current restoration priority system. Current estimates are that the TSP system will achieve its initial operational capability in September 1990.

A TSP point-of-contact will be established at Headquarters, and a procedural structure will be established to manage both DOE internal requests for TSP assignments and the requests from the power utilities for DOE sponsorship of TSP assignments.

National Security Emergency Preparedness (NSEP) Procedural Guide - This guide will be published and distributed. The purpose of the guide is to provide the DOE community with a single source document for NSEP information and guidance.

Other NSEP Activities - Other NSEP activities include the development of plans for all types and phases of emergency operational situations, and preparation of a Departmental plan to access the National Emergency Telecommunications System (NETS).

SECTION 6: PROGRAMMATIC USES OF INFORMATION TECHNOLOGY RESOURCES

Information technology resources have been acquired and used in nearly all facets of the operation of the Department because they provide a cost-effective means of accomplishing a substantial segment of the programmatic work load. In addition, certain types of programmatic work are possible only because of the existence of these capabilities.

In conducting the research, development, and testing work inherent in the energy, weapons, reactor and environmental safety, waste management, and basic research programs, thousands of diverse physical and chemical processes must be modeled and analyzed. Compared to other methods, ITR provide the most cost-effective means of accomplishing the majority of this work. In some cases, such as certain medical research, nuclear reactor safety systems, space technology, etc., there may be no alternative to computerized simulations. ITR are used to help define physical processes, understand problems under investigation, evaluate and optimize designs, and in some cases integrate the manufacturing process. To actually build a scientific experiment typically costs millions of dollars. Therefore, when ITR can be used to reduce the number of experiments needed, or enhance follow-on production, large sums of money and time can be saved.

The following examples of ITR uses are grouped by the DOE program that is supported -- Defense Programs, Energy Research, Nuclear Energy, and Other Program Activities.

6.1 DEFENSE PROGRAMS

One of the major users of information technology resources is Defense Programs. The goal of Defense Programs is to accomplish nuclear weapons research and development, testing, production, data collection and evaluation, and nuclear safeguards vital to the national defense and security of the United States. Information technology resources support is used for Weapons Activities, Defense Waste and Environmental Restoration, Verification and Control Technology, Nuclear Safeguards and Security, and Materials Production. The following examples are typical uses of ITR within Defense Programs. In particular, several of these examples illustrate how important computer-aided engineering is to the accomplishment of the Defense Programs' mission. Drawings, prototype designs, manufacturing, and the transmittal of these drawings from site to site greatly increase the productivity within the nuclear weapons complex design, development, and production cycles.

6.1.1 Computer Integrated Manufacturing (CIM)

CIM is an initiative at the Department's Albuquerque Operations Office to improve the efficiency and effectiveness of the Nuclear Weapons Complex (NWC). NWC is composed of several Departmental sites across the country.

At the Y-12 Plant in Oak Ridge, the CIM project is integrating processes throughout the major manufacturing functions, including metal preparation, fabrication, and assembly product inspection and certification. Improved quality and reduced processing time are being achieved through computer process control. Manufacturing data are handled through interconnected local area networks for manufacturing operations and are integrated into the plant-wide network system. Local area processing, available in the major manufacturing and support areas, provides division-specific information capability, process control, and local data bases. Networks are in place to connect users and manufacturing equipment to the local area processors and to the plant's operation center processors. These networks provide information handling for distributed numerical control systems to (1) transmit tape images produced by computer-aided design (CAD), (2) carry out procedures, (3) collect data, (4) analyze statistics, and (5) control manufacturing processes. Figure 6.1-1 pictorially represents the Product Definition Data Flow process at the Y-12 Plant.

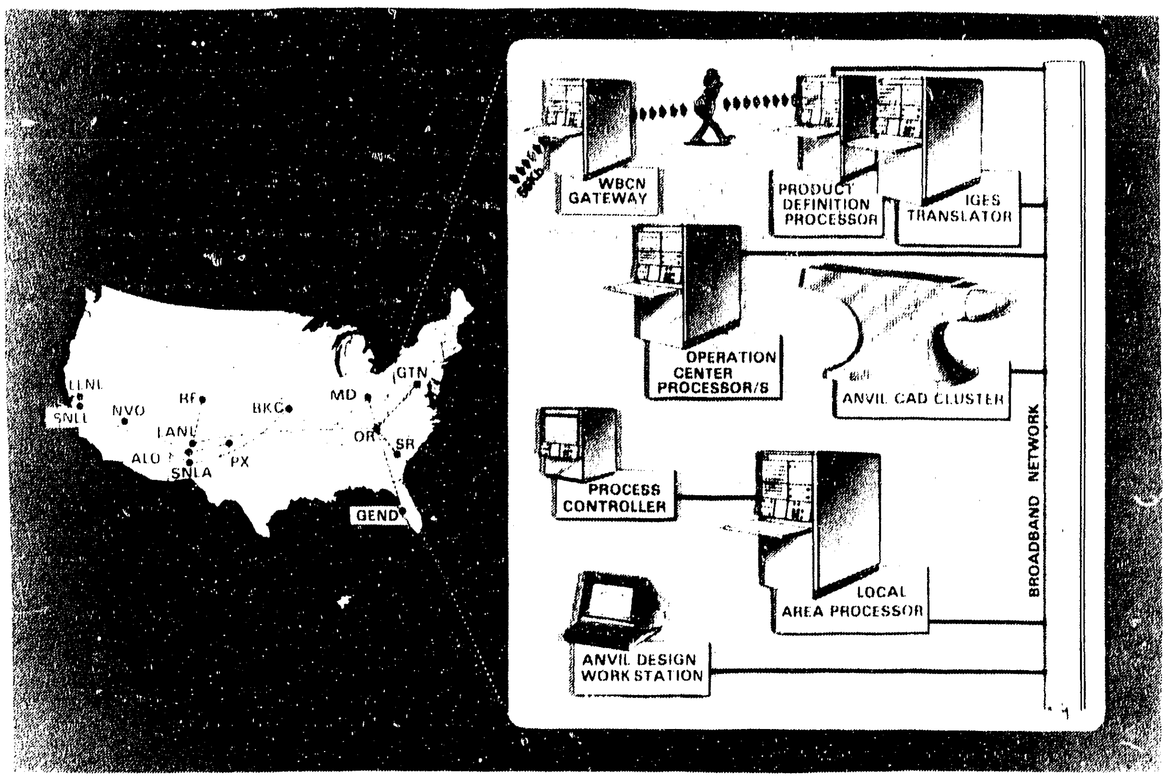


FIGURE 6.1-1 PRODUCT DEFINITION DATA FLOW

6.1.2 Paperless Engineering Support

The purpose of the Paperless Engineering Project at Mound and throughout NWC was to focus on, and coordinate, several active Computer Engineering Applications (CEA) projects in order to optimize their integration with each other. The end result of the project was to develop and demonstrate the capability of electronically receiving a part definition from the originating design agency, performing engineering analyses and process planning functions electronically, and finally produce an on-line operations sheet (manual) for viewing on a shop floor terminal. (See Figure 6.1-2.)

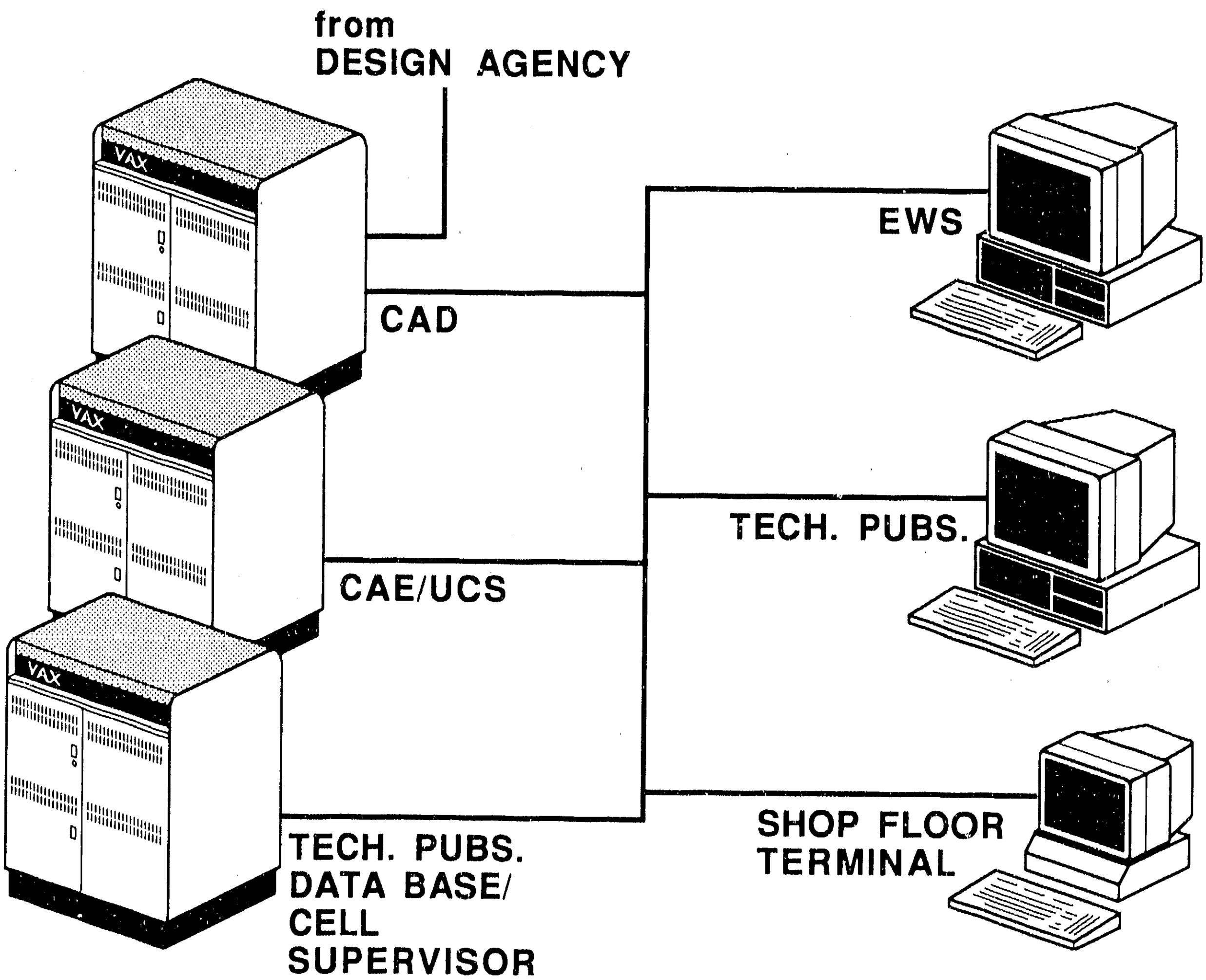


FIGURE 6.1-2 CEA NETWORK SCHEMATIC

The project culminated in a successful demonstration of the following capabilities.

- o Transmit product geometry from the design agency to the Mound Computer-Aided Drawing (CAD) system via the NWC Wide Band Communications Network.
- o Transfer the geometry from the CAD System to the Computer-Aided Engineering (CAE) system.
- o Transfer the geometry from the CAD system to an Engineering Workstation (EWS).
- o Transfer Industrial Engineering 4M standards from the CAE system to the EWS.
- o Perform computer aided process planning functions on the EWS utilizing the 4M standards.
- o Perform engineering analysis on the products utilizing tools on both the EWS and CAE systems.
- o Develop a text and graphics manual (operations sheet) on the EWS.
- o Transmit the manual from an EWS to technical publications.
- o Transmit the finalized manual from technical publications to a demonstration technical documentation data base.
- o From the Shop Floor terminal, access the demonstration technical documentation data base, retrieve, and display the operations sheet.

6.1.3 Material Requirements Planning/Shop Floor Control (MRP/SFC)

Material Requirements Planning (MRP) at the Pinellas Plant is an on-line, interactive planning system which compares demand for a manufactured or purchased part against available inventory and determines the most cost-effective manner in which to meet those demands. The system also monitors the material flow and provides on-line status of production inventories. The system is integrated with the Shop Floor Control System and receives the status of in-process material movement.

MRP uses unclassified output from the Product Scheduling (MPS) System to develop a plan for DOE acceptance. This plan is the master schedule used to develop MRP suggested schedules. The MRP-derived schedules are used in the Shop Floor Control System to schedule specific operations and the in-house-developed purchasing system to order direct production material.

The use of the Product Scheduling System, Materials Requirements Planning, and Shop Floor Control provide the Pinellas Plant with a closed loop Material Requirements Planning System. The system encompasses resource planning at all three levels to help plan and control plant capacity. Figure 6.1.3 provides a schematic of the MRP with all interfaces to other systems on the site also identified.

The savings associated with MRP include productivity savings resulting from consistent priorities and the increased forward visibility afforded by an MRP System. Material savings have resulted from more timely receipts and consistent due dates.

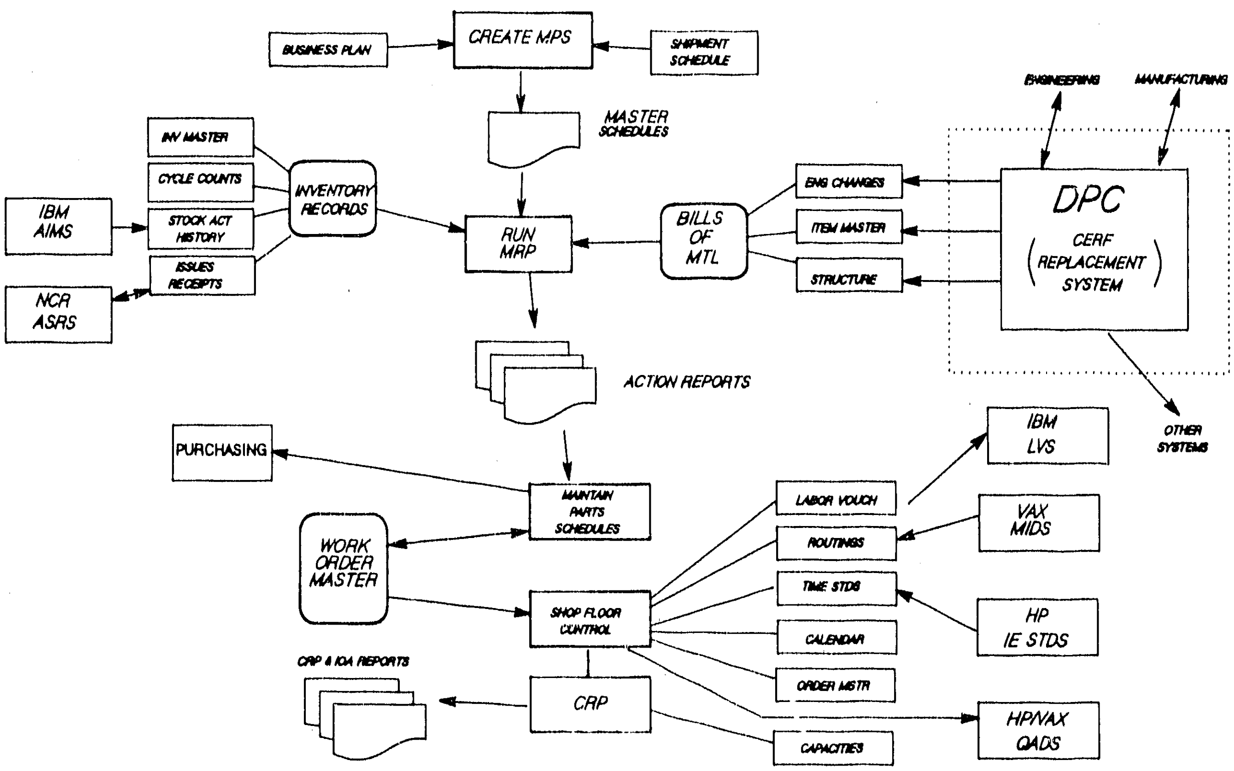


FIGURE 6.1-3 MRP II FUNCTIONS

Shop Floor Control is an on-line communication and control system to support first line supervision in the efficient utilization of people, equipment and tools, and production control in the monitoring of the manufacturing flow to meet scheduled shipments. Through interactive terminals, shop supervision has the ability to monitor the vital signs of their manufacturing operation.

The purchased software package was customized to replace the vouchering and time-card systems with an interactive means to display direct hourly labor efficiencies. In addition, bar coding of routings and products provides the ability to track individual serialized components throughout their manufacturing flow and thus decrease the need to expedite "lot stragglers." QC yields, rework yields, and part quality hold status is captured on the shop floor for use by the quality system.

The general benefits of a Shop Floor Control System are productivity increases in labor, material, and workcenter utilization by reducing in-process inventory levels and fluctuations and manufacturing cycle times.

6.1.4 Impact Response of the MC 3811 Programmer

Sandia National Laboratories in Albuquerque has developed a new three-dimensional transient nonlinear dynamics code, PRONTO. It works in conjunction with newly-developed mesh generation and graphics software having capabilities that are markedly superior to current software. This software has been applied to analysis of a broad range of important practical problems. One example is the calculation of the shock response of a microelectronic package used in the Trident II reentry body. This analysis is the largest of its kind that SNLA has done. Each design variant or loading case analyzed runs for 10 hours on a Cray X-MP and uses 10 million words of its memory.

This microelectronic package consists of 5 boards. Figure 6.1-4 shows the assembly prior to installation of the top board and the encapsulating foam.

The problem is to analyze failures of the microcomputer board (the middle board, a rather complex structure itself) that were occurring when the assembly was subjected to impact testing.

A stress analysis conducted on the assembly as it was designed, and with variations to include some assembly flaws, produced results consistent with observations. The analysis also showed the importance of dynamic effects - the ceramic board that fractured was resonant in the frequency range of importance. Stresses were found to be large, and cracking on the ceramic board in the regions between the chip carriers was to be expected.

Analysis showed that critical stresses increased in cases where the foam encapsulant failed to completely fill the space between the boards, as was observed in some assemblies. Improved encapsulation techniques are being developed to prevent occurrence of voids. Critical stresses are further reduced if less-compliant foam is used; this design change may be implemented. Somewhat surprisingly, use of a thicker ceramic board was calculated to result in increased stress in the dynamic environment. A thinner board leads to decreased stress, but the improvement was judged to be too small to justify a design change. The calculations showed that the board spacers were too rigid and that changing from solid to foam resulted in a significant reduction in the peak stress. Introduction of this change into the design seems probable. The improved understanding of the component dynamics resulting from this analysis was essential to implementing the above changes.

Both the insight gained and the analytical techniques demonstrated are applicable to other components.

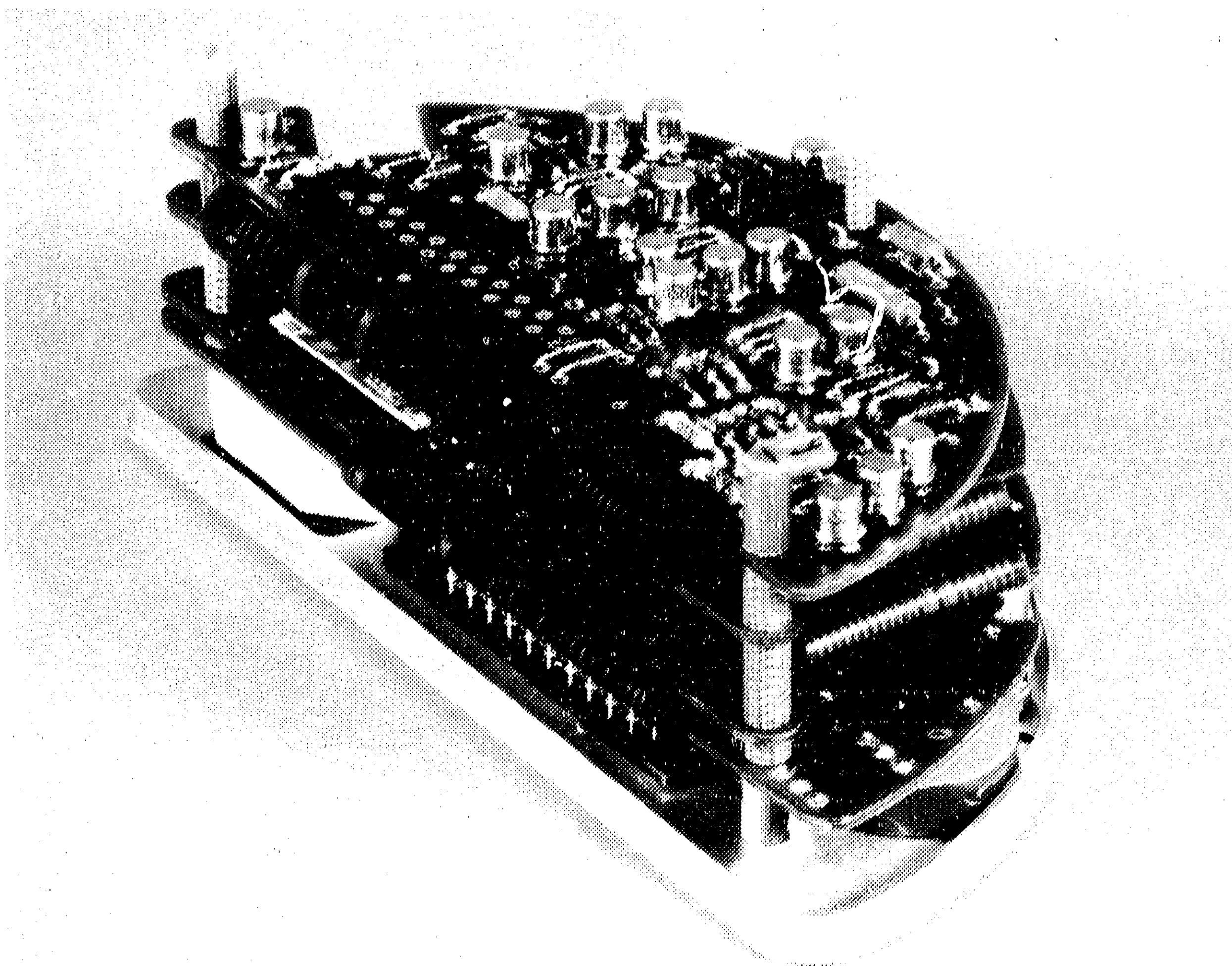


FIGURE 6.1-4 MC 3811 ASSEMBLY

6.1.5 Modeling of Temperature- and Strain-Rate-Sensitive Materials

Weapons system components designed by Sandia National Laboratories, Livermore, must survive hostile environments and severe structural loadings. Some of these environments and loadings can cause intense strain localizations that ultimately lead to component failure. For example, such failures have been observed in certain pinch-welded parts and in structures undergoing rapid deformation during impact. Prediction of strain localizations in weapon system components requires the development and verification of new and complex constitutive models that account for the temperature and strain-rate-sensitivity of materials. Optimum use of these models in the design process can be accomplished only through solution of the coupled thermomechanical problem (i.e., simultaneous solution of the transient, multidimensional, heat-conduction equations and structural equations of motion). However, solution of even the simplest coupled thermomechanical problem is a highly computer-intensive task. Figure 6.1-5 illustrates a prediction of strain localization in a conventional torsion specimen undergoing simple shear. In this example, a torsion load is applied at a constant rate over time. At early times, the strain is seen to be uniform throughout the specimen. However, as the specimen continues to shear through larger and larger deformations, a point is suddenly reached when the coupled effects of strain-induced heat generation and heat conduction from the specimen center cause a rapidly developing shear band. This computation was an implicit, finite-difference solution of the fully coupled, thermomechanical equations. Such simulations aid the development of general temperature- and strain-rate-sensitive material models. These constitutive models will find use in a new, general-purpose, finite-element, thermomechanical code that is currently in development. Successful use of this code for solving the coupled thermomechanical problem will take full advantage of the available storage and vector-processing capabilities of current (and future) computers.

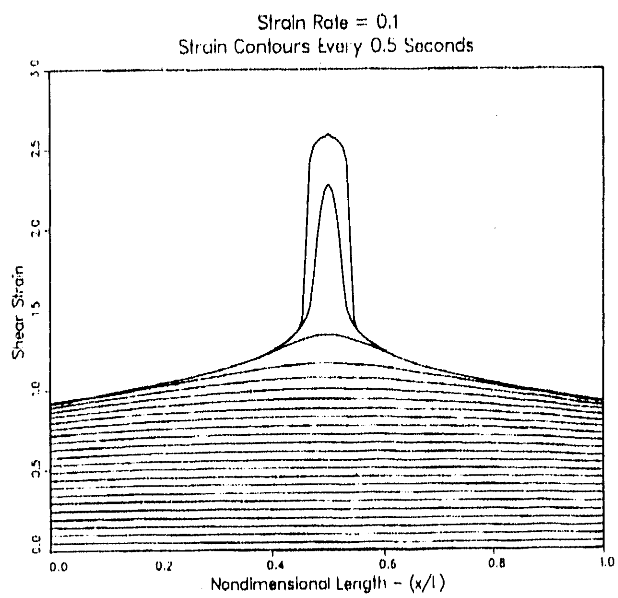


FIGURE 6.1-5 LOCALIZATION OF SHEAR STRAIN

6.1.6 Explosive Power Supply

Neutron generators are used in the initiation of nuclear weapons. A commonly-used energy source for the high-voltage pulse needed to create neutrons is the release of electric charge from special materials subjected to a shock wave from a small explosive charge. The explosive power supply, as well as the neutron tube, must be highly reliable despite the fact that the simultaneous presence of high voltage and shock waves is conducive to electrical breakdowns, especially since the processing of normal and abnormal environments may have introduced flaws from which breakdowns may initiate. The complicated three-dimensional geometry and nonlinear material responses make it extremely difficult, time consuming, and costly to design these devices by trial and error. Sandia National Laboratories uses numerical simulations to calculate internal stresses and electric fields in order to evaluate the potential for failures. The numerical simulations provide a relatively fast means of evaluating devices that have been subjected to a wide range of environments, and may suggest design modifications to reduce stress or field concentrations that can lead to failure. At present, the size of simulations is limited by the memory size of our supercomputers, and some complex designs cannot be modeled. If this limitation was removed, simulations would require tens of hours of computer time each. Even so, computer simulations would be highly cost-effective compared to the time and expense of testing a large number of designs that have been exposed to different environments.

The explosive at the bottom of Figure 6.1-6 has detonated, driving stress waves upward through a vertical stack of flat electrically active elements imbedded in an encapsulating material contained in the cylindrical housing. By this time, much of the electric charge has already been delivered by the device.

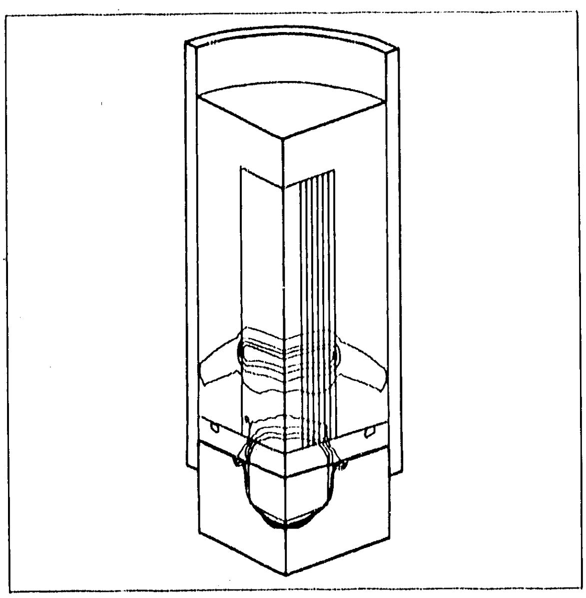


FIGURE 6.1-6 THREE-DIMENSIONAL SIMULATION OF A QUARTER SECTION OF A SIMPLIFIED NEUTRON GENERATOR POWER SUPPLY

6.1.7 Development of a Generic, Computerized Nuclear Material Accountability System (NucMAS)

The NucMAS system, shown in Figure 6.1-7 on the next page, provides basic computerized accountability functions for the Material Balance Areas (MBAs) of the Separation Department at the Savannah River Complex (SRC). These functions include data entry, data management, calculation, and report generation. NucMAS can be used both for routine reporting to the SRC central Material Control and Accounting (MC&A) System and for rapid ad hoc queries in emergency situations. The system is designed to work with any process handling one or more of the accountable nuclear materials specified by the Department. It relies on user-supplied configuration data to drive data prompts, report headings, data validations, and calculations.

Each operating area at SRC must provide routine reports to the central MC&A System. Prior to the development of NucMAS, this was being done with manual record keeping. Problems of the manual system were: (1) transcription errors due to the volume of data, (2) inconsistent use of accountability terms between MBA and MC&A, (3) difficulty relating lab data to transactions reported to central MC&A, and (4) difficult training of accountability personnel in bookkeeping methods. A computerized accountability system was therefore implemented to solve these problems.

The four initial MBA installations were largely dependent on manual entry. The New Special Recovery installation data came largely from process control system entry supplemented by manual entry. With time, the systems at these MBA installations became more real-time, requiring data by process operator entry and automated process control system entry. The system provided for this evolution without major system or support changes.

The software operated smoothly in a concurrent multi-user environment. Response time was subsecond for keystroke echo, a few seconds for routine entries and queries, and a few minutes for more elaborate reports. The MBA custodian restricts access to individual system functions based on user name and assigned duties. An auditable path is maintained from data entry to reported values, especially when making adjustments to previously-entered data.

The major functions provided by NucMAS are to (1) manage information on the movements, material form changes, and measurements of nuclear materials, (2) maintain a current Book Inventory of materials in units appropriate to the material type code(s), (3) manage physical inventory information, (4) produce most routine reports for Safeguards and Security MC&A system, and (5) provide special reports to support routine operation and emergency responses.

A single generic NucMAS application was justified. It greatly reduced development, training, and support manpower requirements, and provided a common environment and interface to the MC&A system.

Relational Technology's Ingres and its 4GL "ABF" were used for the development. Fortran was used for 3GL procedures; Structured Query Language (SQL) was the data base language. It is believed that without such a tool, the quality of NucMAS would have been significantly reduced and development time greatly increased.

Close adherence to the relational data base model provides the greatest flexibility for future additions and changes. Data input functions are decoupled from the data management and report writing features, and a phased implementation of the project provides the desired migration path to automated data input.

An individual NucMAS installation consists of a single executable NucMAS, an Ingres data base for the target MBA, and a few subdirectories for miscellaneous files and reports. The copy of the executable NucMAS and some of the subdirectories can be easily shared by multiple installations on the same processor or kept separate as desired by the system manager.

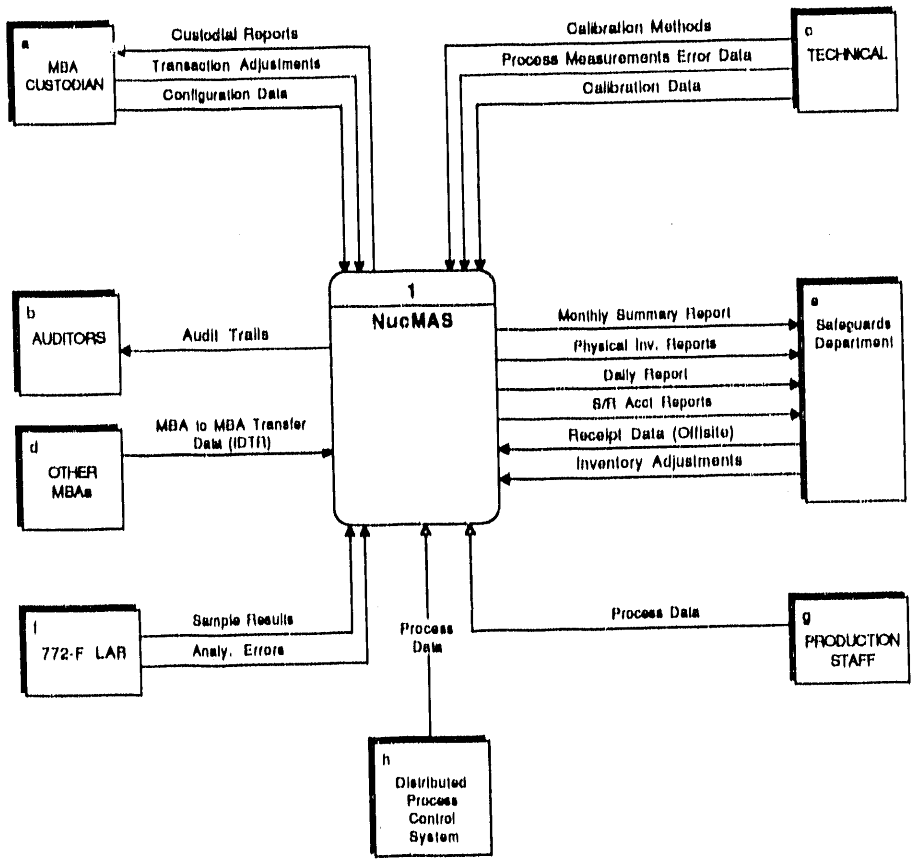


FIGURE 6.1-7 NUCLEAR MATERIALS ACCOUNTABILITY SYSTEM

6.2 ENERGY RESEARCH

Energy Research is another major user of information technology resources. The mission of the Energy Research Program is directed toward research investigations that are expected to have long-term scientific and technological impacts on energy development and utilization. Information technology resources support for Energy Research Programs encompasses High Energy Physics, Nuclear Physics, Basic Energy Sciences, Magnetic Fusion, and Biological and Environmental Research. Several examples of the use of information technology resources for the Energy Research Program follow.

6.2.1 Analytical Modeling for Boron Neutron Capture Therapy

The Idaho National Engineering Laboratory, in conjunction with universities, medical treatment centers, and private medical practitioners, has developed a program in support of the Biological and Environmental Research Program to provide all supporting technology and animal-based biological data required for planning, approving, and conducting human clinical trials of boron-neutron-capture-therapy (BNCT) for a specific human brain tumor. The program's top-level guidance is provided by an advisory board of national experts in the fields of radiation oncology, neurosurgery, radiation biology, and physics.

The BNCT program is centered around DOE's Power Burst Facility reactor and the Eastern Idaho Regional Medical Center. The Power Burst Facility is essential to the program's success because it is the only facility in the United States that can provide a source of neutrons, in the appropriate energy range, of sufficient intensity to allow extensive filtering of undesirable constituents and still deliver a therapeutic dose within a few minutes.

BNCT is a unique two-step experimental radiotherapy for certain types of otherwise fatal brain tumors. Step one of the BNCT procedure involves the selective tumor assimilation of a non-toxic nonradioactive drug. Step two involves neutron irradiation of the affected area. The alpha and lithium fragments have tissue ranges of approximately 8 and 4 micrometers, respectively. Individual tumor cells are on the order of 10 micrometers in diameter so the capture process offers tissue destruction selectivity at the cellular level.

The Idaho National Engineering Laboratory is involved in a collaborative, multi-institutional BNCT research program involving initial animal studies at Brookhaven National Laboratory, possibly leading to human clinical trials at the INEL Power Burst Facility. The parts of the BNCT research program that involve experimental irradiations of animals, phantoms, etc., and, ultimately, patient treatment planning for human trials require detailed computer modeling of the various radiation transport and interaction processes expected to occur, coupled with a display of the results in an easily-interpretable form (see Figure 6.2-1 a computer-generated image of a human brain, courtesy of PDA Engineering, Costa Mesa, California). The basic computational model provides distributions of neutron, gamma, and charged-particle interaction rates, energy deposition rates, and statistical information that can be related to various radiobiological effects in the irradiated area. A graphics workstation is being used at the Idaho National Engineering Laboratory for coupling the computational models to the visual input/output interfaces.

The powerful analytical capability provided to the project team as a result of this task is useful for experiment planning, interpretation of observed experimental results, and, finally, is an aid to the therapeutic radiologist during any follow-on human clinical trials.

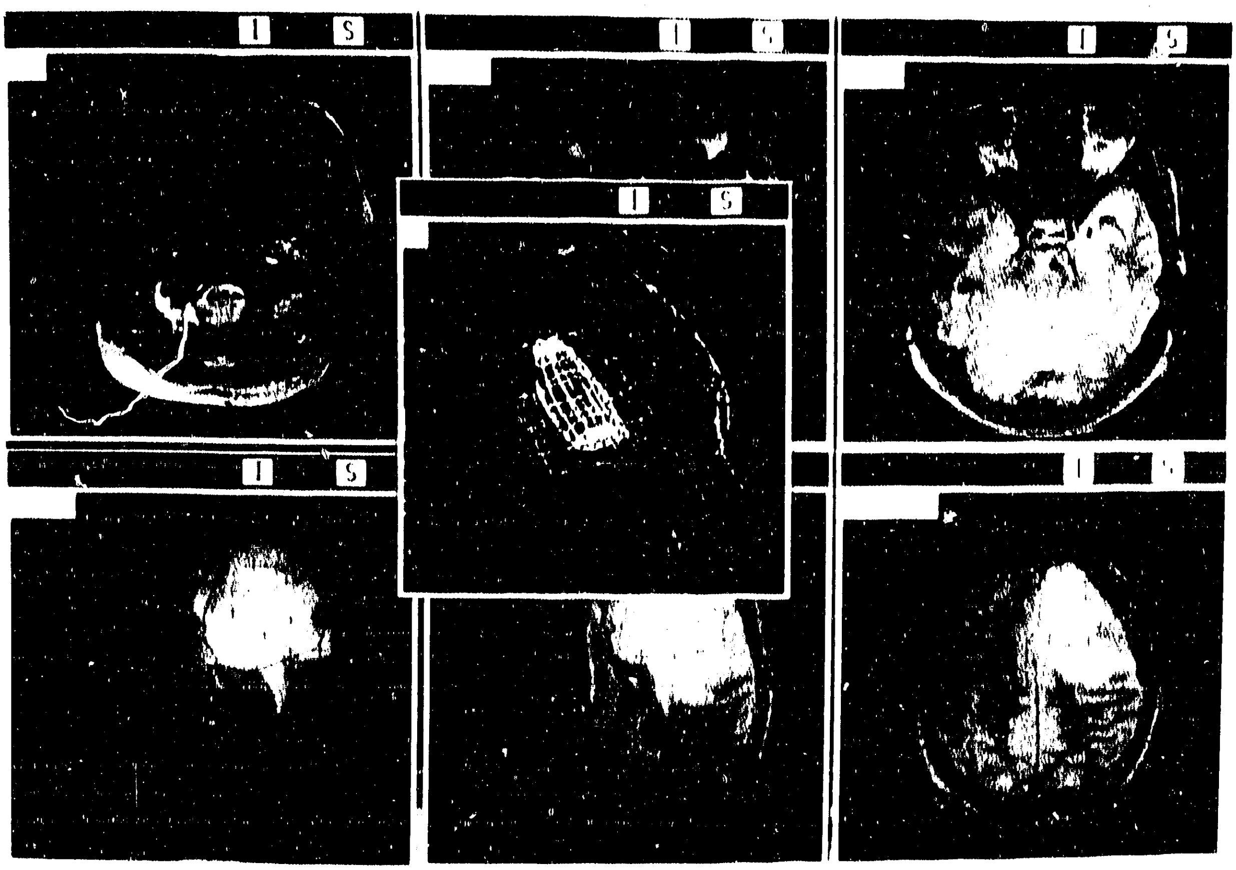


FIGURE 6.2-1 COMPUTER GENERATION OF MEDICAL IMAGING DATA

6.2.2 Neutral Beam Current Drive in the International Thermonuclear Experimental Reactor

The proposed International Thermonuclear Experimental Reactor (ITER) very likely will be driven (in part) by powerful neutral beams. Essential to the device's successful operation will be a high current drive efficiency; that is, a high ratio of current drive in the plasma relative to power deposited by the beams.

In order to anticipate the probable efficiency of the reactor, a Fokker-Planck code has been enhanced to simulate this device. The calculation solves for the distribution function on a large number of flux surfaces (perhaps 20). Plasma particles tend to be confined to the neighborhoods of flux surfaces by the relevant magnetic fields. This allows the Fokker-Planck code to solve 20 relatively-separate problems, rather than one enormous problem. The neutral beams are simulated by a Monte Carlo neutral beam package. Finally, the shape of the flux surfaces themselves are determined.

A typical example of an ITER calculation is attached. In Figure 6.2-2 can be seen the flux surfaces on which the distributions are determined. Flux surface number 4 has been selected for further attention in Figure 6.2-3, where the steady state distribution can be seen. The feature at the right is the footprint of the energetic neutral beam source, which has been superimposed on the distribution function for visual effect. The neutral beam was directed in the midplane so that it would be approximately parallel to the magnetic field at the axis of the device. From this distribution, the current at flux surface number 4 can be computed. Combining the contributions from all the remaining flux surfaces gives a global current which gives the current drive efficiency.

Given the magnitude of the problem, it was essential at every step of the calculation that high efficiency be a priority. For instance, this particular run was done with a modest resolution that resulted in a linear system with 16,800 unknowns. Thus, for each of the 20 flux surfaces, a matrix had to be inverted. Since the problem was mildly nonlinear, five iterations were required to attain convergency, for a total of 100 matrix inversions. Even for a supercomputer, this is a formidable amount of work achieving peak speeds of over 450 million floating point operations per second. The entire calculation is done in core. When the code expands to accommodate the matrix, it requires over 10 million words of memory. The CPU time required for these 100 solutions is about 4 minutes. Also, this is a modest example. Frequently, cases are run in which 40,000 unknowns are present.

We see that this Fokker-Planck code has been able to take great advantage of the unique features of a supercomputer architecture containing large memory and high vector speed.

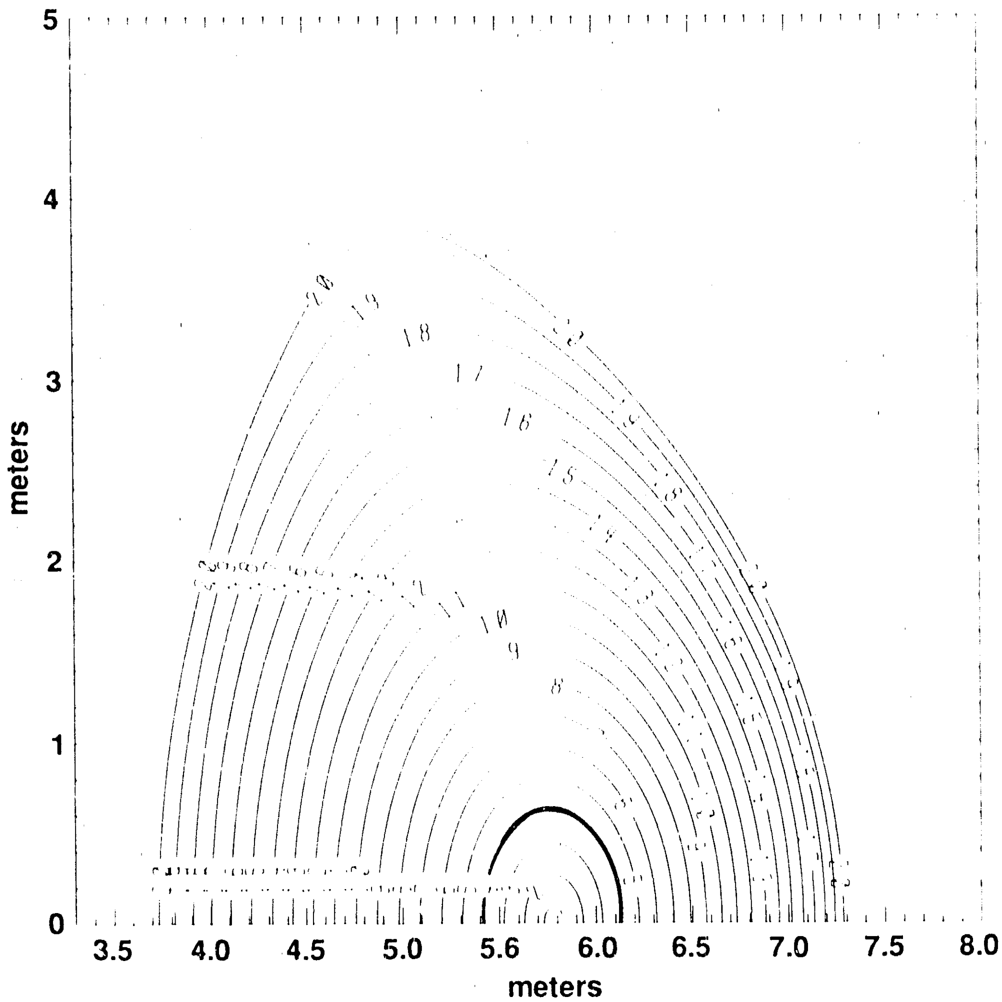


FIGURE 6.2-2 FLUX SURFACES FOR A TYPICAL ITER SIMULATION

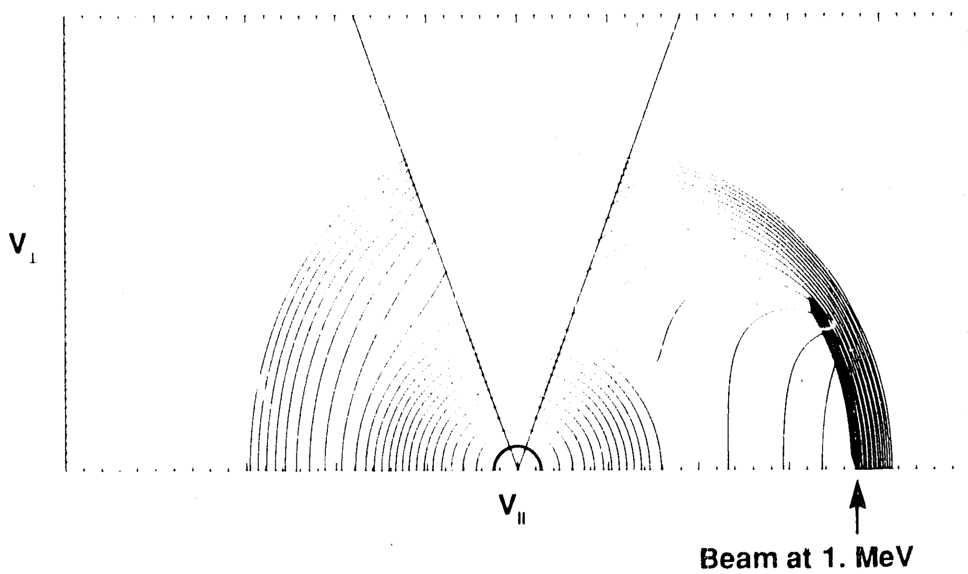


FIGURE 6.2-3 CONTOURS OF STEADY STATE BEAM DRIVEN DISTRIBUTION FUNCTION

6.2.3 Electron Beam Propagation

Electron beams have a number of applications in space and at Sandia -- for example, satellite defense, reentry vehicle detection, and x-ray simulation. It may be possible to propagate high-energy relativistic electron beams very long distances for these applications, although this has not yet been achieved. One way in which this might be done is to inject the beam into a pre-ionized cylindrical plasma channel, which can be formed by a laser. As the electron beam is injected into the channel, the channel electrons are blown away by the beam's space charge, leaving an ion core behind that in turn provides a guiding and focusing force to keep the beam on target. However, the ions in the channel tend to move in response to the beam's space charge, and this motion can diffuse the tail end of the beam to the point that the beam may be ineffective. Sandia National Laboratories are using computer codes, developed at their sites, to simulate the motion and interaction of electrons and ions to explore beam stability prior to large-scale experiments. These experiments are extremely costly and difficult to diagnose. Adequate simulation of the beam requires the inclusion of a very large number of electrons and ions moving and interacting in three dimensions. Individual simulations often require many hours of running time on Sandia National Laboratories supercomputers, but offer the only reasonable means of making progress.

The electron beam is shown in the left computer drawing of Figure 6.2-4 with electrons moving from left to right along the ion channel. The ions, which are moving only very slowly compared to the electrons, are shown separately on the right. The ion channel is collapsing and then moving up and down in response to the electron beam's space charge. This in turn is causing progressing disruption of the tail of the beam. Computer simulations are showing how the beam may be made more stable for space and laboratory applications.

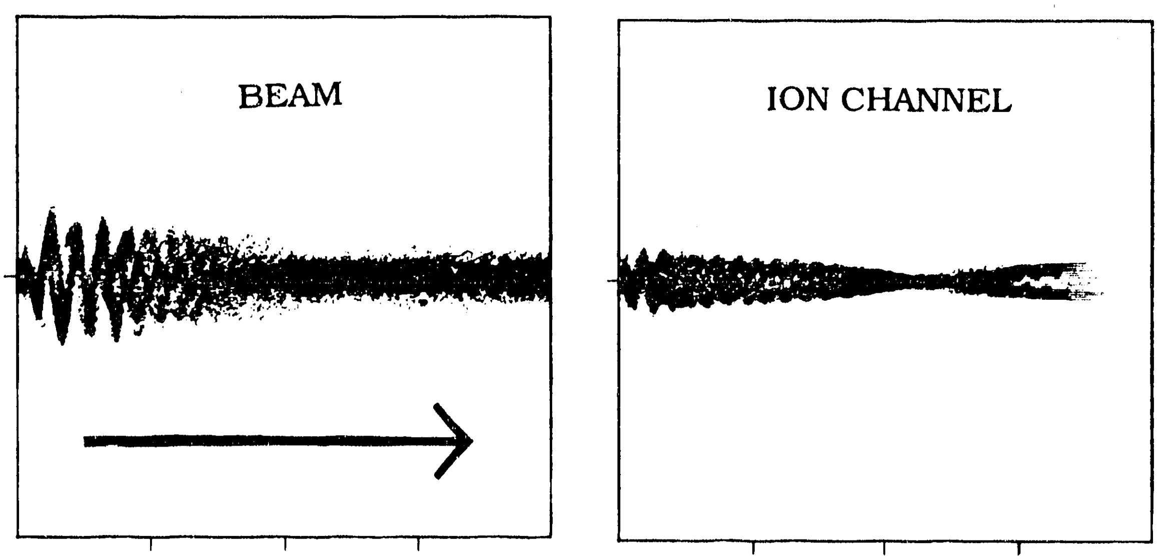


FIGURE 6.2-4 MOVEMENT OF ELECTRON BEAM VS IONS

6.3 NUCLEAR ENERGY

The mission of the Nuclear Energy Program is oriented toward developing and improving the efficiency of nuclear energy technologies. Included in this mission are efforts associated with research, technology development, engineering development, production, and demonstration. Nuclear Energy information technology resources support encompasses Advanced Nuclear Systems, Nuclear Energy Research and Development, Remedial Action and Waste Technology, Naval Reactors, and Uranium Enrichment. Examples of typical uses of information technology resources by Nuclear Energy follow.

6.3.1 ATR Reactor Control Room Simulator Upgrade

The Advanced Test Reactor (ATR) is a 250 megawatt nuclear test reactor located 50 miles west of Idaho Falls, within the boundaries of the Idaho National Engineering Laboratory site. Its mission is to support studies on the effects of intense radiation on nuclear reactor materials in support of the Naval Reactors Program. This unique test facility has three control rooms to handle the reactor core, the primary and secondary coolant systems, and the experiment loops, respectively.

The ATR facility also includes a simulator that is a full replication of the Reactor Control Room (RCR) (see Figure 6.3-1). Until recently, the software used to simulate the reactor systems behavior was limited only to normal reactor operations (start-up, shutdown, routine power shifts).

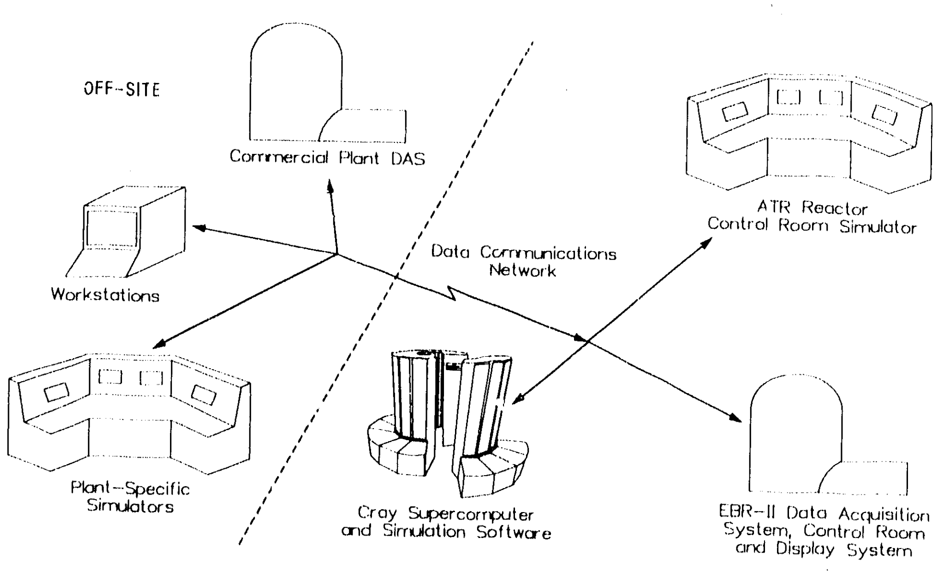


FIGURE 6.3-1 INEL ENGINEERING SIMULATION CENTER

Recently, a second option was added. The ATR RCR Simulator's software for reactor core physics and thermal-hydraulic systems simulation was bypassed and replaced with the widely-used RELAP5 simulation code. This large, high fidelity simulation code resides on the supercomputer at the Idaho National Engineering Laboratory Computer Science Center and is linked by a high speed data communications line to the ATR RCR Simulator (some 50 miles away). The resulting system is an engineering simulator that enables realistic enactment of accident scenarios never before possible with a full scope training simulator. An effort has already begun to reevaluate the operator guidelines for addressing the management of pre-meltdown accident sequences.

6.3.2 Development of Computed Tomography within the Reactor Analysis and Safety (RAS) Division

In recent years, the Reactor Analysis and Safety (RAS) Division at Argonne National Laboratory has been working towards developing a capability to do tomographic reconstructions of nuclear fuel bundles after they have undergone potentially-disruptive tests in the TREAT reactor. The intent of the development is to create a system that can be used to complement the post-test destructive examination and metallography that is normally performed on the test trains used in these safety-related experiments. Computed tomography (CT) will be used not only as a guide to locate optimal sectioning positions, but also to provide cross sectional images at more locations that would be cost-effective for destructive testing.

The underlying principle of CT is that a two-dimensional image of an object can be reconstructed for a number of one-dimensional rays or projections through the object. For the fuel bundle CT, the projections are the measured intensities of parallel neutron beams passing through the assembly. A piece of film is exposed by a neutron-activated foil, and the film density is a measure of neutron intensity. These films are digitized on a scanning microdensitometer and the data loaded in the computer.

The RAS implementation of the CT process has been done on a PDP-11/60 computer. While primitive and slow by today's standards, until recently this machine has been adequate for developing the series of codes used for the reconstruction. The large amount of data storage (typically more than 200 Mbytes) required for one reconstruction series necessitates using an in-house computer.

The resolution of the digitized data is adjustable. A recent test has been digitized at 50 x 400 microns. Normally, 76 views are made at 2.4 degree increments, with a scan area of 23.5 x 21.6 cm. Each view is rotated and aligned, creating a secondary data set. The set is then reconstructed using the standard filtered back-projection technique. An example of the results is shown in Figure 6.3-2. The subject fuel bundle here is a seven-pin assembly of annular fuel pellets. The top reconstruction shows the seven pins nearly intact with a small amount of frozen debris attached to the center pin. The lower image shows a larger accumulation of debris. In both figures, the fluted sodium flow tube is visible as well as the positioning chevrons and the central holes in the fuel pellets.

Future work in the CT development will concentrate on relocating the codes to a faster processor and on refining the filtering algorithm used in the back-projection. This technique will provide a means to answer questions important to the development of the latest generation of metal-fueled reactors.

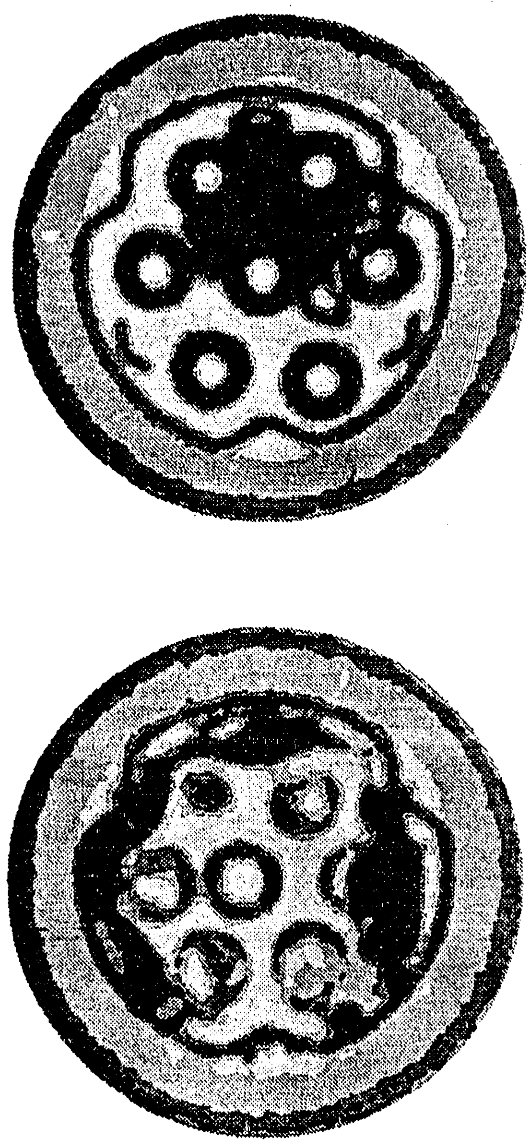


FIGURE 6.3-2 DEVELOPMENT OF COMPUTED TOMOGRAPHY WITHIN THE RAS DIVISION

6.3.3 Reactor Operations Monitoring System

The Reactor Technology, Equipment Engineering, Project and Reactor Departments of the Savannah River Site, are currently engaged in the development of a computer system for monitoring production reactor operations. The Reactor Operations Monitoring Systems (ROMS), as shown in Figure 6.3-3 on the next page, will replace the Safety Computers and data acquisition equipment currently in use. ROMS is designed to incorporate increased data acquisition rates, improved redundancy, and human factors engineered displays in the reactor control room.

ROMS is composed of multiple computer subsystems. Four redundant computer subsystems monitor 2400 temperature sensors. Two computer subsystems share the monitoring of 600 reactor coolant flows. An additional computer subsystem is dedicated to monitoring 400 signals from assorted process transducers. Data from these computer subsystems are transferred to two redundant process display computer subsystems which present process information to reactor operators. ROMS is also designed to carry out safety functions based on its analysis of process data. The safety functions include initiating a reactor shutdown, the injection of neutron poison, and the load shedding of nonessential equipment.

The temperature flow and miscellaneous computer subsystems analyze the process signals 40 times a second. Reduced data are sent to the Control Computer. The four redundant temperature computer subsystems and two flow computer subsystems verify proper reactor operation. If a computer subsystem detects process measurements outside preset limits, it casts a vote to shut down the reactor. When two of the four temperature subsystems or one of the two flow subsystems cast a vote, the reactor is shut down. All subsystems operate independently. Communication between subsystems is accomplished through fiber optics or optical isolation. This optical isolation prevents an electrical failure in one subsystem from affecting other subsystems.

ROMS is designed to analyze over eight million samples per minute. Sixty-eight microprocessors are used in ROMS in order to achieve this real-time analysis. Each computer subsystem contains sufficient memory to store process data and raw data for diagnostics.

ROMS displays and equipment are designed incorporating human factors engineering. High resolution color graphic screens display the reactor process. The operator works with menu and icon selection from two color graphic touch screens. Reactor face maps display temperatures and flows in the reactor according to color scale and numerical value. The radial and axial neutron flux within the reactor are displayed graphically on the screen. Real-time and snapshot traces of process signals are available for viewing on the color graphics screen for the diagnosis of spurious signals or alarms. ROMS is designed to incorporate a color copier for a permanent record of color graphic screen displays.

Department in software development. The Equipment Engineering Division of the Savannah River Laboratory is designing and fabricating the process interface hardware.

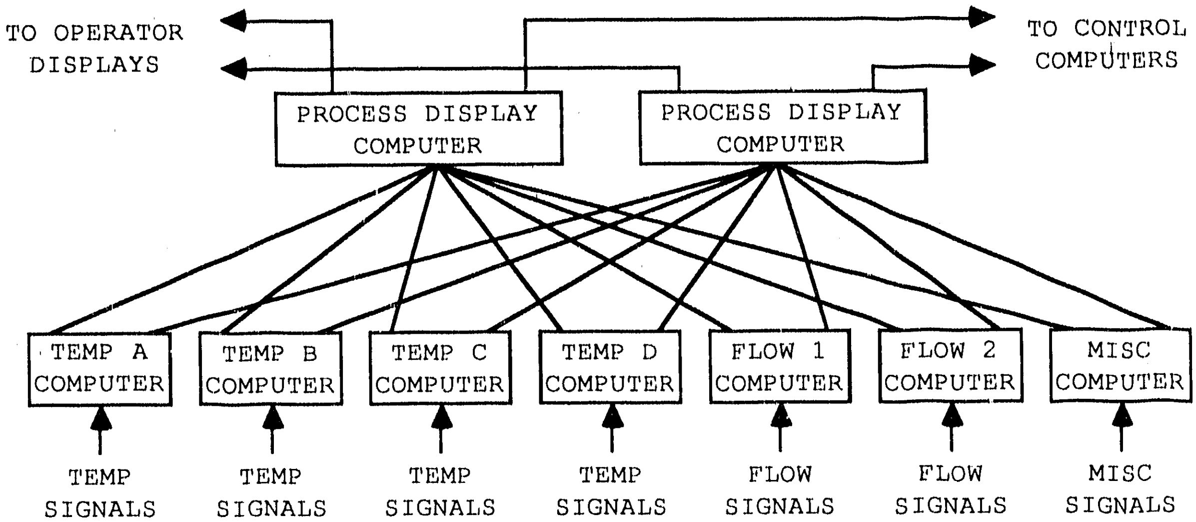


FIGURE 6.3-3 REACTOR OPERATIONS MONITORING SYSTEM SCHEMATIC DIAGRAM

6.4 OTHER PROGRAMS

Some of the activities which make use of information technology resources are Civilian Radioactive Waste Management and Fossil Energy. Computerized systems make vital contributions to mission-related functions of these other programs.

6.4.1 Underground Nuclear Waste Storage

Sandia National Laboratories plays a major role in determining the suitability of Yucca Mountain, Nevada, as a geologic site for the permanent disposal of high-level commercial nuclear waste. See Figure 6.4.1 on the next page. The proposed repository would be 250 meters above the water table, imbedded in a layer of unsaturated volcanic rock, called welded tuff. The site must be evaluated to determine if it can meet the Nuclear Regulatory Commission (NRC) licensing regulations with respect to the flow of water carrying potential contaminants in solution through the rock. Because of the complexity of the site, computer simulations are an essential role in this evaluation. One complication is that the properties of the rock are variable and not precisely determinable; therefore, a statistical number of computer simulations are needed to account for the variability and uncertainty in material properties for each scenario that must be evaluated. A large number of simple one-dimensional calculations have been completed that have provided an understanding of the phenomena and have allowed rough scoping of the extent to which water flow might occur. At this time, two-dimensional calculations are being performed to model the cross section of the proposed repository and the geology in which it is situated in order to investigate water flow in greater detail. Each such calculation requires tens of hours on a supercomputer. Eventually, it will be necessary to perform complete three-dimensional simulations. Using our present supercomputer, these will require hundreds of hours of computer time each. Investigations of material variability, critical for regulatory compliance, will be possible in the future only with a more capable supercomputer.

Although one- and two-dimensional sections have been calculated to date, complete three-dimensional calculations requiring hundreds of hours each will be needed in order to show compliance with licensing regulations.

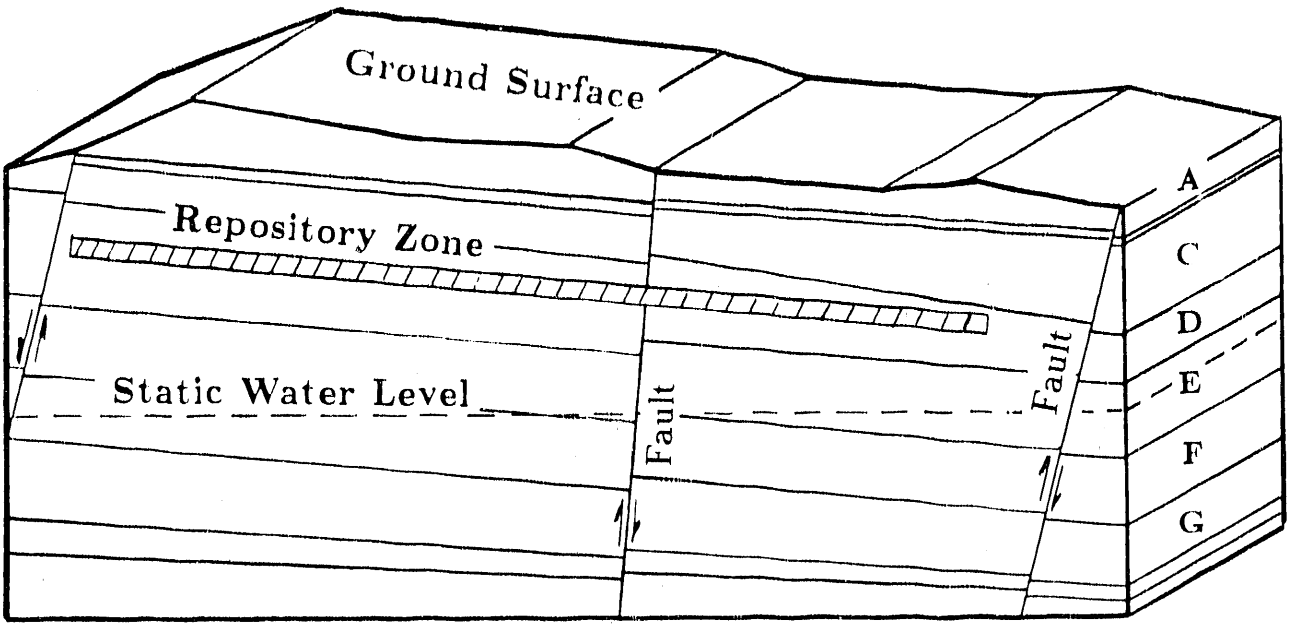


FIGURE 6.4-1 CROSS SECTION OF A COMPUTER MODEL OF THE PROPOSED YUCCA MOUNTAIN REPOSITORY AND THE GEOLOGY IN WHICH IT IS LOCATED

6.4.2 Automated Tracking of Environmental Control Technologies

Programmatically, the Pittsburgh Energy Technology Center implements the Federal Government's applied research and technology development programs in Coal Preparation, Advanced Combustion, Alternative Fuels Development, Flue Gas Cleanup, Coal Liquefaction, and coal-based Magnetohydrodynamics. For each of these technologies, the facility maintains an automated data base designed to achieve the following.

- Provide technology-specific information that can be used by the public and private sectors for analyses and decision-making regarding commercial deployment, environmental and regional impacts, research planning, and program/policy development.

- Provide cross-cutting energy-related information that can be applied for coal resource utilization, technology siting, and market potential, etc., assessments.

Additionally, automated records are maintained on individual research projects to track the technical and administrative status of those projects.

One of the primary areas of current ITR activity is the development of computer models of the processes and energy systems associated with these technologies. Figure 6.4-2, which represents the distribution of coal-fired boilers in the United States, has been used as a basis for formulating strategies and defining potential benefits associated with development of environmental control technologies.

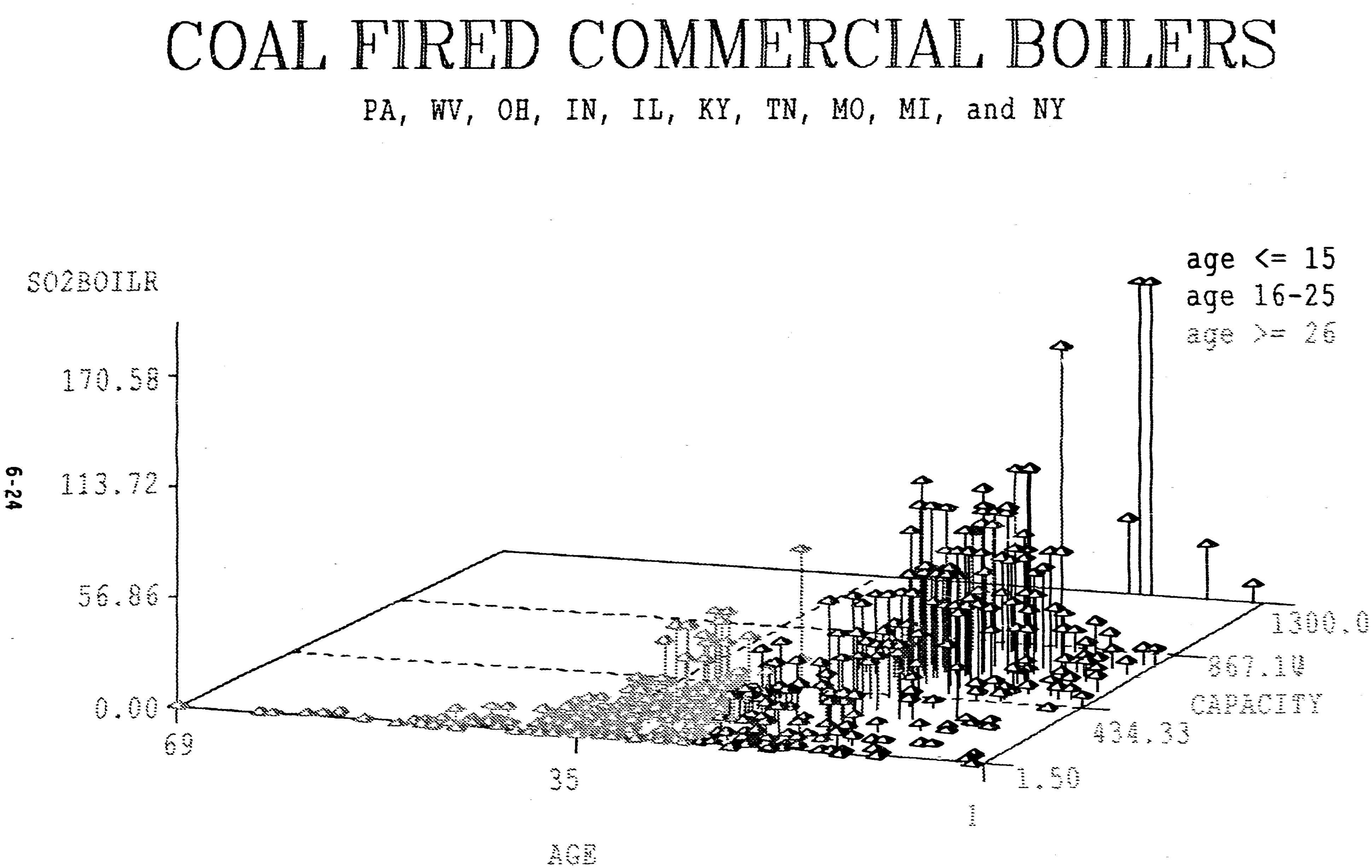


FIGURE 6.4-2 COAL FIRED UTILITY BOILERS

6.4.3 Geological Mapping

Extensive computer resources are required to support the various Morgantown Energy Technology Center geological assessment studies. The WIRE (Well Interactive Retrieval) System was developed to quickly access a data base consisting of data subsets in a matter of hours as opposed to the days or weeks which would be required without computer resources. The data retrieved from the WIRE System (i.e., formation tops, open flow values, initial rock pressures, drilling depths, formation test information) is input into the geological mapping software known as PIXEZ. PIXEZ software allows users to generate geological basemaps, well location maps, traditional contour maps, shaded contour maps (as shown in Figure 6.4-3), statistical (kriged) control maps, fence diagrams, cross-sections, and three-dimensional maps. These maps are used by a spectrum of personnel including geologists, geophysicists, statisticians, petroleum engineers, and chemical engineers to interpret a variety of geological phenomenon such as flow rates, porosity/permeability studies, resource estimate studies, and formation thickness. Maps of these types can take days, weeks, or in some cases even months to complete if done without the computer. The computer and PIXEZ allow maps of this type to be completed usually within 2 to 3 hours.

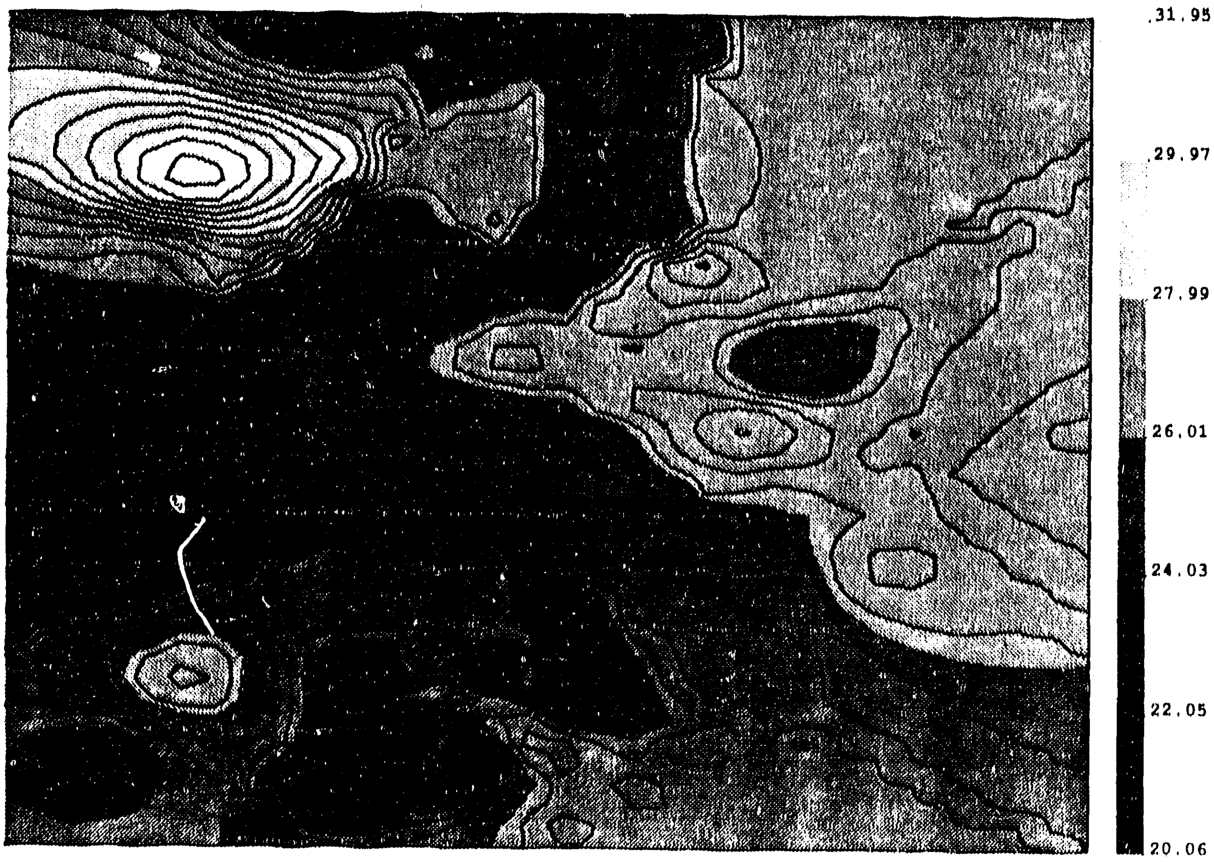


FIGURE 6.4-3 ISOPACH MAP OF THE SUNBURY SHALE

APPENDIX A: SITE PROFILES

Major program activities are supported at various Departmental facilities across the country. This Appendix includes:

- o a map depicting the location and mission category of the 53 DOE facilities participating in the fiscal year 1991 long-range planning process;
- o a chart of the sites indicating which of the plan parts they submitted; and
- o a profile for each of the 53 sites which were required to submit one or more parts of site Information Technology Resources (ITR) Long-Range Site Plan. It briefly outlines the site's location, functions, primary program activities supported, and major ITR resources.

HEADQUARTERS:

CSTM Computer Services and Telecommunications Management
EIA Energy Information Administration
OCRWM Office of Civilian Radioactive Waste Management

OPERATIONS OFFICES:

AL Albuquerque
CH Chicago
ID Idaho
NV Nevada
OR Oak Ridge
RL Richland
SAN San Francisco
SR Savannah River

ENERGY TECHNOLOGY CENTERS:

METC Morgantown
PETC Pittsburgh

POWER ADMINISTRATIONS:

APA Alaska
BPA Bonneville
SEPA Southeastern
SWPA Southwestern
WAPA Western Area

COMPLEXES: (Generally, a complex includes an operations office and one or more research, test, and/or production facilities that are government-owned and contractor-operated.)

HAN Hanford
NVC Nevada
ORC Oak Ridge
SRC Savannah River

PRODUCTION FACILITIES:

KCD Kansas City Plant
MF Mound Facility
PX Pantex Plant
PIA Pinellas Plant
PORTS Portsmouth Gaseous Diffusion Plant
RFP Rocky Flats Plant
WMCO Westinghouse Materials Company of Ohio

RESEARCH AND DEVELOPMENT FACILITIES:

AMES Ames Laboratory
ANL Argonne National Laboratory
BAPL Bettis Atomic Power Laboratory
BNL Brookhaven National Laboratory
FNAL Fermi National Accelerator Laboratory
GA GA Technologies, Inc.
GJPO Grand Junction Project Office
INEL Idaho National Engineering Laboratory
ITRI Inhalation Toxicology Research Institute
KAPL Knolls Atomic Power Laboratory
KMS KMS Fusion, Inc.
LBL Lawrence Berkeley Laboratory
LLNL Lawrence Livermore National Laboratory
LANL Los Alamos National Laboratory
MIT-LNS Massachusetts Institute of Technology - Laboratory for Nuclear Science
NMFECC National Magnetic Fusion Energy Computing Center
ORAU Oak Ridge Associated Universities
PPPL Princeton Plasma Physics Laboratory
SNLA Sandia National Laboratories, Albuquerque
SNLL Sandia National Laboratories, Livermore
SERI Solar Energy Research Institute
SLAC Stanford Linear Accelerator Center
WIPP Waste Isolation Pilot Plant

OTHER DEPARTMENTAL COMPONENTS:

NPOSR-CUW Naval Petroleum and Oil Shale Reserves in Colorado, Utah, and Wyoming
NPRC Naval Petroleum Reserves in California
OSTI Office of Scientific and Technical Information
SPRO Strategic Petroleum Reserve

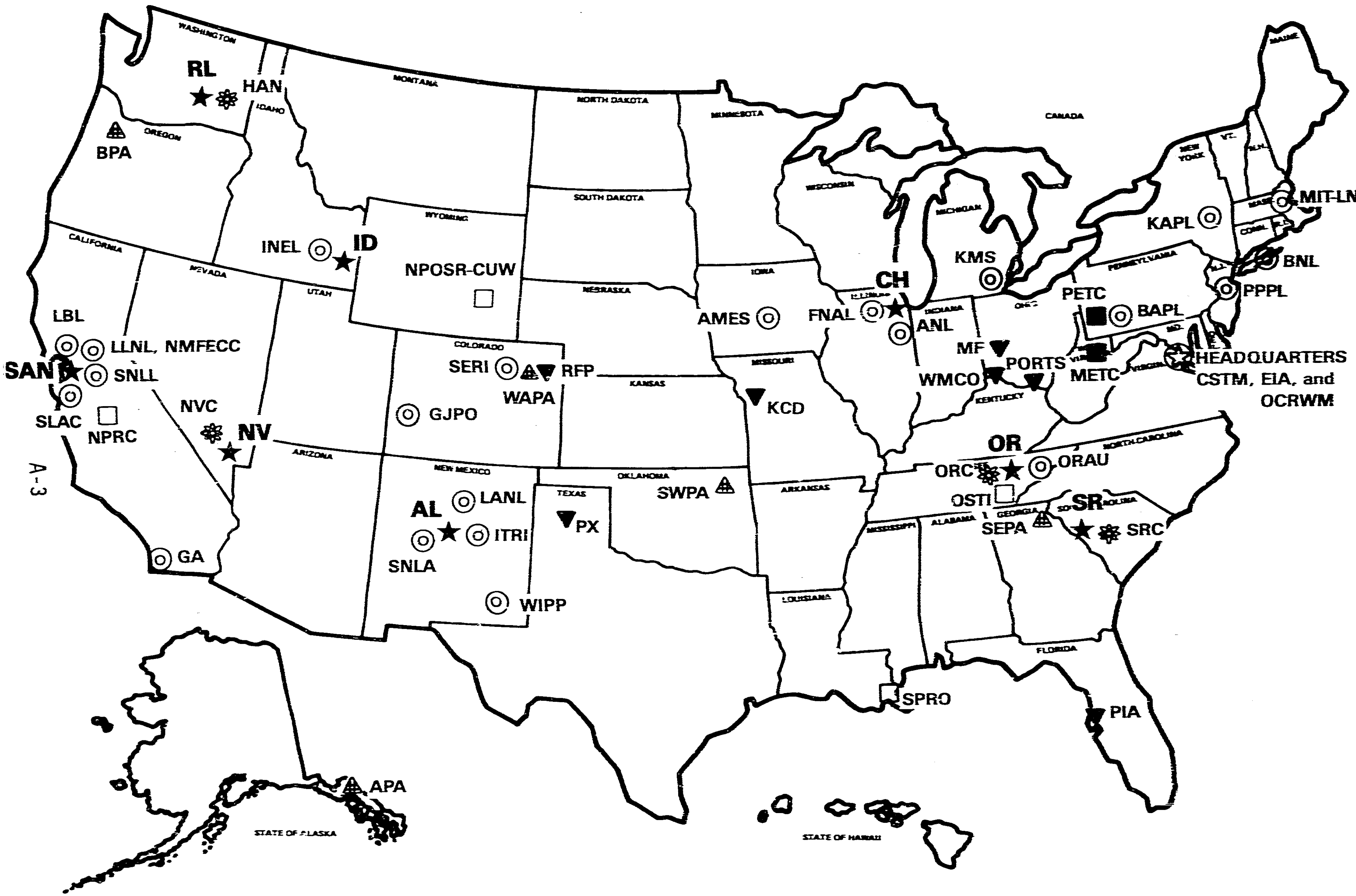


FIGURE A-1 MAP OF DOE FACILITIES PARTICIPATING IN ITR LONG-RANGE PLAN

The chart below lists the sites and indicates which plan part they submitted. The information systems (IS) part is identified for only Departmental organizations. The site ITR resources listed within this Appendix also correspond with this chart.

		IS	CR	TELE
A.1	ALASKA POWER ADMINISTRATION	●		●
A.2	ALBUQUERQUE OPERATIONS OFFICE	●	●	●
A.3	AMES LABORATORY		●*	●
A.4	ARGONNE NATIONAL LABORATORY		●	●
A.5	BETTIS ATOMIC POWER LABORATORY		●	●
A.6	BONNEVILLE POWER ADMINISTRATION	●	●	●
A.7	BROOKHAVEN NATIONAL LABORATORY		●	●
A.8	CHICAGO OPERATIONS OFFICE	●	●*	●
A.9	FERMI NATIONAL ACCELERATOR LABORATORY		●	●
A.10	GA TECHNOLOGIES, INC.		●	
A.11	GRAND JUNCTION PROJECT OFFICE		●*	●
A.12	HANFORD COMPLEX (INCLUDES RICHLAND OPERATIONS OFFICE)	●	●	●
A.13	HEADQUARTERS, COMPUTER SERVICES AND TELECOMMUNICATIONS MANAGEMENT	●	●	●
A.14	HEADQUARTERS, ENERGY INFORMATION ADMINISTRATION	●	●	●
A.15	HEADQUARTERS, OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT	●	●	●
A.16	IDAHO NATIONAL ENGINEERING LABORATORY		●	●
A.17	IDAHO OPERATIONS OFFICE	●	●*	●
A.18	INHALATION TOXICOLOGY RESEARCH INSTITUTE			●
A.19	KANSAS CITY PLANT		●	●
A.20	KNOLLS ATOMIC POWER LABORATORY		●	●
A.21	KMS FUSION, INC.		●	●
A.22	LAWRENCE BERKELEY LABORATORY		●	●
A.23	LAWRENCE LIVERMORE NATIONAL LABORATORY		●	●
A.24	LOS ALAMOS NATIONAL LABORATORY		●	●
A.25	MASSACHUSETTS INSTITUTE OF TECHNOLOGY LABORATORY FOR NUCLEAR SCIENCE		●	
A.26	MORGANTOWN ENERGY TECHNOLOGY CENTER	●	●	●
A.27	MOUND FACILITY		●	●
A.28	NATIONAL MAGNETIC FUSION ENERGY COMPUTING CENTER		●	
A.29	NAVAL PETROLEUM AND OIL SHALE RESERVES IN COLORADO, UTAH, AND WYOMING	●		●
A.30	NAVAL PETROLEUM RESERVES IN CALIFORNIA	●	●*	●
A.31	NEVADA COMPLEX (INCLUDES NEVADA OPERATIONS OFFICE	●	●	●
A.32	OAK RIDGE ASSOCIATED UNIVERSITIES			●
A.33	OAK RIDGE COMPLEX		●	●
A.34	OAK RIDGE OPERATIONS OFFICE	●	●*	●
A.35	OFFICE OF SCIENTIFIC AND TECHNICAL INFORMATION	●	●	●
A.36	PANTEX (AMARILLO) PLANT		●	●
A.37	PINELLAS PLANT		●	●

		IS	CR	TELE
A.38	PITTSBURGH ENERGY TECHNOLOGY CENTER	●	●	●
A.39	PORTSMOUTH GASEOUS DIFFUSION PLANT		●	●
A.40	PRINCETON PLASMA PHYSICS LABORATORY		●	●
A.41	ROCKY FLATS PLANT		●	●
A.42	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE AND LIVERMORE		●	●
A.43	SAN FRANCISCO OPERATIONS OFFICE	●	●*	●
A.44	SAVANNAH RIVER COMPLEX		●	●
A.45	SAVANNAH RIVER OPERATIONS OFFICE	●	●*	●
A.46	SOLAR ENERGY RESEARCH INSTITUTE		●*	●
A.47	SOUTHEASTERN POWER ADMINISTRATION			●
A.48	SOUTHWESTERN POWER ADMINISTRATION	●	●*	●
A.49	STANFORD LINEAR ACCELERATOR CENTER		●	●
A.50	STRATEGIC PETROLEUM RESERVE	●	●	●
A.51	WASTE ISOLATION PILOT PLANT			●
A.52	WESTERN AREA POWER ADMINISTRATION	●	●	●
A.53	WESTINGHOUSE MATERIALS COMPANY OF OHIO			●

LEGEND DENOTES SUBMITTAL OF ITR PLAN PART:

IS - INFORMATION SYSTEMS (DEPARTMENTAL ORGANIZATIONS ONLY)
CR - COMPUTING RESOURCES
TELE - TELECOMMUNICATIONS
* - ABBREVIATED COMPUTING RESOURCES PLAN

A.1 ALASKA POWER ADMINISTRATION, POST OFFICE BOX 020050, JUNEAU, AK 99802

Function: The Alaska Power Administration is a marketing agent for power generated at two Federal hydroelectric projects in the state of Alaska.

Program: Power Marketing.

Telecommunications Support: Administrative telephone service provided by GSA.

A.2 ALBUQUERQUE OPERATIONS OFFICE, P.O. BOX 5400, ALBUQUERQUE, NM 87115

Function: The Albuquerque Operations Office oversees the research, development, production, safety, and surveillance of nuclear weapons for the Albuquerque complex, which encompasses the following prime integrated laboratory and industrial contractor sites.

Los Alamos National Laboratory
Los Alamos, New Mexico

Sandia National Laboratories
Albuquerque, New Mexico

Sandia National Laboratories
Livermore, California

Kansas City Plant
Kansas City, Missouri

Pinellas Plant
Largo, Florida

Pantex Plant
Amarillo, Texas

Mound Facility
Miamisburg, Ohio

Rocky Flats Plant
Golden, Colorado

Additional sites that support nonweapons like energy research, development, and demonstration programs in such areas as nuclear fission, nuclear fusion, solar, wind, and geothermal are:

the Inhalation Toxicology Research Institute which performs research on the toxic effect of inhaled energy related by-products; and

the Waste Isolation Pilot Plant which manages the disposal and storage of waste radioactive materials.

Program: Weapons Activities.

Primary Computer Resources: 2 - IBM 4341, 1 - HP 3000, 1 - DEC VAX 11/785, 1 - IBM 4381, 1 - DEC VAX 6200, and 1 - DEC VAX 8530.

Primary Information Systems (IS) Resources:

- o 52 IS
  - 12 planned new IS
  - 9 new IS under development
  - 31 operational IS (2 are undergoing enhancements)

- o Largest IS
  - Departmental Integrated Standardized Core Accounting System
  - Production and Surveillance Budget System
  - Nuclear Materials Subsystem - Weapons Information System

Telecommunications Support: Voice services through DOE allocated portion of USAF owned Centrex System at Kirtland AFB; local area networks provide majority of data communications with some dialup access via voice system; secure SACNET Replacement Terminal and facsimile; SECOM Network Control Center operating over HF radio system.

A.3 AMES LABORATORY, IOWA STATE UNIVERSITY, AMES, IA 50011

Function: Ames is managed and operated by Iowa State University. Ames is a national, multiprogram, Government-owned, contractor-operated laboratory that conducts basic research addressed to advancing the understanding of the physical, chemical, materials, mathematical, and engineering sciences. The Laboratory's basic research program emphasizes the disciplines of chemistry, metallurgy, and solid state physics, with primary focus on the preparation, characterization, and evaluation of the properties of metals, alloys, and other solid state materials. Present efforts emphasize applied nondestructive evaluation, quantitative determination of environmental pollutants associated with energy conversion, coal preparation, and coal organic chemistry. The Laboratory maintains a continuing program in basic materials research, chemistry, high energy physics, nuclear physics, applied mathematical sciences, and engineering research.

Programs: Basic Energy Sciences and High Energy Physics.

Primary Computer Resources: 1 - SCS -40 XM, 1 - DEC VAX 11/785, 1 - DEC VAX 11/750, 1 HP 3000, 1 - FPS 164AP, and several microvaxes.

Telecommunications Support: Voice and local data services are provided by agreement with Iowa State University; local DECNET supported data network; unclassified TWX, TELEX, and facsimile service; radio communications supports operational functions.

A.4 ARGONNE NATIONAL LABORATORY, 9700 SOUTH CASS AVENUE, ARGONNE, IL 60439

Function: Argonne, as one of the nation's major centers of energy research, carries out broad programs of research and development in the physical, biological, and environmental sciences under a management and operating contract with the University of Chicago. Research is also conducted on fast reactor technology. Historically, fission energy technology has constituted Argonne's largest effort. Today, Argonne programs have expanded into fossil fuel utilization, solar energy, fusion, magnetohydrodynamics, and advanced battery development, as well as health and environmental effects of various energy technologies.

Programs: Coal; Civilian Reactor Development; Advanced Nuclear Systems; Magnetic Fusion; Biological and Environmental Research (Environmental Research and Development); High Energy Physics; Nuclear Physics; Basic Energy Sciences; and Energy Storage Systems.

Primary Computer Resources: 1 - Cray X-MP/14, 1 - VAX 8250, 1 - VAX 8700, 1 - IBM 3033, 1 - IBM 3033 w/3042 AP, 4 - DEC VAX 11/780, 7 - DEC VAX 11/750, 1 - DEC VAX 11/730, 2 - HP 3000, 1 VAX 6200, and several microvaxes.

Telecommunications Support: Voice service provided by digital PBX switch installed in 1987; data communications provided over voice system and over local and wide area networks; radio networks provide administrative, operational, and security support.

A.5 BETTIS ATOMIC POWER LABORATORY, P.O. BOX 79, WEST MIFFLIN, PA 15122

Function: Bettis is a research and development laboratory operated by the Westinghouse Electric Corporation under a management and operating contract for the Federal Government. Bettis is one of two laboratories that carries out the Naval Reactors program. The laboratory provides design, development, and operational engineering support of nuclear reactor plants for propulsion of naval vessels. Activities include work on reactor core and component technology and design, thermal and hydraulic systems, materials, reactor physics, fuel fabrication, and classroom training of naval personnel.

Program: Naval Reactors.

Primary Computer Resources: 1 - CDC Cyber 205, 2 - CDC 7600, 1 - DEC VAX 8800, 1 CDC Cyber 720, 1 - DEC VAX 11/785, 1 - DEC VAX 8600, 1 - DEC VAX 11/780, 4 - IBM 4341, 1 - IBM 4381, and 1 - Cray Y-MP/832

Telecommunications Support: Government-owned voice switching system; secure local network; dialup narrative message services to contractors; radio systems support other modes of communications at the facility.

A.6 BONNEVILLE POWER ADMINISTRATION, P.O. BOX 3621, PORTLAND, OR 97208

Function: The Bonneville Power Administration was created by Congress in 1937 and is a marketing agent for power generated by 30 Federal dams in the pacific northwest. Bonneville has designed and built the nation's largest network of long-distance high-voltage transmission lines. In addition to scheduling and dispatching power from the Federal dams, Bonneville wheels, purchases, and interchanges over its grid about 50 percent of the power generated in the region and has capacity to transmit about 80 percent of the region's power.

Program: Power Marketing.

Primary Computer Resources: 1 - IBM 3084Q, 1- IBM 4341, 4 - IBM 4331, 2 - DEC VAX 8650, and 5 - DEC VAX 11/785.

Primary Information Systems Resources:

- 8 IS
  - 1 new IS under development
  - 7 operational IS (1 IS is undergoing enhancement)

- Largest IS
  - Financial Management Information System
  - Program Management Information System

Telecommunications Support: Administrative voice and data services provided by GSA-leased services; operational voice and data are interconnected by Government-owned microwave (Portland, OR, and Vancouver, WA); data network to regional offices pacific northwest; additional data communications provided by dedicated circuits and dialup connection.

A.7 BROOKHAVEN NATIONAL LABORATORY, UPTON, NY 11973

Function: Brookhaven National Laboratory is a multiprogram, multidisciplinary laboratory, operated by Associated Universities, Incorporated, under a management and operating contract. The Laboratory has the primary mission of conducting basic research centered around large facilities that are constructed, operated, maintained, and upgraded by the Laboratory for the use of scientists from all over the nation. Major facilities are a 33GeV Alternating Gradient Synchrotron, a High Flux Beam Reactor, a Tandem Van de Graaff accelerator, and the National Synchrotron Light Source, which provides the world's most intense, polarized source of X-radiation and vacuum ultra-violet radiation. In addition, there is a multidisciplinary Environmental Inhalation Toxicology Facility, which tests health hazards from chemicals likely to be in the atmosphere due to burning of fossil fuels. Several new facilities are planned that will play important roles in future work at Brookhaven.

Programs: High Energy Physics; Basic Energy Sciences; Nuclear Physics; Biological and Environmental Research (Environmental Research and Development).

Primary Computer Resources: 1 - IBM 3090/180 VP, 6 - DEC VAX 11/780, 1 - CDC Cyber 830, 1 - DEC VAX 11/730, 4 - DEC VAX 11/785, 4 - HP 3000, 1 - DEC VAX 8600, 1 - DEC VAX 8820, 1 - Encore Multivax, 1 - FPS 364, and several microvaxes.

Telecommunications Support: Laboratory-owned voice system; local area network; unclassified TWX, TELEX, and facsimile service; small radio systems complement other communications modes.

A.8 CHICAGO OPERATIONS OFFICE, 9800 SOUTH CASS AVENUE, ARGONNE, IL 60439

Function: Chicago Operations Office (CH) negotiates and manages between 5,000-6,000 contracts and financial assistance instruments. Recipients range from academic institutions and non-profit organizations to business and industry, state and local governments, and individual researchers in most states and several foreign countries. The programs and projects span the spectrum of DOE endeavors, making CH one of the most diverse of DOE's operations offices.

In addition to institutional responsibilities, CH provides specialized support in areas such as construction management, environmental and reactor safety, and nuclear materials safeguards. Most of these efforts are tied to the procurement cycle of negotiation, execution, administration, and close-out of contracts and grants.

Chicago Operations Office management responsibilities include:

o Ames Laboratory, Iowa State University, Ames, IA;

- o Argonne National Laboratory, Argonne, IL and Idaho Falls, ID;
- o Brookhaven National Laboratory, Associated Universities, Inc., Upton, NY;
- o Environmental Measurements Laboratory, New York, NY;
- o Fermi National Accelerator Laboratory, Batavia, IL;
- o Massachusetts Institute of Technology, Laboratory for Nuclear Science, Cambridge, MA;
- o New Brunswick Laboratory, Argonne, IL;
- o New York University/Courant Mathematics and Computing Laboratory, New York, NY
- o Princeton Plasma Physics Laboratory, Princeton, NJ;
- o Solar Energy Research Institute, Golden, CO.

Programs: General Administration.

Primary Computer Resources: 2 - HP 3000 and support by Argonne National Laboratory.

Primary Information Systems Resources:

- o 6 IS
  - 6 operational IS (1 IS is undergoing enhancement)
- o Largest IS
  - Laboratory Information Management System
  - Departmental Integrated Standardized Core Accounting System - Chicago
  - Patents Management Information System

Telecommunications Support: Voice and data services provided by digital PBX switch through Argonne National Laboratory; secure SACNEl Replacement Terminal and facsimile; two-way radio equipment supports security and emergency functions.

A.9 FERMI NATIONAL ACCELERATOR LABORATORY, P.O. BOX 500, BATAVIA, IL 60510

Function: Fermi's primary function is to advance scientific knowledge of the structure of matter. The Laboratory is operated under a management and operating contract by the Universities Research

Association, a consortium of 54 research-oriented universities. The principal scientific instrument at Fermi is a proton synchrotron, the world's largest basic scientific research instrument for high energy physics.

Program: High Energy Physics.

Primary Computer Resources: 1 - AMDAHL 600E; 3 - Cyber 175; 1 - Cyber 875 CPU; VAX cluster consisting of 2 - 11/785, 1 - 8600, and 2 - 8650; 1 - VAX 8800, 2 - VAX 8250; 1 - VAX 8650 with FPS 164; and 1 - IBM 4381.

Telecommunications Support: Leased voice service; data communications provided through local and wide area networks; unclassified TWX, TELEX, and facsimile service; radiocommunications support operational administrative and security functions at the site.

A.10 GA TECHNOLOGIES, INC., P.O. BOX 85608, SAN DIEGO, CA 92138

Function: GA Technologies is an example of DOE's partnership with the private sector to bring complex new technologies to the commercial marketplace. The principal project is "Doublet III," one of the "Tokamak" fusion experiments. This has recently been converted to the DIII-D which increased the plasma volume and current by a factor of 3.

Program: Magnetic Fusion.

Primary Computer Resources: DEC VAX Cluster consisting of: 1 - 8650, 1 - 8600, 1 - 11/750, and 1 - 11/780.

Telecommunications Support: Voice services provided through GA Corporate System; User Service Center for MFE Network with 56kb satellite link; unclassified TWX, TELEX, and facsimile service.

A.11 GRAND JUNCTION PROJECT OFFICE, P.O. BOX 14000, GRAND JUNCTION, CO 81502

Function: The Grand Junction Project Office (GJPO), long involved in uranium resource development, is now primarily involved in environmental cleanup of contaminants resulting from uranium mining and milling activities ongoing in the United States since the 1950's. GJPO's management and operating contractor is UNC Geotech. Administrative support for GJPO is provided by the Idaho Operations Office.

Programs: Remedial Action and Waste Technology; Defense Waste and Environmental Restoration; and Nuclear Waste Fund.

Primary Computer Resource: 1 - CDC Cyber 170.

Telecommunications Support: Voice services provided by site-owned IBM/Rolm 9751 installed in 1988; voice mail and data communications provided by digital integrated system (DIX); unclassified TWX, TELEX, and facsimile service; VHF radio supports security, emergency, and operations activities.

A.12 HANFORD COMPLEX, (INCLUDES RICHLAND OPERATIONS OFFICE) P.O. BOX 550, RICHLAND, WA 99352

Function: Hanford is a multiprogram/multicontractor operation located near Richland, Washington. Activities supported include plutonium production, isotope separation, waste management, liquid metal reactor studies, radioactive facilities decommissioning, and a broad spectrum of research and development.

The Richland Operations Office (RL) has administrative oversight responsibility for the safe, cost-effective management of programs and resources within the Hanford Complex and energy conservation grant programs in the states of Washington, Oregon, and Alaska. The current principal contractors and the respective functions they perform are:

Westinghouse Hanford Company (WHC), with Boeing Computer Services, Richland, Inc., (BCSR) as a subcontractor for Information Resources Management, is the management and operating contractor for operations and engineering. WHC manages waste management, advanced reactor research and development, nuclear engineering, reactor management, and decommissioning and remedial action. BCSR, operates as a fully-integrated department within WHC.

Battelle Memorial Institute, under a management and operating contract, operates the Pacific Northwest Laboratory (PNL). PNL is a multiprogram national laboratory that performs basic and applied research and provides research expertise and program support.

Kaiser Engineers Hanford is the management and operating contractor for architect-engineering and construction services.

Hanford Environmental Health Foundation provides medical and environmental health services and conducts medical research studies.

Programs: Remedial Action and Waste Technology; Nuclear Energy Research and Development; Defense Waste and Environmental Restoration; Verification and Control Technology; Wind Energy Systems;

Nuclear Waste Fund; Materials Production; Environment, Safety and Health (Research and Development); Biological and Environmental Research (Environmental Research and Development); Basic Energy Sciences; and Civilian Radioactive Waste R&D.

Primary Computer Resources: 1 - Cray X-MP/18, 1 - NAS 9080, 1 - NAS 9060, 1 - Univac 1100/63, 1 - IBM 4341, 9 - DEC VAX 11/780, 1 - DEC VAX 11/785, 2 - Prime 750, 3 - HP 3000, 1 - NAS 6620, 1 - IBM 4361, 1 - DEC VAX 8300, 2 - DEC VAX 8350, 1 - Convex C210, and 1 - Sequent Symmetry.

Primary Information Systems Resources (Richland Operations Office Only):

- o 5 IS
  - 5 operational IS (1 IS is undergoing enhancement)
- o Largest IS
  - Departmental Integrated Standardized Core Accounting System - Richland
  - DOE Security System

Telecommunications Support: Leased voice systems and provide automatic exchange systems; two microwave networks sharing voice and data; local area network for data access; secure SACNET Replacement Terminal and facsimile; local security and administrative radio networks.

A.13 HEADQUARTERS, DEPARTMENT OF ENERGY, COMPUTER SERVICES AND TELECOMMUNICATIONS MANAGEMENT, WASHINGTON, D.C. 20545

Function: The Office of Computer Services and Telecommunications Management (CSTM) provides computing support for Headquarters administrative and management information systems needs. CSTM manages the telecommunication resources, DOE-wide commercial time-sharing services, and operates the Secure Automatic Communication Network.

Program: General Administration.

Primary Computer Resources: 1 - AMDAHL 5890-200E, 1 - DG MV8000, 2 HP - 3000, and 1 - IBM 4381.

Primary Information Systems Resources:

- o 370 IS
  - 35 planned new IS
  - 28 new enhanced IS under development
  - 307 operational IS

- Largest IS
  - Approved Funding Program System
  - Budget Table System
  - Procurement and Assistance Data System
  - DOE Integrated Payroll/Personnel System
  - Departmental Integrated Standardized Core Accounting System

Telecommunications Support: Two on-site information exchange (IX) systems serving voice and data; data communications supported by modified Ethernet LANs; SACNET switching center: Technical Control Centers; classified and unclassified narrative and facsimile centers; secure video teleconferencing.

A.14 HEADQUARTERS, DEPARTMENT OF ENERGY, ENERGY INFORMATION ADMINISTRATION, WASHINGTON, DC 20585

Function: The Energy Information Administration's mission is to inform the Congress, the Executive Branch, and the public regarding the nation's energy situation by administering a central and comprehensive program for collecting, interpreting, validating, analyzing, and disseminating energy information.

Program: Energy Information.

Primary Computer Resources: 1 - IBM 3084 QX and 1 - IBM 4341.

Primary Information Systems Resources:

- 4 IS
  - 4 operational IS

- Largest IS
  - Activities Resources and Results Information System
  - Facility Accounting Control System
  - Cost Recovery Information System

Telecommunications Support: All services provided through HQ/CSTM.

A.15 HEADQUARTERS, DEPARTMENT OF ENERGY, OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT, WASHINGTON, DC 20585

Function: The Office of Civilian Radioactive Waste Management (OCRWM) oversees a national program to develop technology and provide facilities for safe, environmentally acceptable, permanent disposal of high-level waste. In 1987, the Information Resource Management Division (IRMD) was created to analyze the information resource management needs of the program and define the integrated approach for managing the resources and technologies (hardware and software, telecommunication networks, data processing, office automation, and information management).

Program: Nuclear Waste Fund.

Primary Computer Resources: 1 - DEC VAX 6330, 2 - DEC VAX 6240, 1 DEC VAX 750, 3 - DEC VAX 785, 3 - DEC VAX 8700, 1 - Prime 6350, 1 - Alliant FX 80, and several microvaxes.

Primary Information Systems Resources:

- o 25 IS
  - 1 planned new IS
  - 15 operational IS
  - 9 under development

- o Largest IS
  - Records Management System (under development)
  - Licensing Support System (under development)
  - Automated Records System
  - Action Item Log

Telecommunications Support: All services provided through HQ/CSTM.

A.16 IDAHO NATIONAL ENGINEERING LABORATORY, P.O. BOX 1625, IDAHO FALLS, ID 83415

Function: EG&G Idaho, Inc., is the management and operating contractor for the Idaho National Engineering Laboratory (INEL). The mission of INEL is to furnish engineering services and products, reactor operations, and fuel reprocessing, principally in nuclear energy and associated technologies for DOE. INEL also provides use of its unique facilities for the benefit of other Government agencies, members of the scientific and technical community, and maintains a close interaction with scientific personnel in regional and other universities and industry to promote interest in developing closer research and collaborative ties.

INEL supports both the research and licensing areas of the Nuclear Regulatory Commission (NRC). NRC research efforts provide the technical basis for rulemaking and regulatory decisions, as well as providing technical assistance to support licensing decisions. INEL directly supports NRC licensing review or regulation for all commercial nuclear power plants in the United States.

Programs: Defense Waste and Environmental Restoration; Nuclear Energy Research and Development; Nuclear Waste Fund; Materials Production; Naval Reactors; Basic Energy Sciences; Nuclear

Safeguards and Security; Environment, Safety, and Health (Environmental R&D); Geothermal; Nuclear Physics; and Remedial Action and Waste Technology.

Primary Computer Resources: 1 - CDC Cyber 830, 1 - IBM 3090-180E, 8 - HP 3000, 1 - IBM 3083J, and 1 - Cray X-MP/24.

Telecommunications Support: Integrated Digital Information Exchange (DIX) provides voice/data service, including voice paging; broadband LANs; local teletype network for narrative and facsimile distribution services; secure SACNET Replacement Terminal and facsimile; provides tenant communications support for Idaho Operations Office, Argonne Laboratory-West, and Naval Reactors Facility (NRF) training site; VHF and UHF radio systems provide support for work coordination as well as for security and emergency operations.

A.17 IDAHO OPERATIONS OFFICE, 785 DOE PLACE, IDAHO FALLS, ID 83402

Function: The Idaho Operations Office directs and administers Departmental programs at the Idaho National Engineering Laboratory and other remote sites. These programs include nuclear safety, research, reactor development, reactor operations and training, materials production, waste management and technology development, energy technology and conservation programs, Strategic Defense Initiative (SDI) research and development, national defense activities, and fuel processing. Other sites reporting to the DOE Idaho Operations Office include:

- The Grand Junction Project Office, Grand Junction, CO;
- A regional support office in Denver, Colorado, which administers energy conservation grants;
- A plant in Butte, Montana, for conducting magnetohydrodynamics research operated by Mountain States Energy, Inc., a management and operating contractor;
- A program office at Three Mile Island, Pennsylvania, for conducting nuclear reactor safety research and development operated by EG&G Idaho, Inc.; and
- A plant in West Valley, New York, for demonstrating solidification techniques which can be used for preparing high-level liquid waste for disposal operated by West Valley Nuclear Services, a management and operating contractor.

Program: General Administration.

Primary Computer Resources: 1 - HP 3000 and 1 - VAX 8850.

Primary Information Systems Resources:

- o 4 IS
  4 operational IS

- o Largest IS
  Departmental Integrated Standardized Core Accounting System - Idaho

Telecommunications Support: Voice system provided by INEL integrated system installed in 1989; relay center for INEL teletype and facsimile network.

A.18 INHALATION TOXICOLOGY RESEARCH INSTITUTE, P.O. BOX 5890, ALBUQUERQUE, NEW MEXICO 87185

Function: Lovelace Biomedical and Environmental Research Institute operates the Inhalation Toxicology Research Institute under a management and operating contract with DOE. The Institute is used to determine the effects of airborne fission product particles from inhalation exposure on humans and their environment. Research is conducted on nuclear energy-related effluents as well as those associated with fossil technologies and automotive emissions. Current emphasis is assessing the long-term health effects associated with chronic inhalation exposure to energy-related by-products.

Program: Biological and Environmental Research (Environmental Research and Development).

Primary Computer Resource: 1 - DEC VAX 11/780.

Telecommunications Support: Voice and data services received through Albuquerque Operations Office/Kirtland AFB.

A.19 KANSAS CITY PLANT, 2000 EAST 95th ST., KANSAS CITY, MO 64131

Function: Allied-Signal, Inc., Kansas City Division, a management and operating contractor, operates the Kansas City Plant for the production and procurement of non-fissile weapon components. The work done at the Kansas City Plant is highly diversified, technically oriented, and embraces the full spectrum of work on non-nuclear products--from research on new materials to the production of complex and reliable weapons components.

Program: Weapons Activities.

Primary Computer Resources: 1 - IBM 3081KX, 1 - IBM 3090/200E, 1 - CDC Cyber 835, 1 - CDC Cyber 855, 1 - CDC Cyber 815, 1 - CDC Cyber 860, 1 - CDC Cyber 990, 2 - IBM 4341, and 1 - DEC VAX 8650.

Telecommunications Support: Voice system shared with GSA, IRS, USMC, and Department of Agriculture; local integrated document distribution system; Satellite Backbone System node; multi-purpose local area networks provide most classified and unclassified data communications.

A.20 KNOLLS ATOMIC POWER LABORATORY, P.O. BOX 1072, SCHENECTADY, NY 12301

Function: The Knolls Atomic Power Laboratory is one of two laboratories having responsibility to support the Naval Nuclear Propulsion Program for the design, development, and safety of nuclear power plants for Naval vessels and the construction and operation of land-based prototypes. The management and operating contractor is General Electric Company.

Program: Naval Reactors.

Primary Computer Resources: 1 - CDC Cyber 205, 2 - CDC 7600, 1 - IBM 4341, 1 - VION AS/XL-50, 1 - DEC VAX 11/785, 1 DEC VAX 11/780, 1 - DEC VAX 8800, 1 - DEC VAX 8250, and 1 - Cray Y-MP/832.

Telecommunications Support: Owned computerized switching system; dialup secure narrative service; unclassified TWX, TELEX, and facsimile services; local area networks support on-site data communications functions.

A.21 KMS FUSION, INC., 3621 SOUTH STATE ROAD, ANN ARBOR, MICHIGAN 48106

Function: KMS Fusion (KMSF), Inc., was incorporated as a subsidiary of KMS Industries, Inc., in May 1971 to pursue research and development in the field of laser-induced nuclear fusion. KMSF is a major supplier of fusion fuel containers to the national laboratories. The company is the only private institution pursuing laser fusion research. The Intertial Confinement Fusion research contract at KMSF is administered by the San Francisco Operations Office.

Program: Weapons Activities.

Primary Computer Resources: 1 - DEC VAX 11/780, 1 - DEC VAX 11-780 with FPS 164, and 1 - DEC VAX 8700.

Telecommunications: Data communications at the site are contained within the facilities with no external connections, internal computing systems are connected via Ethernet LAN to support scientific processing support.

A.22 LAWRENCE BERKELEY LABORATORY, ONE CYCLOTRON RD., BERKELEY, CA 94720

Function: The Lawrence Berkeley Laboratory (LBL) is operated by the University of California under a management and operating contract. Current research includes fundamental studies in nuclear physics; earth, chemical, and materials science; high-energy physics; biological and menvironmntal research; solar; and conservation and renewable energy. The Center for Advanced Materials which focuses on research with direct applications to the needs of industry is a major LBL construction initiative. Another initiative is the Advanced Light Source (ALS), a generation synchrotron light facility that will provide high intensity/high brightness light beams for advanced materials research in the areas of:

-- Surface Science and Catalysis,
-- Advanced Materials Synthesis, and
-- Advanced Device Concepts.

Programs: High Energy Physics; Basic Energy Sciences; Nuclear Physics; Buildings and Community Systems; Geothermal; Nuclear Waste Fund; Magnetic Fusion; Biological and Environmental Research (Environmental Research and Development), and Civilian Radioactive Waste.

Primary Computer Resources: 9 - DEC VAX 11/780, 5 - DEC VAX 8650, 2 - IBM 4341, 1 - Convex C-1XP, 1 - DEC VAX 785, 1 - DEC VAX 8250, and 1 - DEC VAX 3500.

Telecommunications Support: Leased voice service; emergency voice system; local area networks and microwave systems for data communications; regional information center DOE (OSTI) network; unclassified TWX, TELEX, and facsimile service; radio systems support service and emergency functions as well as field crews.

A.23 LAWRENCE LIVERMORE NATIONAL LABORATORY, P.O. BOX 808, LIVERMORE, CA 94550

Function: The Lawrence Livermore National Laboratory is a multiprogram laboratory operated by the University of California under a management and operating contract. The principal program mission of the laboratory is research, development, and test activities of nuclear weapons. A large portion of the Laboratory work effort is devoted to programs in magnetic and inertial confinement fusion energy, biological, ecological, and atmospheric research, basic energy science research, and non-nuclear energy projects.

Programs: Weapons Activities; Materials Production; Verification and Control Technology; Uranium Enrichment; Magnetic Fusion; Nuclear Waste Fund; Biological and Environmental Research (Environmental Research and Development); and Multi-Sector.

Primary Computer Resources: 2 - Cray 1, 1 - Cray Y-MP, 2 - Cray X-MP, 1 - DEC VAX 11/780, and 1 - DEC VAX 11/785 (Lawrence Livermore National Laboratory Computer Center); 1 - UNIVAC 1100/82, 1 - Amdahl 5890/180E, 4 - HP 3000, 1 - IBM 9377, 1 - IBM 4361, 1 - IBM 4381, 1 - DEC VAX 8350, 1 - DEC VAX 8250, and 2 - DEC VAX 8530 (Administrative Information Systems Center); 1 - DEC VAX 11/780, and 1 - DEC VAX 8600 (Magnetic Fusion User Service Center).

Telecommunications Support: Leased voice service; secure SACNET Replacement Terminal and facsimile; Satellite Backbone System node; national network centers for: CATCOMS, TIS, ARAC, MFE; local area networks for data communication support; broadband cable TV networks for education and information services; radio networks for security and administrative services.

A.24 LOS ALAMOS NATIONAL LABORATORY, P.O. BOX 1663, LOS ALAMOS, NM 87545

Function: The Los Alamos National Laboratory was founded in 1943 to design and build the first atomic bombs. Today it is operated by the University of California, under a management and operating contract, and functions as a multiprogram research and development laboratory. The principal fields of research are theoretical nuclear, medium energy, plasma, and cryogenic physics; inorganic, physical, and nuclear chemistry; mathematics; metallurgy; life sciences and biomedicine; and earth sciences. These scientific disciplines support programs in nuclear weapons design and development, the use of nuclear energy for the production of electric power, nuclear safeguards, controlled release of thermonuclear energy through both magnetic and inertial confinement of fusion, in geothermal and solar energy applications of stable and radioactive isotopes, cryogenic applications for electrical energy transmission and storage, and advanced instrumentation development.

Programs: Nuclear Energy Research and Development; Multi-Sector; Weapons Activities; Verification and Control Technology; Basic Energy Sciences; Coal; Petroleum; Nuclear Waste Fund; Geothermal; Defense Waste and Environmental Restoration; Magnetic Fusion; Nuclear Safeguards and Security; Materials Production;

Environment, Safety and Health (Environmental Research and Development); Biological and Environmental Research (Environmental Research and Development); University Research Support; and Nuclear Physics.

Primary Computer Resources: 2 - Cray Y-MP, 3 - Cray X-MP, Thinking Machines CM-2, 3 - CDC Cyber 825, 1 - CDC Cyber 855, 1 - DEC VAX 8650, 1 - DEC VAX 8700, 1 - DEC VAX 8600, 1 - DEC VAX 8550, 2 - DEC VAX 6220, and 2 - DEC VAX 11/785 (Central Computer Facility); 1 - DEC VAX 750 and 1 - DEC VAX 8650 (Magnetic Fusion User Service Center).

Telecommunications Support: Leased CENTRON voice service; secure SACNET Replacement Terminal and facsimile; integrated computing network; high volume wideband data links for shared supercomputing capability; user service center MFE Network; VHF and UHF frequency systems provide a broad range of radio support functions.

A.25 MASSACHUSETTS INSTITUTE OF TECHNOLOGY/LABORATORY FOR NUCLEAR SCIENCE, 77 MASSACHUSETTS AVE., CAMBRIDGE, MA 02139

Function: The Laboratory for Nuclear Science was established in 1946 to do research in nuclear and particle physics. The latest activities of the Laboratory concentrate on theoretical and experimental studies of nuclear structure and reactions, the fusion and fission of nuclei, and the properties and interactions of the elementary particle of nature. The primary experimental programs are in three areas: intermediate energy nuclear physics, high energy particles physics, and heavy ion physics.

Programs: High Energy Physics and Nuclear Physics.

Primary Computer Resources: 3 - DEC VAX 11/780, 1 - DEC VAX 8820, 2 - DEC VAX 6220, and 1 - IBM 4361.

Telecommunications Support: All support provided by MIT.

A.26 MORGANTOWN ENERGY TECHNOLOGY CENTER, P.O. BOX 880, MORGANTOWN, WV 26505

Function: The Morgantown Energy Technology Center is responsible for fostering continuity and competence in the advancement of fossil energy technology. The Center performs research and development activities for coal, petroleum, and gas technologies. They pursue technology base development and provide commercialization assistance.

Programs: Coal; Petroleum; and Gas.

Primary Computer Resources: 1 - DEC VAX 11/780, 2 - DEC VAX 8650, 1 - DEC VAX 8250 with 1 - FPS M64, and 1 - DEC VAX 8350.

Primary Information Systems Resources:

- o 25 IS
  - 2 new IS under development
  - 4 new IS being planned
  - 19 operational IS (6 IS' are undergoing enhancement redesign)

- o Largest IS
  - Medical Database
  - Fact Sheets
  - On-Site Property Management System

Telecommunications Support: Voice service provided by leased Centrex services; unclassified TWX, TELEX, and facsimile service; local area networks, dedicated circuits, and hardwiring provide data communications support.

A.27 MOUND FACILITY, P.O. BOX 3000, MIAMISBURG, OH 45343

Function: The EG&G Mound Applied Technologies, Inc., operates the Mound Facility, under a management and operating contract and supports weapons and energy-related programs. Mound carries out an integrated research, development, and production operation with special emphasis on explosives and nuclear technology. Mound has developed an expertise in the science of precise measurement of heat. They are recognized as the world's leading researcher for the separation of stable gas isotopes and the worldwide sales of a large number of non-radioactive isotopes.

Programs: Weapons Activities; Nuclear Energy Research and Development; Remedial Action and Waste Technology; and Defense Waste and Environmental Restoration.

Primary Computer Resources: 1 - IBM 3090/200E, 1 - IBM 3090-120E, 2 - DEC VAX 8810, 1 - DEC VAX 8800, 3 - DEC VAX 8700, 2 - DEC VAX 8600, 2 - DEC VAX 8550, 1 - DEC VAX 8350, 3 - DEC VAX 8250, and 2 - DEC VAX 11/785.

Telecommunications Support: Voice service provided by leased Dimension 2000; data communications service provided independent local area networks; secure SACNET Replacement Terminal and facsimile; radio systems, including a plantwide radio paging system, support security, and administrative services.

A.28 NATIONAL MAGNETIC FUSION ENERGY COMPUTER CENTER, LAWRENCE LIVERMORE NATIONAL LABORATORY, P.O. BOX 5509, LIVERMORE, CA 94550

Function: The National Magnetic Fusion Energy Computer Center was established to provide large-scale computational support to the Magnetic Fusion Energy Program. The concept of the Center is that different levels of computer capability are provided at various remote locations via a network according to research priorities and anticipated computer demand. A national center located at Lawrence Livermore National Laboratory provides the high level capability to the entire community. There are currently five remote user service centers at the Princeton Plasma Physics Laboratory, the Los Alamos National Laboratory, the Oak Ridge National Laboratory, GA Technologies, Inc., and the Lawrence Livermore National Laboratory. A sixth user service center is located at the National Magnetic Fusion Energy Computer Center itself.

The National Magnetic Fusion Energy Computer Center also provides large-scale computational support for the major laboratories involved in Energy Research programs.

Programs: Magnetic Fusion and Basic Energy Sciences.

Primary Computer Resources: 2 - Cray 2 (NMFECC), 1 - Cray X-MP (Energy Research Programs), and 1 - IBM 4381.

Telecommunications Support: Wideband services to MFE users; voice services provided by LLNL.

A.29 NAVAL PETROLEUM AND OIL SHALE RESERVES IN COLORADO, UTAH, AND WYOMING, 800 WERNER COURT, SUITE 342, CASPER, WYOMING 82601

Function: The Naval Petroleum and Oil Shale Reserves in Colorado, Utah, and Wyoming manages the petroleum and oil shale assets contained in Federally-owned reserves in the three western states mentioned. The management and operating contractor is Lawrence-Allison & Associates West, Inc.

Program: Naval Petroleum and Oil Shale Reserves.

Primary Computer Resource: 1 - HPC HP 1000 and 1 - DGL MV 8000.

Telecommunications Support: Leased administrative telephone service; data communications provided by leased, dedicated point-to-point line and dialup service; radio services support dispersed locations.

A.30 NAVAL PETROLEUM RESERVES IN CALIFORNIA, P.O. BOX 11, TUPMAN, CA 93276

Function: The Naval Petroleum Reserves in California manages and produces crude oil and liquid fuel from Elk Hills and Buena Vista Hills petroleum reserves for both military and commercial use. The management and operating contractor is Bechtel Petroleum Operations, Inc.

Program: Naval Petroleum and Oil Shale Reserves.

Primary Information Systems Resources:

- o 1 IS
  - 1 operational
- o Largest IS
  - DOE Engineering Management Information System

Primary Computer Resource: 1 - IBM 4381 and 2 - DEC VAX II.

Telecommunications Support: Leased voice services; unclassified TWX, TELEX, and facsimile service; data communications provided through on-site dedicated circuits and to off-site resources via dialup; radio system supports operations, emergency, and security functions.

A.31 NEVADA COMPLEX, P.O. BOX 98518, LAS VEGAS, NV 89193

Function: The Nevada Operations Office (NV) is responsible for operations and programs at the Nevada Test Site (NTS). The NTS is an outdoor scientific laboratory that was chosen as a continental nuclear proving ground to reduce the expense and logistics problems associated with testing in the mid-Pacific.

The mission of the Nevada Operations Office is administration and management of the NTS and other designated test locations within and outside the United States; coordination, planning, and execution of nuclear weapons test activities; nuclear waste management; support and technical assistance to the Defense Nuclear Agency at Johnson Atoll; support of DOE activities in the Marshall Islands; planning and execution of field operations for Surveillance Accident Nuclear Detection Systems and Aerial Measurements Systems and directing activities of the Nuclear Emergency Search Team (NEST); providing for planning and coordination of Test Treaty Verification programs; and managing energy-related programs such as geothermal, fuels-handling safety research, laser fusion, and energy conservation.

Three laboratories, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories provide the device designs and most of the scientific expertise for weapons tests. Other contractors of NV include:

- o Reynolds Electrical and Engineering Company (REECO) is the largest contractor in the Nevada Complex under a management and operating contract which provides services as drilling and mining; radiological monitoring; and housing, feeding, and supplies.
- o Holmes and Narver, Inc. (H&N) operates under a management and operating contract as the NTS architect-engineer.
- o EG&G operating under a management and operating contract provides timing, firing, and diagnostic instrumentation support for nuclear events.
- o Computer Sciences Corporation (CSC) provides facilities management services for the Nevada Central Computing Facility (NVCCF) and technical support for computer and telecommunications services.
- o Wackenhut Services, Inc., (WSI) provides security at the Nevada Complex.
- o Science Applications International Corporation (SAIC) manages the high-level nuclear waste geologic repository program.
- o Other contractors include Fenix and Scisson, URS/John Blume & Associates, and the Desert Research Institute of the University of Nevada.
- o Federal agencies associated with the NTS are the Environmental Protection Agency, the Department of Defense, the Defense Nuclear Agency, U.S. Geological Survey, and the National Oceanographic and Atmospheric Administration's Weather Service Nuclear Support Office.

Programs: Weapons Activities; Nuclear Waste Fund; Civilian Radioactive Waste; and Defense Waste and Environmental Restoration.

Primary Computer Resources: 7 - DEC VAX 750, 2 - DEC VAX 780, 3 - DEC VAX 8530, 1 - DEC VAX 8250, 1 - DEC VAX 8650, and 1 - DEC VAX 6230 (EG&G). 2 - DEC VAX 8350, 1 - DEC VAX 6230, 3 - HP 1000, and 4 - HP 9000 (H&N). 4 - DEC VAX 750, 2 - DEC VAX 8650, 1 - DEC VAX 8700, and 2 - DEC VAX 8530 (REECO). 1 - HP 3000, 2 - DEC VAX 780, and 1 - DEC VAX 6210 (NV).

Primary Information Systems Resources (Nevada Operations Office only):

- o 33 IS
  - 2 new IS under development
  - 31 operational IS

- o Largest IS
  - Dosimetry Research Project
  - Security System
  - Coordination and Information Center
  - Personnel Radiation Monitoring System

Telecommunications Support: Voice services provided through central switching center under a 10-year lease contract; significant microwave and other radio services for Test Site support; secure SACNET Replacement Terminal and facsimile; most data communications provided through local area networks, microcomputer networks, distributed processing networks, and radio networks.

A.32 OAK RIDGE ASSOCIATED UNIVERSITIES (ORAU), 170 BADGER AVENUE, POST OFFICE BOX 117, OAK RIDGE, TN 37831-0117

Function: ORAU, a management and operating contractor, is a private, not for profit, consortium of more than 50 colleges and universities conducting research and educational programs in the areas of energy, health, and the environment for the DOE, other private and gove ıment organizations, and its member institutions.

Program: Environment, Safety and Health (Environmental Research and Development).

Primary Computer Resources: 1 - IBM 9377.

Telecommunications Support: User of Oak Ridge shared telephone system; data communications provided by dedicated circuits and dialup connection; radio services support maintenance functions.

A.33 OAK RIDGE COMPLEX, P.O. BOX 2009, OAK RIDGE, TN 37831

Function: The Oak Ridge scientific and engineering complex operated under a management and operating contract by Martin Marietta Energy Systems includes four facilities: the Oak Ridge National Laboratory, Oak Ridge Gaseous Diffusion Plant, Gaseous Diffusion Plant at Paducah, KY, and the Oak Ridge Y-12 Plant.

Oak Ridge National Laboratory is an extensive scientific laboratory performing a broad spectrum of functions including applied research and engineering development in magnetic fusion, nuclear fission, fossil and conservation and renewable energies, nuclear physics, and scientific research in basic physical and life sciences. The Laboratory has established a reputation of excellence in the development of nuclear reactor technology, along with a program for production and sale of radioactive and stable isotopes.

The Gaseous Diffusion Plants at Oak Ridge and Paducah produce enriched uranium for use in the production of nuclear power reactor fuel. The Plants are also responsible for activities in engineering, development, demonstration, and management of advanced enriching technologies.

The Oak Ridge Y-12 Plant is a DOE weapon production facility specializing in highly-sophisticated engineering, development, fabrication, and manufacturing of nuclear weapon components.

Programs: Nuclear Energy Research and Development; Uranium Enrichment; Weapons Activities; Nuclear Safeguards and Security; Basic Energy Sciences; Technical Information Management Program; Magnetic Fusion; Biological and Environmental Research (Environmental Research and Development); and Environment, Safety, and Health (Environmental Research and Development).

Primary Computer Resources: Dual - IBM 3033, 6 - DEC KL10, 2 - DEC Dual VAX 8650, 3 - DEC VAX 785/, 1 - DEC VAX 8300, 2 - DEC VAX 8650, 3 - DEC VAX 8700, and 2 - DEC VAX 8600 (Oak Ridge National Laboratory); 1 - IBM 4341, 1 - Cray X-MP/14, 1 - DEC 2060, 2 - IBM 3083, 1 - DEC VAX 8700, 1 - IBM 4381, 1 - IBM 4361, 6 - DEC VAX 11/785, 1 - DEC VAX 11/750, 6 - HP 3000, 1 - DEC VAX 8200, 1 - DEC VAX 8810, 1 - DEC VAX 8550, and 1 - DEC VAX 6220 (Gaseous Diffusion Plant); 6 - DEC VAX 8650, 6 - DEC VAX 8700, 2 - DEC VAX 4381, 1 - NAS 8053, 3 - DEC 2065, 4 - DEC VAX 11/785, 1 - IBM 4341, and 2 - MV 8000 (Y-12 Plant); 1 - IBM 4331, 1 - IBM 9375, 1 - DEC VAX 8700, and 1 - DEC VAX 11/785 (Paducah Plant); 1 - DEC VAX 8600 and 2 - DEC VAX 8700 (Magnetic Fusion User Service Center).

Telecommunications Support: Leased voice services shared with city of Oak Ridge; secure SACNET programmable terminals and facsimile; secure and unclassified local networks for data services; local radio networks support security and administrative services; user service center for MFE Network with dedicated satellite link.

A.34 <u>OAK RIDGE OPERATIONS OFFICE, P.O. BOX 2001, OAK RIDGE, TN 37831</u>

Function: The Oak Ridge Operations Office (OR) manages major weapons production, uranium enrichment, and laboratory facilities.

OR administers contracts established to provide management, operating, and maintenance of Government-owned facilities. Within the uranium enrichment area, OR is taking action to reduce current cost of production and regain lost market share. Within the weapons arena, OR is implementing new computer-integrated manufacturing technologies that are intended to increase production from existing facilities and lower cost of the product. The Oak Ridge National Laboratory, OR's primary facility, continues a broad spectrum of research, development, and demonstration programs geared toward furthering the nation's energy objectives and to conduct education and training programs serving public, vocational, professional, and technical groups.

The Oak Ridge Operations Office administers the operation of major U.S. Government facilities providing policy and program direction to:

- the Oak Ridge Complex operated by the Martin Marietta Energy Systems;
- the Portsmouth Gaseous Diffusion Plant;
- the Strategic Petroleum Reserve Project Management Office;
- Oak Ridge Associated Universities;
- Scientific Applications, Inc., which conducts research, education, information, and human resource development as well as operates the American Museum of Science and Energy;
- Rust Engineering, a management and operating contractor, provides construction and maintenance support;
- the Westinghouse Materials Company of Ohio; and
- the Continuous Electronic Beam Accelerator Facility.

In addition, Oak Ridge administers contracts with colleges, universities, and private organizations for research, development, demonstration, and educational programs.

Programs: General Administration.

Primary Computer Resources: 1 - HP 3000, 1 - DEC VAX 11/780 and support by the Oak Ridge Complex, and 1 - DEC VAX 8700/8350 Cluster.

Primary Information Systems Resources:

- o 14 IS
  - 1 new IS under development
  - 13 operational IS
- o Largest IS
  - Nuclear Materials Management and Safeguards System
  - DOE Waste Information Network
  - Departmental Integrated Standardized Core Accounting System - Oak Ridge
  - Radioactive Material Packaging Data Base
  - Shipment Mobility/Accountability Collection System

Telecommunications Support: Utilizes Oak Ridge Complex Centrex voice services; secure SACNET Replacement Terminal and facsimile; dialup secure narrative service to contractor sites; high frequency radio service to contractor sites; unclassified facsimile.

A.35 <u>OFFICE OF SCIENTIFIC AND TECHNICAL INFORMATION, P.O. BOX 62, OAK RIDGE, TN 37831</u>

Function: The Office of Scientific and Technical Information, which was established in 1946, manages, collects, processes, and distributes energy-related scientific and technical information generated on all energy technologies and basic supporting science with special emphasis on defense, nuclear, and basic energy science information.

Programs: Scientific and Technical Information Program.

Primary Computer Resources: 1 - Dual DEC KL10, 2 - DEC 8600, 1 - DEC VAX 11/750, 2 - DEC VAX 11/780, 1 - DEC VAX 11/785, 1 - DEC VAX 6220, and 1 - DEC VAX 6210.

Primary Information Systems Resources:

- o 9 IS
  - 9 operational IS
- o Largest IS
  - Record Processing System
  - Integrated Technical Information System

Telecommunications Support: Voice service through Oak Ridge Complex system; hub of DOE Information Retrieval Network; data communications supported by networking and dialup service.

A.36 PANTEX PLANT, P.O. BOX 30020, AMARILLO, TX 79177

Nunction: Mason and Hanger-Silas Mason Company, under a management and operating contract, operates the Pantex Plant which fabricates high explosives and assembles nuclear weapons components. They also conduct new materials laboratory testing and produce weapon support assemblies and components.

Program: Weapons Activities.

Primary Computer Resources: 1 - IBM 3090/200E and 1 - IBM 3083JX2.

Telecommunications Support: Leased Dimension 2000 switch provides voice service and dialup communications; secure SACNET Replacement Terminal and facsimile; wideband communications network, local radio networks for security and administrative services.

A.37 PINELLAS PLANT, P.O. BOX 2908, LARGO, FL 34649

Function: The Pinellas Plant was constructed for the purpose of manufacturing neutron generators for the initiation of nuclear weapons. Today, other weapons components are produced at Pinellas, as well as specialized electronic test equipment. The management and operating contractor is the Neutron Devices Department of the General Electric Company.

Program: Weapons Activities.

Primary Computer Resources: 1 - IBM 3090/180E, 1 - Honeywell 66/60-DPS 8/52, 5 - HP 3000, 1 - IBM 4381, 3 - DEC VAX 11/785, 1 - DEC VAX 8650, 2 - DEC VAX 8350, 1 - DEC VAX 8300, 1 - DEC VAX 8800, and 2 - DEC VAX 8600.

Telecommunications Support: Leased on-site voice switching system; secure SACNT Replacement Terminal and facsimile; local area network; radio systems and networks support security and administrative functions.

A.38 PITTSBURGH ENERGY TECHNOLOGY CENTER, P.O. BOX 10940, PITTSBURGH, PA 15236

Function: The Pittsburgh Energy Technology Center conducts research and development and provides project management support to promote production of clean energy from coal. It was built in response to the Synthetic Liquid Fuels Act of 1944 and holds a patent on a process that is widely used for gas purification throughout the chemical industry. Researchers at the Center are called upon continually to share their expertise in coal utilization and conversion. The site is a leader in the areas of coal liquefaction, alternative fuel utilization, and magnetohydrodynamics. They have also developed and maintain the national coal liquefaction technology data base.

Program: Coal.

Primary Computer Resources: 3 - DEC VAX 11/780, 2 - VAX 8350, and 1 - HP 3000.

Primary Information Systems Resources:

o 30 IS
  1 planned new IS
  29 operational IS (2 IS are undergoing enhancements)

o Largest IS
  Departmental Integrated Standardized Core Accounting System - PETC
  Analytical Laboratory System
  FIND - Modularization, Reformatting and Expansion

Telecommunications Support: Leased voice service shared with Department of Interior and Department of Labor; unclassified TWX, TELEX, and facsimile service; local area networks support data communications functions; radio system provides coordination of site activities and supports security functions.

A.39 PORTSMOUTH GASEOUS DIFFUSION PLANT, P.O. BOX 628, PIKETON, OHIO 45661

Function: Martin Marietta Energy Systems, Inc., operates and maintains the Portsmouth Gaseous Diffusion Plant under a management and operating contract. This facility is used to enrich uranium through the process of separation of U-235 and U-238 isotopes of uranium.

Program: Uranium Enrichment.

Primary Computer Resources: 7 - DEC System KL-10, 4 - DEC VAX 11/780, and 4 - DEC System KI-10.

Telecommunications Support: Leased voice system with partitioned local services for safety and security; dialup secure narrative service to Oak Ridge; unclassified TWX, TELEX, and facsimile service; radio services support security, emergency, operations, and maintenance.

A.40 PRINCETON PLASMA PHYSICS LABORATORY, P.O. BOX 451, PRINCETON, NJ 08543

Function: The Princeton Plasma Physics Laboratory, operated under a management and operating contract, was established in 1951 to conduct plasma physics research in magnetic fusion energy. They are currently concentrating on the development of a plasma confinement system that will meet the requirements of an economically and environmentally attractive fusion power plant for generating electricity. The Laboratory has some of the largest, most flexible scientific devices for the detailed study of plasma behavior in the world.

Program: Magnetic Fusion.

Primary Computer Resources: 2 - DEC VAX 8600, 2 - DEC VAX 11/785, and a Network of 19 - GOULD/SEL (Princeton Plasma Physics Laboratory); 1 - DEC VAX 8700 and 1 - DEC VAX 8600 (Magnetic Fusion User Service Center).

Telecommunications Support: Leased voice services; data communications provided through dedicated and dialup lines; unclassified TWX, TELEX, and facsimile service; User Service Center for MFE Network dedicated satellite link; UHF radio services support physics research, safety services, and maintenance functions.

A.41 ROCKY FLATS PLANT, P.O. BOX 464, GOLDEN, CO 80402

Function: The Rocky Flats Plant was constructed in the early 1950's to process uranium and plutonium and fabricate weapons components for national defense. The management and operating contractor of the Rocky Flats Plant is the North American Space Operations of Rockwell International.

Program: Weapons Activities.

Primary Computer Resources: 1 - IBM 3090/200S, 1 - IBM 3090/180E, 2 - HP 3000, 2 - Harris 800, 1 - CDC Cyber 810, 2 - CDC Cyber 860, 1 - DEC VAX 8650, 2 - DEC VAX 11/785, 2 - DEC VAX 11/750, 1 - DEC VAX 8700, and 2 - DEC VAX 8800.

Telecommunications Support: Leased on-site switch provides voice and data communications service; secure SACNET Replacement Terminal and facsimile; local area networks; radio networks support operation activities.

A.42 <u>SANDIA NATIONAL LABORATORIES, ALBUQUERQUE, P.O. BOX 5800, ALBUQUERQUE, NM 87185</u>
<u>SANDIA NATIONAL LABORATORIES, LIVERMORE, P.O. BOX 969, LIVERMORE CA 94550</u>

Function: Sandia National Laboratories were established in 1945 at Albuquerque and in 1956 at Livermore to manage nuclear weapons program responsibilities. Their primary mission is to develop non-nuclear ordnance for nuclear weapons. The Sandia Corporation, a subsidiary of AT&T Technologies, is the management and operating contractor. At Sandia, research is conducted on new weapon concepts, safety and reliability, and protection of nuclear materials. Sandia also undertakes energy research and development programs of national importance which need the capabilities assembled for the weapons program. Sandia operates a broad range of facilities, many of them specially designed and unduplicated elsewhere in the country.

Programs: Weapons Activities; Defense Waste and Environmental Restoration; Nuclear Safeguards and Security; Basic Energy Sciences; Nuclear Waste Fund; Verification and Control Technology; Magnetic Fusion; and Strategic Petroleum Reserve.

Primary Computer Resources: 1 - UNIVAC 1100/82, 1 - UNIVAC 1100/72, 1 - IBM 3090-120E, 1 - DEC VAX 11/780, 1 - Alliant FX/8, 1 - CDC Cyber 170/730, 1 - CDC Cyber 180/855, 8 - IBM 4300 Series, 3 - DGC MV/10000, 1 - Cray 1, and 1 - Cray X-MP (Albuquerque); 2 - Cray 1, 1 - Cray X-MP, 1 - IBM 4341, and 15 - DEC VAX Systems (Livermore).

Telecommunications Support: Albuquerque: Voice services provided through Kirtland AFB system; secure SACNET Replacement Terminal and facsimile; Satellite Backbone System node subscriber; integrated local area networks utilizing twisted pair, coaxial cable, and fiber optic cable; center for national seismic station system utilizing Westar satellite links and interconnection with Norwegian system for international data collection; wideband computer network system to SNLL. Livermore: Voice services provided by Lawrence Livermore National Laboratory; secure SACNT Replacement Terminal and facsimile; CIIC Network Center; wideband computer network to SNLA.

A.43 <u>SAN FRANCISCO OPERATIONS OFFICE, 1333 BROADWAY, OAKLAND, CA 94612</u>

Function: The San Francisco Operations Office (SAN) administers some 700 contracts and grants nationwide. The mission SAN is to executive defense and energy-related programs and to provide input to program development and policy formulation. SAN is responsible for the management coordination, and support of programs and projects involving weapons research and development, basic research, R&D in all energy technologies (including fossil, geothermal, solar, conservation and renewable energies), nuclear energy development and environmental safety and health.

The following report to the DOE San Francisco Operations Office:

- o Lawrence Livermore National Laboratory, Livermore, CA;
- o Lawrence Berkeley Laboratory, Berkeley, CA;
- o Stanford Linear Accelerator Center, Stanford, CA;
- o General Atomics, San Diego, CA;
- o Energy Technology Engineering Center; and
- o KMS Fusion, Inc.

Program: General Administration.

Primary Computer Resources: 2 - HP 3000.

Primary Information Systems Resources:

- o 15 IS
  - 15 operational IS
- o Largest IS
  - Departmental Integrated Standardized Core Accounting System - SAN
  - Contract Management Information System

Telecommunications Support: Voice service provided by GSA; secure SACNET programmable terminal and facsimile; Satellite Backbone System used for SACNET; local area networks and dialup services support data communications; small radio networks support operations and security functions.

A.44 SAVANNAH RIVER COMPLEX, AIKEN, SC 29802

Function: The Savannah River Complex's primary mission is the production of plutonium and tritium and other special nuclear materials for use in the nation's defense programs. The Complex encompasses laboratory and production plant facilities. Westinghouse Savannah River Company, under a management and operating contract, operates the site for the Government under cost plus award fee. They assumed full responsibility at the site on April 1, 1989. The site contains five heavy water moderated production reactors, three of which are operational; two chemical separation facilities; a reactor fuel fabrication facility; a Naval Fuel facility; a waste processing facility under construction for immobilization of radioactive waste; waste storage facilities; and a multiple discipline research and development laboratory for primary support of the manufacturing activities.

Major efforts continue in technology development for analysis of reactor safety bases, the solidification of nuclear waste, production of nuclear material for naval fuels, as well as expanded efforts to upgrade process technology for reactor operation, fuel fabrication and chemical separations, and the management of radioactive waste. Other major activities include weapons support and environmental studies.

Programs: Materials Production; Defense Waste and Environmental Restoration; Weapons Activities; and Naval Reactors.

Primary Computer Resources: 1 - IBM 3081K, 1 - IBM 3083 EX, 1 - IBM 3090/200, SCS-40/14, and 1 - Cray X-MP/132.

Telecommunications Support: Leased voice system with central electronic switch and dispersed PBXs throughout facility for continuity of service; significant radio activity supporting local security, safety, operations, construction, and administrative services; local unclassified facsimile network; broadband connected local area networks provide data communications support; relay station supporting SECOM.

A.45 SAVANNAH RIVER OPERATIONS OFFICE, P.O. BOX A, AIKEN, SC 29802

Function: The Savannah River Operations Office is responsible for directing and administering programs involving plutonium, tritium, and other special nuclear materials production for use in the nation's defense. Other activities include environmental monitoring and process development support. This office also has responsibility for the management of radioactive waste stored in waste tanks.

The following report to the DOE Savannah River Operations Office:

- o Savannah River Laboratory;
- o Savannah River Site; and
- o Savannah River Ecology Laboratory.

Program: Materials Production.

Primary Computer Resources: 1 - HP 3000 and support by the Savannah River Site.

Primary Information Systems Resources:

- o 14 IS
  - 1 new IS under development
  - 13 operational IS

- o Largest IS
  - Departmental Integrated Standardized Core Accounting System Financial Information System

Telecommunications Support: Shares Savannah River Complex voice services; secure SACNET Replacement Terminal and facsimile service; unclassified TWX, TELEX, and facsimile service; broadband connected local area networks provide data communications support; significant radio activity supporting local security, safety, operations, construction, and administrative services.

A.46 SOLAR ENERGY RESEARCH INSTITUTE, 1617 COLE BOULEVARD, GOLDEN, CO 80401

Function: The Solar Energy Research Institute was established by the Congress in 1977 to perform research, development, and testing necessary to establish solar energy as a viable part of our National energy resources. The Institute's present role is to conduct and coordinate high-risk research and development on solar technologies to advance scientific understanding and establish a technological base of energy production options for private enterprise to commercialize. In 1984, the Institute assumed responsibility of a greater portion of the research program in wind energy. The Midwest Research Institute (MRI) is the management and operating contractor for SERI.

Programs: Solar Energy.

Primary Computer Resource: 1 - IBM 4381.

Telecommunications Support: Leased on-site voice system shared with Western Area Power Administration; unclassified TWX, TELEX, and facsimile service; local area networks provide data communications support; dialup access to off-site networks; radio systems provide administrative, facilities, security, and emergency support.

A.47 SOUTHEASTERN POWER ADMINISTRATION, SAMUEL ELBERT BUILDING, ELBERTON, GA 30635

Function: The Southeastern Power Administration is responsible for the wholesale marketing of electric power produced by Federally-owned facilities in a 10-state region of the southeastern United States.

Program: Power Marketing.

Telecommunications Support: Administrative telephone service only.

A.48 SOUTHWESTERN POWER ADMINISTRATION, P.O. BOX 1619, TULSA, OK 74101

Function: Southwestern Power Administration was established in 1943 to market the electric power and energy produced at 23 reservoir projects in the southwest with currently installed generating capacity of 2150 Megawatts. Southwestern markets power from hydroelectric projects located in the states of Arkansas, Missouri, Oklahoma, Texas, Kansas, and Louisiana. In its power marketing program, Southwestern must secure revenue sufficient to meet the annual costs of operation and maintenance of the generating and transmission facilities and to repay with interest all of the investment in generation and transmission facilities over a reasonable period of time.

Program: Power Marketing.

Primary Computer Resource: 1 - Prime 9755.

Primary Information Systems Resources:

- o 6 IS
  - 5 operational IS (2 IS are undergoing enhancement)
  - 1 new IS under development
- o Largest IS
  - Integrated Financial Accounting System

Telecommunications Support: Voice service provided by GSA and microwave system; unclassified TWX, TELEX, and facsimile service.

A.49 STANFORD LINEAR ACCELERATOR CENTER, P.O. BOX 4349, STANFORD, CA 94309

Function: The Stanford Linear Accelerator Center's (SLAC) single mission is subatomic research, the study of basic particles and forces of the universe. Leland Stanford, Jr. University is the management and operating contractor.

SLAC uses beams of electrons as the backbone of its research instead of proton beams that are used in other DOE subatomic physics studies. The facility's 2-mile long linear accelerator is the only one of its kind in the world.

Program: High Energy Physics.

Primary Computer Resource: 1 - IBM 3081K, 1 - IBM 3033U, and 1 - IBM 3090-200E.

Telecommunications Support: Leased voice and data communications services; local dedicated data networks; unclassified TWX, TELEX, and facsimile service; radio systems support high energy physics research and administrative functions.

A.50 <u>STRATEGIC PETROLEUM RESERVE, CLEARVIEW PARKWAY, NEW ORLEANS, LA 70123</u>

Function: The Strategic Petroleum Reserve consists of underground petroleum storage facilities which are filled and/or being developed in large salt domes in Louisiana and Texas. Private industry contractors perform the bulk of the engineering, construction, and operating work involved in the reserve. The stored petroleum will be used by the commercial petroleum distribution network during a severe petroleum interruption. Boeing Petroleum Services is the management and operating contractor.

Program: Strategic Petroleum Reserve.

Primary Computer Resources: 1 - IBM 3033.

Primary Information Systems Resources:

- 30 IS
  - 3 new IS under development
  - 27 operational IS

- Largest IS
  - Materials Management System
  - Inventory Control System
  - Financial Information System
  - Refining Capacity System

Telecommunications Support: Voice system with Government-owned central switch and leased minor systems at remote storage facilities in Louisiana and Texas; significant microwave and VHF radio systems supporting reserve systems; interfaces with commercial pipeline communications systems; dialup secure narrative service to Washington and Oak Ridge; local area network capability.

A.51 WASTE ISOLATION PILOT PLANT (WIPP) PROJECT, P.O. BOX 2078, CARLSBAD, NM 88221

Function: The Waste Isolation Pilot Plant is operated by Westinghouse Electric Corporation under a management and operating contract for the Department of Energy. The mission is a defense activity for the express purpose of providing a research and development facility to demonstrate the safe disposal of radioactive wastes resulting from the defense activities and programs of the United States exempted from regulation by the Nuclear Regulatory Commission. The primary purpose of the WIPP is to emplace transuranic waste in bedded salt. As part of this waste emplacement demonstration, the waste will remain retrievable for 5 years. By the middle 1990's, assuming all storage and retrievability concerns are satisfactorily resolved, WIPP should be functioning as a proven, mature geological repository for defense transuranic waste. Additionally, WIPP will serve as a laboratory to gather necessary information for future, permanent disposal of defense high-level radioactive wastes.

Program: Defense Waste and Environmental Restoration.

Primary Computer Resources: ADP resources currently accessed by the Project are provided by Westinghouse Energy Systems Computer Center in Pittsburgh, PA.

Telecommunications Support: Voice and data communications are provided through an owned NEAX 2400 PBX; radio services provide site protection and support.

A.52 WESTERN AREA POWER ADMINISTRATION, P.O. BOX 3402, GOLDEN, CO 80401

Function: The Western Area Power Administration was created by Congress in 1977 and is responsible for electric power marketing from 50 Federal hydropower generating plants to wholesale customers in 15 western states. It maintains and operates an extensive high-voltage transmission system.

Program: Power Marketing.

Primary Computer Resources: 2 - DEC VAX 11/785, 1 - DEC VAX 8810, 3 - Prime 9955, 1 - Prime 9950, 2 - Prime 2755, 5 - Prime 9955 II, and 1 - Prime 6350.

Primary Information Systems Resources:

- o 22 IS
  - 3 new IS under development
  - 19 operational IS

o Largest IS
  Financial Management System

Telecommunications Support: Shares leased voice system with SERI; unclassified TWX, TELEX, and facsimile services; operates distributed data network to Regional Offices in support of Power Distribution System; microwave radio systems support operations and maintenance of power transmission systems.

A.53 WESTINGHOUSE MATERIALS COMPANY OF OHIO, POST OFFICE BOX 398704, CINCINNATI, OH 45239

Function: The mission of the Westinghouse Material Company of Ohio, a management and operating contractor, is to operate the Feed Materials Production Center (FMPC) which supplies element cores for nuclear reactors. Westinghouse Materials specializes in the smelting, refining, and conversion of ores to metal products.

Programs: Materials Production and Weapon Activities.

Telecommunications Support: Leased administrative telephone services; secure narrative and facsimile service to Oak Ridge Operations Office; local area networks provide data communications support; radio systems provide security, operations, and emergency support.

APPENDIX B: PROGRAM PROFILES

The Department of Energy organization chart appears in Figure B-1. It shows the principal organizations that use information technology resources to meet their programmatic missions such as Defense Programs, Energy Research, and Nuclear Energy. This Appendix briefly describes the missions of the programmatic activities. Throughout this Plan, they have been categorized into the following major areas:

Mission	Program Areas
Defense Programs	Weapons Activities Materials Production Nuclear Safeguards and Security Verification and Control Technology Defense Waste and Environmental Restoration
Energy Research	Magnetic Fusion High Energy Physics Basic Energy Sciences Nuclear Physics Biological and Environmental Research (Environmental R&D)
Nuclear Energy	Naval Reactors Nuclear Energy Research and Development Uranium Enrichment Remedial Action and Waste Technology
Other Activities	General Administration Energy Information Conservation and Renewable Energy Fossil Energy Power Marketing Environment, Safety, and Health Civilian Radioactive Waste

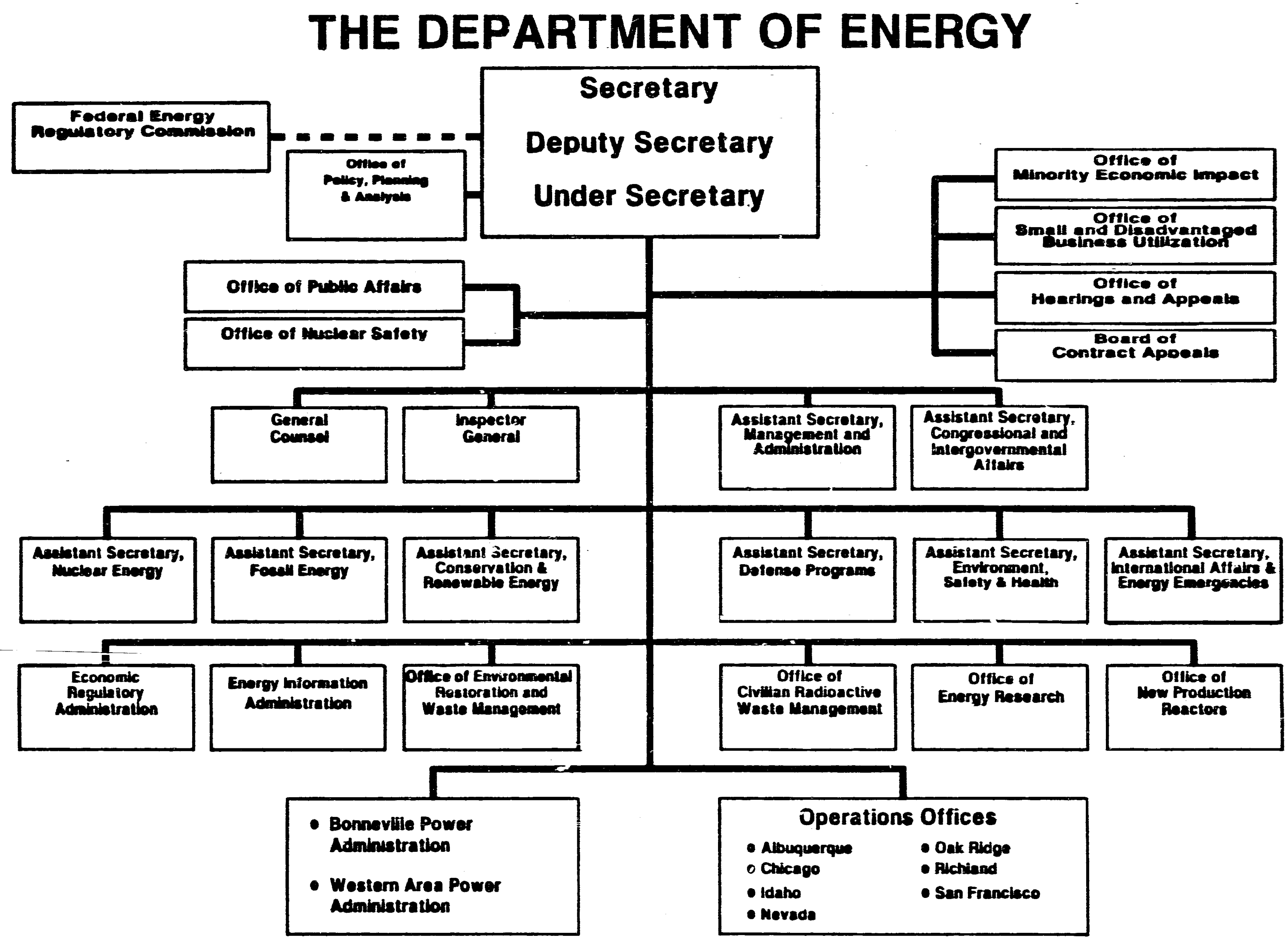


FIGURE B-1 DEPARTMENT OF ENERGY ORGANIZATION CHART

Defense Programs

The Assistant Secretary for Defense Programs is the principal advisor to the Secretary on national security matters and is the manager of the nuclear weapons program and the weapons complex. The Assistant Secretary is also responsible for planning, directing, and executing programs associated with weapons activities, materials production, nuclear safeguards and security, verification and control technology, and defense waste and environmental restoration.

The principal objectives of computer-supported Defense Program areas are summarized below:

- Weapons Activities: Provide for the research and development, testing, production, and reliability assurance of the nation's nuclear weapons. Also included are developmental and operational efforts associated with inertial confinement fusion programs for national security and civilian power applications.

- Materials Production: Operate production reactors for the production of nuclear fuels required for other Departmental programs. Process and fabricate feed materials for reactors.

- Nuclear Safeguards and Security: Set policy, provide oversight, and manage safeguards developmental and operational efforts to provide necessary safeguards and security of Departmental facilities and material. Support is provided for the United States nonproliferation objectives through technology transfer and research and development, and is accomplished in collaboration with other Federal agencies, foreign countries, and international organizations.

- Verification and Control Technology: Perform technical and analytical activities in support of nuclear test monitoring, treaty verification, export control, arms control, and nuclear- and energy-related issues.

- Defense Waste and Environmental Restoration: Assure that radioactive waste generated in the defense nuclear materials production, naval reactors, and research and development programs are safely handled, treated, stored, or utilized, transfered, and disposed of to protect the public health and safety.

Energy Research

The Director of Energy Research serves as principle science advisor to the Secretary in formulating the basic research policy of the Department. In this capacity, the Director provides independent reviews, analyses, and recommendations to the Secretary concerning a wide range of Departmental activities which require scientific counsel. These activities include, for example: national research and development strategies, plans and policies; budgetary priorities for energy research and development programs; the development and management of Departmental technology programs; and policy issues which determine the best use of the multi-purpose laboratories assigned to Energy Research for oversight and management.

The principal objectives of computer-supported Energy Research programmatic areas are summarized below:

- <u>Magnetic Fusion</u>: Perform research and supporting studies aimed at the understanding of plasmas with the eventual objective of obtaining useful power by controlled thermonuclear fusion. Emphasis is placed on the experimental demonstration of improved plasma confinement in magnetic confinement devices.

- <u>High Energy Physics</u>: Perform research involved in experimental and theoretical elementary particle physics research in which the basic properties of matter, energy, and the fundamental forces of nature are investigated at the national laboratories. Progress in the High Energy Physics research program is based on continuing scientific and engineering research and development necessary for maintaining and advancing the technology base.

- <u>Basic Energy Sciences</u>: Provide experimental and theoretical research in nuclear sciences, material sciences, chemical sciences, engineering, mathematical and geosciences, biological energy research, and advanced energy projects.

- <u>Nuclear Physics</u>: Attain a fundamental understanding of the interactions, properties, and structure of atomic nuclei. The frontiers of nuclear physics have progressed to the exploration of the internal dynamics of nuclei and the investigation of the response of nuclear matter to extreme conditions.

- <u>Biological and Environmental Research</u>: Provide computer support for Biological and Environmental Research which encompasses a broad effort to gain an understanding of the interaction of radiation and other energy-related pollutants with living organisms and ecosystems.

<u>Nuclear Energy</u>

The Assistant Secretary for Nuclear Energy is the principal advisor to the Secretary concerning nuclear fission energy. The Assistant Secretary is responsible for planning, developing, and executing Departmental programs for Nuclear Energy research and development, both civilian and naval, for management of nuclear waste technology and for uranium enrichment.

The principal objectives of computer-supported Nuclear Energy programs are summarized below.

- Naval Reactors: Develop nuclear propulsion plants to provide ships with improved power capabilities, increased endurance, and added reliability. The program involves the design, development, demonstration, improvement, and safe operation of naval nuclear propulsion plants and reactor cores for submarines and surface ships. The ultimate objective is to develop new reactors having longer life and enhanced reliability for the naval nuclear vessels.

- Nuclear Energy Research and Development: Develop light water and breeder reactor systems as viable energy options which provide environmentally safe, economic, proliferation resistant, inexhaustible energy sources capable of deployment to meet the nation's future energy needs and to decrease dependence upon foreign energy supplies. Current program emphasis is in advanced converter reactor technology, nuclear fuel cycle research and development, liquid metal fast breeder reactor, water cooled breeder reactor systems, and gas cooled breeder reactor.

- Uranium Enrichment: Gaseous diffusion and atomic vapor laser isotope separation processes are being used to meet domestic, foreign, and United States Government requirements for uranium enrichment services in the most economical, reliable, safe, and environmentally-acceptable manner possible. The Department conducts extensive analyses of uranium enrichment services, supply and demand, economics, and capacity expansion options from which is derived a long-term enrichment strategy to achieve program goals.

- Remedial Action and Waste Technology: Provide for the safe management and disposition of surplus radioactively contaminated facilities and sites.

- Reimbursables for Nuclear Regulatory Commission: Provide major computing support for the programmatic work of the Nuclear Regulatory Commission at DOE facilities. These requirements fall into two basic categories or types of processing: (1) safety analysis to support licensing functions and (2) developing, testing, and using computer codes for the support of ongoing research programs.

Other Programs Supported

Other programmatic support activities primarily include General Administration, Conservation and Renewable Energy, Energy Information, Fossil Energy, Civilian Radioactive Waste, and Power Marketing.

Other activities receiving computer support and their principal objectives are summarized below:

- <u>General Administration:</u> The Assistant Secretary, Management and Administration directs the overall management, control, and utilization of staffing and financial resources, including organization and administrative management, procurement, Federal assistance agreements, contracting, personal property management and related business activities, equal employment opportunity, and all other civil rights activities. The operation of the Office of Scientific and Technical Information is included in the General Administration programs.

- <u>Conservation and Renewable Energy</u>: The Assistant Secretary for Conservation and Renewable Energy establishes conservation program goals for buildings and community systems, industry, and transportation; ensures that the nation's electric energy systems are capable of meeting future demands in a reliable manner while adhering to environmental constraints; encourages commercialization of multisector energy conservation technologies; and facilitates the participation of the private sector in the development of energy policies, strategies, and programs.

  The Assistant Secretary also establishes renewable energy program goals and guarantees loans made by qualified developers of geothermal energy applications. The operations of three power marketing administrations and the Solar Energy Research Institute are included in the renewable energy programs.

- <u>Energy Information</u>: The Administrator, Energy Information Administration, is responsible for conducting a meaningful, timely, and accurate energy data and information program. To accomplish this, the Energy Information Administration collects, processes, and interprets energy data and exercises independent judgment in the gathering, analysis, and dissemination of data and information. This includes forecasts that are relevant to energy resource reserves, energy production, energy demand, energy technology, and related economic and statistical information, or which are relevant to the adequacy of energy resources to meet demands in the near- and long-term future for the national economic and social needs.

- <u>Fossil Energy</u>: The Assistant Secretary for Fossil Energy provides computer support to the Coal, Petroleum, and Enhanced Gas Recovery Programs. The Coal Program develops, demonstrates, and transfers, for commercial use, those technologies which directly support the energy policy goals of the United States. The Petroleum Program seeks to increase the production of oil from domestic sources by developing new and improved techniques of recovering oil from existing and potential oil reservoirs, as well as from non-conventional sources such as shale rock and tar sands. The Enhanced Gas Recovery Program seeks to develop the cost-effective diagnostic and extraction technology required for large-scale commercial production of natural gas from unconventional gas resources. The operation of the energy technology centers is included in the Fossil Energy programs along with the Naval Petroleum and Oil Shale Reserves in California, Colorado, Utah, and Wyoming, and the Strategic Petroleum Reserve.

- Power Marketing at Bonneville and Western Area: These two power marketing administrations operate under the direction of the Deputy Secretary, DOE.

- Other Programmatic Areas: Computer support is also provided for Environment, Safety, and Health and Civilian Radioactive Waste.

Appendix C: Information Technology Resources Assessment

C.1 Introduction

This year the ITRA is provided by Sandia, Albuquerque.

Sandia National Laboratories, Albuquerque, has prepared this year's Information Technology Resources Assessment (ITRA). As before, the purpose is to provide information on the status of selected technologies and to present future developments in these areas, so that site planners may incorporate projected changes and trends in their thinking.

It addresses seven subject areas . . .

We have chosen seven subject areas this year:

C.2 Massively Parallel Computing
C.3 Networking and Communications
C.4 Network Storage Systems
C.5 Scientific Visualization
C.6 Semiconductor Components
C.7 Supercomputers
C.8 Workstations

Some subject areas have been discussed in recent years and need to be revisited. Two topics, scientific visualization and semiconductor components, are making their first appearance this year as stand-alone subject areas. The articles in this assessment were contributed by appropriate technical specialists at Sandia:

. . . and is written by specialists with considerable technical expertise.

- *Massively Parallel Computing*, Bill Camp, Manager of Mathematics and Computational Science Department
- *Networking and Communications*, Mike Vahle, Supervisor of Computer Communications Design Division
- *Network Storage Systems*, Sue Kelly, Distinguished Member of the Technical Staff in the Central Computing Networking Division
- *Scientific Visualization*, Dino Pavlakos, Member of the Technical Staff in the Networking Development and Testing Division
- *Semiconductor Components*, Jamie Wiczer, Supervisor of Intelligent Machine Principles Division
- *Supercomputers*, Ron Jones, Supervisor of Central Computing Systems Division
- *Workstations*, Al Iacoletti, Supervisor of Computer Consulting and Training Division

Projections and forecasts are the opinions of the individual authors and may differ when subject area technologies overlap. Reference to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply an endorsement or recommendation.

This assessment was edited by Frank Mason, Manager of Computing Systems Department.

C.2. MASSIVELY PARALLEL COMPUTING

C.2.1. Introduction

Massively parallel computing is coming into its own because of developments in VLSI technology.

Massively parallel computing has long been recognized as having the potential to circumvent fundamental physical limitations on serial computers. However, due to the absence of a commercial market for such computers — as well as the absence of the inexpensive technology required to make such computers competitive — the potential remained a theoretical one. Two factors have recently caused this situation to change. On the one hand, it is becoming increasingly difficult to achieve exponential growth rates in computing power as new uniprocessor and few-processor computers approach speed-of-light limitations. On the other hand, the advent of VLSI technology has spawned the reliable, low-cost processors and memories needed for massively parallel computing.

Current generation supercomputers are facing natural speed limits . . .

Current generation supercomputers are probably within an order of magnitude in clock speed of the speed-of-light limit [1]. The use of pipelined architectures and vector processing capabilities has helped forestall that inevitable limitation. These new approaches have also required a minor (and generally desirable) revolution in scientific programming styles and have engendered much research on vectorizing compilers. Nonetheless it is known that only 10% to 15% of peak performance can be achieved based on the vectorizeable portion of the typical computing workload at the various national laboratories [2]. This has rendered suspect the use of peak processing speeds in assessing both the capacity (throughput) and capability (ability to carry out very challenging individual computations) of vector supercomputers. Indeed, gauged by actual use in the scientific community, average capability and capacity of such machines is nearly an order of magnitude less than would be expected based on peak vector performance.

. . . and utilization of vector hardware is typically low . . .

. . . so supercomputer manufacturers have turned to parallelism more and more.

To address these limitations supercomputer manufacturers have turned to parallelism in the guise of few-processor multiprocessors that use shared global memories. Until now these machines have been mainly used to increase capacity; that is, they run multiple, independent jobs in a time-sharing mode. Recently, these machines have begun to be used successfully in a multiprocessor mode as both the demand and the needed techniques have emerged. This has led to a significant four to eight times increase in capability [3]. Novel advances continue to be made in the traditional supercomputer arena (as evidenced, for example, by the recent offering of the ES series of supercomputers by Evans and Sutherland) [4]. Even so, the ability of this path to continue to provide exponentially increasing performance at nearly constant real cost is strictly limited. Not only are such machines already expensive to purchase (on the order of $\$10^7$ per machine), but their exotic technologies make them expensive to own: they pose severe cooling loads, require large environmentally-stable plant facilities, and need significant operations, management and maintenance forces. Based on accounting practices at typical sites [5], a CRAY X-MP costs several times $\$10^6$ per year per processor to buy and operate.

While supercomputers are expensive to buy, operate, and maintain . . .

At the same time as this situation is evolving, exciting new capabilities have emerged involving massively parallel computing technologies. For our purposes the term massively parallel indicates several hundred to a thousand or more processors. For example, the most capable of current massively parallel computers have peak performances close to or even exceeding those of a traditional supercomputer (see below) and average performances on a variety of applications considerably exceeding average performance of current-generation traditional supercomputers. Further, newly released massively parallel designs have performances more than an order of magnitude greater than today's vector supercomputers. Massively parallel designs now under development promise another order of magnitude or more in performance.

. . . parallel machines cost significantly less initially and are more like a VAX than a CRAY to maintain.

The current massively parallel designs cost significantly less than vector supercomputers, have very modest cooling and environmental requirements, and have maintenance and system management overhead more typical of a VAX than a CRAY. In the remainder of this discussion, we shall concentrate on current and near term massively parallel designs, their performance on real applications, and the difficulties they pose, as well as the research and development thrusts being undertaken to obviate those difficulties.

C.2.2 Review of Prior Forecasts

This review confines itself to machines with many processors used for numerical computing.

The 1989 and 1990 editions of ITRA have provided comprehensive assessments of current parallel computing technologies and have attempted to extrapolate to the most profitable near term directions for parallel computer development. They concentrated mainly on parallel computers for numerical, scientific applications and did not emphasize designs and software for artificial intelligence, symbolic computing, and real-time applications (*e.g.*, data acquisition and processing and autonomous vehicle control). We take an even narrower perspective on parallel computing. While acknowledging the importance of artificial intelligence and real-time computing, we shall also limit our discussion to numerical computing and restrict the computers we discuss to those involving several hundred or more processors.

C.2.3 Current Status

Architecture Issues

In the past, the success of parallel computers has been limited.

Parallel computers come in several different flavors. Massively parallel designs have been proposed or built based on most of these flavors. Nonetheless, only a few designs have remained competitive once built. All of today's successful designs involve distributed-memory, network interconnected, message-passing machines. There are successful SIMD designs, notably the Connection Machine and AMT DAP. (The term "SIMD" stands for single instruction stream, multiple data streams. A single instruction interpretation unit sends the same instruction to multiple execution units.) In these designs all the processors fire on the same instruction in a given clock cycle. There are also successful MIMD designs, especially the NCUBE family of hypercube machines, in which processors run locally resident code which may differ from processor to processor in the ensemble. ("MIMD" stands for multiple instruction streams, multiple data streams. Multiple instruction interpretation units send the same instruction to multiple execution units.) The SIMD machines commonly utilize many thousands of simple processors (up to 65,536 one-bit processors in the current CM-2). In contrast, the MIMD machines utilize several hundred to several thousand processors with complexity and performance typical of today's fastest personal computer CPUs. For example, the NCUBE-1 family uses up to 1024 processors, each roughly equivalent to a VAX 11/780 processor; and the new generation NCUBE-2 machines contain up to 8192 processors, each roughly an order of magnitude faster than an NCUBE-1 processor. Distributed memory is abundant in both types of machines — ranging up to several gigabytes of memory.

C.2.4 Projections

Having shared memory in computers tends to simplify many complex issues . . .

Why are there currently no successful shared (global) memory massively parallel computers? What about hybrid designs? These questions are especially perplexing since shared-memory computers are closer to preferred theoretical models of parallel computing, and compilers are easier to design for them. Applications are simpler to write for shared memory computers (unless, for example, the user is responsible for maintaining cache coherency). Shared memory computers are the natural outgrowth of serial and vector uniprocessor designs. In shared memory computers all processors have more-or-less equal access to memory. In addition, in these machines all information flows through the memory. Interprocessor communication issues do not arise or are much simpler than in distributed-memory machines if they do arise. However, these features, which make shared memory computers attractive, also currently limit them to coarse or medium-grained parallelism. It is extremely difficult to overcome memory contention issues and to design memory buses and switching networks adequate for more than a few tens of processors. In fact, most current designs are limited to thirty or fewer processors.

. . . but tends to limit the number of processors that are practical.

By contrast, the network technology for distributed-memory machines is relatively simple and highly scalable. The memory contention issue is replaced by one involving message routing induced latency, which has proven to be surmountable in practice. Of course, the cost of surmounting these difficulties involves what may appear to traditional programmers to be fairly arcane programming constructs. These issues have also made the design of robust, friendlier operating systems for these ensembles fairly difficult.

A hypercube interconnect scheme has been exploited . . .

Both the CM-2 and the NCUBE family are based on a hypercube interconnect scheme in which the processing units lie on the corners of an N-dimensional hypercube. There are 2^N processing units. No processor is more than N hops away from any other. Thus communication distances grow logarithmically with the number of processing units. The hypercube belongs to a family of networks, called Cayley graphs, which are optimal networks in the sense that the diameter of the network (number of hops needed to cross it) is minimal for a given degree (number of wires coming out of the processing unit) of the nodes. There exist more optimal Cayley graphs than the hypercube, but none with its spatial regularity. So it would appear natural to use the hypercube scheme. However, the hypercube's advantage over two- and three-dimensional mesh interconnects is not as great as might be expected. For example a three-dimensional torus of 1000 processors is 10x10x10 and involves only 6 wires per node. Its diameter is 15. So at a modest increase in communication overhead, a 1000-processor machine gains four wires per node in utilizing a toroidal interconnect as opposed to a hypercube interconnect. The extra wires could be used to support a hybrid memory concept. Such approaches are being explored, and we expect to see significant mesh-interconnected massively parallel designs soon.

. . . but perhaps toroidal or hybrid interconnects will emerge.

Performance Issues

It is common to think of using massively parallel machines for special scientific problems and vector supercomputers for general scientific problems. This is true to the extent that current supercomputers provide mature operating systems and friendlier computer environments. Massively parallel machines have relatively immature operating environments. They are certainly not user friendly; and they are not yet a threat to replace current supercomputers as workhorse machines providing a broad-base computing environment.

Software environments on parallel computers have not been user-friendly in the past . .

This situation is changing. Operating system research is progressing rapidly, more utilities are becoming available, and these machines may soon prove adequate for general scientific computing demands. What is more likely is that they will be part of a mix of computing resources available to workstation users. These resources will include their personal workstations, very powerful network host workstations (much of the current mix of jobs on supercomputers can be more profitably and easily done on those hosts), traditional supercomputers, graphics engines and massively parallel supercomputers.

. . . but software environments are beginning to improve.

There is a sense in which massively parallel computers are for general scientific problems and vector machines are for special scientific problems. The current thrust of massively parallel computing is to provide a drastic increase in capability. That is, research is aimed at providing the ability to perform calculations which cannot be carried out reasonably today due to speed and memory constraints.

In that context, massively parallel machines retain their supercomputing characteristics over a much broader range of problems than do vector machines. On most of the scientific problems investigated so far these machines perform at over half their peak performance. By contrast, vector machines run far below their peak capabilities on many problems which do not vectorize well. As mentioned above, this drives the average performance of vector supercomputers down as much as an order of magnitude from their peak performance. So, in the sense of maintaining their capability across a wide spectrum of scientific problems it is the massively parallel machines that are for general scientific problems and the vector machines that are for special scientific problems. In the past two years, significant breakthrough computations have been carried out on real scientific applications which have clearly underscored the current capability

Recently, significant breakthroughs have been made in using parallel machines for real applications.

of massively parallel computing and demonstrated their promise.

C.2.5 Implications and Issues

Parallel computers could win head to head face-offs with supercomputers in many application areas.

At Sandia National Laboratories calculations have been carried out using the NCUBE-10 1024-processor MIMD computer for realistic applications in fluid dynamics, acoustics, solid mechanics, computational number theory [6], and radar imaging [7]. In these calculations NCUBE performance was consistently equal to — and often an order of magnitude greater than — performance of the related scalar and vector computations on a single processor of a CRAY X-MP. These results have, in turn, driven breakthrough research in parallel load balance and graphics algorithms. In addition, materials simulations have been carried out on the 16,384-processor CM-2 at Sandia using the embedded-atom method. These calculations achieved performance considerably in excess of CRAY X-MP performance on the same problem [8].

Similarly, at Los Alamos National Laboratories, porous media calculations have been carried out on their 65,536-processor CM-2 with spectacular success: about 10^9 cell updates per second — ten times the throughput of a four-processor CRAY X-MP on the same problem [9]. In California Institute of Technology's Concurrent Computation Program a broad series of applications covering many areas of physics and engineering have and are being carried out using NCUBE machines at CalTech and Sandia, CM-2 machines at Argonne and Los Alamos, an FPS T-series hypercube at Los Alamos, and the MARK-3 hypercube at JPL. Examples include the traveling salesman problem, astronomical data analysis, lattice gauge theory for strong nuclear interactions, the classical many-body problem, neural network simulations, quantum chemistry, plasma dynamics, vortex models for fluids, finite-element models, geometric ray tracing, seismic simulations, classical statistical mechanics of spin models, high-T_c superconductors and game theoretic problems. Although massively parallel machines do not perform equally well on all these problems, according to Fox [10] the performance across the spectrum of problems has been very favorable when compared to vector supercomputers of comparable or greater peak performance.

C.2.6 Summary

Spectacular advances have been made in building and using parallel computers.

In the past two years, spectacular advances have been made in building and using massively parallel computers. For the most challenging scientific applications, current machines have been shown to rival or beat vector supercomputers across a broad range of scientific and engineering problems. At least one second-generation, massively parallel machine has been released, the NCUBE-2. This machine of up to 8192 processors has a rated peak performance of 27 gigaflops. Drawing on our experience with the architecturally similar NCUBE-1 machines, we can predict that this machine will achieve performance in the 10 gigaflops range on real applications. New machines are currently being developed at Intel which will be based on their new million-transistor chips. These machines could provide many-gigaflop performance. Radically new hybrid machines are expected to debut in the next year or two which will challenge the supremacy of distributed-memory hypercubes.

While these developments have ended (at least temporarily) the reign of vector supercomputers as the ultimate computing machines, they pose many interesting challenges. New operating environments, mathematical utilities, graphics capabilities, and extended high-level languages and compilers which are needed by these machines will challenge researchers for years to come. Perhaps the ultimate challenge posed by these machines involves how to deal with the sheer volume of numbers they generate. Three dimensional visualization research and ultra-speed communications networks will be driven by this information deluge.

C.4.7 References

1. With a one-nanosecond clock, a signal could travel no further than 0.3 meters/clock cycle. Due to capacitive effects actual distances could be much smaller, so communications can take many clock cycles.
2. This is based on informal reports from DOE laboratories.
3. For example, calculations by Sandia Laboratories researchers on an 8-processor CRAY Y-MP have achieved over seven times the performance of a single Y-MP processor.
4. Supercomputing Review, p. 25, March, 1989.
5. An extremely competitive pricing structure would be $150/hr/processor, with a 90% utilization being typical. A four-processor CRAY X-MP would then recover about $4.5 million per year.
6. J. L. Gustafson, et al., "Development of Parallel Methods...," SIAM J. Sci. Stat. Comp., 9, 609 (1988). G. A. Montry, "Massively Parallel Mathematical Sieves," Int'l. J. Comp. Appl., Vol. 3, 1989, pp. 59-74.
7. J. L. Gustafson, R. E. Benner, M. P. Sears, and T. D. Sullivan, "A Radar Simulation Program for 1024-Processors," Proceedings of Supercomputing 89, 1989, accepted for publication.
8. R. E. Cline, Jr., Sandia National Laboratories preprint, 1989.
9. B. J. Travis, et al., LANL preprint, 1989.
10. G. Fox, "1989-The First Year of the Parallel Supercomputer," Plenary Presentation at the Fourth Hypercube Conference, Monterey, CA, March 6, 1989.

C.3 NETWORKING AND COMMUNICATIONS

C.3.1 Introduction

This review focuses on performance, management and security of networks and communications.

In this review of communications and networking technology, we will focus on the areas of performance, security, and management. We view the simultaneous optimization of these often conflicting parameters as the goal of future communications and networking. The optimization of these parameters must be accomplished within the bounds of current technology. The communications and networking products currently available seem to be designed with a focus on performance, leaving security and management to be added later. This suboptimal approach to communications and networking will characterize the next few years. As commercial awareness and demand increases, however, solutions will appear that recognize the importance of all three aspects of communications and networking.

The boundary between communications and networking is disappearing, and we use the terms interchangeably.

C.3.2 Review of Prior Forecasts

We are less optimistic about OSI than previous forecasts.

Prior forecasts have focused on the International Standards Organization's (ISO) work on establishing the Open System Interconnect (OSI) standard. We note that the more recent forecasts are less optimistic than the previous, reflecting the fact that true commercial implementation of the OSI/ISO standard is still some years away. In fact, the effort has lagged to such an extent that by the time commercial products implementing the standard appear, the targeted environment will no longer exist.

A prior forecast projected that Ethernet would be the dominant local area networking technology for the 1988-1992 time frame and that Fiber Distributed Data Interface (FDDI) would begin to supersede it towards the end of that time frame. While Ethernet has become dominant, it appears that the replacement of Ethernet by another technology will take ten years; this is equivalent to the time span Ethernet required to reach its current level of dominance. We feel that this delay will occur because, while Ethernet filled a void, the replacement technology must demonstrate a superiority worthy of the additional cost. In addition, the heir apparent to Ethernet, FDDI, will require significant work in the areas of media distribution (*i.e.*, optical fiber) and station management software.

It was projected that TCP/IP would be a viable technology through 1998. It appears that this is still a valid projection in light of its wide availability and the slowness of the development and adoption of standards. It is being recognized, however, that TCP/IP may limit the realization of the potentially high throughput offered by emerging transport media and computer technologies.

C.3.3 Current Status

The current focus is on performance, with little effort given to network security and management.

The last year is characterized by a proliferation of networks that use a combination of TCP/IP with Ethernet communications on a variety of media (coaxial, twisted-pair and fiber optic cable). This is an example of the current focus on providing performance with little effort given to security and management. The provider of communications and networking is, by necessity, concerned with integrating security and management into these existing systems. This involves overlaying products from many vendors which results in a degradation of performance and increased costs. These are natural phenomena of the communications networking environment where component availability, rather than an overall system design, drives implementation.

Large communication networks often evolve from limited applications of a specific technology. However, as networks grow, security and management problems which were tractable on a small scale often become dominant issues. The implementation of the security and management functions often leads to trade-offs in performance. In addition, the per unit connection costs often increase as the size of the network grows, as does the manpower investment required to maintain acceptable levels of availability.

Most attention has been give to local area networks; more work is needed now on wide area and remote access networks.

The development of networking technologies has been focused on the local area network environment. A continuing need exists, however, for wide area networking and gateway access from remote networks to central computing facilities. In reality, the local network is frequently required to provide functionality available only through wide area communications technology. The meshing of wide area technology with that of local area technologies is difficult and has a powerful impact on security, performance and management.

Current communications networks are often assembled from various available technologies such as media access technologies and high level communications protocols. This leads to difficulties because these technologies were not designed to work together. For instance, although Ethernet media is widely accessible along with TCP/IP protocols, a system so constructed will have incompatibilities which lead to performance penalties.

C.3.4 Projections

C.3.4.1 Projections 1991-1995

Optical fiber will become the least expensive technology for high bandwidth.

Fiber optic technology will play a major role in intra-building communications distribution. Optical fiber cable will become the least expensive technology for local distribution of higher bandwidth communications. In order to accomplish wide scale use of optical fiber, a large skilled work force must be available. The present efforts by the phone companies to install optical fiber to the home should generate the necessary trained personnel. The initial application of fiber optic cable to existing communication implementations will not result in a major increase in performance, but will provide an infrastructure which will support new implementations that promise major improvements. In addition, fiber optic cable is more versatile than other media and will be used to provide a spectrum of services encompassing video, high speed data and voice. Major building construction projects will incorporate fiber optic media as a matter of course.

The management issue will gain partial resolution by products from numerous vendors.

The broad use of TCP/IP with Ethernet will continue and result in refined network operations as the incompatibilities among diverse vendors' implementations are resolved. The management issue will gain partial resolution with the advent of specialized products from various vendors utilizing generally accepted protocols such as Simple Network Management Protocol. The available network management tools will still rely on user integration to create a total management solution.

The drawn out process of establishing standards will cause many FDDI "flavors."

With respect to FDDI, only vendor specific implementations of bridges, routers and workstations will be available. The complexities of doing station management and the drawn out process of establishing standards will force vendors to implement their own flavors of FDDI. Security concerns will be addressed by specialized products also, such as modified TCP/IP, specialized routers, and link level encryption. All these solutions will exact a penalty in performance and exacerbate the current management problems.

Similarly, a growing need to interconnect and extend local area networks will arise. While the technology exists to interconnect and extend local area networks, methods need to be developed to incorporate the management of these interconnections. Additionally, these interconnections exact a cost in performance.

Interconnections and extensions of LANs will have costs in performance and network management.

During this period, other local area technologies such as token rings will continue to be utilized in special arenas. The general issues discussed for Ethernet and TCP/IP are the same for these other technologies.

Initial commercial hardware implementations of popular protocols designed to deliver higher performance will appear. This potentially can extend the life of existing protocols and provide more time to develop future protocols.

C.3.4.2 Projections 1996-2000

Work on wide area technology will subsume work on local area and metropolitan area networks. This future environment will be characterized by high bandwidth, low error rate communications. Protocols will be developed that operate efficiently in this environment and management tools will be available across the spectrum of associated technologies. Less reliance on connectionless technologies (*e.g.*, broadcast) will be necessary to avoid inherent security problems.

Management and security issues will finally get serious attention.

Communications networks design objectives will drive the implementations of computer networks reflecting the importance of human interactions. These designs will take into account not only the local environment but recognize the global work environment and the associated demands for wide area networks. Specifically, the implementation of Integrated Services Digital Network by the telephone companies is the harbinger of this development.

By the year 2000, the typical desktop communications media will be optical fiber. This will parallel communications to homes with fiber optic cable installed by local telephone companies. In addition, there will be specialized services to provide researchers' integrated workstations, high definition video and high resolution graphics using very high bandwidth.

The importance of security and management will be recognized as important elements in the design of networks and products will better optimize performance while providing security and management as an integral part. Look for the solution to these needs being driven by communication companies who are better positioned to understand how to balance performance, management and security of large communication systems.

C.3.5 Implications and Issues

Communication network technology is promising increased performance

New protocols are definitely needed.

based on increased bandwidth. While hardware is available to access the increased bandwidth, integrated software products are a bottleneck. These software products implement communications protocols that were not designed for high bandwidth with low error rates. New software protocols are definitely needed.

Recent experiences have shown that standards efforts work more to formalize protocols that have already become a commercial success rather than to define protocols that will later become important. So it is difficult to forecast what networking standards will be prevalent in ten years.

The end user is still confused between the difference between media bandwidth and process speed. It is important to recognize the limitations of all parts of a system in order to use resources to improve the limiting component. Increasing the underlying transmission speed is not a panacea for all performance inadequacies.

Increasing underlying transmission speed is not a panacea for all performance problems.

In general, there is a lack of consensus in how to define the components of a communications network and how they interrelate. Therefore, the impact of changing a network or some part of it are often misunderstood by the various parties concerned. Both system providers and users need to carefully understand requirements when implementing a network to insure that the desired functionality is actually provided.

C.3.6 Conclusion

We recognize that network designs are based on available disparate commercial technology, and this situation will remain for the foreseeable future. We should maintain our flexibility to choose appropriate technologies and focus on system optimization. As system integrators, we should specify the desired system functionality in terms of high speed, security and management without restricting suppliers to specific technologies. Speed, security and management are all important factors in the total performance of networks.

Speed, security and management are all important in the total performance of networks.

Since high performance is required, steps to put in place the appropriate media need to be undertaken without delay. Construction of a pervasive physical plant is expensive and requires a long lead time. Optical fiber cable should be used routinely throughout the distribution system.

This section discusses network storage in a heterogeneous computer environment.

C.4 NETWORK STORAGE SYSTEMS

C.4.1 Introduction

This section discusses network storage systems in a heterogeneous computer environment. Storage systems can be thought of, and are often implemented, as separate nodes in a network. The hardware and software for the system are selected for their input/output features and significant storage capabilities.

The fact that storage systems have not appeared in the ITRA for the last two years . . .

Based on more than ten years of increasing usage, the usefulness of storage systems has been established. In this information age, applications exist in which commonly shared data is updated/processed so frequently that one common copy must be used by all. Applications also exist where the amount of data is so large that it is impractical to maintain multiple copies. Also, storage systems have gained popularity due to their flexible file management capabilities such as access control, archival, and backup mechanisms [1].

. . . is indicative of slow growth in technology.

The fact that storage systems have not appeared in the ITRA for the last two years is indicative of the slow growth in this technology. If the previous statement that storage systems are useful is correct, why is there so little change in the technology? Perhaps the existing technology satisfies current needs? Or perhaps the problems are so difficult that they are as yet unsolvable?

This section discusses the current status of network storage systems and attempts to answer these questions.

C.4.2 Current Status and Trends

Storage systems are available for non-supercomputer mixes of mainframes on networks.

Network storage systems are available for heterogeneous networks consisting of a mix of PC's, workstations, and non-supercomputer mainframes. The capacity and performance of the existing storage hardware is appropriate for the processing capabilities of this class of computers. In addition, networking media such as Ethernet™ and HYPERchannel™ are in the correct performance range.

The selection of software, including the network protocols, is still a difficult process.

The selection of software, including the network protocols, is still a difficult process. How the storage service will be used must be identified in advance. Some storage nodes such as the Network DataMover [2] by the Systems Center, Inc. and the Storage Machine/1 [3] by FileTek, Inc., provide storage and retrieval of entire files. Other systems such as the Epoch-1 InfiniteStorage™ Server [4] by Epoch Systems, Inc., provide access to files at the record or file level. When selecting software, it is very important to inventory all the different hardware and operating systems on the network and ensure that file access software is available for every node on the network that needs access to the storage service. It is also important, but frankly impossible, to be able to project what future hardware/software will be added to the network and verify that the storage service will be able to support it.

Performance capabilities of storage systems lag behind supercomputer processing needs.

The introduction of one or more supercomputers into a network places special demands on a storage system. In general, performance capabilities of storage systems lag considerably behind supercomputer processing needs. Supercomputers are capable of generating or processing a tremendous amount of data in a very short time. Input/output devices on supercomputers to feed an executing program must be extremely fast and have a large capacity. These high performance devices therefore, are very expensive and are generally available only to active jobs (programs) in the system. A storage service is used to store files for completed jobs and jobs scheduled for execution. However, with current technology, the time to load or unload is excessive. The networking medium, coupled with the network protocol can often only provide 3 megabytes per second effective transfer rate. However, this rate is consistent with I/O performance of most storage systems.

The emerging HSC standard has sufficient bandwidth, but there is no storage device for these very high data rates.

The emerging HSC (High Speed Channel) standard has sufficient bandwidth for storage, but to date, there is no available storage device to absorb/deliver the data at this rate. When selecting high performance disks, there is a significant trade-off between performance and reliability. Disk striping is generating considerable activity in the industry. A simplistic example of striping is for each byte of data, a bit is written to one of eight disks. Striping can be implemented in software and/or hardware. The Disk Array Controller [5] by Maximum Strategy, Inc. is an example of hardware striping. IBM has announced the Parallel I/O Access Method, which is a software striping solution. The advantages of striping are that proven, reliable disks can be used and an additional level of reliability can be introduced by providing (in this example) a ninth disk for a parity bit. Some complexities are introduced such as for some implementations, obtaining a meaningful backup of files can be difficult.

Applications on supercomputers often generate large files, in excess of a gigabyte.

Applications on supercomputers often generate large data files, in excess of 1 gigabyte. It is not economically feasible for storage systems to store many such files on magnetic disk. While optical disks have the capacity to store such files, their transfer rates (less than 1 megabyte per second) are totally inadequate. There has been a recent introduction of helical or transverse rotary scan devices [6,7,8]. The media on these devices can hold up to 1000 gigabytes and their I/O transfer rates are adequate (up to 20 megabytes per second). However, they do not have random access capabilities. In a network environment of mixed capability machines, data sharing of a one gigabyte file must be done at the record level.

There has been a recent introduction of helical or transverse rotary scan devices.

In general, a centralized storage system is a visible node on a network.

The discussion thus far is applicable to both centralized and distributed storage systems. In general, a centralized storage system is a visible node on a network. Special, user-initiated, access commands are required to access data from the storage server. Distributed storage systems are often implemented as extensions of local storage. The fact that the file is remote to the computer accessing it is transparent to the user. All files are accessed using the local access mechanisms. The Network File System (NFS) [9] protocol by Sun Microsystems, Inc. is an example of software for distributed file systems. NFS was originally developed for a UNIX-based operating system executing on a workstation. (UNIX™ is a trademark of AT&T.)

Distributed storage systems, such as those using NFS, are extremely convenient for the end user.

Distributed storage systems, such as those using NFS, are extremely convenient for the end user. Productivity is enhanced as users are not burdened with file management tasks. Once introduced to a distributed file system, users are dissatisfied with a storage service that must be explicitly accessed. Unfortunately, the performance of existing distributed file systems do not meet, and were not designed to meet, supercomputer needs.

C.4.3 Review of Prior Forecasts

In the 1988 ITRA, Sam Coleman correctly predicted the popularity of distributed storage systems.

In the 1988 ITRA [10], Sam Coleman correctly predicted the popularity of distributed storage systems. Just as computing has become decentralized, so has storage. The long-term forecast that "distributed storage systems will grow to include support computers and workstations in addition to supercomputers" has occurred earlier than anticipated. For example, NFS is already appearing on a broad spectrum of computers from PCs to CRAYs. It is most common on UNIX-based systems, but it is also available for VAX/VMS [11] and PC/DOS [12] systems.

C.4.4 Projections

C.4.4.1 Short Term Projections (1991-1995)

Distributed storage systems, with file access using local conventions, will continue to grow in popularity.

Distributed storage systems, with file access using local conventions, will continue to grow in popularity. Supercomputer users will insist on transparent network access but will clamor for better performance. As an added constraint, the performance improvements should not change the user's software interface. While hardware advances are always welcomed, new software that must be propagated throughout an existing network is not well received.

C.4.4.2 Long Term Projections (1996-2000)

Storage systems will be mature products by the mid 1990s.

The challenge to supercomputer sites will be to use commercial system software and apply it to their high performance environment.

Storage systems will be mature products by the mid 1990's. Centralized and distributed storage service functionality will be achieved. The performance of storage systems will continue to lag behind the supercomputer industry. The challenge to supercomputer sites will be to use commercial storage system software and apply it to their high performance environment.

An important feature needed in distributed storage systems is a transparent hierarchy of storage. Ideally, a three tier hierarchy needs to be achieved. The local disk space would act as the cache. A distributed file system would then provide permanent on-line and archival storage. The migration between the hierarchies of cache, on-line, and archival would be transparent to the user.

C.4.5 Implications and Issues

A major concern for now and the future is the security and privacy issue.

A major concern for now and the future is the security and privacy issue. A large repository represents a considerable asset to the company. The data files need to be adequately protected. In order to restrict access to valuable data, the storage system requires accurate identification and authentication of the originating user and node. Thus the protection mechanisms cannot be limited to the storage node but must include the network. This problem is often under-analyzed in most networks.

Data integrity protocols for satellite networks are still evolving.

Data integrity mechanisms, for files stored on the storage system, are sufficiently robust. Media life and error correcting codes provide sufficient data integrity for most applications. However, data integrity protocols for high speed and/or high delay (*e.g.*, satellite) networks are still evolving.

In contrast to the privacy concerns, is the need to maintain a responsible owner for all data.

In contrast to the privacy concerns is the need to maintain a responsible owner for all data. When users of the network no longer need its services, their data files often remain. When an account expires on one node, it is not appropriate to automatically delete all distributed files belonging to that user as the user may have, or be about to obtain, an account on other network nodes. The conservative approach is to allow these files to remain indefinitely. Unfortunately the result is often that data languishes with no responsible owner. As storage systems age, they continue to maintain files that are of no value. As long as a storage system has a hierarchy of storage, including a low-cost archival system, this may not be a major concern.

C.4.6 Conclusion

Current technology hardware and software satisfies non-supercomputer networks . . .

Storage systems are technically feasible. Current technology hardware and software satisfies non-supercomputer networks. Storage systems on a non-supercomputer network can be centralized and/or distributed. However, user-transparent distributed systems are increasingly popular and are the most efficient for the end user.

. . . but little progress has been made in integrated packages for supercomputer networks.

Little progress has been made in integrated hardware/software packages for supercomputer networks. Users request the capabilities that are available for non-supercomputer environments but they require higher performance. Unfortunately the design of existing software does not scale to supercomputer performance needs. Several laboratory systems designed for supercomputer networks, such as the Common File System at Los Alamos National Laboratory, and the Mass Storage System at the National Center for Atmospheric Research [13], have been converted to commercial systems for centralized storage systems. These systems have many excellent features but they are currently limited to 3 to 4.5 megabytes per second transfer rate of complete files. Access to these systems requires specialized software and is not transparent.

The answer to the question posed in the introduction to this section can now be given: Why is there so little change in the technology? Because current technology satisfies the commercial industry, such as banking and insurance, and they are the driving market force. However, the problems to scale the functionality, with adequate performance, to supercomputer environments have yet to be solved.

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C.5 SCIENTIFIC VISUALIZATION

C.5.1 Introduction

A couple of simple definitions which have been offered for Scientific Visualization are the application of "graphics and imaging techniques to computational science" [1] and the use of "modern image processing and computer graphics technologies to extract information from data" [2].

The formal discipline of Scientific Visualization was born in 1987 . . .

While such activities have been ongoing for many years, it was in 1987 that the formal discipline of Scientific Visualization was born. It was then that a panel of researchers from academia, industry and government met, ultimately resulting in the publication of a special report on "Visualization in Scientific Computing (ViSC)" [1]. Generally, this report promoted the need for commitment of resources towards development of visualization environments which are badly needed to support the work of scientists and engineers.

. . . and is characterized by a blend of . . .

computer graphics, image processing, computer vision computer-aided design, signal processing, and user interface studies.

The ViSC report characterizes Scientific Visualization as a blend of computer graphics, image processing, computer vision, computer-aided design, signal processing, and user interface studies. The use of inter-disciplinary teams is promoted for tool development which include expertise in the computational sciences and engineering, visualization science and engineering, systems support personnel, artists and cognitive scientists. Application areas identified include: molecular modeling, medical imaging, mathematics, geosciences, space exploration, astrophysics, computational fluid dynamics, and finite element analysis.

The need for visualization tools must be considered at the same level with other components of the environment.

Visualization capabilities are needed in order to assist scientists and engineers in their effort to interpret the massive quantities of application data they produce. The proper assimilation of such data is difficult, if not impossible, with currently available tools [1,2,3]. Indeed, the lack of appropriate tools is resulting in inefficient and/or wasteful use of supercomputing resources, which are often scarce. In building scientific computing environments, the need for visualization tools must be considered at an equal level with other components such as supercomputers, networks, mass storage systems, etc., in order to provide a well balanced environment.

Since the ViSC report, visualization has become an active area of research at scientific and engineering laboratories, National Science Foundation Centers, academic institutions, and in industry.

Some of the desired features of visualization environments which are being emphasized include a high degree of interactivity, including the ability to "steer" computations as they occur; easy-to-use tools which offer friendly user interfaces and adaptability to a wide range of specific application problems; and tightly integrated, high bandwidth, heterogeneous network computing.

C.5.2 Current Status and Trends

Hardware

A vast assortment of hardware is available for visualization, with the supercomputer at the heart, pumping data as fast as it can.

A vast assortment of hardware is available for visualization, with the supercomputer at the heart, pumping data as fast as it can.

More traditional visualization requirements can be met by a variety of low-to-medium cost ($2K-$50K) graphics systems including graphics terminals, PCs, workstations, and recently introduced windowing terminals. Modern systems in this category offer fast 2D drawing rates, while some systems also offer entry-level, real-time 3D geometric graphics. Higher performance graphics workstations are available at higher prices.

Special hardware includes superworkstations . . .

The "Superworkstation" is a class of workstation which was introduced specifically for visualization. These systems integrate mini-supercomputer performance with the highest available graphics performance, all with the single user in mind (starting at about $100K). The goal of such systems is to allow interactive computation, with real-time graphics, at least for some applications. Vendors offering systems in this class include Stellar, Ardent, Silicon Graphics, and Apollo/HP. Such systems are the focus of a recent issue of IEEE Computer Graphics and Applications [4]. An architectural trend in such systems is to move away from lots of specialized graphics hardware and using general purpose processors instead to do graphics as well as computation.

Alliant Computer Systems is promoting a visualization architecture which is somewhat different than the single-user superworkstation model. Alliant's multi-user approach is to offer a mini-supercomputer in combination with multiple visualization stations [5]. The compute and graphics processing resources are centralized and shared by some limited number of visualization stations, with connections to support transmission of video output to the display as well as input from the station back to the central system. The use of a centralized, shared processing architecture, in contrast to expensive single-user systems, does have at least some support outside of Alliant [6].

. . . high speed frame buffers . . .

Yet another approach is to connect frame buffers at very high speeds (*e.g.*, 800 Mbps) directly to the supercomputer. Such a capability is available from UltraNetwork Technologies. This provides the ultimate superworkstation hardware for the person who is privileged enough to have essentially dedicated supercomputer resources, but is less attractive when supercomputing is heavily time-shared.

. . . and image computers.

Image Computers offer an array of interesting capabilities for applications which are image-based (versus geometric-based) [7]. Image Computers are characterized by large image memories, accelerators optimized for image data processing, and memory architectures which enable very efficient memory processing. These large memories can be used to store 3D volumetric data sets, making such systems useful for volume visualization. The large memories can also be used to store pre-computed frames from an animation sequence, in digital form, which can then be played back. Image Computers are available from PIXAR, Sun (TAAC system), and AT&T (Pixel Machine).

Stereo viewing can significantly enhance a user's ability to visualize 3D data.

Stereoscopic display and viewing of images is currently possible [8]. Various vendors offer displays with stereo options, and products are also available from third party vendors. Stereo viewing can significantly enhance a user's ability to visualize 3D data.

Available input devices include crosshairs, buttons, mouse, trackball, dials, scanners, and others. Input devices will continue to play an important role in user interfaces. An interesting experimental input device has been demonstrated at NASA Ames Research Center [8,9]. A "data glove" worn by the user detects hand motions which in turn affect display information which are fed to a pair of stereoscopic goggles worn by the user — the user can actually have the perception of being in the scene.

Color hardcopy is currently available in high quality form from expensive film recording devices, or in lesser quality from video cameras (*e.g.*, Matrix) and/or color printer/plotters. The search is still on, however, for fast, low cost, high quality, convenient color hardcopy (as in black and white laser printers).

Visualization is not complete without animation.

Visualization is not complete without animation. Animation is useful for understanding complex 3D scenes as well as necessary for examining time-dependent results. When real-time animation is not possible (which is a lot of the time), recording sequences for playback can be used. A variety of components are available for recording video sequences. Images can be recorded to videotape and/or laserdisk. Images can be recorded in NTSC format, or, for better quality, using a component video format provided by more recent video technology. Images can also be stored digitally using a digital frame store system such as that which is offered by Abekas. The digital system provides a high degree of viewing flexibility — various speeds, skipping frames, random access, quality stills — and overall viewing quality. Capabilities which integrate video and workstation window environments are starting to appear. High Definition TV (HDTV), which is under development, will eventually provide a superior format for image recording and playback.

The current model for doing visualization is generally to perform batch computations on a supercomputer and use a workstation for postprocessing.

Software

The current model for doing visualization is generally to perform some batch computation on a supercomputer, producing application data (commonly very large amounts), which are then postprocessed to a display. If the display system is a workstation, then the postprocessing is generally performed on the workstation, taking advantage of interactive features when possible.

Software available for visualization includes traditional 2D and 3D graphics packages, as well as more modern graphics software systems. Graphics capabilities have been extended in recent years to include higher level geometric primitives as well as lighting and shading models to support the generation of more realistic images. Fairly sophisticated images, composed of a constrained set of geometric primitives and using limited lighting models, can even be rendered in pseudo real-time. Advanced, more expensive rendering techniques, such as ray tracing, are also available for generation of very high quality images. Such tools are still typically available as subroutine libraries, which require programming by the user, or as postprocessing modules with limited capabilities which are oriented towards specific application areas.

Existing tools still generally require programming, or they are oriented towards specific application areas.

Volume Visualization [10] is a fairly new area — it addresses the visualization of data which is sampled over a 3D grid of cells ("voxels") which approximate some volume. Techniques for visualizing such data include isosurface generation and display (surfaces extracted from the data which represent some constant value), taking real-time slices through the volume data, or high quality volume rendering, such as by ray tracing the volume data to visualize the entire volume at once (based on accumulation of color and opacity values of each of the voxels along the path of each ray). Techniques for examining flows include particle advection and flow ribbons [11].

Volume visualization is a new area.

Two identifiable trends in the development of visualization software tools are a trend towards development of easy-to-use tools, with friendly, *interactive* user interfaces, and a trend towards use of object-oriented software engineering techniques (Stellar's AVS, Ardent's DORE [4]).

Two identifiable trends are . . . development of easy-to-use tools . . . and object-oriented software engineering techniques.

It is becoming more and more common for visualization hardware to be delivered with visualization software. The quality of such software will inevitably be an important factor in evaluating the total solution offered by any specific vendor system.

Standards

Visualization standards do not exist per se. At the same time, graphics standards such as PHIGS, GKS, CGM, and industry standards such as X-Windows provide low-level graphics functionality which can be leveraged for portability of visualization tools which can make use of these standards.

Graphics standards and windowing standards offer helpful foundations.

At the same time, PHIGS+ (which is not a formal standard yet), seems to be an appropriate basis for geometric rendering systems on high performance workstations. X-Windows is an important standard in that it provides some consistency, although currently at a very low level, for windowing environments across various workstation platforms. The proposed PEX standard [12] will integrate PHIGS and X-Windows.

. . . but standards which address higher level visualization needs and new areas are yet to come.

Standards which address higher level visualization needs and new areas such as volume visualization are yet to come.

C.5.3 Projections

C.5.3.1 Short-Term (1991-1995)

Visualization will continue, in the general case, to use the model of batch computation followed by interactive postprocessing, at least until the latter part of this period. This will not necessarily be because the network functionality needed to support tighter integration won't be available, but because applications will not yet be taking full advantage of such capabilities, concentrating instead on the use of new visualization techniques in the postprocessing step and on data management.

Expect more powerful, more cost-effective visualization hardware, and more plentiful, easy-to-use software.

At the same time, significant developments will occur in virtually all of the component areas in the visualization environment. We can expect to see more powerful, more cost-effective visualization hardware. The trend for better performance for the money is likely to continue — the advent of new technology such as Intel's i860 [13] is strong evidence of this. Visualization software tools will become more plentiful and easier to use. Networking itself will become faster (100Mbps to 800Mbps) and functionally richer. Some other advances which are likely:

Some other advances which are likely are in software, integration, and standards.

- Pseudo real-time, high quality volume rendering.
- The ability to deal with higher resolution 3D data sets in common practice (512x512x512 and more).
- The availability of PEX for network transparent 3D graphics.
- Integration of video into workstation window environments as a common feature.
- Digital animation capabilities inherent to the workstation (as a result of large memories, higher speed internal buses, and somewhat faster mass storage devices).
- The arrival of HDTV.
- Integration of geometric rendering and imaging.
- Start-up of standards efforts addressing visualization needs.

C.5.3.2 Long-Term (1996-2000)

Visualization applications will begin to do more interactive computing.

Visualization applications will begin to take fuller advantage of network computing features, providing a much tighter link between computation parts and visualization parts of the application. The user will be able to monitor computations visually as they progress, interacting as necessary. Whether the user actually chooses to continually monitor computations as they occur throughout the course of the computation is another question.

Networks will become faster yet, with 1Gbps becoming common (this begins to approach the estimated bandwidth of the brain's visual input channel). Of course, supercomputers and workstations will also become much faster. High speed networks will obviate the need for local disk at the user's workstation. Mass storage transfer rates will increase, although they still could become a bottleneck. This technology does not seem to be advancing as rapidly as compute power and network speeds.

We can expect continued advances in visualization hardware and software. A couple of areas where radical developments are possible are true 3D display technologies and human-machine interfaces.

The first visualization standards will be completed.

The first visualization standards will be completed.

C.5.4 Implications and Issues

In order to provide appropriate visualization tools, a commensurate level of resources must be provided towards development and/or provision of such tools. Visualization must be recognized as a critical component of scientific computing environments. Resources dedicated to visualization will be needed within central computing organizations, to provide generic tools and necessary computing environment functions, and within application communities to provide more direct development and integration for specific application environments.

Visualization must be recognized as a critical component of scientific computing environments.

General issues which must be addressed to provide complete visualization environments include data storage hardware, data management software, networking, visualization software and hardware [2]. Some more specific issues include:

- Whether or not to implement special, high-speed graphics networks for visualization, in addition to providing basic LAN connectivity.
- How to spend hardware dollars? Whether to buy fewer high-end, single user systems, lots of low-end systems, or some hybrid combination which allows sharing of high-end systems.
- The search for optimal distributed configurations for specific applications.
- The impact of software on hardware purchases. Users will tend to look for complete solutions — the availability of appropriate software tools will counteract hardware performance.

C.5.5 Conclusion

Visualization tools can significantly increase the ability of scientists and engineers . . .

. . . to comprehend results of computation, while also preventing the waste of compute cycles.

As computers and networks become even more powerful, their capacity to produce more and more data continues to grow. Modern scientific visualization tools are badly needed to help keep pace with these volumes of data. Visualization tools can significantly increase the ability of scientists and engineers to comprehend computation results, while also preventing the waste of compute cycles. Imagine the difficulty facing an application programmer who is trying to program a supercomputer which has no higher level programming languages — the current predicament of the scientist is much the same in that currently available visualization tools are inadequate to match the raw power of the scientific computing environment.

The awareness of Scientific Visualization and the need for appropriate tools has heightened over the past two years. At the same time, there is much work to do. Resources must be committed, but the payoffs will be very satisfying. The next ten years should produce substantial changes in visualization capabilities actually at the disposal of the scientist or engineer. Ultimately, the result should be a much higher degree of productivity for the scientist or engineer.

Resources must be committed, but the payoffs will be very satisfying.

C.5.6 References

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C.6 SEMICONDUCTOR COMPONENTS

C.6.1 Introduction

Advances in semiconductor components, to a large extent, have been the key ingredient fueling the "Computer Revolution."

Advances in semiconductor components, to a large extent, have been the key ingredient fueling the "Computer Revolution" [1]. During the past 50 years, as logic and memory devices have decreased in size and cost, computers have become more powerful, more compact, less expensive, and more available. Recently, the widespread use of personal computing systems in many aspects of our businesses and homes has increased the financial motivation to bring new technology to the marketplace in a timely manner. Technological advances announced at scientific conferences today can be found in the marketplace in the next three to five years; a 16-Mbit DRAM (16 million bits of dynamic random access memory on a single silicon integrated circuit) announced at the 1988 IEEE International Solid-State Circuits Conference in February 1988 [2] is expected to be available

All computer users benefit from these significant market pressures that rapidly fire semiconductor component technology from the research lab to the marketplace.

as a commercial product in 1991. The US personal computer market alone is estimated to be $31.6 billion market in 1989 [3]. All computer users benefit from these significant market pressures that rapidly drive semiconductor component technology from the research lab to the marketplace. In brief, these technology advances in semiconductor components have resulted in more computing power being put in smaller boxes at lower costs.

C.6.2 Current Status and Trends

We will begin this section with a discussion of general technology trends effecting most types of digital integrated circuit devices. We will then refer to specific devices currently available from commercial suppliers or devices that can be made available with appropriate economic incentives but need no additional technology development. In the "Short Term Projection" section we will discuss devices that have been demonstrated in research laboratories but may need two to five years of additional research and development before becoming commercially available products.

The number of functioning transistors that can be placed on a single silicon chip has increased dramatically, from 1 single device to over 16 million devices.

Since the first integrated circuit (IC) was demonstrated in 1959 [4], there has been a continuing trend of integrating more devices onto a single semiconductor chip while operating at faster speeds and using less power per gate. The number of functioning transistors that can be placed on a single silicon chip has increased dramatically, from one single device to over 16 million devices [2]. In general usage, an electronic integrated circuit "chip" refers to a small rectangular chunk of crystalline semiconductor, either silicon (Si) or gallium arsenide (GaAs), generally less than 1 cm x 1 cm x 0.040 cm in dimension, that contains a complete electronic circuit to perform functions such as data storage or digital computation operations. The current trend is to quadruple the number of devices that can be integrated onto one of these chips every three years. The first integrated circuit oscillated at 1.3 MHz [4], today Si integrated circuits can oscillate at over 30 GHz and individual GaAs devices can function at over 100 GHz [5].

The current trend is to quadruple the number of devices that can be integrated onto one of these chips every three years.

These technology trends have had significant impact on the most important integrated circuits used by computers — memories and microprocessors. In the memory area, there are three main types of semiconductor components used: DRAM — Dynamic Random Access Memory (which must be refreshed periodically for them to retain their data), SRAM — Static Random Access Memories, and EPROM — Erasable Programmable Read Only Memory. Each type of memory has an application niche. DRAMs are used in moderate speed applications (60 to 200 nsec access time) requiring high densities at modest costs; these applications must tolerate the refresh cycle delay generally required every 16 milliseconds with DRAMs. Currently 4-Mbit (4 million bits per integrated circuit) DRAMs are available for approximately $200/chip with prices expected to drop to around $50/chip in 1990 [6]. SRAMs are used in high speed applications (15 to 60 nsec access time) and generally cost more. Currently 1-Mbit SRAMs are available for approximately $200/chip.

Finally 1-Mbit EPROM and EEPROM (electrical erasable programmable read only memories) are also commercially available. Since no electrical power is required for EPROMs to retain their data, EPROMs are generally used for long term storage of program instructions and data tables, particularly data that the CPU (central processor unit) needs to access at medium to high speeds.

Recently Intel has introduced the 80860 which is claimed to be a "CRAY on a Chip."

The performance of microprocessors has also made significant advances since the first 4004 microprocessor was announced by Intel in 1971. Recently Intel has introduced the 80860 which is claimed to be a "CRAY on a Chip" [7]. Although microprocessor speed ratings are highly application dependent, Intel's 80860 (also known as N10 or i860) has been rated at 33 MIPS (millions of VAX integer instructions per second) and between 10 and 100 MFLOPS (millions of floating point operations per second), depending on the specific task. Current devices have clock speeds of 33 MHz and 40 MHz and prices of approximately $750/chip. Bipolar Integrated Technology has announced an ECL (Emitter Coupled Logic) version of their SPARC microprocessor with clock speeds of 80 MHz and performance ratings as high as 65 MIPS. This comes as a 6 chip set for $3300. Cypress Semiconductor makes a 33 MHz clock rate, CMOS (complimentary metal oxide semiconductor) SPARC chip rated at 24 MIPS. A 20 MHz version of Motorola's 88000 series RISC (reduced instruction set computer) chip is currently rated at 17 MIPs and 7 MFLOPS. Other currently available microprocessor chips include the 32 MHz Intel 80386 rated at 5.6 MIPS, the 25 MHz Intel 80486 rated at 15 MIPS and 5 MFLOPS, and the Motorola 25 MHz 68030 rates at 5.6 MIPS.

Advanced material technologies have demonstrated about 2.5 times faster operational speeds than silicon ICs.

Advanced material technologies, primarily gallium arsenide based ICs, have demonstrated approximately 2.5 times faster operational speeds than silicon ICs. With GaAs semiconductor materials and device technology, switching times of less than 40 picoseconds have been demonstrated in laboratories. Fully operating flip flop logic gates operating at 8 to 10 GHz clock rates are available through a few vendors specializing in these ICs [8]. After several years of development, GaAs ICs are finally becoming commercially viable products that can compete with Si devices on a price-performance basis.

C.6.3 Projections

Projecting future trends is a risky endeavor for a rapidly changing technology. Uncertain market forces determine the future level of product research and development. Since the semiconductor business is notoriously cyclic, it is possible for an apparently straightforward extension of existing technology during periods of healthy business activity to become a major technological hurdle during periods of weak business activity.

C.6.3.1 Short Term Projections (1991 - 1995)

In the short term, 16-Mbit DRAM and 4-Mbit SRAM memory ICs will become readily available in the commercial marketplace. These devices have already been demonstrated in various industrial research and development laboratories [4]. In the mid-1990s, 64-Mbit DRAMs and 16-Mbit SRAMs may begin to enter the marketplace. Application specific memories with specialized on-chip logic functions will become more widely available.

Advanced microprocessors with 50 to 100 MIPS integer performance and 15 to 30 MFLOPS floating point performance will become available. To achieve these processing speeds, trends of putting more devices on a single microprocessor chip will continue. It will be common for microprocessors to have 64-bit internal registers. Floating point units, memory management units, graphics units, data caches, and instruction caches will increasingly be found on the microprocessor chip. These future microprocessors will not only increase the processing speed of computers but also decrease the overall cost of the system by including more functions in fewer chips.

An increasing variety of gallium arsenide circuits will become available for a growing array of applications.

An increasing variety of gallium arsenide circuits will become available for a growing array of applications requiring high speed processing. Levels of integration in GaAs will continue to grow as these circuits become accepted in the marketplace and greater resources are devoted to product research and development. Specialized GaAs IC logic circuits with 10 to 30 GHz performance will be available. GaAs microprocessors will become available for some high speed processing applications. These devices may exhibit 2.5 times greater processing speed than Si devices.

C.6.3.2 Long Term Projections (1996 - 2000)

It appears that with silicon technology 64-Mbit DRAMs and 16-Mbit SRAMs will become available at moderate to low prices.

Of course as we project further into the future, the uncertainty of these projections grows. However, it appears that with Si technology 64-Mbit DRAMs and 16-Mbit SRAMs will become available at moderate to low prices. Application specific chips combining large memory arrays with significant other logic functions will also become available. Technologies to implement 256-Mbit and 1-Gigabit DRAM ICs will be developed and experimental 1-Gigabit memories will be tested. Current chip density growth rates suggest that gigascale integration can be achieved in the late 1990s.

Silicon based microprocessors will continue their trend of incorporating more functions onto a single, higher speed chip. Clock speeds of 100 to 200 MHz will be available. Internal register lengths may grow to 128 bits or longer. Microprocessors will routinely include functions such as graphics processing, memory management, floating point arithmetic operations, and large high speed instruction and data caches. Single chip processing speeds in the 150 to 250 MIPS range will be available. Floating point operations may achieve speed in the 50 to 150 MFLOPS range, depending on the applications. Features such as on-chip bootstrap EEPROM (electrical erasable programmable read only memories), digital signal processing units, analog to digital and digital to analog converters, and on-chip DRAM may also become available on these high speed, 64-bit and 128-bit processors. Microprocessors with multiple 64-bit CPU engines on a single chip may also become available.

Josephson-effect-based logic gate technologies may begin to become commercially available.

Josephson-effect-based logic gate technologies may begin to become commercially available as high temperature superconductor materials technology continues to develop. Superconducting Josephson logic devices have the potential for extremely high speed operation and very low power dissipation. A 4-bit, 770 MHz, 5 milliwatt Josephson microprocessor has already been demonstrated [2]. Widespread use of this technology will depend strongly on the development and maturing of the new high temperatures superconducting materials. The existing Josephson junction logic gates must be operated at liquid helium temperatures (4 K) and therefore will probably not be feasible for many applications. The new high temperature superconducting materials can exhibit superconducting characteristics at liquid nitrogen (77 K) or warmer temperatures. Some early attempts at building logic devices with these new materials technology has already been successful at IBM. This technology could have important impacts on future computing hardware.

GaAs IC technology will become a viable alternative to Si based circuits for high speed digital logic applications. An entire family of standard GaAs ICs will become commercially available with 20 to 50 GHz clock capabilities. New strained layer superlattice device technology will become standard tools for GaAs IC logic circuit designers. This technology should be useful in maintaining at least a 2.5 times speed-up factor of GaAs logic devices over Si technology [5, 8].

C.6.4 Implications and Issues

The implications of semiconductor component advances during the next ten years on computer systems, large and small, can be estimated based on insights from long term device trends and exploratory research devices in the laboratory today. Extrapolations from these trends must be tempered somewhat as computing cycle times approach sub-nanosecond values and device feature sizes approach 0.1 microns. Fundamental limitations associated with the finite time required for electromagnetic energy to propagate from one computing element chip to another will ultimately limit both the size of the computer and the minimum computer cycle time. Other less clearly defined limits may be associated with ultra-small device geometries. "Single event" logic level upset resulting from single "cosmic ray" photons creating excess charges in critical regions of ultra-small devices may limit the extent of device down-sizing that can be achieved. Fault tolerance effects in complex structures may also require extensive investigation.

The greatest impact of component technology is likely to be in silicon memory and microprocessor chips.

The greatest impact of component technology within this time frame is likely to be in the area of silicon memory and microprocessor chips. Memories will benefit most directly from the increase in integration density especially since scaling and error recovery techniques for regular arrays of memory elements are well understood. The availability of larger memories will have substantial effects on a wide range of applications ranging from multi-dimensional scientific computations to word processing. A single 16-Mbit DRAM chip (already demonstrated in the laboratory) can contain 436 pages of text with 60 lines per page and 80 characters per line. For a relatively small system containing eight of these memory chips, the user can have rapid access to 3500 pages of text in RAM memory. With eight

64-Mbit devices, the user can put 14,000 pages of text in high speed, fast access memory. This increase in fast access, RAM memory storage capability will greatly increase processing speeds by reducing the need to frequently access slower speed, mass storage devices like fixed disks. Text manipulation, data base operations, task switching, expert and knowledge based systems will all significantly benefit from larger capacity, high-speed semiconductor memory advances. Scientific and engineering codes performing operations on large, multi-dimensional grids will run much faster if the CPU can access all the required information in high-speed local memory.

Three dimensional problems imply huge increases in the amount of memory needed.

Even larger memories and faster processors will be needed to satisfy future computing needs. There are a number of scientific and engineering applications in which users need to extend their computational analysis from two to three dimensions to achieve more realistic models of physical systems. The memory requirements for such problems increase as the number of grid points, and the number of grid points grows as the power of the dimension. A typical two-dimensional application may need a 1000 x 1000 array of grid points requiring 1 million memory locations; this same application expanded to three dimensions and a 1000 x 1000 x 1000 array requires 1 billion memory locations. For these types of engineering and scientific problems currently implemented on large computers, a 1000 fold increase in memory is required to advance to the next level of computational analysis. Current advances in semiconductor memory are achieving a 4 fold increase in memory on a chip every three years. At this rate, it may take 15 years to achieve a 1000 fold memory increase to satisfy the needs of these types of problems.

Microprocessors announced this year will permit personal computers and small workstations to achieve speeds found only in supercomputers previously.

Microprocessors announced this year by IC development and research laboratories will permit personal computers and small work stations to achieve processing speeds previously found only in supercomputers. This represents an order of magnitude improvement over existing Intel 80386 and Motorola 68030 microprocessors. By utilizing higher levels of integration and faster semiconductor materials (*e.g.*, GaAs or InP), processing speeds may increase another order of magnitude during the next ten years.

Processor performance will also be enhanced by substantial architectural changes made possible by increases in integrated circuit integration density. New architectures will be able to execute multiple instructions per clock cycle rather than the current average 1.5-2 cycles/instruction on RISC (Reduced Instruction Set Computer) processors and 8-10 cycles/instruction on CISC (Complex Instruction Set Computers), such as a VAX. These architectural advances will give microprocessors even higher peak performances. However, to take full advantage of this peak processing potential in actual applications, much effort is still required by the programmer and compiler.

Packaging technology issues may become one of the most critically important issues during the next decade.

There are many important technology issues to be addressed before these improvements can be achieved. In assessing the impact of semiconductor component technology on computers, one must consider how these components are put together and in particular the issue of packaging technology. Packaging technology issues may become one of the most critically important issues for large and small computer systems during the next decade. Significant research and development efforts will be required to address the following issues: (1) Cooling of densely packed chips is becoming increasingly difficult and expensive. (2) Limitations on the number of signal pins out of an integrated circuit already limit the implementation of some parallel processing computer architectures and this issue is expected to become severe as parallel implementations expand to create higher speed systems. (3) Propagation delays associated with the finite time required for electronic signals to travel from one part of a circuit board to another will limit the size of future computers and further exacerbate the need to package components optimally.

As microprocessor clock speeds increase, propagation delays associated with electronic signals traveling from one part of the computer board to another part of the board will become an extremely important issue. For example, consider the design problems associated with a 1 GHz clock rate (1 nsec cycle time) microprocessor synchronously transmitting 10 Gigabits/sec of data to certain memory or logic chip 3" (0.4 nsec propagation delay) away and another IC 10" (1.2 nsec propagation delay) away. These two ICs will receive their data during different clock cycles; memory and digital logic chips may not be able to operate synchronously under these circumstances. It has been estimated that a synchronous computing system operating with a 1 nsec cycle time would have to occupy a volume no larger than 1 liter in size. The use of optical interconnects, both fiber and free space, is being investigated to help address this problem although significant technology development is still needed.

Cray CPU speeds have tripled in 12 years while improvements in high-speed semi-conductor components have improved orders of magnitude.

For these and related reasons, the development of a 1 nsec supercomputer has not yet been accomplished. For example, Cray computers now under development operate in the 2 nsec/cycle range. It is important to note that while orders of magnitude improvements have been achieved in developing high-speed semiconductor components during the last twelve years, high-end supercomputers during this same period have only achieved a factor of 3 increase in clock speeds. In 1976 the Cray 1 was announced with a clock period of 12.5 nsec and in 1988 the Cray 2 was announced with a clock speed of 4 nsec. Further advances in design and component technology will be needed to achieve the technologically difficult goal of a 1 nsec/cycle computer.

There are other issues specific to semiconductor device technology that will ultimately limit the improvements that can be achieved. The trend toward shrinking individual memory and transistor elements to increasingly smaller sizes on the IC chip will eventually reach physical limits associated with device characteristics. Power supply voltages will have to be decreased to prevent electrical breakdown as device sizes shrink. Ultimately, as the device shrinking and power supply voltage reduction processes continue, thermally generated, electrical noise effects will dominate device characteristics, resulting in unacceptable device performance at room temperature. Active cooling of these components (*e.g.*, liquid nitrogen) may reduce these problems, but this will add expense and limit the applications of these actively cooled computers to high-end systems.

Advances in semiconductor component technology have resulted in the development of high-speed computing systems utilizing parallel processing techniques. These techniques appear to be some of the most promising approaches to developing very high-speed computing systems and are already in use for applications from workstations to supercomputers. Some high-end computer systems (*e.g.*, Cray X-MP, IBM 3094, Alliant, Sequent, Encore) and work stations (*e.g.*, Ardent Stellar, Apollo) use architectures which employ two to 32 processors to provide greater overall computational capability. Other vendors are supplying systems of thousands of coupled microprocessors which are potentially capable of providing enormous computing speeds. While there are many problems to be resolved in parallel systems, this approach is practical.

C.6.5 Conclusions

The effect of advances in semiconductor component technology will continue to strongly impact the lower price end of the computing spectrum. Within the next five years, the processing power of personal computers and work stations is likely to increase another order of magnitude to the 100 Megaflop range. This will be achieved by improvements in both systems design and component technology. These improvements coupled with an order of magnitude increase in memory densities will provide scientists and engineers with desktop processing powers rivaling that of supercomputers a decade earlier. For example, in 1982, the widely accepted standard for defining a "supercomputer" was the ability to sustain over 20 Megaflops on a database of at least 1 million, 64-bit words. This level of computing hardware capability can almost be attained today by using a single IC processors such as the Intel 80860 and sixteen, 4-Mbit DRAM chips. The small scale use of parallel processing will also be seen in this marketplace to further enhance the overall system processing capability in such dedicated functions as graphics and background computations.

Supercomputer CPU speeds will improve by a factor of 3 to 10, but faster speeds would be difficult to achieve.

The effect of advances in semiconductor component technology on the development of higher speed supercomputers is likely to be much less dramatic. A factor of about 3 increase in clock speed within the next 5 years to about a 1 nsec cycle time may be achieved. During the next ten to fifteen years an overall improvement in clock speed of an order of magnitude should be expected. As sub-nanosecond cycle times are approached, electrical signal propagation speed and fundamental solid state device limitations will make progress much more difficult.

The fundamental difficulties in achieving substantially faster cycle times will probably force supercomputer development to exploit the advances in super-microprocessors.

In the next decade, we can expect the performance gap between microprocessors and supercomputers to steadily diminish with high-speed processing capability becoming available to individual users. The fundamental difficulties in achieving substantially faster cycle times will probably force supercomputer development to exploit the advances in super-microprocessors. Supercomputers will move into the realm of highly parallel systems to achieve performance in the teraflop regime and beyond. Advances in semiconductor component technology will become essential for improvements in both small computer systems and larger supercomputers systems.

C.6.7 References

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C.7 SUPERCOMPUTERS

C.7.1 Introduction

In this year's ITRA, topics usually discussed under a single heading of "Supercomputers" or "Parallel Processing" are being discussed in two separate sections: one on Massively Parallel Computing and this one on Supercomputing. In addition, workstations are also treated separately. We have attempted therefore to appropriately narrow the scope of this section.

This class of machines will almost surely evolve into "medium scale" parallelism over time.

To review, the term "supercomputer" is used to refer to that class of general purpose scientific computers that are the most powerful (fast, accurate, large shared memory) available at any given time. For the last several years the supercomputer class has been epitomized by the latest offerings from Cray Research Inc., which offers systems with up to eight very powerful processors sharing a large common memory. This class of machines will almost surely evolve into "medium scale" parallelism over time. Highly parallel systems, which are generally characterized by having their memory distributed among the processors rather than centrally shared, are not classed as "supercomputers" for the purposes of this report. The theoretical peak power of certain massively parallel machines certainly has exceeded the power of available supercomputers, but algorithmic and programming difficulties of applying such distributed memory machines to general scientific problems have thus far kept them from being popularly perceived as supercomputers. We have left further discussion of this issue to the section of this report on that topic. Another category of computers not discussed here is the "mini-supercomputer" class of machines from such vendors as Convex, Alliant, Sequent, etc., whose performance and price are generally an order of magnitude below that of the current supercomputers.

C.7.2 Review of Prior Forecast

Discussion of supercomputers or parallel computers in recent ITRA reports has rather accurately forecast the evolution of supercomputer hardware, and important software issues have been well identified. Major areas of projections have been:

It has been accurately projected that the speed of a single processor in a supercomputer would increase at a slower and slower pace.

Processor Speed: It has been accurately projected that the speed of a single processor in a supercomputer would increase at a slower and slower pace. In the ITRA three years ago, it was projected that supercomputer vendors would slowly push the cycle times of their processors into the 1 to 2 nanosecond range. In the last decade cycle times have only dropped by a factor of two to three: from about 12 nanoseconds in a CRAY-1 to 6 nanoseconds in the CRAY YMP8/832 and 4 nanoseconds in a CRAY-2. However, several vendors are currently expected to offer machines with cycle times in the 2 to 3 nanosecond range for sale by 1992. We know of no reasonable possibility of reducing cycle times much lower than the 1 nanosecond range. Even the use of new materials such as gallium arsenide with faster switching times is not likely to change this trend because of the spacial and cooling realities of assembling large-scale systems.

Number of Processors: It has also been well understood that general purpose systems would likely have a fairly small number of powerful vector processors. This holds true even for the next generation of machines currently being built by the major vendors.

The degree of difficulty to program parallel computers has perhaps been overstated for shared memory machines.

Multiprocessing: Difficulties in programming parallel machines for multiprocessing (*i.e.*, to apply several processors to one program, not just run many separate programs) have been highlighted for several years. However, the degree of difficulty has perhaps been overstated for shared-memory systems. This will be discussed below.

C.7.3 Current Status and Trends

Several interesting trends in supercomputing are identifiable currently:

It appears that the US market and the international market are both likely to experience plenty of healthy competition.

Marketplace Changes: In mid-1989, the sudden demise of ETA Systems, Inc., created some concern because it seemed to leave the US with just one supercomputer vendor. The spin-off of Cray Computer Corp. from Cray Research Inc. offset this concern slightly, but in the longer term it appears that the US market and the international market are both likely to experience plenty of healthy competition during the next few years. In July, Evans & Sutherland announced the availability of a somewhat different architecture machine in the supercomputer range. This machine is characterized by less sparkling vector performance than the Cray YMP8, but is balanced by high claimed scalar performance. Additionally, Supercomputer Systems, Inc. (SSI), which has business relations with International Business Machines (IBM), is expected to offer a competitive supercomputer in 1992. Internationally, Honeywell-NEC Supercomputers Inc. (HNSX) recently announced a four-processor supercomputer which is expected to have vector performance exceeding that of the Cray YMP8, and it will be surprising if Amdahl/Fujitsu and Hitachi are far behind in offering parallel supercomputers. (Amdahl recently purchased Key Computer Laboratories for a premium price. Key was known to be developing a fast scalar processor.) It is also possible that certain of the mini-supercomputer vendors could evolve their offerings into the true supercomputer range during the next few years, but there is no clear evidence that is happening yet.

Number of Processors: The CRAY-3 from Cray Computer Corp. (CCC) and the C-90 from Cray Research Inc. (CRI) are both projected to have at most 16 processors, which continues the past trend of supercomputers having a small number of powerful processors. However, this trend will not last forever: the Cray-4, which is presumably half a decade away, is projected to have 64 processors, which can no longer be considered to be a small number. The recently announced Evans & Sutherland (E&S) ES-1 consists of up to eight "processors", each of which is actually composed of 16 separately usable "computation units", for an aggregate of 128 parallel units. Such expansion into the range of "medium scale" parallelism is inevitable. A side effect of this trend, assuming that overall system prices remain about the same as in the recent past (excluding inflation), is that supercomputer vendors will have the option of selling "small" systems with one or a few of the same processors that are in their large systems, for a price in direct competition with the mini-supercomputer vendors.

For the particular case of supercomputers, it appears that there is more cause for optimism than in previous years.

Multiprocessing: Multiprocessing (also referred to as multitasking) has been a topic discussed with considerable concern in recent ITRAs. Those concerns have been well founded. However, for the particular case of supercomputers (or any shared memory system), it appears that there is more cause of optimism now than in previous years. For example, the mini-supercomputer vendor, ALLIANT, has been able to develop a Fortran compiler which does a credible job of recognizing and exploiting inner loop vectors AND outer loop parallelism. The technology involved is certainly not fundamentally limited to mini-supercomputers. A second example is CRI's "Autotasking" capability which has recently been developed for the Fortran compiler on their UNICOS operating system. This capability effectively applies multiple CPUs to a single Fortran routine, with minimal "overhead". In addition, CRI offers a pre-processor (FPP, developed by Pacific-Sierra Research Corp.) that can assist programmers in writing code that will be recognized by the compiler as parallelizable. These vendors are not the only such examples — progress clearly is being made in various ways in this area. It is notable that these parallelization efforts focus on regular Fortran, based on the Fortran 77 standard.

Memory Size: The last few years has seen a substantial growth in central memories and fast auxiliary memory (sometimes called "SSD" memory for *solid state disk* or CRI's term, *solid state storage device*). However, this growth seems to have slowed. This slowing is evidently due to the failure of the industry to develop progressively higher memory chip densities. For example, the slowdown in growth of SSD memories is due to the unavailability of volumes of reasonably priced 4 Megabit (4 Mb) DRAM chips. While it is impossible to predict whether a major breakthrough might occur in this area, it appears that supercomputers may be hitting a plateau in their memory sizes. For example, as the number of memory to CPU interconnects grows the amount of control circuitry required to build a large shared central memory (such as planned for the Cray-3) is progressively burdensome.

Supercomputers may be hitting a plateau in their memory sizes.

Physical Size: An interesting side light in supercomputing is the future role of miniaturization in building supercomputers. The current offerings and near-future planned offerings from most vendors (including CRI, E&S, and HNSX) appear "conventional" in cooling technology, chip packing density, and physical size of the complete unit. The Cray-3, however, continues Seymour Cray's trend of putting more and more power into less and less space: a complete CPU module set for the Cray-3 could fit into a shirt pocket. The implications for this dichotomy in the industry are not clear.

"CRAY-on-a-Chip": The huge performance increases being seen recently in the desktop workstation arena cannot be ignored when discussing supercomputers. The processor chips that these systems are built around could become the basis for supercomputers as well. (Highly parallel systems are already doing this.) However, it is no small matter to take these powerful computers-on-a-chip and construct a balanced, large, shared memory computer. While this technology will be important in the mini-supercomputer area, its impact on current state-of-the-art supercomputer architecture is uncertain.

UNIX: A clear and present trend is that toward UNIX as the de facto standard operating system on all supercomputers (as well as on the powerful workstations that are being networked to supercomputers). No major vendor would now think seriously of offering a system without a UNIX-based operating system and the attending networking functions which are rapidly becoming industry standards (*i.e.*, TCP/IP, Telnet, etc.)

No major vendor would now think seriously of offering a system without a UNIX-based operating system.

Network Support: As supercomputers become more powerful, and the protocols and conventions in their service networks become industry standard, a developing problem is that the performance of that support network is generally not growing at a rate which will provide adequate service to a supercomputer. Perhaps the prime example here is the lack of file storage systems appropriate to service machines such as the coming Cray Research Inc. C-90 and Cray Computer Corp CRAY-3. Output files from large computations may be in the multiple gigaword range. However, even the best supercomputer support networks today typically off-load such data at a rate of a few megabits per second, which translates to perhaps hours to off-load a single file. And, the storage media available to store such a file once it is present at the file-storage node are below the gigaword range in storage per volume (except perhaps for laser disk media which are generally relatively slow). These problems are receiving attention from vendors and standards groups. Substantial progress is

The performance of the support network is not growing at a rate which will provide adequate service.

expected in the area of network speed: the 100Mbps (Mega-bit-per-second) FDDI standard is coming to market, and the High Speed Channel (HSC) championed by LANL is receiving broad interest as a medium for speeds of 800 and 1600 Mbps. In the meantime, special situations are being served by vendors such as Ultra Corp which sells a proprietary 800 Mbps network.

C.7.4 Projections

C.7.4.1 Short Term

Supercomputer Performance: The current hardware trends identified above should continue. Overall supercomputer performance should continue to grow at a significant rate over the next five years as cycle times continue to push toward 1 nanosecond and the number of processors grows toward the range of medium scale parallelism (*i.e.*, the vicinity of 100 powerful processors). The number of offerings available in the marketplace is likely to increase significantly, and along with that should come a richer choice of architectures. The next five years should be very interesting times for supercomputing.

The era when one could identify the most capable supercomputer will probably end.

Marketplace Complexity: The era when one could identify the one most capable general purpose supercomputer will probably end. A variety of offerings from a variety of vendors will make the choice of the best machine for a particular laboratory progressively difficult to determine. The use of appropriate benchmarks in such determinations will be especially important (and difficult). The best supercomputer for one class of applications may well not be the same as the best one for a different class of applications.

Software Performance: The recent hopeful trends toward solving multiprocessing difficulties for many applications using standard Fortran (on shared memory machines) should continue.

Memory Size: Progress to larger memories (whether central or auxiliary) will continue, but at a slower rate than in the last few years.

Sufficient speed and capacity of supporting file storage for supercomputers will likely continue to be a problem.

Network Support: The matter of sufficient speed and capacity of supporting file storage for supercomputers will likely continue to be a problem, due at least partly to the rather thin market for systems at the top end of the performance range.

C.7.4.2 Long Term

Parallel Processing: Parallel processing will be an ordinary fact of life for computers in all capability ranges. However, it is not clear what machine architecture or architectures will be preeminent in supercomputing in the 1996-2000 range, as this subject may evolve significantly by the year 2000. The best guess today as to how supercomputers will be programmed in that time frame is that it is likely not to be greatly different from today. Revolution in programming languages is unlikely.

Industry Growth: More and more industries (and countries) are recognizing the value of supercomputers and near supercomputers. The number of supercomputers and mini-supercomputers in place has increased greatly over the last half decade. This trend will almost certainly continue, so that by the 1996-2000 time frame the number of machines delivered will be much larger than today, as will be the number of persons who view supercomputing as a normal part of their processes. It is not so clear as to where in the available performance range the bulk of these machines will lie.

C.7.5 Implications and Issues

Customers who have a clear need for supercomputer capability may be fewer in number ten years from now.

Marketplace Changes: Due to the vigorous competition arising in this market, ever more powerful general purpose supercomputers will continue to appear for the next several years. However, the number of customers who will have a clear need for capability at the upper end of the then available supercomputer capability may not be as large ten years from now as today. The reason for this is that as computers become faster, the percent of applications which are well satisfied with less than then state-of-the-art capabilities grows. (Though everyone likes a more powerful machine if their applications run more cheaply on it.) This situation could lead to an eventual slow-down in availability of very large scale state-of-the-art general purpose systems for those remaining users (such as DOE laboratory sites) who require ever greater computational resources. As this situation begins to take shape users will need to pay closer attention to choosing computer architectures that support their particular application most efficiently. The next step would be to build hardware specifically adapted to run certain applications. Examples of such performance are present today in the workstation market, where specialized workstations perform specific computations with speeds roughly equal to that of a supercomputer, and in the massively parallel market, where certain applications run faster than on a traditional supercomputer.

We need a strategy that allows laboratories to apply their computing dollars the best way.

Foreign Competition: Over the next few years we must resolve the issue of the role of foreign-made supercomputers. While we have traditionally thought of computers from CRI and other vendors as being domestic, many of the integrated circuit chips in them have in fact been of foreign manufacture. We need a strategy that allows laboratories to best apply their available computing dollars, that protects the defense posture of the DOE, and that recognizes that machines generally cannot be cleanly labelled as domestic or foreign.

C.7.6 Conclusions

Other limits besides cycle time will appear, such as practical memory size limits and numbers of processors.

Supercomputers are vital to the operation of DOE laboratories. Conversely, demand for supercomputers at DOE sites was a major driving force in the development of the supercomputer industry. The current vigor in this marketplace should serve well to provide for the computational needs of the DOE laboratories over the next several years. However, just as there are apparently limits to how low the cycle time of supercomputers can be driven, other limits will begin to show by the end of the 1990s. Likely such areas include practical limits on memory sizes and practical limits on the number of powerful processes that can productively be connected through a single shared memory. Nevertheless, new architectural developments and the use of specialized hardware will no doubt supplement the fundamental push to lower cycle times, more processors, more memory, etc., with the end effect of continued growth in capability and capacity of supercomputers for the ten year time scale addressed herein.

C.8 WORKSTATIONS

C.8.1 Introduction

Workstations together with personal computers constitute one of the more dynamic areas of computer technology.

In view of the fact that only a year has elapsed since the preparation of the 1990 ITRA, neither the technology nor our experience base have subsequently changed to a large degree. Therefore, it should come as no surprise that the conclusions and projections in the workstation area are not so very different from the prior report. Nevertheless, certain areas do seem to require somewhat different emphasis, and these and other minor changes will be reflected in the following sections of this report. In any case, what is still abundantly clear is the fact that workstations together with personal computers constitute one of the more dynamic areas of computer technology.

C.8.2 Review of Prior Forecasts

Security issues are perceived as the critical factor that will slow down more use of workstations in the DOE.

Prior forecasts noted the rapid evolution of VLSI technology and the impact on cost/performance. This trend is certainly continuing. In addition, the growing importance of software standards in the workstation picture is still a vital consideration. Moreover, the critical link between the effective use of workstations and the implementation of computer networks continues to represent a key element in the picture. Security issues (the need for secure operating systems, networks, and applications software) are perceived as the critical factor that can slow down the more widespread use of these systems in our environment.

C.8.3 Current Status and Trends

With the continuing improvement in computing power, the cost per unit of computation continues to go down rapidly. This, together with a general advance of technology in all areas, has resulted in a rapid escalation in the overall capabilities of workstations from year to year. Therefore, a $10K workstation can be bought today which has the same power as a $20K machine built a year or two ago. Nevertheless, workstations can be compared in terms of their relative cost at any point in time. Typically, the low end today is the $10K to $20K range which overlaps the cost of high-end personal computers. The middle range of $20K to $50K continue to compete favorably with traditional minicomputers and, indeed, workstations have displaced minicomputers for a number of applications. Workstations in the $50K to $100K range typically possess considerable computational capacity, relatively large storage, and sophisticated graphical display features. Workstations can also be classified in terms of being essentially dedicated to CAD/CAM/CAE and other highly graphics-oriented applications versus their use as general purpose computational platforms. In general, workstations have been strongly UNIX-oriented, and this continues to be the case. In contrast, although UNIX is starting to "catch on" in the PC market, MS-DOS has traditionally been the operating system of choice with OS/2 coming in as a relatively new alternative.

UNIX is clearly the operating system of choice.

As noted earlier, standards and networking considerations continue to be important considerations. Proprietary operating systems are still available, but UNIX is clearly the operating system of choice. X-windows has emerged as the industry-standard windowing system and is supported even by vendors which have their own windowing alternative (*e.g.*, SUN's NeWS). Various graphical interface products, such as Presentation Manager and Open Look, are also vying for supremacy, and time will tell which will predominate. It should be noted that several of these are being designed to work on top of an X-windows platform. The battle for standards recently took front stage with the two separate UNIX alliances, *i.e.*, the AT&T and SUN alliance, now known as UNIX International (UI), versus the Open Software Foundation (OSF), a consortium led by IBM and DEC, as mentioned in last year's report. It is clear that standards increasingly will be defined by such industry groups in addition to the various national and international associations such as ISO, NIST, and IEEE (which includes POSIX).

The trend toward the networking of workstations continues.

The trend toward the networking of workstations continues. The security of such networks is particularly critical for weapons-related activities, but its importance is really industry-wide. The recent intrusion of a computer virus (worm) into the ARPA network was a warning. Yet networking is essential for communications purposes and to enable the workstation user to have access to costly special purpose systems.

C.8.4 Projections

C.8.4.1 Short Term (1991-1995)

Expect major improvements directed toward robust, heterogeneous networking environments.

In the upcoming five year period, we should expect to see continued improvements in the processing power of workstations, as well as substantial breakthroughs in local high capacity optical storage and other peripherals. In the software realm, one should expect major improvements in system facilities, particularly directed toward operation in a robust, heterogeneous networking environment. These changes will be of an evolutionary nature, with industry standards playing a vital role.

Processors will continue to evolve along two fronts, one front involving the use of reduced-instruction-set (RISC) chips and the other employing the more conventional expanded instruction sets. It is worth noting that the VLSI leaders (*e.g.*, Intel, Motorola) are developing chips along both lines. Interestingly, computer vendors such as SUN and MIPS have developed their own RISC architectures. SUN, in particular, is attempting to convert its own RISC design into a de facto industry standard by licensing it for general use.

In any case, integrated circuit technology has reached the point where, as in the case of the recently announced INTEL i860 RISC chip, roughly a

The CEO of Intel predicted that chip densities will double every 18 months through the end of the century.

million transistors can now be placed on a chip approximately one-half inch square. The i860, moreover, is designed with a 64-bit architecture and has a single precision floating point processing rate of 80 MFLOPS while running at 40MHz [1]. The i860 and the i486 are already beginning to impact both the workstation and PC markets. By 1993 it has been projected that these products will be succeeded by chips containing roughly 4 million transistors. Dr. Andrew S. Grove, president and chief executive officer of Intel Corporation, predicted in a recent IEEE keynote address that chip densities will double every 18 months through the end of the century [2].

C.8.4.2 Long Term (1996-2000)

Effective computing rates may increase by a factor of 100 to 200.

Industry projections predict that by 1996 microprocessor technology will achieve densities on the order of 20 million transistors per chip. By the year 2000, the figure is expected to reach 100 million. The latter may run at 250 MHz and may achieve an effective computing rate of 2000 million instructions per second (MIPs) compared to the current nominal 10 to 20 MIP range.

Aside from the speed factor, one should expect major advances to have been put into effect by the end of the decade in the following areas which will impact workstation technology: (1) user-friendly interfaces employing AI technology such as neural nets to provide convenient interaction with the user, (2) optical computing (photonics) elements appearing in place of their electronic counterparts on a modest scale [3], (3) extremely large application packages making use of the added storage capacity of these machines, (4) gigabit communications facilities [4], and (5) integration of video technology with workstations.

C.8.5 Implications and Issues

Fundamental issues are security, reliability, simplicity of networking, and ease of use.

Workstations and PCs have assumed the position of a key focus in the computing scene. In the 1990's such systems linked via networks will represent the basic computational paradigm — most computing will be done in this environment. Special purpose systems (*e.g.*, parallel computers, supercomputers, ultra-high capacity storage subsystems) will be conveniently accessed remotely from one's local workstation. Such networks already exist, but certain key improvements are clearly needed. The fundamental issues are ***security, reliability, simplicity of networking,*** and ***ease of use.*** Heterogeneous workstation networks must be more easily put together, maintained, and modified over time. They must be full functioned, allowing for remote computation and data access. These entities must be robust, in that failures must not propagate. Moreover, failures must be quickly isolated. The security element is a vital consideration. This includes the protection of data, access privileges, and system resources. Finally, workstations themselves, as well as the networks in which they are imbedded, must be much easier to use than is currently the case. Adding an application package, for example, should be no more difficult that loading the software (ideally, by downloading it from the network) and answering simple questions concerning one's particular hardware configuration. Unfortunately, this is not currently the case. Bringing the power of the computer ever closer to the end-user implies that these systems be used effectively by non-computing professionals. We still have a distance to go in this area, and many of the significant computing developments occurring during the decade will be directed toward these objectives.

C.8.6 Conclusion

Reduced cost, memory chip miniturization, larger file storage, and better communications will make workstations even more attractive.

Workstations are part of a significant long term trend toward bringing all facets of the computing picture closer to the end user. The increasingly reduced cost of the CPU component made the computer-on-the-desk possible. The trend toward miniaturization of computer memory elements, as witnessed by the availability of 4 megabit chips, is also evident. The trend toward higher capacity magnetic and optical storage subsystems is also apparent. These trends show no sign of abating. Advances in high speed communications and in networks are extending the reach of workstations so that special purpose facilities which are physically distant can be accessed conveniently. The fulfillment of these trends necessitates continued hardware and software advances. Key issues are reliability, security, and ease of use in what is admittedly an increasingly complex computing environment. Industry standards are playing a vital role in this evolutionary process.

C.8.7 References

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APPENDIX D: ACRONYMS

ABC	-	Analysis of Benefits and Costs
ADP	-	Automated Data Processing
ADPE	-	Automatic Data Processing Equipment
ARAC	-	Atmospheric Release Advisory Capability
AT&T	-	American Telephone and Telegraph
AUTODIN	-	Department of Defense Automatic Digital Network
bps	-	Bits per second
CAD	-	Computer-Aided Design
CAE	-	Computer-Aided Engineering
CAM	-	Computer-Aided Manufacturing
CIAC	-	Computer Incident Advisory Capability
CIM	-	Computer Integrated Manufacturing
CMIS	-	Contract Management Information System
COMSEC	-	Communications Security
COP	-	Committee of Principals
CPP	-	Computer Protection Plan
CSAR	-	Computer Security Assurance Review
CSTM	-	Office of Computer Services and Telecommunications Management
DDN	-	Defense Data Network
DES	-	Data Encryption Standard
DIX	-	Digital Information Exchange
DOE	-	Department of Energy
DOENTS	-	Department of Energy Nationwide Telecommunications Services

EOC	-	Emergency Operations Center
ESNET	-	Energy Sciences Network
ESS	-	Electronic Switching System
FAX	-	Facsimile
FDDI	-	Fiber Distributed Data Interface
FMS	-	Financial Management Systems or Frequency Management System
FTS	-	Federal Telecommunications System
FTS 2000	-	Federal Telecommunications System Network
FY	-	Fiscal Year
GAO	-	Government Accounting Office
GOSIP	-	Government Open Systems Interconnection Profile
GSA	-	General Services Administration
HEPNET	-	High Energy Physics Network
HF	-	High Frequency
ICN	-	Integrated Communications Network
IRAC	-	Interdepartmental Radio Advisory Committee
IS	-	Information Systems
ISDN	-	Integrated Services Digital Network
ITR	-	Information Technology Resources
IX	-	Information Exchange
Kbps	-	Kilobits per second
LAN	-	Local Area Network
Mbps	-	Megabits per second
MFENET	-	Magnetic Fusion Energy Network

MHz - Megahertz

MUX - Multiplexer

NCS - National Communications System

NEST - Nuclear Emergency Search Team

NETS - National Emergency Telecommunications System

NLP - National Level Plans

NRF - Naval Reactors Facility

NSA - National Security Agency

NSDD - National Security Decision Directive

NSEP - National Security Emergency Preparedness

NSF - National Science Foundation

NSU - Nominal Service Unit

NTIA - National Telecommunication and Information Administration

NWC - Nuclear Weapons Complex

NWCNET - Nuclear Weapons Complex Network

OADPM - Office of ADP Management

OMB - Office of Management and Budget

OPM - Office of Personnel Management

OPMODEL - Operational Model

OSI - Open Systems Interconnection

PBX - Private Branch Exchange

PC - Personal Computer

PCM - Pulse Code Modulation

PD - Product Definition

PDS - Protected Distribution Systems

PMA	-	Power Marketing Administration
RAP	-	Radiological Assistance Program
RCU	-	Relative Capacity Unit
RF	-	Radio Frequency
SACNET	-	Secure Automatic Communications Network
SDIS	-	Switched Digital Integrated Service
SECOM	-	Secure Communications
SNM	-	Sensitive Nuclear Materials
SPAN	-	NASA Space Network
SRIS	-	System Review Inventory System
SRT	-	SACNET Replacement Terminal
STU	-	Secure Telephone Unit
TCP/IP	-	Transmission Control Protocol/Internet Protocol
TEMPEST	-	Emission Security
TIP	-	Telecommunications Improvement Program
TSP	-	Teleprocessing Services Program
TSP	-	Telecommunications Services Priority
TWX	-	Telewriter Exchange
UCS	-	Unclassified Computer Security
UHF	-	Ultra High Frequency
UL	-	Underwriters Laboratory
VHF	-	Very High Frequency
WAN	-	Wide Area Network
WBCN	-	Wide Band Communications Network

APPENDIX D: GLOSSARY

Budget Year	-	Fiscal year for which funding requests are to be presented to Congress. (In December 1988, the Budget Year is FY 1990).
Computer-Aided Design/ Computer-Aided Engineering	-	Computer-assisted technologies that provide drafting, design, and/or engineering analysis capabilities of buildings, facilities, parts, circuits, assemblies, and/or models at stand-alone or graphics workstations connected to a computer.
Computer-Aided Manufacturing	-	Computer-assisted technologies (including materials movement, machining and assembly, inspection of quality of operations performed) utilized in transforming raw materials and purchased components into final products.
Computer Integrated Manufacturing	-	A cohesive manufacturing process that utilizes computers as the enabling technology to integrate design, engineering, manufacturing, and business processes.
Central Processing Unit	-	A component of a computer system that has circuits for controlling the interpretation and execution of instructions.
Computing Resources	-	Includes ADP equipment, hardware maintenance, and ADP services.
Financial Management Systems	-	Any manual or automated Federal accounting, budget, and payroll systems, either manual or automated. Subsystems shall be considered part of the FMS they support. Other systems which interface with FMS but which have primary purposes other than financial management shall not be categorized as FMS.
Fiscal Year	-	For Federal Government purposes is defined to be that period of time from October 1 through September 30.
General Management Computer	-	Any general purpose computer that is not a special management computer. General management computers include data base machines; front-end and back-end processors; and computers used for management information systems, scientific/engineering applications, network functions, office systems, and computer-aided design/computer-aided engineering, and/or computer-integrated manufacturing.

Impact IS	-	Any information system which requires input from one or more DOE or DOE contractor organization(s) other than the sponsoring organization.
Information Systems	-	An automated information system is defined to include all computer software processed on general management computers and related processes and procedures used for program, project, and business management activities in support of management of DOE and/or DOE contractor activities, the stewardship of its resources, and/or the provisions of day-to-day general operations and services.
Intercity Telecommunications Services	-	Services which are used primarily to send and/or receive data, facsimile, voice, and record telecommunications transmissions to a location or locations outside the local dialing area in which the transmission originates. This definition precludes services integral to the Teleprocessing Services Program (TSP). Severable telecommunications costs are defined as those telecommunications costs that are separately chargeable under the TSP program; i.e., not included in the per unit cost under the program.)
Local Dialing Area	-	The geographical area within which a telephone call can be made for which no commercial long-distance toll charge (either local long distance or true long distance) is normally assessed. Use of foreign exchange or private line services do not qualify as local dialing area.
Major Item of ADP Equipment	-	The acquisition of an ADPE component or group of group of ADPE components resulting from one solicitation that has a purchase equivalent value of $1 million or more. The $1 million threshold level applies irrespective of the actual method of acquisition (purchase, lease, lease/purchase combination, etc.) or the type of funding used.
Micro-Computer (Personal Computer)	-	The smallest class of computers, using microprocessors for computer their central processing unit, which are capable of performing a wide variety of analytical, computational, and text processing applications, and which are most typically operated directly by their end users.
Nominal Service Unit	-	A relative measure of computing capacity, defined as one ten thousandth (.0001) of the normal capacity of a CDC 7600. This metric is used by DOE, so capacity and

requirements can be aggregated for a site, program, or the Department.

Obsolescent ADP Equipment	- ADP equipment that is no longer meeting program requirements in a cost-effective manner primarily because of aging technology. (Generally, ADP equipment that is over 8 years old, based on its first delivery date of its first unit, should be examined to determine whether it is approaching obsolescence.)
On-site/ Off-site	- The definitions of on-site and off-site communications are derived from the Federal Information Resources Management Regulation definitions (FIRMR 201-2.001) of local dialing area and intercity communications services. See definitions for local dialing area and intercity telecommunications services.
Out-Years	- Four fiscal years beyond the budget year (in this Departmental Information Technology Resources Long-Range Plan, they are FY 1992 to FY 1995).
Purchase Equivalent Value	- The purchase value of ADP equipment regardless of the acquisition method, e.g., purchase, lease, lease with purchase option, etc.
Relative Capacity Unit	- The standard metric used to report computing requirements and installed capacity to DOE Headquarters for long-range planning purposes. Four categories have been defined: Category P (minicomputers and super minicomputers), Category Q (mainframe computers), and Category R (supercomputers). The relationship between the categories generally is as follows: 100P = 10Q = 1R. The Office of ADP Management maintains a Computer Capacity Table listing the categories and ratings of computer systems installed at DOE facilities.
Satellite Backbone System	- This is the current title of the Department's satellite transmission system. The former title was DOE Operational Model (OPMODEL).
Special Management Computers	- A general purpose computer used in one of the following categories: o <u>Control</u>. ADPE that is a vital part of a facility or larger complex of equipment (non-ADPE) and has the primary purpose of real-time process control

functions (including controlling, monitoring, analyzing, or measuring a process) for the facility or non-ADPE.

- Data Acquisition. ADPE that is an essential part of a facility or larger ADPE item or system and has the primary purpose of collecting data from the facility or equipment for further analysis.

- Classified. ADPE whose physical location is classified information.

- Mobile. ADPE located on ships, planes, trains, or other motor vehicles.

System Review Inventory System - The automated system that maintains a central repository of information on each DOE automated information system which is planned, under development, or operational.

Super-computers - The generic nomenclature for the largest, most powerful computers commercially available.

Telecommunications Facilities - Equipment used for such modes of transmission as telephone, telegraph, teletypewriter, data, facsimile, telephotographic, video, audio, and such corollary items as distribution systems and communications security facilities.

Telecommunications Services - The transmission, emission, or reception of signals, signs, writing, images, sounds, or intelligence of any nature, by wire, cable satellite, fiber optics, laser, radio, visual or other electronic, electric, electromagnetic, or acoustically coupled means.

Tele-processing Services - Contractual services for the computation or manipulation of data in support of administrative, financial, communicative, scientific, and other similar Federal Program Agency data processing applications. It includes teleprocessing, full service (interactive and remote batch), interactive, and remote batch processing.

Word Processor - A microcomputer based electronic device which normally consists of at least a keyboard, terminal, and printer which displays, stores, retrieves, manipulates, and prints textual information as opposed to other analytical or computational capabilities.

Workstation - Small high-powered single user computing system with a well integrated visualization programming environment generally utilized by scientists and engineers to generate sophisticated graphics, and/or capable as acting as a dedicated computational resource.

APPENDIX E: RELATIVE CAPACITY UNIT (RCU)

INTRODUCTION

Some years ago, a standard measurement parameter, known as the Nominal Service Unit (NSU), was implemented to provide a quantitative metric that could be used for:

- o preparing gross estimates of the total computing requirements of a program;
- o estimating the distribution of programmatic work among many sites; and
- o determining trends and rates of change.

The NSU was intended to enable the field to report computing requirements and installed capacity concisely, in compatible terms, and in a manner that permitted aggregation across the entire Department. The NSU accomplished these objectives. There were, however, some areas of concern with the NSU that became more significant as time passed and computing requirements grew.

As a result of these concerns, the concept and definition of the NSU underwent two reviews. The first, in 1977/78 (shortly after the introduction of the NSU), resulted in rather minor adjustments. The second, in 1984/85, resulted in refinement of the NSU with implementation of the Relative Capacity Unit (RCU) as a new field reporting mechanism. The RCU serves the purpose of the NSU, but eliminates the primary areas of concern: i.e., the illusion that computing capacity on different types of computing systems is interchangeable; overemphasis on the capacity of large computer systems--and correspondingly understating the importance of small systems--because of the very large number of NSUs associated with high-end systems; and awkward application in the field, because NSUs were not a natural estimating unit for expressing either computing requirements or current capacity at DOE sites. In addition, however, it provides generalized conversion capability back to the NSU to allow aggregation on a Departmental basis.

Thus, by introducing categories of computers, the use of RCUs makes it possible to:

- o differentiate between different types of computing systems if they are of different categories;
- o express capacity and requirements in terms of categories and prevent large systems from obscuring smaller ones; and

- o provide a natural set of tools for the estimation of capacity and requirements in the field.

The RCU was developed as a planning tool for Headquarters and a reporting tool for field sites. It was not intended for use as a planning tool at the site level; sites are expected to accomplish their planning using whatever techniques and procedures they deem appropriate and to translate the results into RCU terms.

It should be noted that RCUs reported by the individual sites have been converted back and shown as NSUs throughout this Plan. The NSU has been retained as a gross aggregate measure for displaying total Departmental capacity and requirements. The conversion factors are explained on the next page under the Definition of the RCU.

<u>Definition of the RCU</u>

The RCU is a gross capacity measure. It is used to express computing requirements and installed computing capacity in a form that allows aggregation of each type of unit across whole programs, program areas, and even the whole Department of Energy (DOE). It differs from the NSU primarily in that it introduces three categories of computing instead of treating all computing as essentially equivalent. Its function can perhaps be best expressed by way of an analogy: When you hire a moving company, the company provides you with a number of different kinds of packing boxes. The different sizes and designs of boxes are capable of different uses. There are tall boxes for hanging clothes; there are big square boxes for light, bulky articles, such as lamps and sweaters; there are smaller square boxes for denser articles, such as books and records. One would be foolish to order only the largest boxes available, thinking that biggest is always best. Similarly, if one were provided with only the small square boxes, he could never pack a large object. This analogy illustrates the concept of capability as opposed to mere capacity, where the NSU was a measure of capacity alone. The RCU metric also measures capacity, but goes a bit further by acknowledging the existence of broad classes of capability among computers.

The RCU rating has no direct relationship to any of the conventional absolute measures of computer power (e.g., MIPS or MFLOPS), but the rating of one system relative to another reflects DOE experiences concerning the capacity of those systems for work typical of that done at DOE sites. Three fundamental units corresponding to three categories of computing systems were initially identified with the introduction of the RCU: P, Q, and R. Examples of the categories of computers identified are: Category P consisting of minicomputers and superminis, Category Q consisting of mainframe computers, and Category R consisting of supercomputers. Generally, the relationship between the categories has been defined as follows:

1P = 1,000 NSU, 1Q = 10,000 NSU, and 1R = 100,000 NSU;

100P = 10Q = 1R.

Capacity ratings have been established for most systems in use in the DOE community; they are provided in the Computer Equivalence Table for Installed Departmental Computers (Figure E-1). Some examples of current RCU ratings are: in Category P, the DEC VAX 8300 has a capacity rating of 1.60P, and the Prime 9955 has a rating of 2.40P; in Category Q, the CDC Cyber 170/855 has a capacity rating of 0.80Q, and the IBM 3090-180E has a rating of 2.80Q; and, in Category R, the CDC Cyber 205 has a capacity rating of 0.44R, and the Cray X-MP/24 has a rating of 1.00R.

The initial assignment of systems to categories was based primarily upon the power of the system as reflected in the prior NSU capacity, although the values and nominal configurations for some systems were adjusted to reflect current DOE experience and practice more accurately.

Due to the wide range of overall cost and performance, DOE has further classified supercomputers in terms of classes. The class designations vary according to capability/capacity and technology of the system. Class VI and VI enhanced are current generation supercomputers exemplified by the Cray-1 and Cray-2, respectively. Class VII machines are near-term announced technology systems that are not yet available from the vendors, such as the Cray-3. Class VIII machines are planned for out-year acquisitions and are to be developed from future, as yet undetermined, technology.

USE OF RELATIVE CAPACITY UNITS

Long-range planning for computing requirements is usually cast in terms of machine-equivalents for machines with which the planners are familiar. The raw data is expressed in a wide variety of ways--in budgetary terms, for example, or relative usage terms, or in some absolute terms such as number of events, transactions, or queries--and the planners convert it into machine equivalents. The P, Q, and R units introduced by the RCU categories conform to this model in the sense that they essentially establish a set of hypothetical machines (with relative capacities of 1.00P, 1.00Q, and 1.00R, respectively), in terms of which programs and sites are to express their requirements and installed capacities.

Sites determine not only their aggregate requirements, but also the appropriate mix of categories of systems on which to satisfy them. In considering which category is appropriate for a specific program, sites take into account the nature and magnitude of the computations required by the program. There are many jobs that can be reasonably accomplished on systems of any size, but there are also some tasks that are practical on systems of only one category. Weather forecasting is a good example. In the sense that the calculations can be done in such a system, they could be assigned to a Category P machine. A requirement that the forecasts be available before the fact instead of 6 days after it, however, means that assigning such work to a Category P system would not be a reasonable match of system to application. (To return to the packing box analogy, this corresponds to attempting to pack a six foot mirror into a number of three foot boxes.) Another mismatch might be the assignment of an interactive document-preparation task to a supercomputer: Such a machine certainly has the capacity to do the work, but adequate software tools for this sort of application are often not available on very large systems, and the necessary interrupt handling can result in inefficient use of an expensive resource.

In large scientific environments, a useful approach to handling the computation loads may be to perform pre- and post-processing chores, such as a simple mesh generation and the compilation of graphic results, on Category P machines, while leaving the larger Q and R category machines free to perform high-speed number crunching. It is the task of ADP planners to find the right mix of resources for optimum execution of its computational needs.

FORECASTING COMPUTING RESOURCE REQUIREMENTS

This section of the ITR Plan defines the RCU as it relates to today's computer systems. The forecasting of computing requirements in support of DOE programs over the planning period is of prime importance. When looking ahead, it is certain that new technology and new techniques will alter and improve computing systems. What is necessary is to forecast programmatic computing support with reasonable accuracy and defensible arguments. The RCU provides for such forecasting on a relative comparison basis with the cost, capacities, and capabilities of today's computers.

Each site can establish the percent use of its computer(s) by each program in the current year, convert to RCUs, determine the expected growth for each program, then state the forecast in "RCUs by program by year." At the same time, total program visibility is obtained by summing each program's forecasts across all sites supporting the program.

Each site forecasts its total expected computing support for all programs at that site. These forecasts, stated in RCUs by program and by year, may exceed a site's present capacity. When the ADP requirements exceed the site's capacity, additional computing capacity is needed either by acquisition, resource sharing, or commercial services contract. The availability of good long-range forecasts will enable more timely consideration of each site's future computing needs and enable the Department to plan comprehensively for the most cost-effective and efficient solutions to satisfying DOE program requirements. Figure E-2 shows a simplified site reporting example of computing requirements and capacity wherein requirements exceed or become greater than the site's existing capacity during the planning period and acquisition of additional computing resources is identified for consideration to meet processing demands.

CATEGORY P SYSTEMS

Manufacturer	Model	Capacity (P-unit)
HP	9000/560	1.00
HP	3000/48	1.10
CDC	Cyber 830	1.50
DEC	VAX-8300 VAX-11/785	1.60
IBM	4361/5	1.70
IBM	4341-12	2.00
WANG	VS 300/9	2.00
HP	3000/68	2.20
HP	3000/70	2.40
DGC	MV10000	2.40
PRIME	9955	2.40
IBM	9377/90	2.50
DEC	VAX-8500	3.00
IBM	4381-12	3.50
DEC	VAX-8600	4.80
IBM	4381/R13	4.80
DEC	VAX-8650	6.72
DEC	VAX-8700	7.20
IBM	4381/R23	9.00
DEC	VAX-6230	10.08
DEC	VAX-8800	14.40

CATEGORY Q SYSTEMS

Manufacturer	Model	Capacity (Q-unit)
SPERRY	1100/62	0.41
IBM	3083E	0.70
CDC	Cyber 170/855	0.80
DEC	VAX-11/780 + FPS-164	0.85
CDC	7600	1.00
NAS	AS/8053	1.20
IBM	3083J	1.33
IBM	3090/150E	1.60
CDC	Cyber 180/990	2.00
IBM	3090-180E	2.80
AMDAHL	5890-180E	2.89
CDC	Cyber 170/875 (Dual)	3.00
IBM	3081K	3.00
IBM	3090/180	3.00
NAS	AS/9080	4.10
IBM	3084QX	5.40
AMDAHL	5890-200E	5.57

CATEGORY R SYSTEMS

Manufacturer	Model	Capacity (R-unit)	Class
CVX	Convex C1XP	0.12	VI
SCS	40/14	0.15	VI
CRI	Cray X-MP/12	0.40	VI
CDC	Cyber 205	0.44	VI
CRI	Cray 1S-2000	0.44	VI
CRI	Cray X-MP/24	1.00	VI Enhanced
CRI	Cray X-MP/48	2.00	VI Enhanced
CRI	Cray 2	2.00	VI Enhanced
CRI	Cray X-MP/416	2.20	VI Enhanced

FIGURE E-1 COMPUTER EQUIVALENCE TABLE FOR INSTALLED DEPARTMENTAL COMPUTERS

COMPUTING REQUIREMENTS (RCUs)

SITE Rocky Top Laboratory - RTL

B&RC CODE	PROGRAM		PAST	CURRENT	BUDGET	PLAN	OUT-YEARS			
			FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995
AM	Geothermal	Category P	1.00	1.20	1.50	1.75	2.12	2.50	2.25	2.25
		Category Q	0.35	0.40	0.50	0.60	0.60	0.75	0.78	0.84
		Category R	--	--	--	--	0.10	0.20	0.40	0.60
KA	High Energy Physics	Category P	1.50	1.80	2.00	2.23	4.75	5.33	4.95	4.95
		Category Q	0.35	0.35	0.45	0.55	0.60	0.70	0.73	0.79
		Category R	0.05	0.10	0.20	0.30	0.40	0.70	0.95	1.35
KC	Basic Energy Sciences	Category P	1.25	1.65	1.85	2.00	2.15	2.25	2.00	2.00
		Category Q	0.40	0.45	0.55	0.70	0.70	0.93	0.96	1.02
		Category R	--	--	--	--	--	--	--	--
	Total Requirements	Category P	3.75	4.65	5.35	5.98	9.02	10.08	9.20	9.20
		Category Q	1.10	1.20	1.50	1.85	1.90	2.38	2.47	2.65
		Category R	0.05	0.10	0.20	0.30	0.50	0.90	1.35	1.95

COMPUTING CAPACITY (RCUs)

SITE Rocky Top Laboratory - RTL

UNIT/ SYSTEM OR MIE NUMBER	ADPE SYSTEM	PAST	CURRENT	BUDGET	PLAN	OUT-YEARS			
		FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	FY 1992	FY 1994	FY 1995
	Central Network								
123-1	System AA (1.20P)	2.00	2.00	2.00	1.00	--	--	--	--
RTL-90-1	System BB (9.60P)	--	--	--	4.80	9.60	9.60	9.60	9.60
123-2	System CC (2.10Q)	1.00	1.55	2.10	2.10	2.10	2.60	2.60	2.60
RTL-91-1	System DD (1.00R)	--	--	--	--	0.50	1.00	1.00	1.00
RTL-93-1	System EE (1.00R)	--	--	--	--	--	--	1.00	1.00
	Administrative System								
123-4	System XX (1.80P)	1.80	1.80	1.80	1.80	1.80	0.90	--	--
RTL-92-1	System YY (0.50Q)	--	--	--	--	--	0.25	0.50	0.50
	TOTAL CAPACITY								
	Category P:	3.80	3.80	3.80	7.60	11.40	10.50	9.60	9.60
	Category Q:	1.00	1.55	2.10	2.10	2.10	2.85	3.10	3.10
	Category R:	--	--	--	--	0.50	1.00	2.00	2.00

FIGURE E-2 EXAMPLE OF SITE REQUIREMENTS AND CAPACITY REPORTING

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