ADP LONG RANGE PLAN for the LAWRENCE BERKELEY LABORATORY

February 1979

Lawrence Berkeley Laboratory
University of California
Berkeley, California

LAWRENCE BERKELEY LABORATORY
Room: 3130 Bldg.: 90 Ext.: 5110

February 9, 1979

TO: DOE San Francisco Operations Office

FROM: Jack M. Hollander, Associate Director for Planning

SUBJECT: LBL ADP Long Range Plan

Enclosed is the Lawrence Berkeley Laboratory FY 1981 ADP Long Range Plan.

Jack M. Hollander

LBL ADP LONG RANGE PLAN

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LBL ADP LONG RANGE PLAN

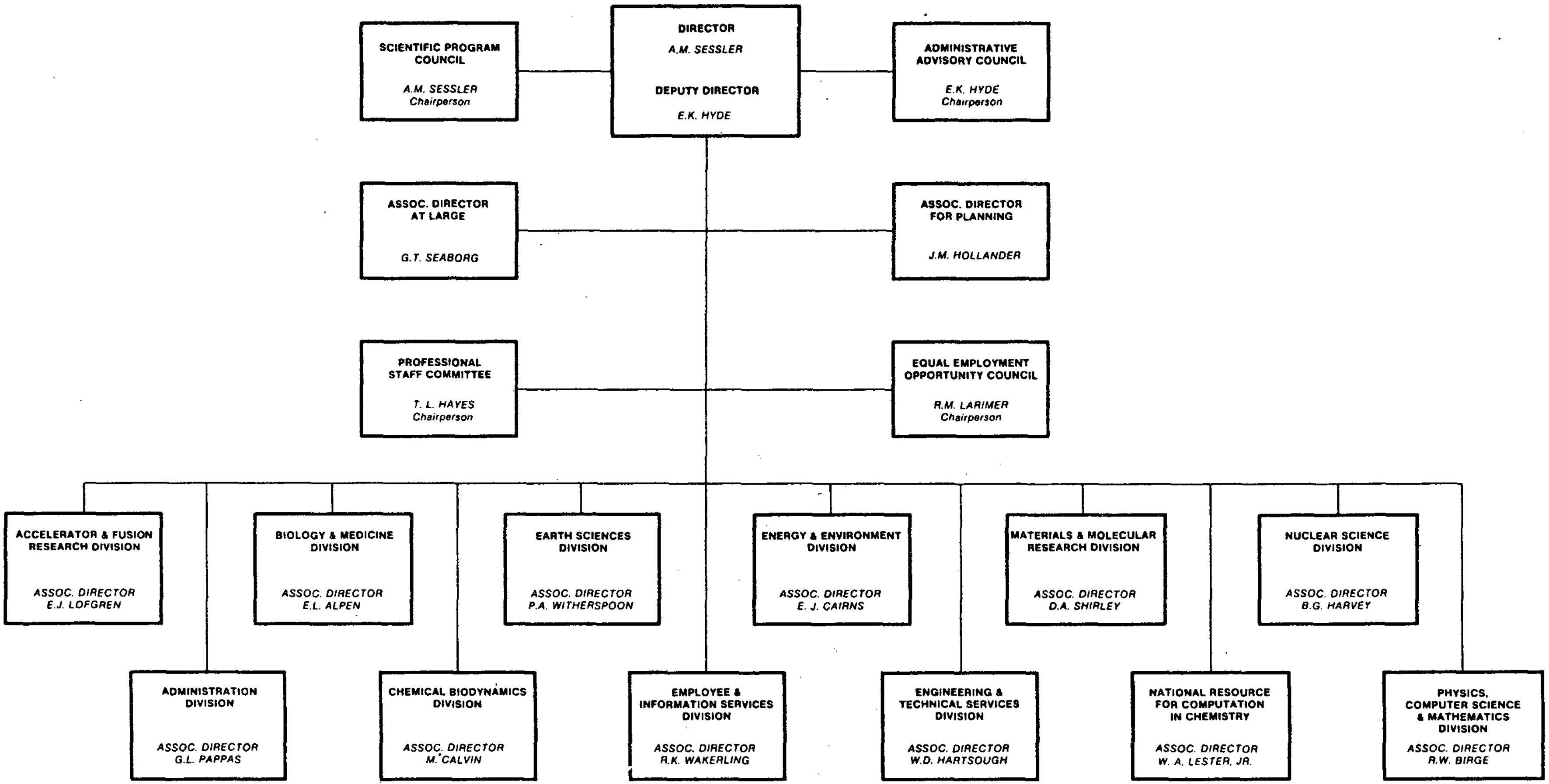
SECTION A. SITE OVERVIEW

LBL is required to submit an Institutional Plan and is therefore exempt from reporting Section A with the exception of the organizational structure and the summary.

A1. Organizational structure. The organizational structure of the Lawrence Berkeley Laboratory is specified in Figure LBL-1. The organization of the Computer Center, a department of the Engineering & Technical Services Division, is specified in Figure LBL-2.

Figure LBL-1

LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA



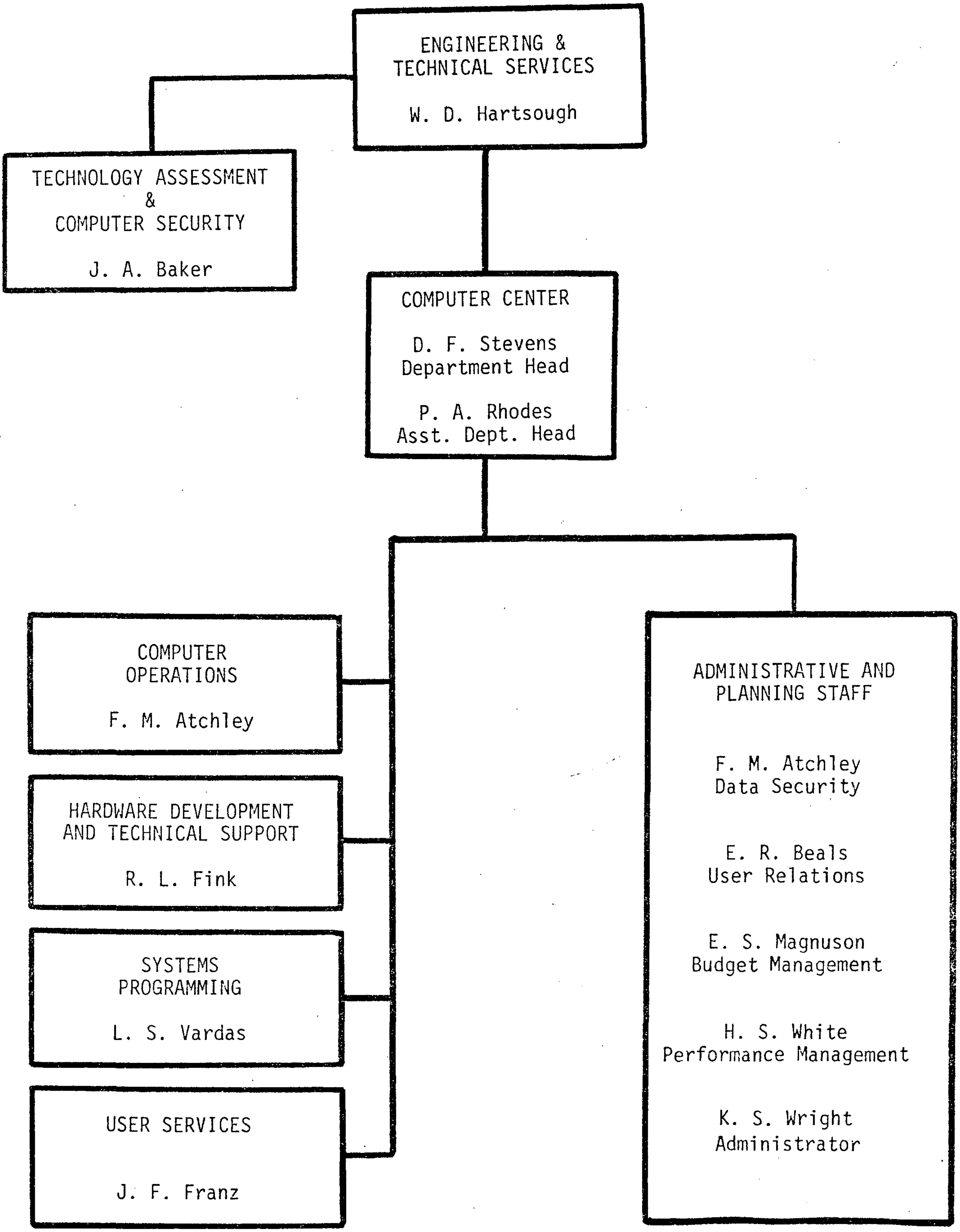
LBL-2/Feb 79

Date: DECEMBER, 1978
Contractor: THE REGENTS OF THE UNIVERSITY OF CALIFORNIA
Contract: W-7405-ENG-48
Type of Contract: RESEARCH

Andrew M. Sessler
Director

Figure LBL-2

The LBL Computer Center



A2. Site Overview Summary

Early Development. The Lawrence Berkeley Laboratory is named for its founder, Ernest Orlando Lawrence, who invented the cyclotron in 1929 and subsequently attracted to his Laboratory an outstanding group of researchers. Lawrence and his colleagues were architects of the modern way of doing science: while traditionally a scientist had worked alone in a small laboratory, at Lawrence's Lab an interdisciplinary team, including scientists and engineers from numerous fields, combined their talents to tackle new scientific challenges. Together they built successively larger accelerators with higher energies and carried out research which produced pioneering discoveries in nuclear and elementary particle physics, nuclear chemistry, biology and medicine. Through almost five decades, researchers at this Laboratory have continued to work on the frontiers of scientific exploration, gaining world renown and eight Nobel Prizes.

Three of the basic kinds of accelerators--the cyclotron, the linac, and the synchrotron--were invented and developed at Lawrence Berkeley Laboratory. Most of the unstable elementary particles were discovered by LBL researchers; scientists here were involved in the discovery of all the 14 known transuranium elements; the basic steps in photosynthesis were first traced at LBL; and the field of nuclear medicine was pioneered at this Laboratory.

Current Research. LBL today is supported almost wholly by the Department of Energy, concentrating its research in the mission areas of Energy Supply (Research and Technology Development), Conservation, Environment, and the Basic Sciences. Significant programs exist in all of these areas, and new ones are being developed there and in Energy Information. This research effort is spread among nine research divisions: Accelerator and Fusion Research, Biology and Medicine, Chemical Biodynamics, Earth Sciences, Energy and Environment, Materials and Molecular Research, the newly-established National Resource for Computation in Chemistry, Nuclear Science, and Physics, Computer Science and Mathematics.

Research directions have evolved rapidly over the years, as Lab scientists have opened entirely new areas of research and provided leadership in developing fields. In response to the nation's pressing need for new energy technologies, the latest shift in emphasis has been to establish a major effort in energy development and environmental research. LBL is involved in these areas on a number of fronts, including fusion power, solar energy conversion, geothermal power, and the production of clean fuels from coal and cellulose. For example, researchers are developing a novel idea of breeding new kinds of plants which can be harvested for fuel and therefore provide a renewable source of energy. The Lab's Controlled Thermonuclear Research Program is designing and developing the neutral beam facilities for the Tokamak reactor under construction at the Princeton Plasma Physics Laboratory, and for General Atomic's Doublet III.

Other Lab scientists are studying environmental pollutants produced by modern society, specifically the effects on living systems of some of the nuclear and non-nuclear pollutants resulting from energy technologies. LBL has also been given "lead laboratory" responsibility for programs in Geothermal Energy, Basic Geosciences, Regional Environmental and Health Assessment, Materials and Alloy Development, and Energy Conservation in Commercial Buildings.

In other work nuclear physicists and chemists are exploring totally new nuclear phenomena with the Lab's three heavy ion accelerators; scientists and engineers are collaborating with the Stanford Linear Accelerator Center to build the Positron-Electron Project, the newest high energy accelerator; and LBL physicists are collaborators in the high energy research which has revolutionized that field with the discovery of the new psi family of particles and the particle property known as "charm".

LBL and the University. LBL has a unique character because its location in the immediate vicinity of a major university campus provides an opportunity for faculty and students to work closely with the distinguished staff of scientists and engineers at LBL. Many faculty members in the physical and biological sciences and engineering departments of the UC Berkeley campus hold key positions of programmatic and administrative responsibility in LBL including Associate Director status. Dozens of others supervise important research activities and more than 400 graduate students in many fields are heavily involved in LBL activities. New programs at LBL are beginning to involve faculty from the social sciences and the professional schools. The extensive involvement of staff, faculty, students, post-doctoral appointees and foreign visitors creates an atmosphere of vitality and renewal in which creativity flourishes. It also serves a strong training and educational function for professionals who will continue their careers in energy activities in industry, government and other universities.

Facilities. "The Lab" is comprised of 57 buildings covering more than 120 acres in the Berkeley Hills. As a national laboratory, LBL designs, constructs and operates major research facilities as national resources available to qualified scientists from around the world. Three of the Lab's accelerators--the SuperHILAC, the Bevalac, and the 88-Inch Cyclotron--comprise an international center for heavy ion research in both nuclear science and biology and medicine. LBL's Microscope Center will have a variety of electron microscopes available to outside users. The LBL Computer Center, already in use remotely by DOE scientists at many locations, will become a powerful research tool to the national chemistry community through the NRCC. Other major facilities at the Laboratory include advanced controlled-environment facilities for animal research, and a major alloy development and test facility.

LBL and the Private Sector. The information generated by the Laboratory's research programs is available to the public through regularly published reports and journal articles. There is a special emphasis at LBL on the transfer of this information and new equipment and techniques developed here to the private sector where the ideas can be implemented for the benefit of society. To facilitate this process, there is a Technology Liaison Office which makes LBL's wealth of scientific and engineering know-how for solving specific technological problems available to industry, small businesses, and state and local governments.

SECTION B. INSTALLED COMPUTING SYSTEMS

B1. Scientific/Engineering Systems. The central computing facility is based upon three interconnected large-scale CDC computers (a 7600, a 6600, and a 6400), 2000 megabytes of disk storage, 40,000 megabytes of (on-line) mass storage, and more than 650 remote batch and interactive ports (see Figure LBL-3).

The system has developed in an evolutionary fashion from the (for its time) powerful but primitive initial configuration (6600 + 6411) installed in December, 1965. The principal emphasis, in both hardware acquisitions and software development, has been the provision of consistent, high-quality batch service to the Laboratory, with a minimum of catastrophic discontinuities. (It is the effort to avoid discontinuities which led us to do our own software development.)

The major hardware changes which have taken place since that initial installation include the addition of a second 6600 in June, 1967; the introduction of the two mass-storage systems (based upon the IBM photodigital store and data cell) in mid-1969; the delivery of the 7600 and 6400 in April, 1971; and the achievement of the present configuration with the cannibalization of the 6411 to provide additional memory for the 6400 (December, 1972), the release of one 6600 (March, 1973), and the expansion of the remaining 6600 to 20 PPUs (August, 1973 to February, 1974).

Figure LBL-3.1

The LBL Central Computing Facility

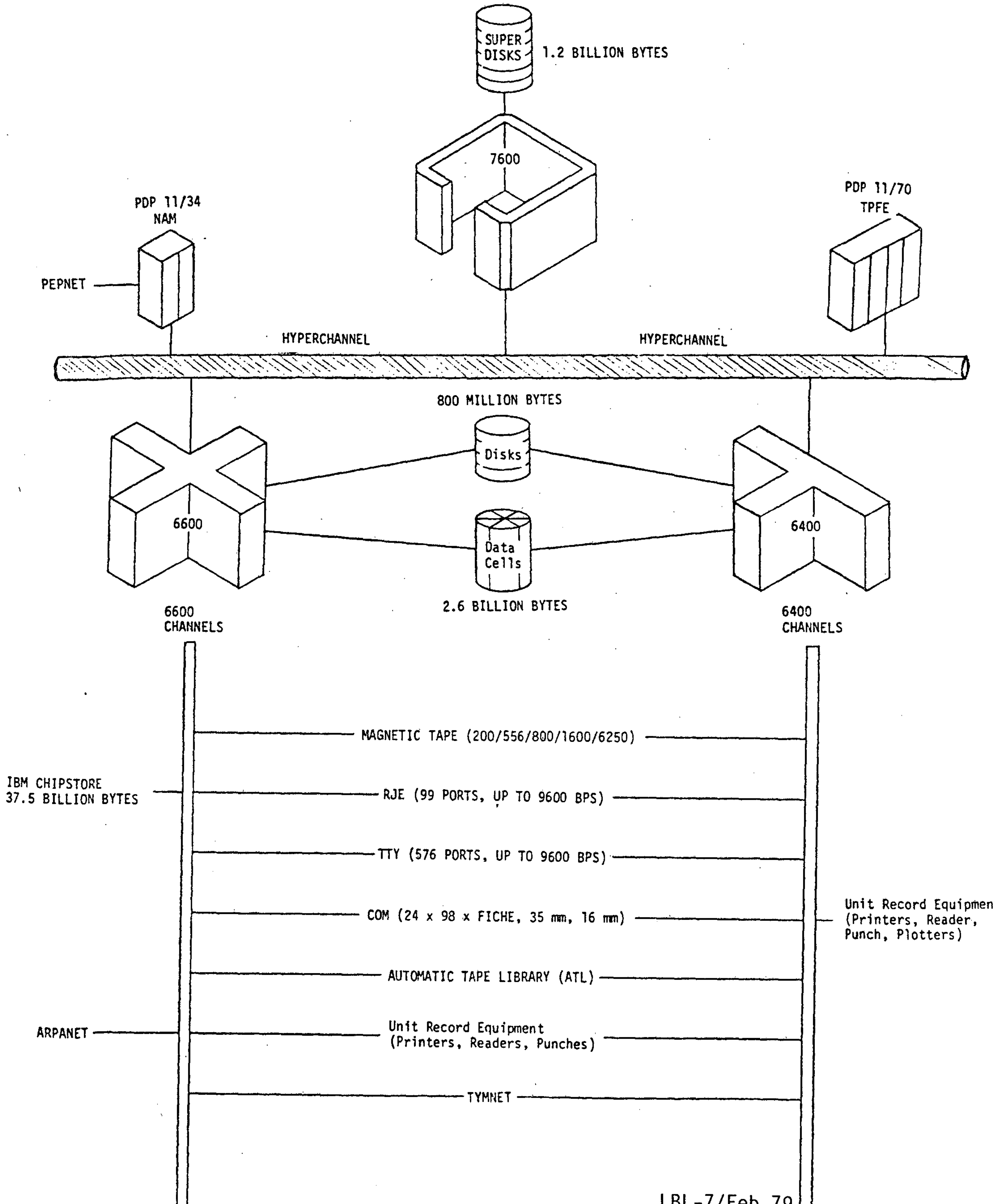
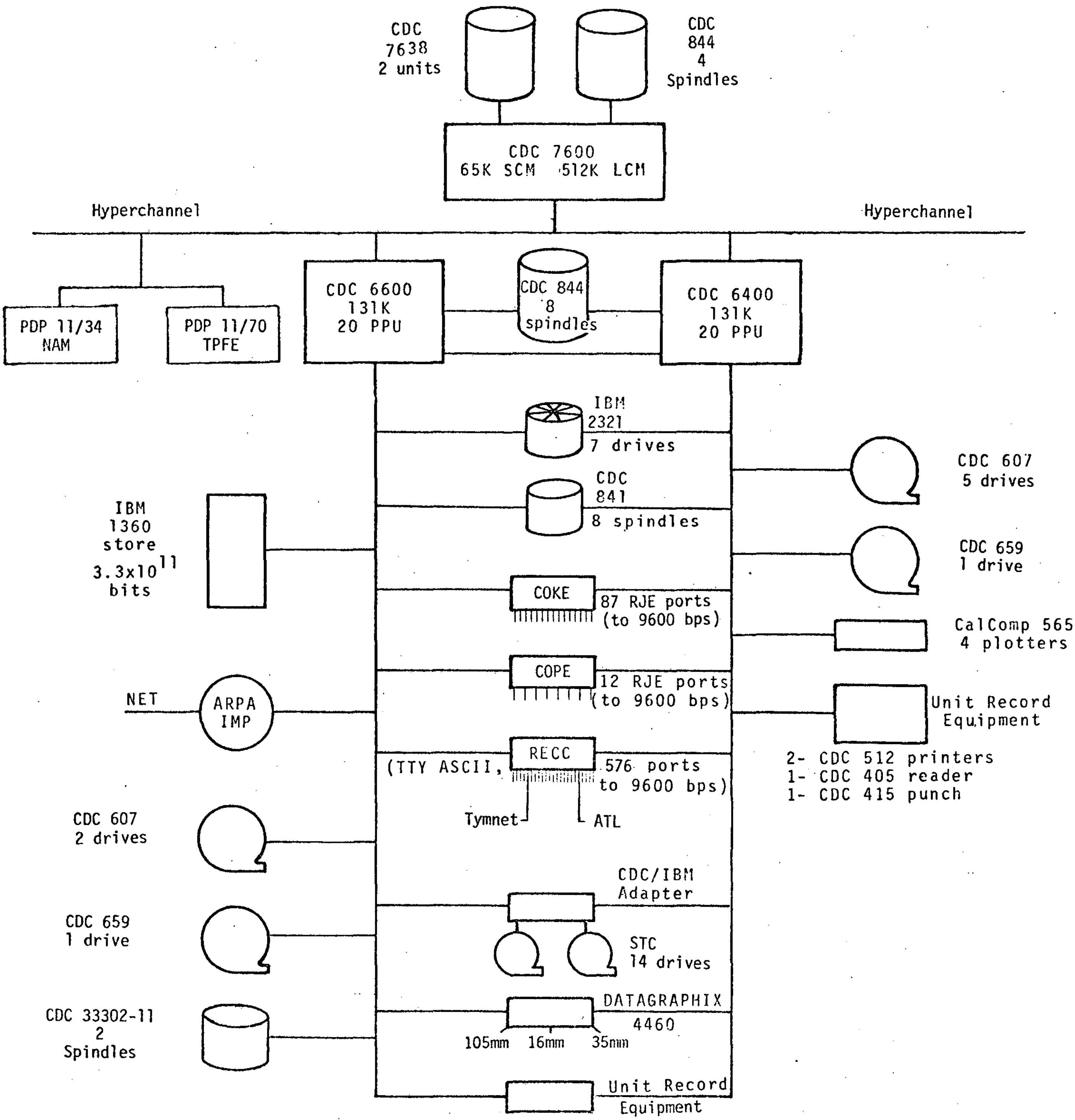


Figure LBL-3.2

The LBL Central Computing Facility



5-IBM 1403 printer; 3-CDC 405 card readers; 1-CDC 415 card punch

LBL ADP LONG RANGE PLAN

The present configuration suffers from significant defects in four areas, all of which adversely affect our ability to provide adequate support for the Laboratory's DOE mission:

(1) Interactive computing.

As a result of the earlier emphasis on batch processing, the interactive capacity of the LBL system is sub-standard. Its present limitations (which allow at most 70 simultaneous users, and then with agonizing delays) effectively prevent the scientific staff of the Laboratory from benefitting from many of the new techniques developed by their colleagues on strongly interactive systems.

(2) The mass storage system.

The present mass storage system is too small and too old. The bulk (more than 90%) is now a read-only device and is accessible to only one of the interactive front-end computers, and is therefore not suitable for interactive file residence. Neither of the devices used (data cell and photodigital store) is in production any longer, and parts and supplies must come from existing stocks; furthermore, IBM has announced its intention to halt maintenance on the photodigital store in 1979, and on the data cells in 1982.

(3) Disks.

The existing disk system on the 7600 is extremely unreliable and is responsible for a large share of the hardware failures of the 7600 system. The front-end disk systems have insufficient capacity and access to support the present interactive workload.

(4) Obsolescence.

The above three problems are all compounded by the obsolescence of the principal elements of the configuration. None of it is still in production, and all of it is very expensive to maintain: the total maintenance bill for that portion of the system comes to $36,000 per month. The data cells and disks are unreliable and difficult to repair. Between them there are a dozen serious crashes per month, each requiring several hours of equipment down time.

These defects are being addressed by a sequence of acquisitions designed also to provide a flexible base for further development.

The major elements of this plan (which is described in more detail in Section E14) are

1) the distribution of the various functions to a larger number of front-end and worker computers;
2) the utilization of a high-speed bus to simplify inter-machine communications; and
3) the gradual replacement of unsatisfactory devices with more reliable and cost-effective ones.

Full implementation of the plan is expected to take nearly a decade. The first step, the design and construction of a CDC/IBM channel adapter, was completed during FY 1976. This device, which now supports both 6250 bpi tape and IBM plug-compatible disks, gives LBL a much greater range of equipment from which to choose because it opens to us the extremely competitive IBM-plug-compatible peripheral equipment market. The high-speed bus was acquired in FY78, as was a terminal/front-end interconnection switch, an Automatic Tape Library (to serve as an interim mass storage device in the absence of a fully suitable replacement for the photodigital store), and a small front-end computer to be dedicated to text processing. We expect to acquire more disks and front-end capacity in FY79 and FY80; additional front ends in FY81-84; and a permanent replacement for the photodigital store, when one becomes available (FY81 or later). (None of these acquisitions, except possibly the last, will be a major item of equipment.)

The operating systems in use on these computers have been developed by LBL from early Control Data systems. They provide the usual amenities plus access to LBL's mass storage systems, on-line documentation, a selection of compilers, cross-compilers, and subroutine libraries. Details may be found in Figure LBL-4.

A number of smaller scientific systems are being developed by other departments within the Laboratory. Three of these are nearing productive use. The first of these systems is being developed by the Computer Science and Applied Mathematics Department (CSAM) as part of a joint research effort between DOE and DOL in the area of networking. The first elements of this system were acquired late in FY78. The DOE portions of the network include two DEC computers (a PDP 11/70 and a VAX 11/780) and their associated peripheral equipment. The configuration is shown in Figure LBL-5.

The second small system is being developed by the Laboratory of Chemical Biodynamics (LCB). It will be used to support biology and biophysics experimentation in the areas of human interface, experiment control, data acquisition, storage and retrieval, and interactive graphical analysis. The real-time aspects of the system will be implemented in LSI-11/PDP-11 memory only network nodes attached to the VAX-11/780. The VAX will supply system and task download and data storage and retrieval services to the network nodes. Interactive graphical analysis of the collected data will be implemented in the VAX. The configuration shown in Figure LBL-6 is a development configuration sufficient for software/hardware development only. It has no terminals for scientific users, insufficient disk for data storage or disk to disk backup. This system will be installed in February 1979.

The third small system is being developed for the TPC (Time Projection Chamber) detector at PEP. Like the CSAM system mentioned above it utilizes a two level computer structure consisting of a DEC PDP-11/70 and a DEC VAX-11/780. The PDP-11/70 will connect to TPC primarily by low data rate CAMAC instrumentation interfaces to allow monitoring and control of TPC. It will be dedicated to control of the experiment and do no general purpose computing. The VAX-11/780 will connect to TPC primarily by specially designed high-speed event collecting semiconductor memories to allow a first level on-line physics analysis and to save the data on 6250 BPI magnetic tape for off-line bulk processing on the LBL 7600. The TPC VAX-11/780 will also have a 250K bit per second data link (PEPNET) to the LBL Computer Center CDC 7600. This link will allow verification of event data at the highest level and provide program mass storage access for software development uses. The configuration is shown in Figure LBL-7.

Other small scientific systems may be acquired in the years ahead to satisfy the special requirements of various Laboratory programs, such as Nuclear Science and NRCC.

B2. Business Systems. About half of the Laboratory's administrative computing is done on the Scientific/Engineering System described in Section B1. The rest of it (318 NSU's in FY78) is done at the administrative computing facility at LLL. For historical reasons the master personnel and accounting data bases reside at LLL; reproducing them at LBL and transferring the work would be more costly than the present system.

B3. Other Systems. LBL has two other systems which have been in continuous use for more than ten years. Both use locally-developed software.

(1) On-line data analysis. An IBM 7044 system connected directly to several scanning/measuring devices for bubble-chamber film.

(2) Miscellaneous support. An IBM 1401 system, operated by the users themselves, to provide various ancillary services: card-to-tape; tape copy; tape-to-printer; tape dump; label printing; etc.

No development is being done on these systems. Maintenance will be continued as long as it is justified by use and performance. None of the work done on either of these systems is included in projections of requirements or capacity.

Figure LBL-4: Software at the LBL Computer Center

1. Operating systems: Two locally-developed multi-programming systems (named BKY), one for the 6000 machines, one for the 7600. Both systems feature automatic job-recovery procedures; sophisticated pre-emptive scheduling; automatic memory management; and a simple and flexible job-control language. The 6000 system also supports shared files on several devices, shared access to the remote subsystems, and supports several forms of interactive computing. Insofar as is practical, the systems for the two types of machines are user-compatible.
   A nearly standard UNIX system (level 6) for the PDP 11/70.

2. Assembler: COMPASS

3. Compilers: Fortran: FTN version 4; MNF; RUN
   COBOL version 3
   BLIMP (a systems programming language)
   SNOBOL (an interpreter)

4. Cross-assemblers: for HIS 516; PDP 8 and 9; MODCOMP I, II, III; NOVA; INTEL 8080; ALPHA LS 5/2; Motorola 6800

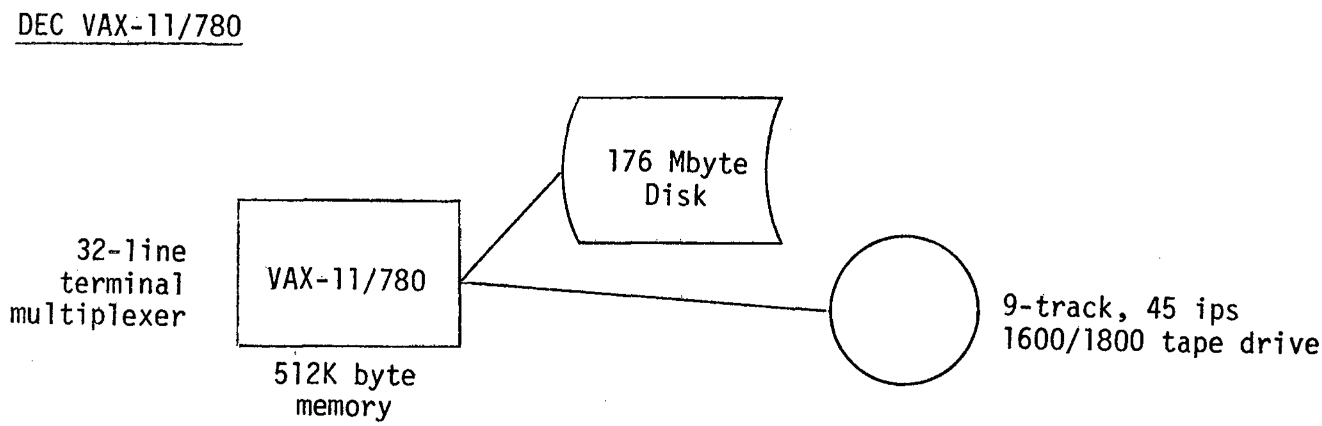
5. Editors: UPDATE (the standard CDC source-library editing facility)
   MODIFY (similar to UPDATE)
   NETED (ARPANET interactive editor)
   PTSS (a line-oriented context editor for interactive use)
   LIBEDIT (the standard CDC object-library editing facility)

6. Subroutine libraries and packages:
   IMSL, SPSS, BMD, EISPAC (math and statistics packages)
   SAC1, ALTRAN (symbolic algebra)
   MIMIC (continuous system simulation)
   MINUIT (function minimization)
   GRAFPAC, IDDS (graphics packages)
   CAM, CARTE (cartography)
   CHART (display and analysis of tabular data)

7. Data-base management systems:
   SYSTEM 2000 (a commercially available package developed and marketed by MRI)
   BDMS (a semi-experimental local product)

Figure LBL-5

CSAM Configuration



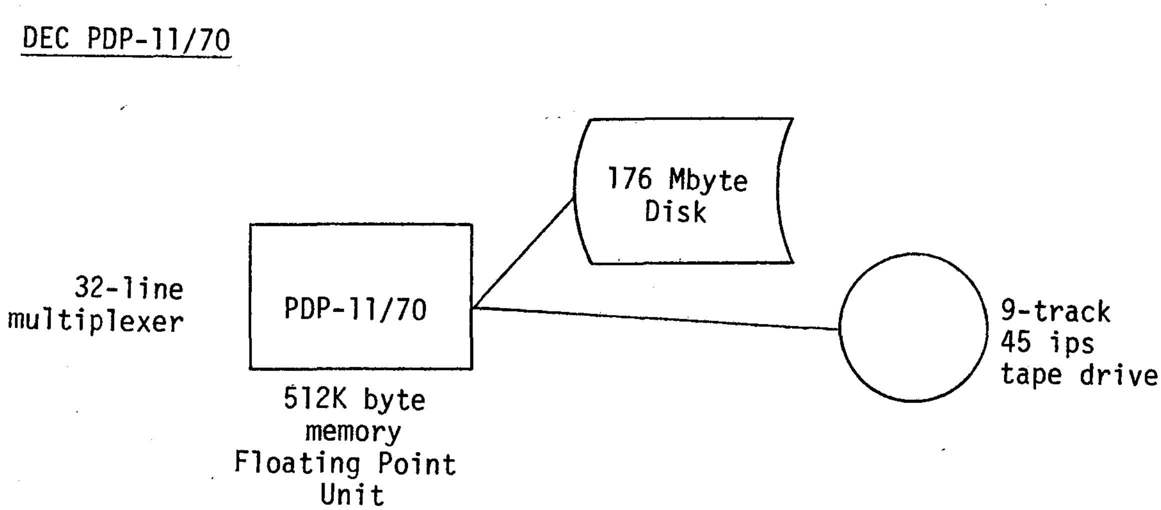


Figure LBL-6

LCB VAX Configuration

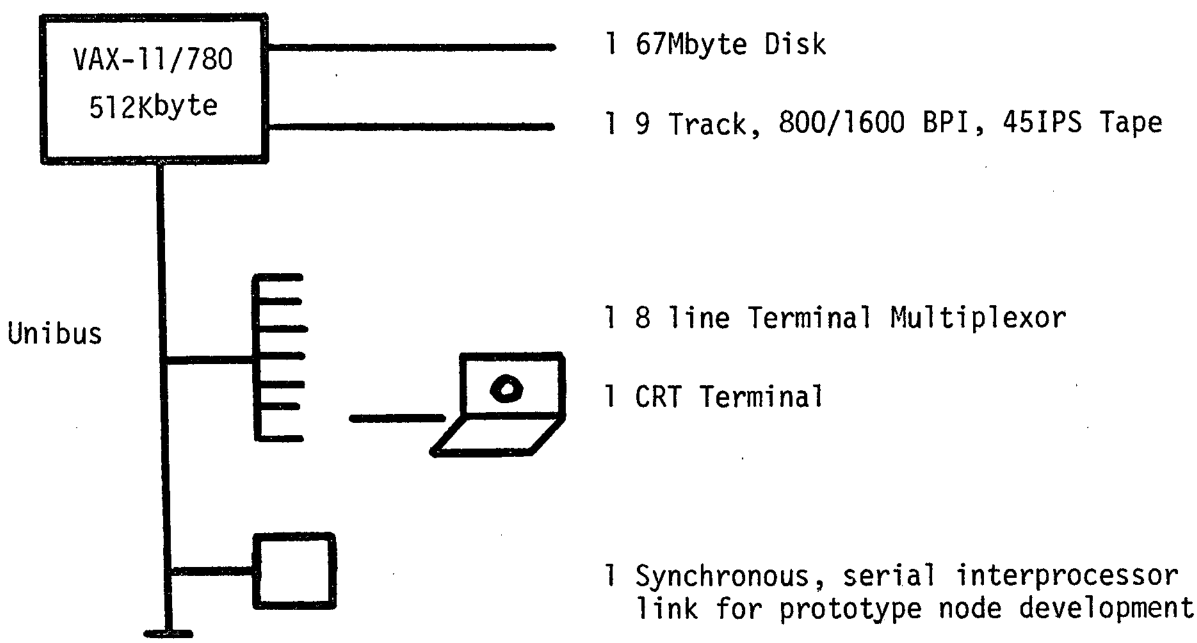
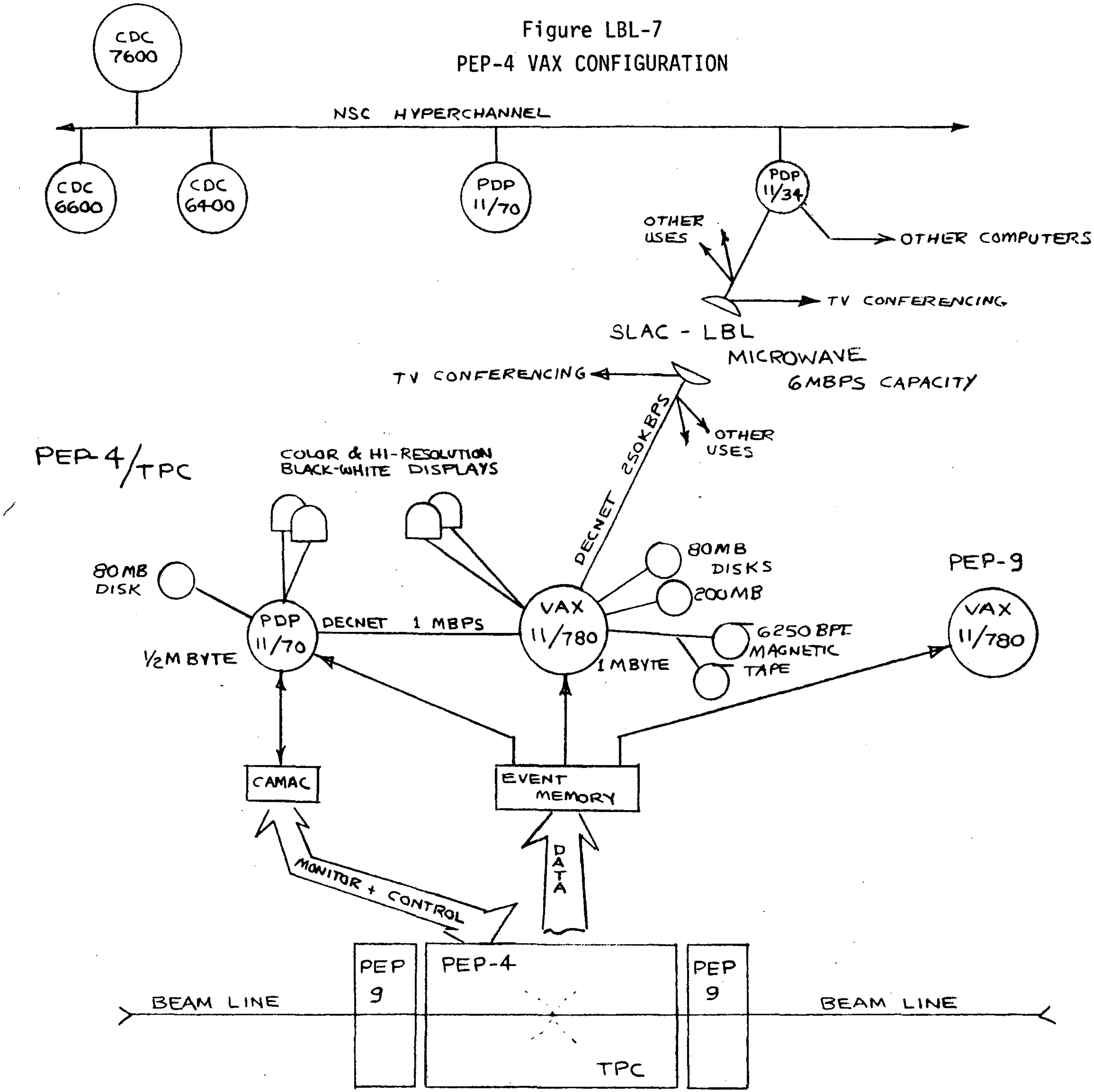


Figure LBL-7

PEP-4 VAX CONFIGURATION



SMALL COMPUTER SYSTEMS INVENTORY AND PLANNING SUMMARY
(Dollars in Thousands)

SITE Lawrence Berkeley Laboratory - LBL

SECTION C SCHEDULE A

	INVENTORY		FY 1979		FY 1980		FY 1981	
	NO. SYSTEMS	ORIGINAL ACQUISITION COST	NO. SYSTEMS	ESTIMATED ACQUISITION COST	NO. SYSTEMS	ESTIMATED ACQUISITION COST	NO. SYSTEMS	ESTIMATED ACQUISITION COST
• GENERAL PURPOSE	6	$ 341	-	$0	-	$0	-	$0
• SPECIAL PURPOSE	84	$4,197	12	$700	13	$740	14	$800
TOTAL	90	$4,538	12	$700	13	$740	14	$800

COMMENTS (OPTIONAL):

SECTION D. COMPUTER CENTER ENVIRONMENT AT LBL

The Lawrence Berkeley Laboratory operates a computing center in which the principal computers are CDC 7600, 6600 and 6400 machines. The 6000 machines support input-output processing for the 7600 in addition to simultaneous independent operation. A considerable variety of online storage is provided, available to any of the machines, in the form of disks, tapes, IBM 2321 Data Cells, and the IBM 1360 Mass Store (Photostore). The CalComp Automatic Tape Library (ATL) will soon become an interim substitute for the Photostore.

The workload of the Center consists of about 3400 widely diversified jobs each day. These represent a broad spectrum of DOE-related users at the Laboratory and in university and contractor communities across the nation. The workload is primarily scientific computation, with many of the problems being of such size or complexity as to require a computing engine of the capability of the 7600. While some jobs require more than an hour of 7600 processing time, others are quite small; the largest 10% of the jobs accounts for half of the work, while the smaller 50% of the jobs accounts for less than 10% of the work. Increasing use is made of the large online storage capacity for the storage of, and access to, major data bases of interest to the scientific community. Application programming is entirely open shop, with assistance provided by consultants. Documentation describing how to use the computer systems, and a library of mathematical packages are maintained by the Center.

The Center is in continuous operation, and the principal computer was available to general-purpose users 90.5% of the year 1978. Availability of at least one of the 6000 front-end machines was more than 99%. Substantially less reliability was displayed by the mass storage devices, especially the data cells and CDC 817 disks. All of these are older pieces of equipment nearing the end of their life cycles. Maintenance of the major computer and storage components is by vendor service engineers; most of the equipment of the communications interface, including the embedded minicomputers, is maintained by Laboratory personnel.

The Center uses a locally written operating system, BKY. This was required initially by the advanced requirements for scientific computation support, a field in which LBL has been at the forefront since the earliest years of computing. More recently the BKY system has been required by the diversity of storage devices and communications interfaces incorporated into the system. Intermixed batch and interactive processing are supported on the 6000 machines, which also handle I/O staging for the 7600. Because of the very high degree of computing power possessed by the 7600, only batch processing is performed with this computer. Somewhat less than half of the total work of the Center (42% of the jobs, 41% of the workload units) is submitted by means of remote batch entry facilities. Harris COPE protocol and CDC 200UT protocol are currently supported, and IBM HASP Multileaving protocol is being implemented. There are 65 RJE ports in active use, with an average of 50 connected during workday hours.

Interactive processing now accounts for 15% of the total workload (16% of jobs). Access is provided by means of ARPANET and TYMNET, and by direct dial facilities. There are 448 ports in dedicated or dial-up use, together with 12 virtual ports used to support ARPA network connections. During workday hours an average of 48 interactive jobs is simultaneously connected, out of the maximum of 70 allowed by the system. This maximum is necessitated by the 6000 hardware configuration, with memory limitation being the most severe constraint.

The interactive system has reached the saturation point, as evidenced by a backlog of users unable to sign on. This "log-on queue" averages about 5-6 in length during normal working hours, which under normal circumstances translates into an average delay of about 20 minutes before a user can get access to the system.

SECTION E. ADP PLAN

E1. ADP Planning Process

Organization: ADP functions exist within many groups at LBL, but there are three departments whose primary responsibilities lie within the areas of ADP: the Computer Science and Applied Mathematics Department (CSAM) (in the Division of Physics, Computer Science, and Applied Mathematics), and the Computer Center and the Real Time Systems Group (RTSG) (both in the Division of Engineering and Technical Services.)

The Computer Center maintains and operates the central computing facility, through which passes essentially all of the general-purpose computation for the Laboratory. Computer Center staff numbers about 100, of whom roughly half are involved in computer operations activities; the balance of the staff includes departmental administration, systems programming, system consultants, accounting, and the supervisory portion of a small hardware development effort. (The design and fabrication engineers utilized by this effort belong to the Laboratory pool, not to the Computer Center.)

CSAM efforts are roughly evenly divided between applications programming (on a contract basis for various users of the Computer Center) and research efforts in computer science and applied mathematics. In the course of these research efforts, particularly in the graphics and networking areas, CSAM operates some mini-computer-based stand-alone and front-end systems. CSAM staff numbers about 85.

RTSG provides a wide range of services, especially in the areas of data acquisition and real-time control, to a number of the Laboratory's research and engineering projects. RTSG's work is strongly mini-computer oriented, and they use the central facility primarily to support their small computer installations. The RTSG staff numbers about 125, and includes hardware and software specialists, maintenance personnel, and documentors.

Workload Projection: Workload projections for continuing programs are based upon historical trends, tempered with the most current available information on new/proposed programmatic developments and budgetary considerations. Each of the ADP departments prepares the projections for the systems for which it is responsible. Estimates originate with program personnel, but are frequently modified by ADP personnel in the light of past experience.

Workload projections for new programs are based upon comparisons with familiar programs which have similar requirements.

Plan Development: Much of the planning for stand-alone mini-computer systems is ad hoc, the intention being to devise and implement an optimum solution to a specific problem. It is believed that the amount of planning effort expended in an area should be proportionate with the total size of the project.

The development of the plan for the central facility, on the other hand, is a relatively formal process. The Computer Center is the principal architect of the plan, but input, counsel, and consent are sought from RTSG and CSAM before the plan is submitted for review. The principal elements of the present plan were derived from a series of personal interviews between Computer Center and program personnel, focussing as much upon direction (style of computing, kinds of applications) as upon quantity of computing necessary. A distillation of the results of this process will be found in Section E14. The information in Section E3 (ADP Support of DOE Programs) was furnished directly by program personnel.

Plan Review: Various elements of the plan, including workload projections, are reviewed by Departmental and Divisional management. The plan as a whole is reviewed, first by the Computer Advisory Committee (which includes representatives of the major LBL computer users), then by Laboratory management, and finally, by the San Francisco Operations Office (SAN). All acquisitions envisaged by the plan are coordinated by the Laboratory's Budget Office.

Implementation: Most elements of LBL's ADP plan are implemented wholly by the ADP department most directly concerned, but many are joint efforts. Implementation normally consists of the following steps:

1) Mitigation: It generally happens that saturation outruns the acquisition process. In these cases several different techniques are used to prevent total system collapse. Among the most common are

    - allocation, apportionment, and rationing
    - selective price adjustments
    - alternative approaches, methods, and sources

- postponement of programmatic objectives

2) Evaluation: In examining the possible alternatives in any given situation, the following factors are considered; the weight given to each of these varies from case to case:

    - urgency and duration of the requirement
    - applicable local experience
    - applicable experience at other installations
    - availability of suitable packages or services
    - reputation and responsiveness of various manufacturers and vendors (including those in-house)

3) and 4) Selection and Development/Installation:

In these areas a policy of minimum impact is followed, where "impact" includes, in addition to raw cost, such factors as consistency, continuity, timeliness, usability, flexibility, expandability, and reliability. Following installation and acceptance all elements of the complex become subject to continuing informal review, aimed at detecting shortcomings and limitations. As these are uncovered, encountered, or created (by changing workload), the process begins anew.

DEPARTMENT OF ENERGY PROGRAMS SUPPORTED
(PERCENTAGE BREAKDOWN)

SITE Lawrence Berkeley Laboratory - LBL

SECTION E2 SCHEDULE B
(Page 1 of 2)

B&R CODE	PROGRAM	PAST	CURRENT	BUDGET	PLAN	OUT-YEARS			
		FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
AE	Geothermal ES/R&TD	2.0	2.2	2.3	2.4	2.5	2.4	2.4	2.4
AK 01	Basic Energy Sciences ES/R&TD	4.8	5.4	6.7	8.2	9.9	11.2	12.4	13.5
C3	Commercial Conservation	1.1	2.2	3.5	3.4	2.6	1.9	1.9	1.8
GK 01	Environmental Res. & Dev.	1.1	2.0	2.1	2.7	3.3	3.9	4.4	4.8
HK 01	Life Sciences Research and Biomedical Applications (Basic Sciences)	0.7	1.3	1.4	1.6	1.6	1.6	1.6	1.6
HK 02	High Energy Physics (Basic Sciences)	7.5	10.2	12.0	13.7	14.5	14.8	15.5	16.5
HK 03	Nuclear Physics (Basic Sciences)	3.4	3.6	3.9	4.1	5.3	6.4	6.8	7.2
Misc.	C4, C8, AG04, AD, JF, C1, AB, C5, AA, AF01, BD, AJ, KN02, KK	1.7	1.8	1.9	2.1	2.3	2.6	2.8	3.0
	General Support	12.5	13.2	14.1	15.1	15.8	16.7	17.4	18.0
	Non-DOE LBL[1]	2.7	2.9	3.1	3.4	3.3	3.2	3.1	3.0
	Non-LBL DOE[2]	27.1	21.8	19.4	17.2	16.5	16.1	15.5	15.0
	DOE Related[3]	11.1	11.6	12.0	12.4	12.5	12.8	13.1	13.2
	Others[4]	24.3	21.8	17.6	13.7	9.9	6.4	3.1	---
	Program Requirements	22.3	28.7	33.8	38.2	42.0	44.8	47.8	50.8
	General Support	12.5	13.2	14.1	15.1	15.8	16.7	17.4	18.0
	Reimbursables	65.2	58.1	52.1	46.7	42.2	38.5	34.8	31.2
	TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

(SCHEDULE B CONT.)

DEPARTMENT OF ENERGY PROGRAMS SUPPORTED
(PERCENTAGE BREAKDOWN)

SITE Lawrence Berkeley Laboratory - LBL

SECTION E2 SCHEDULE B
(page 2 of 2)

B&R CODE	PROGRAM	PAST	CURRENT	BUDGET	PLAN	OUT-YEARS			
		FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
(1)	Funding sources for Non-DOE LBL Collaborations: DOL, local governments, DOE, EPA, DOI, Navy, Army Corps of Engineers, NRC, NIH, DOC, Navy/NASA, NSF, DOT, state governments								
(2)	Funding sources for Non-LBL DOE Users: Ames Laboratory, Applied Decision Analysis, Atlas Corp., Atomics International (Div. of Rockwell Intl.), Ayres Assoc., Boeing Computer Services, BNL, Battelle-PNL, Bechtel Corp., Bendix Field Engr. Corp., Donald Bentley & Assoc., John A. Blume & Assoc., Wm. M. Brobeck & Assoc., CalTech, Donald Clark Assoc., Columbia Univ., Consultants Computation Bureau, DOE HQ, E. T. Dupont, EG&G, Energetics Mkt. & Mgr. Assoc., Engineering-Economics Assoc., Fairchild Industries, W. S. Fleming & Assoc., GE Fast Breeder Reactor Dept., General Atomic, Intelcom Rad. Tech., Interactive Resources, Inc., John Hopkins Univ., Jaycor, Kaiser Engineers., LASL, MIT, NAL, Northwestern Univ., ORNL, Oregon St. Univ., Pacific-Sierra Res. Corp., Ralph M. Parsons Co., Physical Dynamics, Princeton Univ., R&D Assoc., Rockwell Intl., Rockwell Hanford Opns., SLAC, SRI Intl., Sandia Labs., Science Applications, Solar Energy Research Inst., Suntek Res. Assoc., Systems Applications, Tera Corp., Union Carbide-Nuclear Div., UC Berkeley, UC Davis, UC Irvine, UC Los Angeles, UC Riverside, UC Santa Cruz, UC San Diego, Univ. of Colorado, Univ. of Hawaii, Univ. of New Mexico, Univ. of Utah, Univ. of Wisconsin-Madison, Weidlinger Assoc., Westinghouse Advanced Reactor Div.								
(3)	Funding sources for other DOE related users: EPRI, EPA, Army Corps of Engineers, NSF, non-federally funded, NIH, DOI, DOC, DOT, Navy, NASA, HUD, DOA, Public Health Service, USAF, state governments								
(4)	Funding sources for Others: Navy, Army Corps of Engineers, NSF, DOI, USAF, NASA, Army, Defense Nuclear Agency, DOT, HUD, EPA, DOA, Space and Missile Systems Organization, EPRI, NIH, Office of Naval Research, HEW, DOC, state governments, DOL, non-federally funded, NOAA, EEO, DOJ, TVA, local governments, VA								

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E3. ADP Support of Department of Energy Programs

AA Coal ES/R&TD

Energy and Environment Division coal researchers are located on campus, and therefore primarily use the campus computing facilities. Occasional use is made of the LBL facilities, totalling about 2 NSU/year.

AD Solar ES/R&TD

Solar research at LBL includes a variety of projects. Computing facilities are used to:

(1) analyze data on solar hardware, solar radiation, and ocean properties.

(2) model solar-powered systems

(3) model transmission through the atmosphere

(4) process applications in the Appropriate Technology program

(5) model passive, high thermal mass, buildings.

Both batch and interactive modes are used (about 70% batch). There is a need for both large central memory capabilities and for mass storage. Slow interactive turnaround time is a frequently encountered difficulty. Present use is around 53 NSU per year (of which 36 NSU is associated with the passive modeling efforts). This should stay roughly constant.

AE Geothermal ES/R&TD

1) The National Geothermal Information Resource GRID (Geothermal Resource Information Database) project uses LBL computing facilities primarily for document preparation, statistical analysis, and data entry, editing and retrieval. Both batch and interactive processing are important, but an increasing portion of the workload will consist of interactive processing. Capabilities such as reliable on-line storage, rapid response, a good data base management system, and publication-quality graphics and document production will be required. The Computer Center's new text processing front end will be used for much of the document production and batch job preparation. Large, fast CPU is not needed for this work--a smaller computer oriented to non-numerical interactive processing with adequate response time and on-line storage facilities would be better. The computing activities of this project will grow at a rate of 10-20% per year over the next three years, subject to available funds and improved service. Estimated usage is 18 NSU in FY78, 23 NSU in FY79, and 27 NSU in FY80.

2) Because of the excellent computer facilities at LBL one of the principal directions in the Geothermal Exploration Technology program has been to develop advanced computer codes for processing and interpreting geophysical data of the type acquired in geothermal exploration and reservoir delineation. While some of this work has been directed to seismological problems, such as array processing in beam-forming modes to determine source location and mechanism, the majority of the past, present and future work will be in solving

electrical and electromagnetic problems. One type of problem involved is the scattering of plane or non-planar waves by arbitrary geometries, approximating realistic geologic structures. Another type of problem is the response of realistic earth models when energized by dc current impressed between two electrodes. These classes of problems are appropriate to interpreting results from, as well as planning surveys for the magnetotelluric, telluric, controlled-source EM, and galvanic resistivity techniques of applied geophysics.

The availability of large memory, very high-speed computers has allowed us to obtain solutions for arbitrary two-dimensional earth structures, and work has begun in finding efficient and accurate programs for arbitrary three-dimensional earth structures. The degree of computing power needed for the three-dimensional problems is very large, and whereas most two-dimensional problems require a few minutes of CPU time, the three-dimensional problems contemplated are estimated to require up to one hour of CPU time. We are beginning to realize the need to improve LBL computing capabilities to enable us to perform large calculations with reasonable turnaround time and cost.

3) Computer facilities at LBL are also heavily depended upon in geothermal reservoir engineering work including (a) well test data analysis and (b) numerical modeling of reservoir behavior. In the latter topic, the trend is toward larger codes requiring long CPU time. Here again an improvement of LBL computing capacity to allow long calculations with reasonable turnaround time and cost is much desired for the near future.

AF 01 Magnetic Fusion ES/R&TD

1) Two major R&D construction projects in neutral beam development for fusion reactor sources are the responsibility of the Engineering and Technical Services Division. These are the NBSTF project for the Princeton TFTR and the Neutral Beam Injector for the General Atomic Doublet III. These projects have required extension of existing project management and control facilities, including CPM. The E&TS Division is investigating the practicality of developing a distributed intelligence systems approach to the general problem area of project and construction management, which would utilize micro-computer-based intelligent terminals to replace the standard keyboard/video terminals now used. This investigation is expected to continue with applications testing through FY79 and into FY80.

2) All administrative data processing (cost accounting and project management and control systems) for the NBSTF Project are provided by the BKY Computer Center. These activities amount to about 13 NSU per year, and will continue through FY 1978; ADP support may increase slightly in FY 1979 through FY 1981 due to emphasis on the scheduling of critical test operations through project completion in FY 1981.

   Additional projects of similar nature are expected in the future (beyond FY 1978), which would cause a steady increase in computer operations in support of project administration activities. (13 NSU/project-year.)

A further comment is that the above support is preferably (almost necessarily) accessed interactively, i.e. via TTY, and any system or facility which would improve the present interactive access to the Computer Center is strongly recommended. Possible approaches which appear to be acceptable to me include priority access in specified time blocks, or distributed processing of data input to the Computer Center.

3) LBL's computer facilities are used extensively by Scientists/Engineers and Project Administrators on the Doublet III Neutral Beam Injector System Project. Programs dealing with molecular gas-flow conductance, pressure distributions, particle power densities and magnetic fields are used to model and analyze portions of the injector system. The scientific calculations and data provided by these computer codes aid the Engineer in executing the system design.

Project Management uses many different types of computer output concerning cost accounting and procurement data to collect project costs, control, and monitor the project's work schedule. A new computer program utilizing Critical Path Management techniques has been instituted on the project. This program gives a detailed analysis of project completion status as well as budgetary information.

The Project's computer usage time is increasing, thus adding to the problem of slow "turnaround time" for a computer run. Presently, over 1/3 of the Doublet III work force directly uses the computer-generated output. Use of the computer facilities will increase as more sophisticated and applicable scientific computer programs are developed. Project management will also require more computer time as schedule and budgetary requirements become more stringent.

Computer usage is an integral part of both project control and the development of the Neutral Beam Injector System.

It is expected that the neutral beam prototypes will be completed before FY 1981.

AG 04 Nuclear Research and Applications (Fission) ES/R&TD

Calculations are carried on in support of geological storage of nuclear reactor waste. Mathematical models are developed and applied to analyze the thermomechanical response of rock masses to decay heat as well as the influence of this response on water flow through fractures. The ultimate objective of the calculations is to predict the probable behavior of a nuclear waste repository and hence assess its safety. Data storage and analyses will also be provided in situ to field experiments simulating burial of high-level wastes.

The computing capability of the CDC 7600 at LBL and the availability of a good mathematical subroutine library have greatly facilitated the calculations. However, the poor turnaround (due to input/output bottlenecks and MFE block time), the unreliability of tape drives, and the unavailability of interactive graphics equipment at the Building 90 site have seriously impeded progress.

During the early 1980's computer modeling efforts in support of waste storage is expected to increase.

AJ 01 BIOMASS ES/R&TD

1) Chemical Biodynamics Division: Hydrocarbons and Energy from Plants

This research is exploring the feasibility of extracting reduced photosynthetic materials, such as hydrocarbons, terpenoids, steroids, etc. from the latex of Euphorbia for direct use as fuels or for chemical feedstocks. Two species of this plant are now being used in field trials designed to develop optimum growing and harvesting conditions. In the laboratory, solvent extraction methods are being explored; in addition, improved analytical techniques, such as GCMS, are being used to characterize the chemical nature of the extracts and its dependence on various field variables.

Computer facilites are used mainly for interactive modelling of a few specific codes on the 6600 machine; these are large memory jobs and poor interactive response is a problem. Another problem has been the recurrent unavailability of the data cells. Usage is expcted to be about constant over the next few years.

2) Energy and Environment Division

Researchers in this category use facilities for modeling reaction processes, and for process optimization studies. Use is made primarily of the interactive mode; no operating difficulties have been encountered. Around 1 NSU per year of computing is used; this will remain roughly constant.

AK 01 Basic Energy Sciences ES/R&TD

1) National Resource for Computation in Chemistry

The LBL Computer Center is of utmost importance to the National Resource for Computation in Chemistry (NRCC). In fact it is one of the principal reasons for NRCC's presence at LBL.

One of the primary NRCC missions is to serve as a focal point for developing codes for a broad spectrum of computational chemistry research that utilizes high speed computers like the CDC 7600 and minicomputers like the VAX 11/780. Some of the subdisciplines of chemistry in which the NRCC will be active are chemical kinetics, crystallography, quantum chemistry, statistical mechanics, and physical organic chemistry. Specifically, NRCC will be focusing its attention on the development and refinement of codes used by computational chemists in carrying out complex calculations on computers. Many of these codes have not been readily available to the general chemistry community. This effort will involve taking codes that may be inefficient, poorly documented, machine specific, or bug-ridden and turning them into efficient well-documented transportable bug-free codes. Finally, information on these and other codes are disseminated throughout the chemistry community.

The first phase of NRCC's development is funded through fiscal year 1980; however, an extension of Phase I through fiscal year 1981 has been requested by the director's office and is expected to be approved in January by NSF and DOE. NRCC's 1979-81 budget plan for LBL computer time is:

	FY79 (NSU's)	FY80 (NSU's)	FY81 (NSU's)
Totals	528	531	721

Pending DOE approval, NRCC will be acquiring a VAX 11/780. This machine will be utilized for the development of a variety of mini-based codes. It will be used by the NRCC staff and selected outside users. Initial plans call for the VAX to be connected to Gandalf. Later it is expected that a high speed data channel will be utilized to connect the VAX directly with the CDC computers. It is hoped that the VAX will arrive sometime in Spring 1979.

There are several areas of research where computer-generated graphics are of value to researchers. Crystallography is a good example. At the present time the NRCC staff is in the process of defining the type of graphics system that will be best suited for their needs. Several types of systems are being investigated. These include basic graphics terminals such as the Tektronix and Hewlett-Packard terminals and also microprocessor-based stand alone systems. Color systems are also being considered. NRCC also plans to utilize Livermore's Dicomed system.

NRCC has established a $5,000 account at Argonne National Laboratory. This money will be used to buy time on their IBM machine for the purpose of testing codes for transportability.

Current problems encountered by NRCC are: extremely slow interactive response time, making it impossible to use the system for code development or production jobs; slow PSS access, prohibitive down times, and lack of permanent file space, for which the use of GSS tapes is only a partial alternative.

2) Solar Energy Utilization Based on Photosynthesis

This research is directed towards developing methods, based on research in green plant photosynthesis, for the economic utilization of solar energy. Its major components are:

(a) Sensitized photodecomposition of water.

This work is a study of model systems of synthetic molecules that are part of donor-acceptor pairs; their electron transfers may be driven by light, leading to the oxidation and reduction of water.

(b) Sensitized photovoltaic devices.

Based on knowledge we have obtained on photoconversion by single crystal semiconductor electrodes sensitized by adsorbed dyes, we will continue investigations in two directions. Using dyes covalently bonded to a pellet of powdered semiconductor, we hope to make considerable improvements in both stability and efficiency of these cheaper electrolyte-electrode systems. We are also developing a novel dry, dye-sensitized Schottky barrier solar cell that should also operate well with polycrystalline materials easy to fabricate.

(c) Microbiological solar energy conversion.

The biochemical mechanism of H(2) evolution by wild type and mutant photosynthetic bacteria is being evaluated to determine conditions for efficient H(2) generation from organic compounds and agricultural wastes.

3) Low Energy Nuclear Science

This program requires ADP support for three separate and distinct purposes:

(1) Scientific calculations of a mainly theoretical nature. This batch-processing work requires a computer with high speed, long word length and large core memory, such as the LBL CDC 7600.

(2) Nuclear data compilation and evaluation. This project requires both batch and interactive processing, coupled with a very high-reliability mass storage system and publication-quality text and graphics output devices. Interactive computing and database management will grow relative to batch processing and computation, the extent depending on system responsiveness and the availability of adequate software. An interactive database management system would be a great advantage to the project. Usage is anticipated to drop in FY79 with the completion of the 7th edition of the Table of Isotopes, then to increase gradually. Estimated usage over the next three years is 4.5 NSU in FY79, 9 NSU in FY80, and 15 NS in FY81.

(3) Interactive computing for budget management. It is expected that this system will soon expand to include manpower data.

A current limitation is the saturation of the interactive facilities, which impacts especially task (2), and artificially inflates computing costs. The pending loss of the present mass store system would have a highly adverse effect on task (2), unless that system is replaced with one that has an equally high (i.e. perfect) data-recovery capability.

The usage for these three items is as follows:

	FY77 (Actual) (NSU)	FY78 (Estimate) (NSU)	FY79 (Anticipate) (NSU)
Purpose 1	5	9	10
Purpose 2	33	37	28
Purpose 3	<1	<1	1

4) Computer Science and Applied Mathematics

Research programs in applied analysis, computational mathematics, and computational modeling emphasize numerical studies of laminar and turbulent combustion and fluid flow, the numerical computation of two-phase flow in petroleum or geothermal reservoirs, the numerical solution of elliptic partial differential equations, and the reconstruction of the image of an object from projection data of its transverse sections. Large-scale scientific computing capabilities are inherently required by research of this type. Anticipated growth of these research programs will require continued and expanding use of large-scale computational resources. These research programs used around 27 NSU in FY78. It is anticipated that up to 40 NSU will be required for the next year or two, increasing to about 200 NSU in five years--mostly for combustion research.

The computer science research program is part of the DOE-wide focal point for advancing the state-of-the-art in computer science and information systems. The major areas of development include data management, distributed systems and software engineering. The Computer Center's 7600/6000 computers and several large-scale minicomputer systems, including DEC VAX-11/780 and PDP-11/70 systems, provide test-bed and computational resources for the research program. Computer system capabilities that are required include interactive systems, high-level graphics, and ARPANET access.

5) Energy and Environment

Combustion researchers use the Computer Center for batch processing of complex problems in fluid mechanics and chemical kinetics. Present usage is about 36 NSU per year per month of time on the CDC 7600 computer. Researchers are beginning to take data using a PDP-11 computer in the laboratory. There is a need for a way to transmit this data, in batch form, to the CDC 7600 for processing.

6) Actinide Chemistry Group (MMRD)

The actinide group program consists in the synthesis and measurement of the physical and chemical properties of compounds of the actinide and lanthanide elements, and the development of sequestering agents for plutonium. The computer facilities are used in (1) crystal structure determinations from X-ray diffraction methods, (2) calculating formation constants from potentiometric titration data in the Pu sequestering project, (3) atomic structure analyses of optical spectra using Hartree-Fock calculations, and (4) parametric analysis of optical data.

All of the above work enters the computer via batch mode. Graphics facilities, primarily CalComp, are required and used by the crystal structure and potentiometric programs. Very large matrices in the work of the analysis of optical spectra requires the large core memory of the 7600. The crystal structure determination of large molecules also requires the use of a large core to store large matrices. Much of the group's work, however, could be done on smaller and cheaper computers.

A reliable and cheap method for transferring moderate amounts of data from our data collecting systems to the computer would be desirable. Large magnetic tape units are too expensive for small scale projects. Magnetic tape cassettes or floppy disks could be an alternative.

The amount of computing we would anticipate for the next five years is strongly coupled to the cost of computing. If the rate remains constant we would anticipate a 10% growth rate per year; should the rate decrease significantly we would anticipate a 25% growth rate.

7) <u>Materials Science (MMRD)</u>

The current level of use of the LBL computer facilities by investigators supported by the Materials Science Division of BES is about 15 NSU/month. The bulk of this usage is concentrated in four research groups. The first of these is concerned with the computation of the fundamental physical properties of metals and semiconductors and their surfaces, largely through the use of pseudopotential models. The second concentrates upon the direct simulation of phase transformations and mechanical behavior in idealized solids, which particularly address the kinetics of those processes at finite temperature. The other two most computationally oriented groups are concerned with the structural analysis of crystals and defects, and surfaces, through the analysis of electron diffraction data. The remaining Materials Science usage is spread over a large number of smaller efforts and principally involves data analysis and routine computation.

One can safely predict that the level of computer usage in Materials Science will increase substantially over the next decade. The trend of our field, particularly in metallurgy and ceramics, is toward an increasing recognition of the value of numerical computation and simulation as a theoretical tool.

BD, C2, C3 Residential and Commercial Conservation

Research in this area covers heat transfer in residential and commercial buildings, ventilation and air infiltration, and windows and lighting.

The largest demand on computing facilities comes from the DOE-1 (formerly Cal-ERDA) building energy analysis program. This is a public domain program, devised at LBL, which analyzes energy usage in buildings. Presently it is operated about 25% in batch mode, and 75% in interactive mode. Calculations require 65K octal of core, while temporary storage uses 100 K decimal. Notable difficulties have been the slow interactive turnaround time (during daytime hours), and excessive downtime for the card reader and printer at the Building 90 terminal. Aggregating maintenance, development, and several specific upcoming studies, the usage is estimated to be as follows:

Year:	1979	1980	1981	1982	1983
Usage: (1979 NSU)	152	152	205	205	205

This usage could increase considerably if the program is accessed by users at DOE locations around the country.

Research on windows and lighting at LBL utilizes computers for engineering analysis of window systems, analyses of data from demonstration buildings, and for studying the economics of various window and lighting systems. Both batch and interactive modes are used. Researchers have not needed large amounts of computer memory; nor have difficulties arisen in running programs. Annual usage is estimated to be:

Year:	1979	1980	1981	1982	1983
Usage: (1979 NSU)	15	18	23	23	23

Tracer gas experiments are utilized to study air infiltration through building envelopes. Presently computer facilities are used to provide background data processing for an experimental house in a nearby suburb. Equal use is made of batch processing and interactive usage (for submission of editing and batch needs). Long turnaround times with the interactive system is the major complaint of researchers in infiltration. Present usage is 36 NSU per year, projected as roughly constant for the near future.

Researchers on ventilation use computing facilities for data analysis and ventilation data base development and implementation. Both batch and interactive modes are used. There is no need for large amounts of computer memory; however mass store is utilized. Usage is projected to be around 76 NSU per year.

Research is also undertaken on educational facilities and hospitals. Computing is done to evaluate the effects of modifications on the facilities. Present use is 41 NSU per year, and will be constant over the next five years.

C5 Transport Conservation

Members of the Engineering Sciences Department are using the LBL central computer facilities for projects and programs in the Transporation Energy Conservation field. These include the remote facilities in Building 90 as well as the Building 50 facilities. Current usage is about 35 NSU per year of CDC 7600 time. The loss of easy access to such facilities would seriously hamper these programs.

GK 01 Environmental Research and Development

1) Epidemiological studies on the effects of environmental pollution, and on the incidence of cancer, are the major computer users in this program category. Populations at Risk to Environmental Pollution, an extension of an earlier study, requires large amounts of computer memory and mass store. The interactive mode is primarily used, as are the graphic capabilities of the LBL computers. Major difficulties are the long interactive turnaround time, and the disk track limit on interactive jobs. Usage should be around 76 NSU per year during 1979 and 1980.

The PAREP study uses a 300 megabyte on-line disk storage. This is obtained by using the VAX computer, rather than the machine previously used. A Tektronix 4014 graphics terminal was recently purchased (15K$).

The Atmospheric Aerosol group at LBL uses computing facilities for archiving data on pollution, producing graphs and histograms, and modeling dispersive processes in the atmosphere. Batch processing is primarily used. Future applications may require large memory and mass store. The long time lag to receive an 8-1/2 x 11 inch printout is one difficulty noted by the investigators. Present usage is on the order of 5 NSU per year; this could go up to 8 NSU per year over a five year period.

Combustion researchers use facilities to model combustion processes. Present usage at LBL is around 15 NSU per year. This could double over a five year period.

The Gas Chromatograph/Mass Spectrometer researchers use computing facilities to archive data, run statistical analyses, design subsystems, and interactively collect data from the Gas Chromatograph. Both batch and interactive modes are used. The CACHE storage system is needed. Long turnaround times are a problem for users. Present usage is 11 NSU per year, which could grow to 14 NSU per year in five years.

Researchers on eco-system stability utilize the computing facility to solve equations, store data, make correlations, and produce graphics. The interactive mode is used, despite its very slow turnaround time. Present use is less than 3 NSU per year.

Researchers studying energy use utilize computing facilities to analyze the economic and environmental impacts of energy development. Program development is done in the interactive mode, with production runs using the batch mode. A large core storage and mass store facilities are required. Difficulties encountered include slow interactive turnaround time, lack of easily available graphic facilities, and the inability of compilers to access all of the memory in the 7600 system (thus making use of large matrices difficult). Present use is 42 NSU, and will increase 20% per year over the next five years.

Researchers in the area of shale oil utilize the Computer Center for general computations, and for execution of complex groundwater flow and chemical equilibria models. Usage in 1979 will be about 5 NSU. This will double in FY 1980 and thereafter remain roughly constant.

No use is made of LBL computing facilities by groups doing research on applied laser spectroscopy, and on surveying instruments for environmental analysis.

2) Computer Science and Applied Mathematics

The Computer Science and Applied Mathematics Department is developing the Socio-Economic Environmental Demographic Information System (SEEDIS) to provide data management, analysis and display capability in support of energy-related environmental research programs. The objective of the SEEDIS project is to establish a comprehensive, computer-based information system for energy policy analysis, environmental impact studies and other socio-economic analysis applications. Under a Memorandum of Understanding between DOE Assistant Secretary for Environment and the Department of Labor Employment and Training Administration (DOL-ETA) development and demonstration of SEEDIS is supported jointly by DOE and DOL.

SEEDIS requires relatively rapid access to a large amount of on-line information. Current SEEDIS databases total more than 10 billion bytes-- this is expected to double in size with the addition of the 1980 Census. This data has, in the past, been managed with the IBM 1360 photodigital chipstore. The size and access requirements of SEEDIS dictate the procurement of a comparable mass storage device as the chipstore is abandoned in October 1979. High quality graphic devices are critical to the effective display of SEEDIS information; there is an increasing demand for color display hardware and new display techniques.

The Populations at Risk to Environmental Pollution (PAREP) project is a continuation and expansion of research funded in FY78 through the Environmental Protection Agency. The principal computer activity in the PAREP project in FY79 will involve (a) acquisition of additional data files relating to mortality, cancer incidence, industrial activity, and environmental pollution; (b) conversion of those files to a standard format and installation in SEEDIS; (c) use of SEEDIS to produce maps and reports as requested by DBER and other agencies; and (d) statistical analysis of both new and existing data files.

Computational resources to support this work include the CDC computers, the SEEDIS VAX-11/780 research system, and systems at Brookhaven National Laboratory and EPA. Requirements on the LBL central computing complex include 1000 megabytes of archival mass storage (GSS) and 20 megabytes of quick access storage (PSS). The PAREP project use is estimated at 10 NSU's on BKY for the fiscal year. Use in coming fiscal years will require approximately the same amount of additional storage and comparable usage.

3) Chemical Biodynamics Division: Chemical Mutagenesis and Carcinogenesis and Plant Biochemistry

These two areas of research may be described as follows:

(a) The mutagenesis and carcinogenesis research will undoubtedly have a number of medical and scientific consequences. First, it will reveal how environmental factors influence the normal functions of cells. Mutations produced by environmental chemicals are a rapidly increasing cause of cancer. We propose to learn how chemicals cause mutation and what role this process has in the neoplastic transformation of mammalian cells.

This project makes use of approximately 27 NSU of 7600/6600 computer time per year, mostly for data analysis.

(b) Plant biochemistry research is concerned with the biochemistry of photosynthesis and biosynthesis in green plants, and ranges from biochemical structures of the membrane responsible for light conversion to the elucidation of biosynthetic pathways leading to end products such as sugars, proteins, alkaloids, hydrocarbons, toxins, etc. formed in plants. Bacterial conversion of plant organic compounds to H(2) and other useful substances is investigated.

HK 01 Life Sciences Research and Biomedical Applications (Basic Sciences) - Chemical Biodynamics Division

This effort comprises many basic research projects in the areas of molecular and cellular biology, organic and photochemistry, and biophysical chemistry. Major examples of this work are the mechanisms of chemical and viral transformations of living cells, chemical evolution, the role of biological structure in the energy conversion processes of green-plant photosynthesis, and the applications of the newest biophysical techniques (such as NMR and X-ray spectroscopy) to study fundamental processes in nucleic acids, proteins, membranes, and nerves.

This project makes use of approximately 27 NSU of 7600/6600 computer time per year, mostly for data analysis.

HK 02 High Energy Physics (Basic Sciences)

The high energy physics program is a comprehensive research effort with two basic thrusts: experimental and theoretical particle physics, and efforts in advanced accelerator design and construction.

The bulk of HEP computation is devoted to experimental design, data reduction and analysis, and the development of the programs which support those activities. Program development demands both a good interactive facility (for program creation and modification) and a fast-batch capability (for rapid turnaround of test runs). The other activities depend heavily upon the brute-force capabilities of the configuration: the very large storage capacity and the very fast CPU. The analysis phase in particular features complex simulations, including kinematic reconstructions, and sophisticated pattern recognition procedures applied to large amounts of data; graphical output is essential.

Experimental high-energy physics is centered around the large accelerators at SLAC and FNAL, with the major part of the future program being destined for PEP, the 20-GeV positron-electron colliding beam facility to be completed in the autumn of 1979. Three proposals in which LBL plays a key role have been selected by the PEP Experimental Program Committee: the Time Projection Chamber (TPC), the Mark II Magnetic Detector, and the search for quarks.

The Computer Center will be used for off-line analysis of TPC data, and Monte Carlo generation and analysis of events for comparison. In addition, mass storage facilities will be needed to provide access to a large data base of analyzed data which will be used locally by LBL scientists and remotely, either by RJE or interactively, by University collaborators. The maintenance of a data base at LBL is extremely important to the effectiveness of the TPC group. The 7600 will be used via the PEPNET link for real time response on about 10% of the data taken at PEP. Some estimated numbers for TPC use of the Computer Center are:

286 NSU in FY79, with emphasis on Monte Carlo for software development, etc.

429-715 NSU in FY80, with some data and extensive reanalysis; on-line programs may not be as advanced as in the steady state;

429-715 NSU per year in FY81 and beyond when this program has reached a steady state.

Increasing use will be made of text processing capabilities for job preparation and document preparation; for the latter, usage is estimated at about 1 thesis/month and 1-2 papers/month for scientific journals.

High priority items for HEP use of the Computer Center include mass storage facilities to maintain collaborations with many outside groups, 6250 BPI tapes (particularly for the TPC group), and interactive facilities.

The Trilling/Goldhaber group effort is devoted to the study of the interactions occurring in the electron-positron collisions in the energy region 3-8 GeV. This work is done in the large magnetic detector at SPEAR in collaboration with two groups at SLAC and several other people at Berkeley. This work has opened up a new particle spectroscopy, culminating in the discovery of particles carrying the new quantum number, charm. Also in collaboration with SLAC groups, the Trilling/Goldhaber group has designed a new and much improved magnetic detector facility, Mark II, which will permit much deeper study of the new spectroscopy at SPEAR. Estimated computer usage is 108 NSU per year over the next five years.

The Kerth Physics Group, in addition to its commitment to the TPC experiment, is involved in a long range program of muon experiments at FNAL, in collaboration with groups from Princeton University and Fermilab. The construction of a new muon spectrometer was completed at FNAL in FY78; the first data run was finished in May 1978, and additional running time is expected in FY80 and FY82. Almost all off-line computing for the experiment is done on the 7600, with the raw data stored on 6250 BPI tapes. A common data base for programs, raw data and analyzed data is essential to the coordination of the anaysis effort. The data reduction depends heavily on the speed and size of the 7600, the various storage systems available, the interactive capability, and the micrographic and microfiche facilities. Estimated computer usage for the Kerth Group (not including their involvement in analysis of the TPC experiment) is as follows:

	FY79	FY80	FY81	FY82	FY83
NSU's	167	76	182	76	182

PEP will have the potential to generate about 850 NSU's per month (i.e. about four times the computational load generated by the Mark I detector at SPEAR), but the actual load will be subject to the vicissitudes of the budgetary process. The HEP workload projections in Schedule D are in fact limited by budgetary considerations; they could reasonably be expected to double were these constraints to be removed.

HK 03 Nuclear Physics (Basic Sciences)

1) Nuclear Science Division

This program is heavily dependent upon massive ADP support for three separate and distinct activities:

(1) Scientific calculations of a theoretical nature. This work requires very high computing speeds, long word length and large program storage capability. Many calculations are of extreme complexity requiring the availability of very sophisticated programming techniques.

(2) Data analysis (batch jobs).

(3) Interactive computing for budget management.

Usage is expected to be as follows:

	1979 (NSU)	1980-85 (NSU)
Category 1	53	61
Category 2	322	349
Category 3	3	5

There is a great need now in the Nuclear Science Division for rapid interactive data analysis. A design goal is to sort 5 million 16-bit words in 20 seconds and present a display (histogram, etc.). The projected use of such a machine depends upon its cost. If it were possible to support an average of 100 such sorts per day for approximately $200-400K per year plus some equipment money, the project would be feasible. There are proposals within the division to set up this capacity. A decision must be made by February 1979.

2) Accelerator and Fusion Research Division

At the Bevatron/Bevalac and the SuperHILAC, use of Computer Center facilities amounts to 30 NSU and 6 NSU, respectively, in annual charges. Most of the use is interactive for such functions as beamline optics calculations, statistical management and analysis of accelerator operations and calculations of parameters for advanced accelerator devices. Computing requirements for both on-line and batch work are expected to increase 10-15% over the next five years.

Word processing is being approached with a single stand-alone unit, with the expectation of the addition of more units to offices within the Division. UNIX word processing will also be tried at the Bevatron. Some additional computing will be carried out as a side benefit of the installation of control computers at the Bevatron.

JF(& HK 02) Fusion (Defense) - Heavy Ion Fusion, Accelerator Theory, PEP

Annual usage of Computer Center facilities for the above programs are estimated below:

PEP	18 NSU
Magnetic Fusion Energy	67 NSU
Heavy Ion Fusion	46 NSU
Accelerator Theory	.9 NSU

For the above programs, calculations are performed for analytical, design and theoretical studies. A small amount of computer time is used in management activities. Very long runs are rare, but fast turnaround, reliability, easy access and fairly large memory requirements are most important and should be improved. The computing needs of the above programs are not expected to increase, but at present they are somewhat inhibited by the heavy workload and frequent interruptions at the Computer Center.

For the magnetic fusion energy program, the bulk of data acquisition and anaysis is done with the group's three minicomputer systems. Additional design work, data analysis and theoretical studies are done on the NMFECC Network. In some cases, use of the Computer Center may decrease as work is shifted to minicomputer systems and NMFECC.

Word processing for all of these programs is being handled with stand-alone word processing units (and the NMFECC).

KN 02 Institutional Relations

The Information Methodology Research Project (IMRP) conducts state-of-the-art research in several computer science fields including artificial intelligence, expert systems, continuous decision system modelling, fuzzy sets, information space graphics, and the management, construction and mapping of bibliographic and numerical/fact databases. The project utilizes many facets of the Computer Center in its work, including various FORTRAN processing facilities, data storage and manipulation devices, the ARPANET hookups, graphical processing packages, special device handlers, database management systems, and critical path management systems. Via ARPANET, the project also uses computing facilities at SRI and Argonne National Laboratory. In the past year IMRP has acquired several microprocessor-based intelligent terminals and many program operations are now done in a distributed multiprocessor environment.

IMRP will benefit from the Computer Center's planned improvements in the areas of interactive response time, implementation of UNIX document processing and program editing facilities, and increased graphical display device support. Additional improvements that would benefit this project include (1) implementation of block- or page-oriented communication to allow more efficient utilization of the microprocessor-based intelligent terminals and microcomputers; (2) acquisition of versatile, truly interactive database management software; and (3) implementation of a powerful interactive LISt Processng (LISP) capability to support transportability of artificial intelligence programs between BKY and the remainder of the artificial intelligence community.

Estimated computer usage is as follows:

	FY79	FY80	FY81
NSU:	11	30	53

E4. <u>ADP Capacity (NSU's)</u>. Schedule C lists the ADP capacity for LBL general purpose scientific computer systems. We chose to make no distinction between nominal, theoretical, and practical capacities for the existing 7600/6600/6400 system. The planned replacement of the CDC 6600 and CDC 6400 will cause a slight increase in capacity as the small interactive front-end computers (of the class of the DEC VAX-11/780) are acquired and the CDC 7600 support functions currently being accomplished by the 6000's are moved over to the new front-ends. The drop in capacity in FY83 is the result of the release of the CDC 6600. The remaining rise results from the continued planned acquisition of small interactive front-end computers.

<u>CSAM VAX</u>. The CSAM VAX was purchased to support research, development and demonstration projects. It is not intended to replace the use of the LBL Computer Center for batch production jobs, for which the Computer Center has much larger machines. Since the machine is for direct use by scientists, the practical capacity is limited to approximately 12 hours/day, 5 days/week. Thus the practical capacity is 60 hours/168 hours (35%) of the theoretical capacity = 190 NS's.

<u>LCB VAX</u>. The FY79 theoretical capacity is downrated from the DOE nominal rated capacity due to factors such as reduced disk and tape capacity and limited user memory. The theoretical capacity will increase in FY80 with the addition of floating point and some disk capacity. Since the LCB VAX configuration in FY79 is a development-only configuration, the practical capacity is estimated at less than 10% of theoretical capacity. Real time response requirements to network nodes and interactive response

requirements preclude utilization in FY80 above 50% of theoretical capacity. The increasing sophistication of biological and biophysical experimentation imply growing use of real-time and interactive computing technology within the Laboratory. As the amount and maturity of experimental support software grows, practical capacity will approach 50% of theoretical capacity; thus, growth is predicted in both theoretical and practical capacity over the period FY81-85, but growth in practical capacity will be greater.

PEP-4 VAX. The PEP-4 computer system's primary purpose is the real time control of data collection/filtering for the TPC detector. The theoretical capacity of the PDP-11/70 is not included because its practical capacity is zero due to its very limited configuration and the constant monitoring and diagnostic engineering functions it must perform for TPC. The theoretical capacity of the VAX-11/780 is downrated to a factor of .75 of the DOE nominal rated capacity due to reduced tape and disk capacity. The practical capacity of the VAX-11/780 will be limited by its use online to TPC and use for further development to support TPC online or for site considerations. This is computed as follows: 8760 hours per year (365 days x 24 hours) -2000 hours online per year -2000 hours development and site use/8760 x 800 = 435 NSU. The practical capacity figure for FY80 is based on a mid-FY80 startup of TPC.

MISCELLANEOUS. The continuing increase in cost effectiveness of small computers of the class of DEC's VAX-11/780 makes this class of computers increasingly available to solve particular programmatic requirements of various divisions of LBL. It is to be expected that one or two computers of this class may be acquired each year. For example, NRCC is planning to acquire one this year to enable them to make their general chemistry software operational on this class of computer and to provide a demonstration of a standard small chemistry computer which could be acquired by most university chemistry departments.

ADP CAPACITY (NSU's)

SITE Lawrence Berkeley Laboratory - LBL

SECTION E4 SCHEDULE C

UNIT/ SYSTEM NO.	ADP SYSTEM	PAST	CURRENT	BUDGET	PLAN	OUT-YEARS			
		FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
1701-04	CDC 7600/6600/6400, DEC 11/70, Plus Other Front Ends								
	Theoretical	13300	13500	14100	14500	14900	14600	15400	15800
	Practical	13300	13500	14100	14500	14900	14600	15400	15800
N.A.	CSAM DEC VAX*								
	Theoretical	528	528	528	528	528	528	528	528
	Practical	190	190	190	190	190	190	190	190
N.A.	LCB DEC VAX*								
	Theoretical		120	480	600	700	800	900	1000
	Practical		10	120	200	300	400	450	500
N.A.	PEP-4 DEC VAX*								
	Theoretical		-0-	800	800	800	800	800	800
	Practical		-0-	217.5	435	435	435	435	435
N.A.	Miscellaneous Small Computer Systems resulting from particular programmatic requirements**								
	Theoretical		400	600	600	800	800	1000	1000
	Practical		400	600	600	800	800	1000	1000
	TOTAL								
	Theoretical	13828	14548	16508	17028	17728	17528	18628	19128
	Practical	13490	14100	15227.5	15925	16625	16425	17475	17925

* See preceding page for explanation of difference between theoretical and practical capacity.

** See preceding page for description.

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ADP REQUIREMENTS (NSU'S)

SITE Lawrence Berkeley Laboratory - LBL

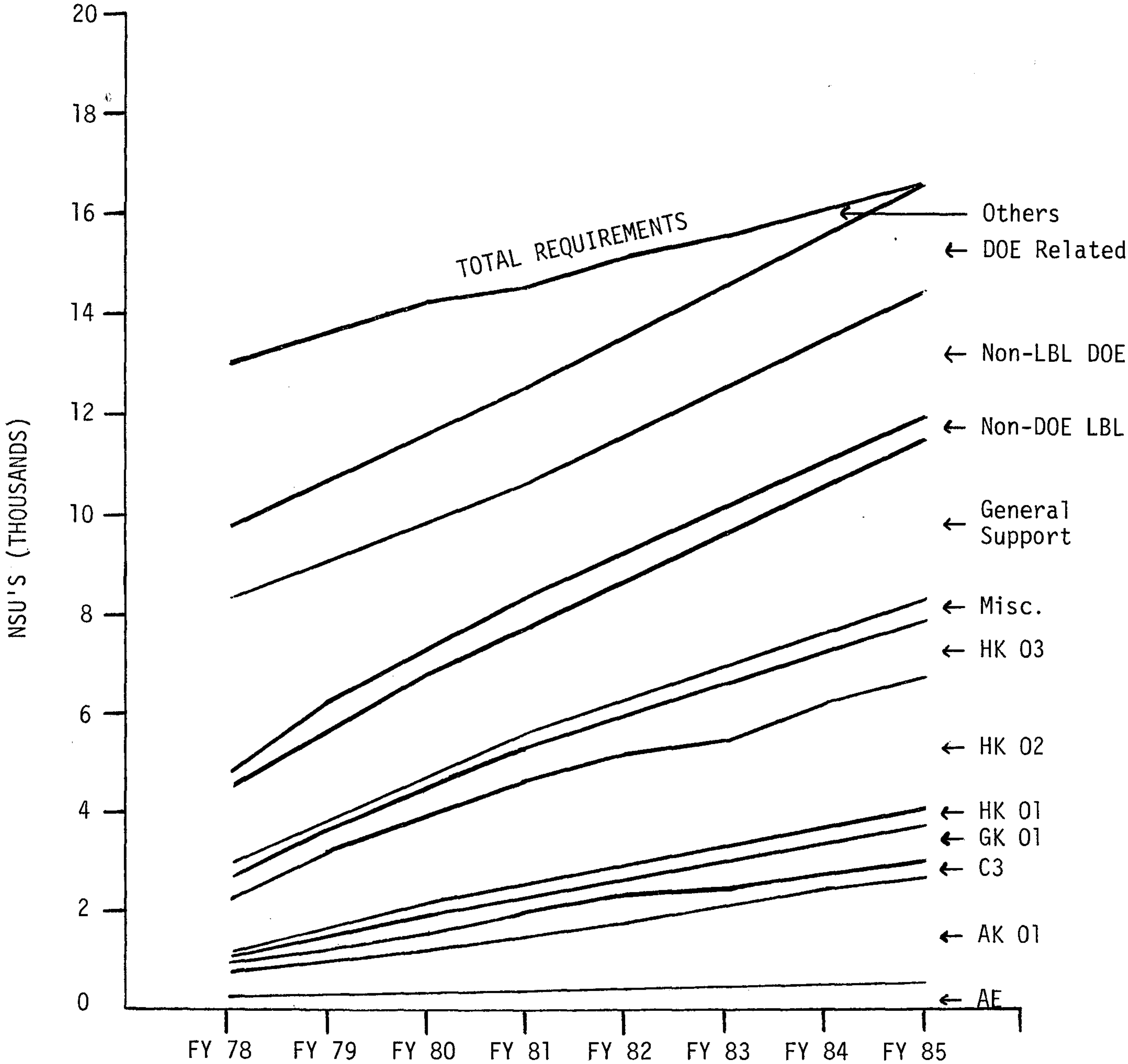
SECTION E5 SCHEDULE D

B&R CODE	PROGRAM	PAST	CURRENT	BUDGET	PLAN	OUT-YEARS			
		FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
AE	Geothermal ES/R&TD	261	300	325	350	375	380	390	400
AK 01	Basic Energy Sciences ES/R&TD	629	750	950	1200	1500	1750	2000	2250
C3	Commercial Conservation	147	300	500	500	400	300	300	300
GK 01	Environmental Res. & Dev.	139	280	300	400	500	600	700	800
HK 01	Life Sciences Research and Biomedical Applications (Basic Sciences)	84	175	200	225	240	250	260	270
HK 02	High Energy Physics (Basic Sciences)	980	1400	1700	2000	2200	2300	2500	2750
HK 03	Nuclear Physics (Basic Sciences)	435	500	550	600	800	1000	1100	1200
Misc.	C4, C8, AG04, AD, JF, Cl, AB, C5, AA, AF01, BD, AJ, KN02, KK	220	250	275	300	350	400	450	500
	General Support	1629	1825	2000	2200	2400	2600	2800	3000
	Non-DOE LBL*	350	400	450	500	500	500	500	500
	Non-LBL DOE*	3525	3000	2750	2500	2500	2500	2500	2500
	DOE Related*	1450	1600	1700	1800	1900	2000	2100	2200
	Others*	3155	3000	2500	2000	1500	1000	500	---
	Program Requirements	2895	3955	4800	5575	6365	6980	7700	8470
	General Support	1629	1825	2000	2200	2400	2600	2800	3000
	Reimbursables	8480	8000	7400	6800	6400	6000	5600	5200
	TOTAL	13004	13780	14200	14575	15165	15580	16100	16670

* See Schedule B for list of funding sources.

SECTION E5

GRAPH OF ADP REQUIREMENTS (NSU'S)



ADP SYSTEM RESOURCE SHARING (NSU'S AND COST)
(Dollars in Thousands)

SITE Lawrence Berkeley Laboratory - LBL

SECTION E6.1 SCHEDULE E
(Page 1 of 2)

PROGRAM B&R CODE	IDENTIFICATION OF SHARING PARTNER/TYPE OF SERVICE/ ADP SYSTEM	PAST	CURRENT	BUDGET	PLAN	OUT-YEARS			
		FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
	Resource Sharing Requirements								
HK 02	SLAC[1]	120	150	200	250	300	300	300	300
		(-0-)	(-0-)	(-0-)	(-0-)	(-0-)	(-0-)	(-0-)	(-0-)
Gen Supp	LLL[2]	318	350	380	420	460	500	550	600
		(120)	(130)	(145)	(160)	(175)	(190)	(205)	(225)
	Resource Sharing Commitments								
unknown	Richland, Washington[3]	678	550	450	475	475	475	500	500
		(457)	(370)	(300)	(325)	(325)	(325)	(350)	(350)
unknown	GE Sunnyvale[4]	462	500	500	500	500	500	500	500
		(334)	(360)	(360)	(360)	(360)	(360)	(360)	(360)
unknown	LLL[5]	221	250	275	300	325	350	375	400
		(185)	(200)	(225)	(250)	(275)	(300)	(325)	(350)
AF 01	MFECC[6]	720	---	---	---	---	---	---	---
		(176)							
HK 02 + some NSF	CalTech[7]	325	300	325	350	375	400	425	450
		(115)	(100)	(115)	(125)	(140)	(150)	(165)	(175)
unknown	University of California[8]	380	400	400	400	400	400	400	400
		(260)	(275)	(275)	(275)	(275)	(275)	(275)	(275)
HK 02 + NSF	Other universities[9]	100	125	200	300	325	350	375	400
		(75)	(90)	(150)	(175)	(240)	(260)	(280)	(300)
AK 01 + NSF	NRCC[10]	100	200	250	300	300	300	300	300
		(75)	(150)	(175)	(225)	(225)	(225)	(225)	(225)
unknown	Misc. DOE facilities[11]	477	500	500	500	500	500	500	500
		(355)	(375)	(375)	(375)	(375)	(375)	(375)	(375)
	EPRI[12]	672	800	1000	1000	1000	1000	1000	1000
		(395)	(545)	(650)	(650)	(650)	(650)	(650)	(650)
	Resource Sharing Availability								
	CDC 6400/6600/7600[13]		4000	4000	4000				

(SCHEDULE E CONT.)

ADP SYSTEM RESOURCE SHARING (NSU'S AND COST)

(Dollars in Thousands)

SITE Lawrence Berkeley Laboratory - LBL

SECTION E6.1 SCHEDULE E
(Page 2 of 2)

PROGRAM B&R CODE	IDENTIFICATION OF SHARING PARTNER/TYPE OF SERVICE/ ADP SYSTEM	PAST	CURRENT	BUDGET	PLAN	OUT-YEARS			
		FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985

(1) LBL use of SLAC IBM for high energy physics codes and work on shared projects.
(2) LBL administrative computing on LLL administrative computer for shared accounting, payroll, etc.

(3) Richland, Washington use of LBL's computers. Mostly Westinghouse Hanford's use of 7600 versions of nuclear codes.
(4) GE Sunnyvale Fast Breeder Reactor Division use of LBL 7600 versions of nuclear codes.
(5) LLL use of LBL's computing facilities for unclassified work which has difficulties being run at LLL because of a general overflow of work on their computers.
(6) MFECC use of LBL 7600 because of a general overflow of work on their computers.
(7) CalTech use of LBL computers to do their high energy physics work.
(8) University of California use of LBL computers to support research in energy related fields (DOE and NSF funded).
(9) Other universities use of LBL computers to support their high energy physics work (DOE and NSF funded).
(10) NRCC customers' use of LBL's computers in support of NRCC goals (DOE and NSF funded).
(11) Miscellaneous DOE facilities' use of LBL's large scale scientific computer. EG&G, SAN, Ames and Argonne are the most significant.
(12) Electric Power Research Institute use of LBL computers for funded research in support of DOE interested projects.

(13) Rate is $200-$1500/NSU depending on the priority of service requested.

ADP COMMERCIAL SERVICES (NSU'S AND COSTS)
(Dollars in Thousands)

SITE Lawrence Berkeley Laboratory - LBL

SECTION E6.2 SCHEDULE F

PROGRAM B&R CODE	IDENTIFICATION OF VENDOR/ TYPE OF SERVICE/ADP SYSTEM	PAST	CURRENT	BUDGET	PLAN	OUT-YEARS			
		FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
General Support	CDC PLATO Services	12.6	---	---	---	---	---	---	---
General Support	Bolt Baranek Newman (Computer Network Teleconferencing)	33.8	45.0	50.0	55.0	---	---	---	---
General Support	NCSS (Nomad Personnel System)	---	---	25.0	45.0	50.0	55.0	60.0	65.0

PLANNED ACQUISITIONS
(In Priority Sequence By Fiscal Year)

SITE Lawrence Berkeley Laboratory - LBL

SECTION E7 SCHEDULE G

FISCAL YEAR	BRIEF DESCRIPTION OF PROPOSED ACQUISITION	RESPONSIBLE HEADQUARTERS PROGRAM	METHOD OF ACQUISITION	MILESTONE DATES (MONTH/YEAR)			
				IMPLEMENTATION PLAN	SOLICITATION DOCUMENT	CONTRACT AWARD	INSTALLATION
	DOES NOT APPLY: No MIE's planned.						

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ADP RELATED ITEMS

SITE Lawrence Berkeley Laboratory - LBL

SECTION E8 SCHEDULE H

DESCRIPTION OF ITEM	COST BY FISCAL YEAR	TYPE OF FUNDS REQUIRED	PROGRAM B&R CODE	RELATIONSHIP TO PROPOSED ADP ACQUISITION
DOES NOT APPLY: None planned.				

ADPE SYSTEM REUTILIZATION OPPORTUNITIES

SITE Lawrence Berkeley Laboratory - LBL

SECTION E9 SCHEDULE J

UNIT/ SYSTEM NO.	ADP SYSTEM/MAJOR SUBSYSTEM	ESTIMATED RELEASE DATE	COMMENTS
1701-04	CDC 607 Tape System 11 drives 2 controllers (owned)	4Q79	None
1701-04	CDC 659 Tape System 6 drives 1 controller (owned)	4Q79	None
1701-04	CDC 7638 Disk System 2 817 disk drives and 2 7638 disk controllers (owned)	4Q81	Replacement system installed successfully
1701-04	CDC 6600 (owned)	4Q82	Assumes collection of smaller front ends successfully off loads all of the 7600 support functions of the 6600
1701-04	CDC 6400	4Q84	Assumes collection of smaller front ends successfully off loads all of the 7600 support functions of the 6400
1701-04	IBM 1360 Photodigital Store (owned)	1Q80	None (Maintenance is being discontinued by IBM)

CAPITAL ADP ACQUISITION FUNDS
(DOLLARS IN THOUSANDS)

SITE Lawrence Berkeley Laboratory - LBL

SECTION E10.1 SCHEDULE K

B&R CODE	PROGRAM/ITEM IDENTIFICATION	PAST	CURRENT	BUDGET	PLAN	OUT-YEARS			
		FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
HK 03	Nuclear Physics (Basic Sciences)	500	325	400	800	875	900	950	500

OPERATING EXPENSE ADP FUNDS
LEASE AND MAINTENANCE OF ADP SYSTEMS INSTALLED AND PLANNED
(DOLLARS IN THOUSANDS)

SITE Lawrence Berkeley Laboratory - LBL

SECTION E10.2 SCHEDULE L

(Major Items of Equipment Only)

B&R CODE	PROGRAM/ITEM IDENTIFICATION	PAST	CURRENT	BUDGET	PLAN	OUT-YEARS			
		FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
	Multiple Programs								
(1)	CDC 6000/7000 (maintenance only)	576.	578.	609.	637.	652.	685.	719.	755.
(1)	IBM (Mass Storage System) (maintenance only)	120.	47.	---	---	---	---	---	---
(1)	CDC 6614/15 Memory Increment								
	Lease	93.	93.	70.					
	Maintenance	29.	29.	31.	33.	36.	38.	42.	45.

(1) Pro-rated across all programs computing at LBL.

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CONSTRUCTION PROJECT ADP ACQUISITION FUNDS
(DOLLARS IN THOUSANDS)

SITE Lawrence Berkeley Laboratory - LBL

SECTION E10.3 SCHEDULE M

B&R CODE	PROGRAM/ITEM IDENTIFICATION	PAST	CURRENT	BUDGET	PLAN	OUT-YEARS			
		FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
	DOES NOT APPLY: None planned.								

FY 1978 MAJOR COMPUTER CENTER OPERATING COSTS AND REVENUES
(DOLLARS IN THOUSANDS)

SITE Lawrence Berkeley Laboratory - LBL

SECTION E11.1 SCHEDULE N

COST CATEGORIES	IN-HOUSE COSTS				CONTRACTED COSTS				TOTAL COSTS			
	(1) Application Software	(2) Systems Software	(3) Production Operations	(4) Sub Total	(5) Application Software	(6) Systems Software	(7) Production Operations	(8) Sub Total	(9) Application Software	(10) Systems Software	(11) Production Operations	(12) Grand Total
DIRECT LABOR/FRINGE BENEFITS (1)	1861.	459.	2003.	4323.	N.A.	N.A.	N.A.	N.A.	1861.	459.	2003.	4323.
ADP EQUIPMENT DEPRECIATION	432.	113.	461.	1006.	N.A.	N.A.	N.A.	N.A.	432.	113.	461.	1006.
ADP EQUIPMENT LEASE	N.A.	N.A.	N.A.	N.A.	149.	38.	160.	347.	149.	38.	160.	347.
• OEM	N.A.	N.A.	N.A.	N.A.	145.	37.	155.	337.	145.	37.	155.	337.
• THIRD PARTY	N.A.	N.A.	N.A.	N.A.	4.	1.	5.	10.	4.	1.	5.	10.
ADP EQUIPMENT MAINTENANCE	60.	15.	65.	140.	359.	92.	385.	836.	419.	107.	450.	976.
• OEM	N.A.	N.A.	N.A.	N.A.	352.	90.	376.	818.	352.	90.	376.	818.
• THIRD PARTY	N.A.	N.A.	N.A.	N.A.	8.	2.	8.	18.	8.	2.	8.	18.
• IN-HOUSE	60.	15.	65.	140.	N.A.	N.A.	N.A.	N.A.	60.	15.	65.	140.
ADP SERVICES	-0-	-0-	-0-	-0-	-0-	76.	-0-	76.	-0-	76.	-0-	76.
SPACE	43.	11.	47.	101.	N.A.	N.A.	N.A.	N.A.	43.	11.	47.	101.
TELECOMMUNICATIONS	29.	8.	31.	68.	95.	24.	101.	220.	124.	32.	132.	288.
OTHER OPERATING EXPENSES	395.	101.	422.	918.	132.	34.	141.	307.	527.	135.	563.	1225.
ALLOCATED EXPENSES (2)	1261.	322.	1349.	2932.	-0-	-0-	-0-	-0-	1261.	322.	1349.	2932.
TOTAL COSTS	4081.	1029.	4378.	9488.	735.	264.	787.	1786.	4816.	1293.	5165.	11274.
REVENUES FROM NON-DOE SOURCES	1238.	309.	1341.	2888.	240.	69.	241.	550.	1478.	378.	1582.	3438.

(1) In-house ratios of manpower used às percentage to distribute all other expense categories (except ADP services) across applications software, systems software and production operations.

(2) LBL general overhead.

FIXED VS. VARIABLE COST RELATIONSHIPS AND
OPERATING EXPENDITURE PROJECTIONS BY PROGRAM
(DOLLARS IN THOUSANDS)

SITE Lawrence Berkeley Laboratory - LBL

SECTION E11.2 SCHEDULE P

B&R CODE	PROGRAM	PAST	CURRENT	BUDGET	PLAN	OUT-YEARS			
		FY 1978	FY 1979	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
N.A.	PERCENT OF PROJECTED OPERATING COSTS THAT ARE FIXED	N.A.	99	94	91	88	90	84	81
N.A.	PERCENT OF PROJECTED OPERATING COSTS THAT ARE VARIABLE	N.A.	1	6	9	12	10	16	19
AE	Geothermal ES/R&TD	176	201	219	242	271	269	291	305
AK 01	Basic Energy Sciences ES/R&TD	421	492	637	828	1072	1257	1505	1714
C3	Commercial Conservation	97	201	333	343	282	213	231	229-
GK 01	Environmental Res. & Dev.	97	182	200	273	357	438	534	609+
HK 01	Life Sciences Research and Biomedical Applications (Basic Sciences)	61	118	133	162	173	180	194	203
HK 02	High Energy Physics (Basic Sciences)	659	930	1141	1383	1570	1661	1881	2095
HK 03	Nuclear Physics (Basic Sciences)	299	328	371	414	574	718	825	914
Misc.	C4, C8, AG04, AD, JF, C1, AB, C5, AA, AF01, BD, AJ, KN02, KK	149	164	181	212	249	292	340	381
	General Support	1098	1204	1341	1525	1711	1874	2111	2285+
	Non-DOE LBL*	237	264	295	343	357	359	376	381
	Non-LBL DOE*	2380	1988	1846	1738	1788	1808	1881	1905-
	DOE Related*	975	1058	1142	1252	1354	1437	1590	1676
	Others*	2134	1988	1674	1383	1072	718	376	---
	TOTAL	8783	9118	9513	10098	10830	11224	12135	12697

* See Schedule B for list of funding sources.

SCHEDULE P - NARRATIVE STATEMENT

Fixed vs. Variable Costs

Fixed versus variable cost estimates were derived by flagging fiscal 1978 as the base year and (per NSU capabilities in Schedule C) varying costs directly with variances in NSU capacities over the years.

The rationale for this method stemmed from the fact that our total manpower and related expenses are expected to remain constant regardless of shifts in programmatic utilization of the central Computer Center and the further conclusion that no reasonable corollary could be arrived at linking slight variances in demand with a corresponding variance in costs; i.e., marginal costs per incremental computing unit yielded no identifiable "fixed" versus "variable" cost.

OUT–YEAR EXPENDITURES FOR PLANNED ACQUISITIONS
(DOLLARS IN THOUSANDS)

SITE Lawrence Berkeley Laboratory - LBL

SECTION 11.3 SCHEDULE Q

PLANNED ACQUISITIONS ≥ $1 MILLION	PLAN	OUT–YEARS			
	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985
DOES NOT APPLY: No MIE's of value ≥ $1 million planned.					

E11.4 Cost Recovery Algorithm

See attached Computer Center Rate Schedule.

E12. Justifications

No MIE's planned for this time period.

E13. General Comments/Critical Issues

None

E14. Summary

E14.1 Deficiencies

The principal deficiencies in the central computing facility are outlined in Section B: inadequate interactive capacity and capability; inadequate and unreliable mass storage systems; inadequate and unreliable disk systems; and senescent equipment. They are discussed here in more detail.

a) Inadequate interactive capacity and capability

Interactive capacity is measured in terms of the number of simultaneous users the system will support with reasonable response. This in turn is primarily a function of the number of programs which can reside in main memory at one time, plus the swapping time required to bring a program into main memory from secondary memory. (It is to a much lesser extent also a function of CPU capacity.) Many interactive systems utilize a technique known as "paging" to break a job up into small pieces, only a few of which need to be in core at one time. By making the effective job size smaller, they thus increase the capacity of the system in two ways: more jobs can fit into memory at once, and the swapping time (which depends upon the size of jobs to be moved) is decreased.

The computers in use at LBL (CDC 6000 series) do not support paging. As a consequence, the number of jobs which will fit into memory at once is relatively small. Furthermore, these machines are not dedicated to interactive work but are also required to perform many jobs in support of the Center's principal computer, the 7600: jobs which take their toll on the total memory and system table space available. The net result of these various limiting factors is an effective capacity of 40-50 simultaneous users. That this is insufficient for current demand is evidenced by the existence of a "log-on queue" (composed of users who have requested interactive access when the system is too full to accept any more jobs) throughout normal working hours. Queue length averages about 5 or 6 (see Figure LBL-8).

Interactive capability is a function of kinds of work the interactive system will allow the user to do in a reasonably straightforward, timely, and cost-effective manner. Capabilities which are lacking or deficient in the LBL interactive system include the following:

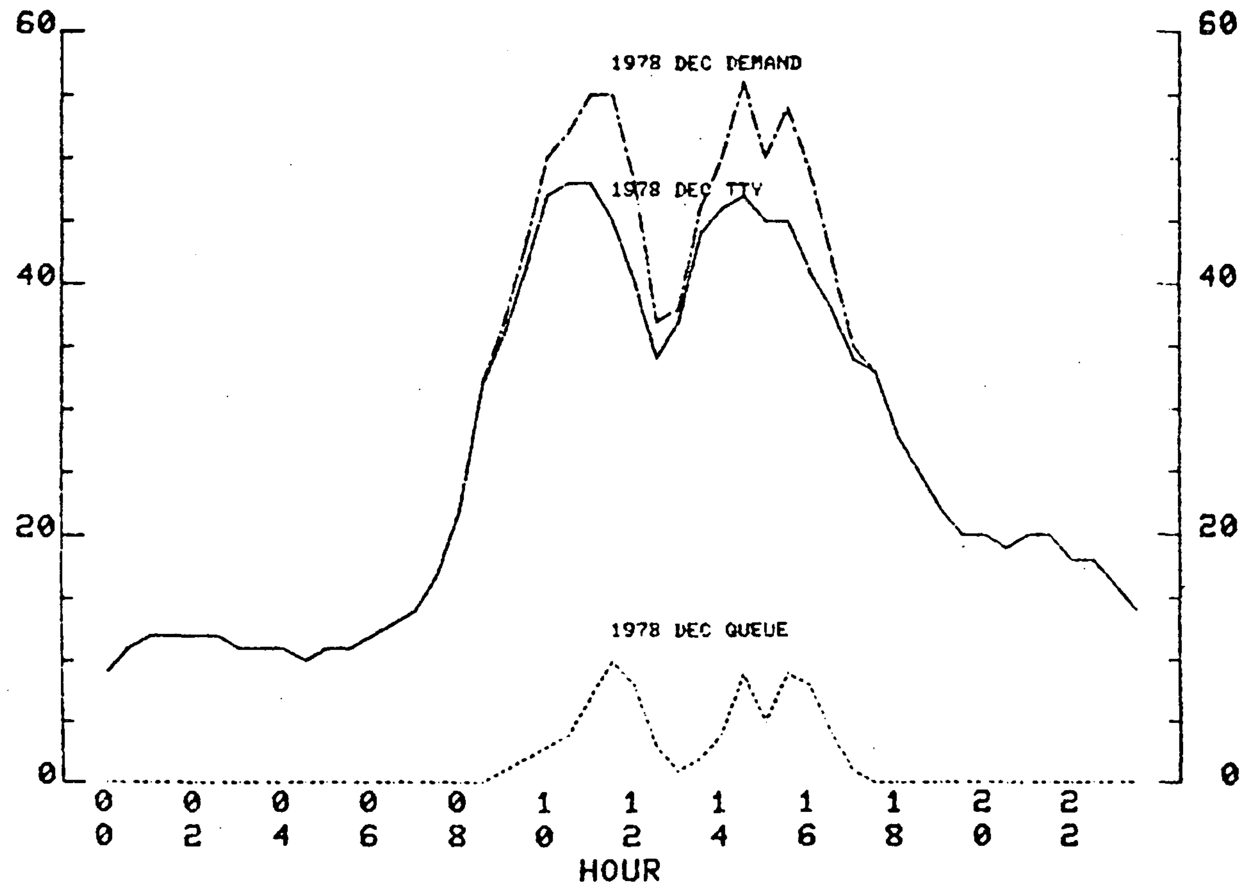
- generalized interactive graphics
- any work requiring large amounts of memory or disk space
- support for upper- and lower-case ASCII
- convenient facilities for saving work files
- interactive debugging aids
- a "HELP", or prompting, facility
- facilities for creating, maintaining and using procedure libraries

Figure LBL-8

LBL COMPUTER CENTER
PERFORMANCE MEASURES

INTERACTIVE CONNECTIONS AND UNSATISFIED DEMAND
6600 AND 6400 COMPUTERS

DECEMBER 1978 WORKDAYS



b) Inadequate and unreliable mass storage systems

LBL's present mass storage systems, MSS and PSS, are based upon obsolete IBM devices: a model 1360 photodigital store (MSS) and a number of 2321 data cells (PSS). These devices exhibit the following deficiencies:

(i) The photodigital store is a read-only device which will not be maintained by the manufacturer beyond 1979.

(ii) The photodigital store is connected to only one of the two front-end machines.

(iii) Demand for data cell space exceeds supply by 50-100%.

(iv) IBM has announced a cut-off date for maintenance (1982) on the data cells.

(v) The data cell system breaks down every three days, and requires several hours to repair. (Each breakdown requires some users to reconstruct a portion of their data.)

(vi) Disk limitations require the use of the data cells as interactive file storage devices; their access time (500 ms) is much too slow for this purpose.

c) Inadequate and unreliable disk systems

The two front-end machines share 1100 MB of disk storage, none of which, for software reasons, is removable. This supports the input and output queues for the whole complex, all files associated with active jobs, and a rudimentary permanent file system. Demand for disk space is so high that "permanent" file residence time averages two days. There is thus no possibility of using the existing disks as interactive file storage devices.

A second restriction which limits the usefulness of the front-end disk system is a job-oriented disk space limit of about 25 MB. This has occasioned the partitioning of jobs in the past, and is this year necessitating the acquisition of a private disk by a project (Particle Data Group in High-Energy Physics, HK02) which absolutely cannot live within the limit.

The principal disk system on the 7600 is a pair of 7638 disks, also containing about 1100 MB of storage. These disks, while not as overloaded as those on the 6000's, share the same problems: inadequate capacity as evidenced by occasional "disk full" situations, and a disk space limit which, while large (about 190 MB) is still too small for some of the jobs which use this machine.

In addition, these disks (the 7638's) are aging. They fail several times a month, with the average down time exceeding 6 hours per failure. (The loss of either disk causes a 30% degredation in the performance of the 7600.) Furthermore, their maintenance future is quite doubtful: they are the last remaining 7638's in active service in the US.

d) Senescent equipment

Various aspects of this problem have been alluded to above. The situation is summed up in Figure LBL-9, which shows all of the major elements of the central computing facility. These items range in age from 7 to 12 years. None of them is still being manufactured. All of them are expensive to maintain. As has already been noted, the maintenance future of some pieces ranges from non-existent to dim. All of them are showing increasing signs of the brittleness of age: they are easily broken and slow to mend. Major breakdowns average more than one a day and require an average of three hours to fix; if we except the 7600, the averages are one breakdown every two days requiring four-and-a-half hours to fix.

Figure LBL-9

SENESCENT EQUIPMENT: NATURE OF THE PROBLEM

	FIRST INSTALLED	MONTHLY MAINT.	BREAKDOWNS AND HOURS LOST (PER MONTH)	
CHIPSTORE READER	1968	2.7K$	5.7	46.5 *
7638'S	1971	3.3	3.0	19.9
DATA CELLS	1967/8	6.1	9.7	39.9
6000'S	1967/71	23.6	3.3	10.4
7600	1971	20.4	14.9	16.4
		56.1K$/MO	36.6	

* THIS FIGURE IS INFLATED SINCE THE CHIPSTORE IS SOMETIMES LEFT DOWN UNTIL THE NEXT SCHEDULED PM PERIOD. IT IS NOT USED IN CALCULATING THE MEAN-TIMES-TO-REPAIR GIVEN IN THE TEXT.

E14.2. Goals/Objectives

a) Interactive computing

The most urgent goal is to eliminate the log-on queue, so that users can access the system at the times most convenient for them. We project that, by 1985, the central facility alone will require a minimum capacity of 200 simultaneous users.

The secondary principal goal is the provision of a complete and modern set of interactive utilities, with particular emphasis on program development tools, user assistance aids, and text-processing utilities.

b) Mass storage

There is only one reasonable goal: replacement of the photodigital store and data cells as quickly as possible with a mass storage system allowing quick multiple and random access with archival capacity, longevity, and reliability.

c) Disk systems

First, capacity on the front-end systems must be at least doubled. Second, a reliable successor to the 7638 system on the 7600 must be found. (Some expansion of capacity here is also necessary, but it is not as crucial as simple replacement with reliable devices.)

d) Senescent equipment

Again, the only thing which makes sense is to replace that equipment which no longer functions reliably or in a cost-effective manner.

E14.3. Strategy

a) Interactive computing

There is a great deal of evidence which suggests that for today's architectures and a general-purpose scientific workload like LBL's one can expect reasonable support for 30-40 simultaneous users per front-end machine. This number appears moreover to be relatively independent of the raw power of the front end.

LBL possesses relatively powerful front ends, but only two of them. To achieve our goal of approximately 200 simultaneous users for the central facility we need to think in terms of five front-end machines. We do not expect our need for front-end CPU power to grow nearly as rapidly as our need for interactive capacity. Therefore our proposal is to replace the two 6000 machines in an incremental fashion by 4-6 smaller machines, with an aggregate CPU power of perhaps two 6600's. (Potential candidates for these front-end machines include the VAX-11/780 and PRIME 750.)

The first steps in this proposed scenario have already been taken: the Laboratory has acquired a Hyperchannel high-speed link (which will simplify the potential interconnectivity problems implicit in a multi-computer complex), a many-way switch (which allows any connected terminal to have convenient access to any of several systems), and a small front-end computer which is to be dedicated to text-processing applications. The next step, in FY80, will be the lease of a prototype replacement front-end.

Lease is necessary to ensure that we can successfully transfer all of the functions supported by the 6000 machines--not merely the interactive ones--to the new series.

Once we have verified that the new series has the requisite capabilities, we will undertake incremental acquisition of the appropriate number of the new machines, over a three-to-four-year period, FY81-FY84. We would expect to release one of the 6000's about midway through this period, and the other shortly after installation of the final machine of the new series.

We also expect this series of acquisitions to provide the long-term solution to the problem of inadequate interactive capability: one of the fundamental selection criteria will be the existence of a large repertoire of user-oriented facilities.

This approach also yields, as a side benefit, a significant increase in reliability and stability: each single component will be a smaller portion of the whole than is now the case. Individual failures will occur less frequently (because of more reliable design) and will impact the users to a lesser degree.

b) Mass storage

At the present time there does not exist a commercially available device which possesses all of the attributes required of our mass storage system, although a number of possible devices appear to be in the advanced design or prototype stages. Nevertheless, the imminent departure of the photodigital store and the unsatisfactory performance of the data cells make their replacement necessary. This replacement, by relatively conventional devices, has thus already begun.

In the case of the photodigital store we have selected 6250 BPI tape as a suitable medium: it is available in quantity, is reliable, and is expected to remain one of the standards of the industry for 10-20 years. In order to simplify and expedite handling, we have also acquired an Automatic Tape Library (ATL) capable of storing more than 2000 reels. We thus have a device with acceptable capacity and multiple access, but with less than desirable speed, and very poor random access capability. These defects can, for a time, be mitigated by fronting the ATL with a disk farm, but this remains a less than satisfactory solution for programs requiring dynamic access to very large data bases.

In the case of the data cells, which are used for frequently accessed and relatively volatile data, we have selected disk as a suitable interim medium. Recently announced high-capacity disks can be leased at less than the maintenance cost of comparable data cell capacity. They are also faster than the data cells, but somewhat more vulnerable to accidental destruction of user data. (For this latter reason they are not considered acceptable as a permanent replacement for the data cell system.)

Our plan is then to make do with these interim solutions until a suitable device appears on on the market. At this time we cannot say with certainty whether or not the forthcoming devices will be able to stand alone or will need continued higher-speed buffering, and whether or not disks will be suitable buffers. We can say that the likelihood is high that an acceptable mass storage device will appear within the time span covered by this Long Range Plan. It also seems reasonable to assume that a reasonable first increment will cost less than $1 million; for this reason no mass store acquisition appears in the plan.

c) Disk systems

For the short term the strategy is simple: add more capacity to the front-end system and replace the 7638 system. In the case of the front-end system, moreover, our analysis indicates that the increased capacity will be more fruitful if associated with the ATL (as a high-speed, random access buffer memory) than if simply added to the general-purpose disk store. Workload patterns at LBL are changing, a result both of the change in mass storage devices and of the changes in the mission of the Laboratory which are now in progress. It is therefore not yet clear that the FY79 addition of 1200 MB to the front-end disk capacity will solve the space-limitation problem.

Another factor in our disk planning is the possibility that the underlying front-end system will change during the lifetime of any newly-acquired disk system. For this reason we intend to limit our consideration to IBM plug-compatible disks: they can be supported by many different brands of front-end.

The 7638 replacement is expected to entail significantly more software support than is the case for the front-end expansion. For this reason we have adopted a phased introduction of the replacement devices, extending over several years (beginning in FY79). Since we do not anticipate early replacement of the 7600, this system may be either CDC- or IBM-compatible.

d) Senescent equipment

The execution of the plans already described will accomplish the replacement of the oldest and most brittle equipment: the data cells, 7638's, chipstore, and 6000 machines. Of the items listed on Figure LBL-9 there thus remains only the 7600. At this time there seems to be, other than its rather large maintenance burden, no compelling reason to replace the 7600: its reliability is marginal, but acceptable so long as it gets no worse. Furthermore, there is no clear programmatic need to consider the acquisition of a more powerful principal computer within the time scale of this Long Range Plan. We therefore have no plans for the replacement of this machine.

E15. Points of Contact

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ATTACHMENT ATTACHMENT

LAWRENCE BERKELEY LABORATORY
COMPUTER CENTER RATE SCHEDULE

October 1, 1978

(1) *Rates* *$0.0475 per Accounting Unit (AU) + LBL Overhead*

Note: *This approximates $250 per hour for the CDC 6600 or $1000 per hour for the CDC 7600. There is no exact hourly rate available, but for estimation purposes these rates approximate charges made by a typical job's use of the facilities.*

(2) *Accounting Algorithm*

(a) *Accounting Units (AUs)*

*AUs = p*CU+J on weekdays*

= 0.5 ((P*CU)+J) on weekends and holidays*

where P = 2.0 for rush jobs
1.0 for normal jobs
0.75 for deferred jobs on weekdays
0.5 for deferred jobs on weekends or holidays

J = 10 for CDC 7600 job and 2 for CDC 6600 job

(b) *Computing Units (CUs)*

7600 CUs = 3(CP+SS)+0.5*BLD + ITO + STAGING*
*6000 CUs = (M*CP+20*KMR)*(1+CM/32768)+(10*MT)+TTY*

where CP = CPU time in seconds used by the job
SS = CPU time for 7600 jobs' systems tasks
BLD = LCM buffer loads
ITO = Interference to others factor
*= (4*MAX(1.2*CP, BLD/3) - (3*CP+BLD/2)) * LCM/400000*$_{10}$
LCM = instantaneous LCM field length
MAX = algebraic maximum
STAGING = staging job's CUs on the 6000 computers
M = 0.7 for 6600, 0.4 for 6400
KMR = number of monitor requests for system services (in thousands)
CM = instantaneous field length
MT = number of magnetic tapes hung
TTY = teletype CUs if a teletype is connected to the job:

midnight to 6 AM:	0.25	CU/connect minute
6 AM to 10 AM:	0.50	"
10 AM to 6 PM:	1.00	"
6 PM to midnight:	0.50	"

(3) *Supplies and Handling Charges*

0.10 AU per printed page
0.05 AU per punch card
5.00 AU per 105mm fiche
0.20 AU per 35mm frame
0.10 AU per 16mm frame

1.00 AU per 20 inches of Calcomp plot paper or per 1 minute of plotting time

5.00 AUs per queued output file processed on weekdays
2.50 AUs per queued output file processed on weekends or holidays

(4) *Remote Use Charges*

Line Capacity	*Dial Up Line (Bell System)*	*Dedicated Line*
2000 baud	3.50/hr + LBL overhead	$150/month + LBL overhead
4800 baud	5.00/hr + LBL overhead	200/month + LBL overhead
7200 baud	not available	275/month + LBL overhead
9600 baud	not available	300/month + LBL overhead

(5) *LBL Overhead*

Charges described above are all subject to the current Laboratory overhead charge. This is estimated at 40½% for the fiscal year ending 9/30/79 but is subject to monthly fluctuations.

(6) *Full-Cost Recovery Including Depreciation and DOE-Added Factor*

The recent Comptroller General's decision, B-136318 (1-21-77), requires services rendered under the Economy Act be reimbursed on the basis of actual cost plus all significant indirect costs. Under this policy, the Laboratory must charge other federally-funded users at the DOE full-cost recovery rate including depreciation and the DOE-added factor unless the work qualifies as DOE-related and an exception is approved. Depreciation and the added factor will add approximately 12% to all applicable costs outlined above.

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TPH

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