SECTION I

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

APPLICATION FOR RESEARCH GRANT

007

LEAVE BLANK (For PHS Office Use Only)		
TYPE: 1	PROGRAM: P07	NUMBER: FR 00311-01
REVIEW GROUP: COM		FORMERLY:
COUNCIL (Month, Year): Mar. 66		DATE RECEIVED: 10/4/65
APPLICANT CODE:		D CODE:

TO BE COMPLETED BY PRINCIPAL INVESTIGATOR *(Items 1 through 9 and 17A)*

1. ABBREVIATED TITLE OF RESEARCH PROPOSAL *(Do not exceed 53 typewriter spaces)*
Advanced Computer for Medical Research

2. TYPE OF APPLICATION (Check one)
XXX NEW PROJECT
☐ RENEWAL OF PHS GRANT NO.________
☐ REVISION OF PHS APPLICATION NO.________
☐ SUPPLEMENT TO PHS GRANT NO.________

3. DATES OF ENTIRE PROPOSED PROJECT PERIOD *(This application)*
FROM: April 1, 1966
THROUGH: March 31, 1971

4. TOTAL AMOUNT REQUESTED FOR PERIOD IN ITEM 3
$2,763,407

5. AMOUNT REQUESTED FOR FIRST 12-MONTH PERIOD
$522,334

6A. NAME OF PRINCIPAL INVESTIGATOR (Last, First, Initial)
Lederberg, Joshua

B. DEGREE: Ph.D.

C. SOCIAL SECURITY NO.: [redacted]

D. TELEPHONE DATA
Area Code: 415
Telephone Number: 321-1200 Ext. 5049

E. TITLE OF POSITION
Chairman, Computer Policy Committee

F. DEPARTMENT, SERVICE, LABORATORY OR EQUIVALENT *(See Instructions)*
Stanford University School of Medicine

G. MAJOR SUBDIVISION *(See Instructions)*
Stanford University School of Medicine

H. MAILING ADDRESS OF PRINCIPAL INVESTIGATOR (Street, City, State, Zip Code)
Department of Genetics
Stanford University School of Medicine
Palo Alto, California 94304

7A. IDENTIFY ORGANIZATIONAL COMPONENT RESPONSIBLE FOR CONDUCT OF SCIENTIFIC ASPECTS OF PROJECT
School of Medicine

B. DEPARTMENT
School of Medicine

8. ADDRESS WHERE RESEARCH WILL BE CONDUCTED (if same as Item 6H, check box) ☐
Stanford University School of Medicine
Palo Alto, California 94304

9. ARE FEDERAL FACILITIES TO BE USED FOR THIS RESEARCH?
XXX NO ☐ YES ________% OF TIME

TO BE COMPLETED BY RESPONSIBLE ADMINISTRATIVE AUTHORITY *(Items 10 through 15 and 17B)*

10. APPLICANT ORGANIZATION (Name and Address-Street, City, State, Zip Code) *(See Instructions)*
Stanford University
Stanford, California 94305

11. NAME, TITLE AND ADDRESS OF OFFICIAL TO WHOM CHECKS SHOULD BE MAILED
Mr. K. C. Creighton, Controller
Encina Hall, Stanford University
Stanford, California

12. TYPE OF ORGANIZATION (Check applicable item) ☐ INDIVIDUAL
PUBLIC INSTITUTION: ☐ FEDERAL ☐ STATE ☐ LOCAL ☐ OTHER
PRIVATE INSTITUTION: XXX NONPROFIT, ☐ PROFIT

13. NAME AND TITLE OF OFFICIAL SIGNING FOR APPLICANT ORGANIZATION
Dr. Robert M. Rosenzweig
Associate, Graduate Division

14. PHS ACCOUNT NUMBER (Enter if known)
458210

15. ESTABLISHED PHS INDIRECT COST RATE (Enter if known)
________%

16. **TERMS AND CONDITIONS.** The undersigned accept, as to any grant awarded, the obligation to comply with Public Health Service Research Project Grant Regulations in effect at the time of the award (42 CFR, Part 52), the terms and conditions in the Grants for Research Projects Policy Statement, and the undersigned agree to comply with Title VI of the Civil Rights Act of 1964 (P.L. 88-352), and the Regulation issued pursuant thereto and state that our formally filed Assurance of Compliance with such Regulation (Form HEW-441) applies to this project. The undersigned also certify that they have no commitments or obligations, including those with respect to inventions, inconsistent with compliance with such Regulations, the Manual, and the Act.

17. SIGNATURES *(Use ink. "Per" signatures not acceptable)*
A. SIGNATURE OF PERSON NAMED IN ITEM 6A — DATE: 9/29/65
B. SIGNATURE OF PERSON NAMED IN ITEM 13 — DATE: 9/30/65

PHS-398 (REV. 1-65)
(All previous editions obsolete)

Form Approved
Budget Bureau No. 68-R249

SECTION 1

NOT FOR PUBLICATION OR PUBLICATION REFERENCE.

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

RESEARCH OBJECTIVES

LEAVE BLANK - (For office use only)
SIE PROJECT NUMBER

ABBREVIATED TITLE OF PROJECT

Advanced Computer for Medical Research

NAME, SOCIAL SECURITY NUMBER, OFFICIAL TITLE AND DEPARTMENT OF ALL PROFESSIONAL PERSONNEL ENGAGED ON PROJECT

Computer Policy Committee: (Joshua Lederberg, Chairman)

Dr. Lincoln Moses	Professor, Depts. of Preventive Medicine & Statis/tics.
Dr. John W. Bellville	Professor, Dept. of Anesthesia
Dr. Lubert Stryer	Assistant Professor, Dept. of Biochemistry
Dr. Keith Killam	Associate Professor, Dept. of Pharmacology
Dr. Frank Morrell	Professor, Department of Medicine, Div. of Neuro/logy
Dr. Edward Feigenbaum	Assoc. Professor, Director, Stanford Computation Center
Dr. Joshua Lederberg	Professor, Dept. of Genetics

NAME AND ADDRESS OF APPLICANT ORGANIZATION

Stanford University
Stanford, California

USE THIS SPACE TO MAKE A BROAD STATEMENT OF YOUR RESEARCH OBJECTIVES

A special research resource to support health research at Stanford University School of Medicine. The computer and its supporting staff are intended to complement the services available from the University Computation Center. A variety of data-oriented services will be offered on a [redacted]ystem. Facilities for scheduled operation with high data-rate [redacted] and for high-priority access in developing clinical research uses. Applications range from data analysis in biochemical analytical instrumentation to multiple channel electroencephalography.

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FR 00311-01

SECTION II - PRIVILEGED COMMUNICATION

4. DETAILED BUDGET FOR FIRST 12-MONTH PERIOD (DIRECT COSTS ONLY)	FROM April 1, 1966	THROUGH March 31, 1967

DESCRIPTION (Itemize)			AMOUNT REQUESTED (Omit Cents)		
PERSONNEL NAME	TITLE OF POSITION	TIME OR EFFORT %/HRS.	SALARY	FRINGE BENEFITS	TOTAL
See attached sheet for detail in all categories					
Total Personnel					172,334
CONSULTANT SERVICES					
EQUIPMENT Computer IBM/360-50/1800 lease					225,000
I/O writers, data lines, interfacing, etc.					30,000
Analog tape reproducer					25,000
SUPPLIES					20,000(RG)
TRAVEL DOMESTIC					2,000
TRAVEL FOREIGN					
HOSPITALIZATION (Study patients)					
OUTPATIENT OR SUBJECT COSTS (Study patients)					
ALTERATIONS AND RENOVATIONS					30,000
PUBLICATION COSTS Program documentation and technical reports					8,000
ALL OTHER EXPENSES Communications (including data/phone or TWX					10,000
TOTAL (Enter on Page 1, Item 5) →					$ 522,334

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PHS-398 (REV. 1-65)

Enc. 1

ADVANCED COMPUTER FOR MEDICAL RESEARCH

Stanford University

This proposal is submitted on behalf of Stanford University School of Medicine with the aim of furnishing a computation facility that can match the other dimensions of research capabilities and facilities of the school.

The sequence of our presentation is arbitrary, and reviewers are urged to undertake a detailed scan after a quick pass to map the salient blocks. SCC refers to the Stanford Computation Center. ACME is an acronym for Advanced Computer for MEdical Research.

Outline

(1) Source of the proposal. Medical School Computer Policy Committee.

(2) Medical School - University relationships. ACME will be an advanced facility to complement, not compete with SCC.

Health research at Stanford - Medical School.

(3) Present services of SCC. IBM 7090 and Burroughs 5500. Efficient job shop but language incompatibilities; limited file service, A-D, programming and engineering support.

(4) System efforts on small computers now running: 4 LINC's, 1 PDP-8. Further prospects in data acquisition and process control.

(5) Automated Biological Laboratory - NASA supported program for comprehensive system study of automation of biochemical experiments.

(6) The ACME proposal: dynamic complementarity. Operating policy, starting Spring 1966. Multitasking under Operating System/360. Adjustment of priority schedules for multiple users, telecom, file service; long jobs; high data rate interactions.

Hardware: IBM/360-50 and an 1800 satellite, process-control computer. A-D and D-A I/O gear. Lines to 20+ peripheral typewriters and data links. Central display consoles and plotter.

(7) SCC-67 plans - starting Spring 1967. Switchover for time-shared use, releasing ACME for special applications. Policy convergencé.

(8) ACME management and staff. Deputy Director from SCC for technical management under policy committee direction. Technical support staff accounts for half of budget.

(9) Responsibilities of policy committee; policy guidelines and preliminary time table.

(10) Some applications, not an exhaustive list, but submissions mainly from policy committee members. These go from neurophysiological data correlation to vital statistics to mechanized inference for analytical biochemistry.

a.	Biochemistry	(Stryer)
b.	Pharmacology	(Killam)
c.	Genetics - Demography & Instrumentation	(Lederberg - Bodmer)
d.	Computer Science - Mechanized Induction	(Feigenbaum)
e.	Neurology	(Morrell)
f.	Anesthesia	(Bellville)
g.	Scientific Information Retrieval	

(11) Housing the computer. Initially in present Medical School building. Potential for adjacent quarters juxtaposed to SCC.

(12) Interim support during staff buildup. (Engineers from Instrumentation Research Laboratory. System programming from SCC. Macy Foundation planning grant.)

(13) Curriculum vitae of committee members.

Bibliography of publications from Stanford Medical School illustrating computer applications.

(14) Budget.

(1) Source of the proposal.

The initiative for and endorsement of this proposal come from the computer policy committee, and the draft text from its chairman. Members of the Computer Science Department and Stanford Computation Center (SCC) have then been consulted on technical issues and for agreement on the management responsibilities. A larger interdepartmental users' group and the Executive Committee of the Medical School have likewise been informed and consulted, and Dean Glaser has played an active role in developing these plans. Thus every effort has been made to frame a proposal that would reflect the requirements and interests of the entire medical school, as well as the long range interests of Stanford University. The policy committee will continue to act in this representative role as there are now too many competent users for them all to sit at once on a briskly functioning committee. Regular meetings of a users group will however be continued.

The membership of the policy committee* is:

Dean Robert J. Glaser	(ex-officio)
Prof. Lincoln Moses	(Statistics and Preventive Medicine)
Prof. John W. Bellville	(Anesthesia)
Prof. Lubert Stryer	(Biochemistry)
Prof. Keith Killam	(Pharmacology)
Prof. Frank Morrell	(Neurology)
Prof. Edward Feigenbaum	(Director, Stanford Computation Center)
Prof. Joshua Lederberg	(Genetics), Chairman

*appointed jointly by the Dean of the Medical School and the Provost.

(2) Medical School - University relationships.

Stanford made a calculated decision to move the medical school from San Francisco to the Palo Alto campus, and did so in 1959. This was a conscientious self-dedication to far-reaching communion of medical research and education with university life, based on the principle of mutual interdependence of medicine with the physical sciences and with human affairs. In future outlook, computers will be central to communication within the University, and this motive alone reinforces a policy of the greatest feasible convergence with the central facility for the University, serviced by SCC. In addition, there are important economies in avoiding redundant programming systems and languages, maintaining common libraries and files as well as in using the most sophisticated hardware. However, medical research does have special requirements and challenges and there is bound to be a significant gap, at least in time, between the level of service that the SCC can offer the University as a whole and the technical possibilities of the art. The gap arises in part from the specialized requirements of medical research (in some measure the possibility of leapfrogging over a good deal of analogue hardware that should have been developed, but has not been); in part from the special impetus and financial support enjoyed by medical research, which after all conveys the purpose of a distinctive NIH program; in part from the greater flexibility with which a service to a more coherent group can be administered compared to one announced campus-wide.

The purpose of this proposal is not to compete with the SCC but simply to fill that gap, i.e., to complement SCC services. To a very large extent, ACME will be a computer for research and development in computer techniques in health sciences; insofar as these techniques become reliably available on SCC service, they will be withdrawn from the ACME schedule. In view of the rapid anticipated growth of demand, this is quite essential if ACME is to remain available for further systems research and special applications. This policy is also consonant with the view that production-type services should eventually be charged as current expenses to individual research grants, a limitation which would be stifling for development work on the computer systems themselves. An outline of SCC services is appended (Sections 3 and 7).

As will be noted, the urgent gaps ACME will face are expected to evolve with time: those now most evident are a general time-sharing and file access system; priority batch processing, high data rate (> 10kc) closed loops, and symbiotic interactions of the computer with live experiments.

(3) Present services of SCC.

The Center, located only a few hundred yards from the medical school, operates a job shop for the campus, serviced by what is now full time service on two computers: an IBM 7090/1401 with SUBALGOL, LISP and FORTRAN, and a Burroughs 5500 with ALGOL. For such a shop, the Center has an excellent reputation: for example, actual performance of three express runs daily on the IBM 7090, with deck-in to program-out time less than 90 minutes for 1 - 2 minute runs being the rule. Turnaround on the B-5500 is often much faster. Part of this performance is attributable to the local monitor and SUBALGOL compiler which were written at the Center.

On the other hand, some justifiable complaints may come from the unwillingness or inability of SCC to offer complete problem-solving services. From a user's standpoint the utter incompatibility of languages on the two computers appears like a calculated source of frustration. Until recently, even data tapes were mutually unreadable with no recourse.

Programming assistance for file manipulation is difficult to find, and many users have not had enough incentive (or resources) to recruit full time staff for their individual needs.

Attempts to operate direct wire communication from a LINC computer to the IBM 7090 (for interchange of data and programs via disk files see Section 4) will have borne fruit only after two years of intermittent effort. Not that this is an easy task for the 7090, but the main problem has been the preoccupation of SCC systems staff with other, perhaps generally more urgent concerns.

SCC has been unable to offer A-D conversion service, not for lack of the suggestion. It has, however, pioneered in the routine availability of plotter outputs from a job shop, supported by excellent programming packages.

The grievances are recited not in malice, but to point out the kind of initiative that must be mounted at the medical school for the full realization of the enormous potential value of the basic services from SCC.

In any case, the 7090 is rapidly obsolescent in competition with the larger, faster, more versatile, and above all, more accessible machines of the next generation. However, SCC now plans to retain the 7090 at least through Spring 1967. Indeed, its displacement by the next central system, a time-shared IBM/360-67, will not be a completely unmixed blessing (except for FORTRAN stalwarts) since SUBALGOL will probably be discontinued and there will doubtless be some delay in the reconstruction of program packages, especially for statistical analysis.

Substantial use of the 7090 by the medical school must therefore be expected to continue, ACME notwithstanding, as long as SCC maintains it. Indeed for an interval we may envisage some users conditioning their data on ACME to a certain point, then moving to the 7090 to exploit existing programs.

The administration of SCC has recently been strengthened by the appointment of Professor Feigenbaum as Director, in preparation for the broader services established for the next generation computer. This promises much more effective communication on the problems of mutual concern of SCC and the medical school.

(4) System efforts on small computers now running.

Stanford was perhaps unique in obtaining two machines under the LINC evaluation program. One of these (a) was funded independently by Professors Chow, Killam, Morrell and Pribram for neurophysiology, and the other (b) was allocated to Professor Lederberg for general instrumentation. Subsequently, a third and fourth LINC (c) have been purchased for additional neurophysiology work, and recently a PDP-8 (d) by Professor Pribram to monitor behavioral studies. In spite of the software limitations, the machines are signed up fully for the day shifts and have more than a little tie-up for odd hours.

Applications have consisted of a fairly versatile series of programs making maximum use of the relatively limited capacity of the LINC and PDP-8 computers. This has been invaluable for preprocessing of data and rapid assessment of various computational techniques as applied to a wide range of biological problems. Actual applications have been listed in Section 10 for the most active groups, and the list is by no means exhaustive.

The Instrumentation Research Laboratory had special needs for versatility in new programming and its programming group wrote an operating system to generate a BALGOL-like compiler (BLINC), a new assembler with deeper diagnostics, a linking loader for library utility routines (kept, with the monitor, on microtape) which include several I/O and displays - teletype, plotter (out) and curve-reader (in), scope display, and an IBM-compatible tape drive. The compiler runs on the IBM 7090 at SCC, being a revision of the SUBALGOL compiler to generate LINC code, which is written on tape for communication to the LINC. With some bootstrapping, the rest of the system was written in BLINC; after compilation on the 7090, it is maintained on the LINC. This has motivated a long-standing, finally dubiously successful effort to communicate from the LINC to the 7090 by phone wire.

The utility routines have also incorporated multiple precision floating point arithmetic which has been made available to a statistical desk-calculator program. This keeps many students and department staff waiting in line for jobs like n x m X^2.

Other typical applications are curve-reading to digitize strip-chart recordings from a gas chromatograph and calculate areas of marked segments. This has so far been more economical and manageable than analogue tape recording.

The experience has been educational, but tantalizing, the LINC being barely capable for pointing up the possibilities of computer interaction with a variety of instruments. LINC programming software is still primitive, and if it were not, we would soon lack for enough copies of the machine unless it could be time-shared.

(5) Automated Biological Laboratory.

This program, under Professor Lederberg's direction and NASA support, is intended to be a convergence of medical research methodology and mission requirements for biological exploration of the planets. Given the high performance capabilities of the Saturn V launchers (e.g., 50,000 lbs. soft-landed on Mars) of the mid-70's, we seek to emulate in an automatic laboratory a broad and flexible opportunity comparable to work in a terrestrial facility. This in effect demands the capability to <u>program</u> and <u>reprogram</u> an experiment in biochemistry or microbiology. While remote operation is not often so vital for medical research, many other aspects of laboratory automation would be extremely useful. Indeed, they may be quite indispensable for programs like health survey work for biochemical idiosyncrasies, or the chemical synthesis of functionally important polypeptides and polynucleotides. We believe further that many less exotic uses of intruments could be augmented by routine access to computation. In fact, many instruments that are now prohibitively expensive, or do not reach theoretical potentials of speed and sensitivity, would become available by the use of programmed logic on a time-shared general purpose computer in place of special purpose analogue hardware. The design of an integrating (and transfer-function-correcting) photodensitometer or microspectrophotometer, or of an interferometric IR-spectrometer shows this clearly.

An Instrumentation Research Laboratory, with a professional and senior engineering staff of some eight people currently, has been established, mainly with NASA support at present, with these stated objectives:

(a) General system study of an ABL for a Mars landing in 1975 or so.

(b) Some specific experiments for detection and characterization of exotic organisms.

(c) Find maximum advantage of this technology for analogous problems in biomedical research.

Each of these objectives is highly relevant to ACME.

(a) We have proposed to use the existing functional operation of the Genetics Department and some cooperating laboratories as a prototype. If this proposal is accepted, a number of experimental procedures will be engineered for automated operation under time-shared computer control. Most important will be the system-design study of the information and control traffic of such a set of diverse experiments with unpredictable demands for each next step. IBM Federal Systems Division is also collaborating on this study.

(b) The most exciting of these is the sensitive detection of optically active molecules by mass spectrometry and gas chromatography. A related project is the scanning of a specimen with a microbeam to elicit a mass spectral fingerprint of each picture-point of a specimen, say a set of chromosomes. Programs for the automated analysis of mass spectral data are being pursued for the reduction of this encyclopedic information.

(c) NASA policy encourages parallel emphasis on terrestrial applications. Its support of the LINC evaluation program is a historic example. We can reasonably expect continued backup from NASA for our instrumentation laboratory as an important complement to NIH-supported work.

ACME should, however, be distinguished as a general medical school resource, of which the Instrumentation Laboratory will be only one among many users.

(6) The ACME proposal.

ACME is not a single machine but a continuous adaptation of the medical school to evolving requirements and technology in computation, on the one hand, and the tested production services that can be purchased from the campus system on the other. The opportunity to lease the hardware so that specifications can be changed on short notice is an important element of flexibility. The availability of an expanding series of program-compatible machines is another. Finally, it rests on the basic policy that users should buy services from the central system wherever this is technically justifiable. This has two crucial advantages: the economy of scale with the strengthening of intra-university communication by centralizing well-established modes of services, and also releasing the staff, budget and hardware of ACME as far as possible for experimentation in newer and untried modes of operation.

The IBM/360-50 has been selected for the initial realization of ACME (1) as a machine technically appropriate to the immediate tasks in mind, and (2) for its system compatibility with the 360-67 already selected for the eventual replacement of the 7090 by the Stanford Computation Center. The 360-50 will be installed in ACME May 1966 and will run on three shifts under Operating System/360, subject to review by the policy committee. These will be dedicated respectively:

(A) A prompt access time-sharing mode - perhaps over most of the working day.

(B) A scheduled, full-use, on line mode - to service development work on high data rate and on line control applicatons, and for similar systems development.

(C) Job-shop, especially longer runs for which overnight turnaround is acceptable, and which cannot be serviced with comparable effectiveness by SCC.

These functions in fact are represented by alterations in the Supervisor program of Operating System/360, being mainly the reallocation of priorities for service under it.

The outline of the computing environment that will be available to ACME users might occupy a substantial part of this text. However, facilities of Operating System/360 have been outlined in great detail in a series of IBM publications which are readily obtainable (IBM Operating System/360: Introduction; Concepts and Facilities; and further references, especially, Job Control Language; Telecommunications; Data Management; Fortran IV, PL-I, and Assembler Language; also IBM System/360 Summary and Principles of Operation). Since we intend to adhere closely to Operating System/360 for ACME, we can save unnecessary padding by reference to these publications. Job control specifications may well be incompatible as between ACME and the SCC, but they should represent a small burden, while user programs and data set references should remain fully compatible.

To implement (A) a network of twenty typewriters will be installed (in general, one for each department). Additional lines will be available for further users, and some 35-50 are expected, presumably < 32 active at one time, at this stage. An equal number of data lines will accommodate information from the many instruments that furnish less than 4 cps output. This network will feed a data bank, each account of which is recallable by name by the originator.

Mode (A) will support most program-writing and debugging, information-retrieval, and data-management operations. It will also cover a substantial portion of production runs as the background jobs, subject to interruption under the time-sharing system. An important aspect of this as a system experiment is the level of service that is established for the longer jobs, on which a legitimate and controversial uncertainty now persists (i.e., whether their completion will be intolerably deferred by cyclic service to the mix of short jobs if these always have higher priority).

(B) Some examples of high data rate work which is now rather frustrated are multiple channel electroencephalography, mass spectrometry, and video interpretation, e.g. for fluoroscopy and scintillography. Eventually it is hoped to develop more economical ways to deal with these situations, either with small peripheral computers or with high speed channels, but it would be very painful to work these out on a computer so dedicated to uninterruptable general service that this work cannot proceed at a high priority.

(C) The job shop run of the mill is probably typical of any school with active programs of physiological research, as well as a number of demographic and epidemiological studies. However, some clinical research applications of electroencephalographic spectral analysis may require long runs with reasonably prompt turnaround, which it is not immediately obvious can be serviced adequately without special priority.

Besides the peripheral lines and the main frame, a comprehensive data interface will be installed at the computer. The detailed design of this is still under study (See Section 10c) particularly the pros and cons of an 1800 satellite computer vs. an 1827-4600 data control and high speed multiplex or channel. This would service a number of digital and analog input and output lines and relay registers. A tentative configuration is outlined for budget purposes.

ACME INITIAL CONFIGURATION: IBM/360-50 .. 1800

/360-50F processor, 65K bytes main core; direct control; multiplexer channel; 3 selector channels

large core storage 1 megabyte
data cell drive 400 megabyte
2 (#2311) disks
transmission control; 20 (#2741) terminals
4 tape drives (2 with 7 track operation)
card read punch; paper tape

1801 processor 8K words main core
adapter for S/360
1 #2310 disk

The 1801 is intended mainly as a programmable high-speed multiplexer channel, analogous to the 1827-4600, also being considered.

Data channels, A-D, and other front end hardware details are still under study. This includes RPQ studies for high speed A-D units; channel logic for averaging, and microprogram hardware for direct access to external lines as addressable pseudo-memory.

(7) SCC-67 Plans.

Starting Spring 1967, i.e., in ACME's second year, SCC will install an IBM/360-67 as a central campus computer supported by users' fees together with other funds. It will be operated under the now generally familiar IBM/360-67 time sharing system, like a number of other universities! As the SCC reaches an acceptable standard of service of various types, that mode will be discontinued on ACME, as determined by the policy committee. From the outset, ACME consoles will have the option of being switched to the /360-67.

The release of ACME from the otherwise high-priority demands of general time sharing will of course leave it available on a much more flexible basis for special applications. This will, of course, be the occasion for reconsideration of the most appropriate hardware. At the very least, important economies could be won by sharing files and routine I/O equipment.

The depth and reliability with which this /360-67 system can service data-oriented users is a subject of lively controversy. We expect to have an answer to this question without the penalty of the frustration of experimental progress that a miscalculation would impose.

The policy guidelines and a preliminary time-table are presented in Section 9.

(8) ACME Management and Staff.

The facility would be under the direction of a computer policy committee (designated in Section 1). This consists of medical faculty representatives with the participation of the Director of the Stanford Computation Center (Professor Edward Feigenbaum). The technical management of the computer, particularly with reference to system programming, will be delegated to an associate director of the Center. This device is intended to minimize the duplication of system efforts on campus, and is similar to the arrangements already in effect for the very large SLAC (linear accelerator) computation center. ACME will be staffed by some two or three system programmers, three or four general applications programmers, and two "hardware engineers", in addition to operators, dispatch assistants, etc. We have a strong university department of computer sciences, and especially close relationships with Professors McCarthy and Feigenbaum, and our own established interest and competence in a variety of computational techniques. Hence the appointment of a new specifically computer-oriented faculty is not regarded as a sine qua non, and the main progress will continue to be on a broad front across existing departments.

In effect, the computer policy committee will function as an ad hoc department of medical research computation. Present departments already offer ample scope for graduate study in this field; Stanford also has a well-established tradition of flexible, ad hoc Ph.D. programs in interdisciplinary studies. However, some interesting possibilities for further strength in specific areas of computer applications in medicine are being studiously pursued. The most obvious opportunities are perhaps in statistics and epidemiology and in the inductive logic and linguistics of health sciences.

The operating staff of ACME listed in the budget is likewise merely a core group; most of the applications will be engineered and programmed by a much larger staff, in aggregate, in the respective laboratories. Already visible are some 8 - 10 qualified engineers and over a dozen full-time programmers, not to mention the problem-oriented involvement of faculty and students in these same functions. This number will undoubtedly grow rapidly; the core staff will not.

(9) Responsibilities of policy committee; preliminary guidelines and timetable.

The policy committee, whose members are signatory to this application, will act on behalf of the medical school in setting ACME policy, subject to the following guidelines and such revisions as may come from or be negotiated with the NIH as granting agency. Its principal functions will include:

1. Confirmation of the associate director (nominated by the Director, SCC).

2. Fiscal and operating policy. User fees except for more-than-nominal expendable supplies may be suspended during the earlier stages of ACME's operation. Some expansion of its budget may be financed by prorated user fees payable from current grants. However, our colleagues should have some notice of this in order to adjust their various applications and the details must inevitably be negotiated with NIH.

   Initial operating policy will be the maintenance of OS/360, on three shifts with variation of priority schedules to facilitate, respectively, prompt telecommunication access; scheduled high data rate experiments; batch processing of larger jobs.

3. Relations with SCC and evolution of the system.

4. Technical consultation and indoctrination for colleagues interested in computer application in their own fields.

5. Budget management and hardware selection.

6. Definition of qualified users. Initially lines will be available to each academic department of the medical school. Any research, development or demonstration that contributes to its programs of health research will be encouraged. Since ACME is primarily a research, only secondarily a service, facility, there will be few opportunities for ambiguity that might arise where applications have reached a production stage, e.g. as may be hoped eventually, for routine clinical care or library retrieval. However, the research and development for such applications would properly qualify as a use of ACME.

   The committee may also consider a limited number of lines to users elsewhere on campus whose work is closely related to and sponsored by health research activities within the medical school.

System programming for ACME itself, or in connection to simulating of the /360-67, that may contribute to the medical school's utilization of either machine, would also be a natural and qualified function. Writing, debugging and testing of /360 utility programs that will be useful and available for its public library also qualify. Lines for these purposes may connect to one or a few stations in the SCC and the Department of Computer Science.

The committee will also review and may qualify other suggestions for inter-communication of ACME with other computers, local or not, that in its judgment would result in a net benefit to the medical school research program.

7. The committee will administer the distribution of startup support, funded from this grant, for such purposes as

   computer time at SCC

   programming and engineering assistance

   ACME user fees (as may be set up).

   This support is intended mainly to introduce new users, and experienced users will be expected to arrange to finance these charges from their project grants.

MILESTONES

Epoch 1.

The general plans for this epoch are fairly straightforward, and comprise the bulk of the text of this application.

October 1, 1965. Submit grant application. Continue technical studies on data acquisition network and "databank". Indoctrination of present potential users on prospective facilities and languages of S/360. Exercises on the /360 simulator and a PL-I interpretor now available on the 7090.

January 1, 1966. Activate Macy Foundation planning grant. ACME director and engineering support staff appointed. Begin to plan and effect wire connections for data network.

April 1, 1966. Activate NIH grant. Recruit additional staff. Installation of consoles and data links. As interim these can be checked out on the LINC computer; possibly by leased wire interconnection to other /360-50 systems. IBM promises its OS/360 for this month.

June 1, 1966. Install ACME (the /360-50). May 23, 1966 is the scheduled delivery for an 1800. Scheduled system and experimental work can begin immediately. Operate a time-sharing system under OS/360 as expeditiously as possible.

Continue planning for Epoch 2. (User's experience under this system will be highly relevant to scheduling algorithms, file organizations, etc.)

Epoch 2.

February 1967. SCC installs its /360-67 T/S system.
? March 1967. Campus service startup.
? May 1967. Routine T/S service discontinued on ACME.

Many problems remain to be defined for this period, have not been decided, and only suggestions can be offered at the present state of information. In any case, there will be a continuous adaptation to the contemporaneous environment.

(a) Extent of physical integration of ACME and SCC hardware. Certainly all peripheral consoles will have optional connection. There is no obvious reason why the SCC hardware should not be located in immediate proximity to ACME, the building-investment being trivial compared to the computers, and the present location of the 7090 having no special technical basis. This would allow a policy choice along a technical continuum, with, of course, the most economical mutuality of access to memory files and other accessories.

(b) Adjustment of user fees for T/S service from SCC. Many users will simply charge these to current operating accounts under their various grants. Additional support might be represented by programming assistance under the present grant. In addition, some allocation of funds should be negotiated for medical research users' time on this service (see budget for year II).

(c) Retain the /360-50? This processor may or may not remain the ideal choice once T/S responsibility is offloaded. For example, the /360-44 could have many advantages if, by then, an adequate operating system were developed, almost necessarily with some hardware upgrading (memory protection). Even within this period we may anticipate another technological cycle, especially in the field of medium size (by then they will be "small") machines for process control.

(d) 24-hour service. Some users both in laboratory and clinical research will benefit especially from an opportunity for 24-hour service, uninterrupted by the usual round of maintenance and emergency downtime, or by commitments to other functions. A combination of the SCC-67 and ACME-50 could give an approximation to such service to the point of utility, if not reliability. Future plans for this type of service would benefit from experience on the weakest points that need to be shored up.

Epoch 3.

1968-70? SCC services may have evolved to a point justifying a comprehensive merging of the central processors, e.g., into a dual /360-67 or into a /360-92 level system (or whatever the technology then offers). If our experience up to that time justifies a conclusion that more efficient and economical service can be obtained this way, the medical school policy committee has the authority to pool ACME resources with SCC to make such a confluence a possibility. Our general policy is to give all possible support to the university system consonant with responsible administration of the grant as a health research award, and prudent attention to the special requirements of medical research. Indeed, the viability of the SCC campus-wide service is outstanding among these requirements.

Continued experimentation with separable processors remains almost certainly necessary. By then a machine the size of the /360-44 will not be regarded as unreasonable for a "peripheral processor". The main issue is not whether, but which unforeseen challenges will have arisen justifying still higher levels of capability. However, the troops will have a great deal to do in developing the sensors and activators to mesh with the control logic. The development work hence goes beyond the scope of general computational facilities and must be dealt with on its own merits in the course of time.

(11.) Housing the computer.

As an early expedient, the computer and core staff will be housed in an area within the present medical school building which is becoming vacant in the course of some moves into the Clinical Sciences Research Building about to be completed. This is an area of some 2400 $ft.^2$ now occupied by the Instrumentation Research Laboratory which will then be a few yards away. Shops and consulting support of the Instrumentation Research Laboratory will be available to ACME. Additional office space is also being worked out. We are, however, seeking means to support more attractive quarters in a small building that might be erected just adjacent to the medical center in an area designated for the next expansion. This would facilitate the eventual more effective consolidation of resources with other campus computers during the next few years.

Pending an alternative plan for housing the computer, some $30,000 will be needed for remodelling, the existing laboratory, mainly to install false flooring and augment lighting and air conditioning.

(12) Interim support during staff buildup.

The Macy Foundation has just announced a planning grant of $80,000 for the year 1966 which will enable us to proceed with the recruitment of a deputy director and engineering staff. (The new Clinical Sciences building was designed to facilitate cabling; common carrier services may be the mainstay in other parts of the medical center). This group will detail the orderly program needed for an effective May 1 start up.

Interim support is also available from the SCC in recruitment, software system design, and negotiations with suppliers.

The Instrumentation Research Laboratory will also furnish interim engineering support. Particularly relevant is a cooperative program with IBM Federal Systems and Research Divisions in connection with their interest in the Automated Biological Laboratory. (See Sec. 5). This is not predicated in any way on procurement decisions, IBM D-P Division having had no involvement. The system design of data networks for laboratory instrumentation is one of the main tasks of this study which will be proceeding over the next few months.

Professor William Miller (primarily responsible for SLAC computation) has had uniquely important experience in real time computer interactions in high energy physics experiments and will be particularly helpful in high data-rate problems.

BUDGET

Grant Request Renewal

September 1, 1966 to August 30, 1967

Existing funds have been completely allocated as of September 1, 1966.

We have received an award from the NIH now specified for an 11 rather than a 12 month interval, which covers the following categories:

Equipment	$261,000
Personnel	$ 85,000
Supplies	$ 15,000
Travel	$ 4,000
Alterations & Renovations	$ 30,000
Miscellaneous	$ 7,000

When reported on a 12 month basis this adds up to $440,000 per year.

Requested from the Macy Foundation:

To complete the installation of the computer in a glass-walled enclosure at an open site between two buildings of the medical school	$ 20,000
Supporting personnel (detail on attached page)	$100,000
	$120,000

PROGRAMMING STAFF REQUIREMENTS
FOR THE ACME PROJECT

5-1/2 System Programmers	
Gary Y. Breitbard (compiler) @ 900	$ 10,800
Dave E. Cummins (terminal) @ 1000	12,000
Gerald D. Miller (input/output) @ 900	10,800
Ann Hintz (analog input/output) @ 800	9,600
Unfilled (scheduler) @ 900	10,800
Franklin Zweiman (medical student) @ 225	2,700
2 Support Programmer-Statisticians	
1 Unfilled @ 1100	13,200
1/2 Warren Anderson (medical student) @ 225	2,700
1/2 Zeva La Horgue @ 375	4,500
1 Operator in Charge	
Charles Class @ 760	9,120
Part-Time	
March Schumacher @ 300/month	2,000
Unfilled @ 500/month	3,600
	$ 91,820
10.5% Fringe Benefits	9,641
	$101,461