REPORT OF THE SUBCOMMITTEE ON RESEARCH COMPUTING

Goals Report of the Subcommittee on Research Computing

Summary and Recommendations

Computing is becoming an increasingly important factor in all academic disciplines. A computing environment of the highest calibre will be required in order that the university be able to attract and keep the best faculty and students. The computing resources of a university are an increasingly important factor in the assessment of its academic quality. Many undergraduates are involved in the research of the faculty especially where computing is involved, so the state of the computing environment has significant impact on undergraduate education. Indeed, in many fields the availability of a computing environment at the cutting edge of technology is essential for the proper education of undergraduate students.

A more precise description of the research computing environment which Rice should aim for is left to the implementation report. This report presents general strategic recommendations to be used in developing implementation plans.

Research computing is done on computers of all sizes. For example, a musicologist uses a micro-computer to analyze ancient music; a political scientist uses a main frame computer to extract information from large data bases; an engineer studies problems in contaminant fluid flow that can only be performed on the largest supercomputers currently available.

1. **The computing environment of the university should provide adequate access to computing power at all levels, ranging from that of a micro-computer/workstation, through mid-level computing, to supercomputing.**

High speed electronic communication provides the capability to transfer data quickly and efficiently. It also provides easy access to high performance computers. This need for networking on the research side of the university only echoes the needs in education and administration.

2. **A high speed network should be installed to connect all of the research computers on campus and to provide access to regional and national networks.**

It is important to realize that a computing environment involves more than just equipment. There are several dimensions to a properly constituted environment, including:

1) Equipment;
2) Software;
3) Equipment and software maintenance;
4) Support personnel.

Two of these dimensions need elaboration. Often, when computer systems are set up, very little thought is given to the continuing problem of maintenance. The annual cost of equipment maintenance is at least 10% of the retail cost of the equipment.

3. **Any plan for the acquisition of hardware and software must include a detailed plan for the maintenance of that hardware and software.**

Although computers are becoming ever more "user friendly", they are still highly technical machines. For most computer users it is simply not a viable option, in terms of their time and intellectual effort, to become complete masters of the computer systems that they use in their work. What is needed is support personnel who can help to provide an interface between the researcher and the computer. In addition, support personnel perform routine equipment maintenance, they are a critical element in software maintenance, and they are vital in outreach and education activities that enable researchers to use computers and software in the most efficient manner.

4. **The computer environment of the university must include a provision for sufficient support personnel.**

Finally, there is no aspect of university life that is changing more rapidly than computing. The changes over the past five years have been phenomenal. It is safe to assume that there will continue to be rapid evolution for the foreseeable future. Indeed it is probable that equipment installed today will be obsolescent, if not obsolete, five years hence.

5. **The computing environment of the university must be structured so that it can change and grow to meet new needs and opportunities.**

Discussion

In the interviews conducted with faculty and graduate students, the committee learned much about the impact of computing on research (see Appendix C for a list of interviews). Moreover, the interviews revealed a surging demand for more -- more applications, more hardware, more software, and especially more help. There is a pervasive and contagious excitement about the prospect of building a state-of-the-art computing environment on the Rice campus. To be sure, relative priorities are not precisely the same across all disciplines, but there appears to be an absolute consensus about what ultimate goals are desirable.

Computers are clearly changing the way research is done. The development and proliferation of computers over the last five years has had a dramatic impact on the methodology of research. This impact has been felt, albeit in different ways, across every discipline actively engaged in research.

High speed communication via computer networks has graduated from a luxury, engaged in by a select few, to a necessity for almost all active researchers. The sending and receiving of everything from data to software both across campus and around the world can now make the difference between staying current and falling seriously behind. The ability to sit at a workstation in one's own office and log onto a computer located elsewhere on campus or perhaps thousands of miles away, provides new vistas in computing. With this kind of convenience, interactive supercomputing becomes a possibility.

Computer networking is also an important mechanism for transferring data. For example, in Physics, many of the experiments of Rice faculty are performed at major national laboratories such as the Stanford Linear Accelerator and the Fermi Lab. The data from these experiments are captured and stored on the lab's central computer. To be analyzed, it is frequently necessary that the data be transferred to computers at Rice. In other fields large scale data bases are necessary for research, including those residing at the National Center for Atmospheric Research (NCAR) and the Michigan Survey Research Center (MSRC). Unless a network supporting high speed data transfers from remote sites is made available, Rice faculty will not have access to increasingly rich sources of data.

High-speed visualization of models and data was a fascinating frontier in 1984. For several fields in 1989, high-speed visualization is a commonly-accepted method for analyzing data. Done properly, the turn around time in experiments or in computation is greatly reduced.

The expanded memory and ever increasing processing speed found in today's supercomputers have made possible the simulation of everything from the weather to the spread of AIDS. The capability to thus combine modeling and large-scale computing in order to simulate time-change in phenomena at first created new opportunities exploited by only a few researchers. In field after field as the full power of simulation became evident to all researchers, it was adopted as one of several tools for a majority of researchers, rather than the methodological specialization for a small few. Indeed, knowledgeable people now refer to mathematical and computational modeling as a third way of doing science, taking its place with theory and experimentation.

A more comprehensive listing of the ways in which computers support research is contained in Appendix B. Some vignettes illustrating how computing has been or could be used at Rice are contained in Appendix A.

So far the discussion has focussed on the positive. That is, what faculty <u>could</u> do with enhanced computer support in 1994. It is also necessary to consider the downside -- what problems will Rice encounter if the computer environment is not sufficiently enhanced by 1994. First, there are clear opportunity costs in terms of lost hires. As computers become more and more useful in research, the presence of a sophisticated computer support network will become more and more a necessity. As a result, schools that cannot or do not keep up will lose more and more current and potential faculty to schools that do keep up.

Another important cost is in terms of the research that could be done by Rice faculty but cannot be done due to the lack of sufficient computational resources (examples from among our own faculty are presented in Appendix A). There is a corollary cost here that is even harder to bear. The best faculty are not likely to remain long at a university that is unwilling to provide what is needed to adequately support their research.

It is easy to overlook the very intimate connection between research, especially research computing, and education of undergraduates. Many undergraduates at Rice are currently involved in the research of computing faculty. More will be if the computing environment is enhanced. The active involvement of students in computational research is perhaps the best way of educating them. In addition, equipment obtained primarily for research can often be used for educational purposes. This is probably the only way in which the university could afford to have state of the art equipment available to the students.

There are very good reasons to want to involve the undergraduates in research. The first is alluded to above, i.e. such involvement is a very effective means of education. But there is another, equally important reason. A study of the demographics of university faculties indicates that faculties are getting older, and that there is a real danger that the universities of this country will not be producing Ph.D.'s at a rate sufficient to fill the vacancies that will occur early in the next decade. It is time for universities to make extra efforts to recruit students into graduate work, and ultimately into the ranks of the faculty. The involvement of students in research is a very effective way to do this recruiting.

These facts are recognized by the funding agencies. The National Science Foundation has introduced a Research Experiences for Undergraduates Program to fund the participation of students in research. Recognition of the importance of undergraduate involvement in research is also indicated by the Ford Foundation, which is supporting Rice's innovative course in research.

It is unambiguously clear that the use of computers to support research will continue to expand and even gain momentum, especially over the next few years. More researchers will adopt current applications, and new applications will appear on the horizon. The question for Rice, in particular, is how this transition will take place. Will it proceed in a fragmented, and therefore inefficient, manner or with only externally supported researchers participating? Or will it proceed in a coordinated manner, led by a faculty consensus, and supported by meaningful investment and leadership from the administration?

As is clear from Appendix A, the research computing environment at Rice currently supports many important research activities. However, computing is currently in a very dynamic period. Most universities recognize the need to upgrade their computing environment, and they are acting accordingly. At the very least Rice will have to improve on the present situation simply in order to remain competitive. Hopefully Rice will choose to become a leader.

APPENDIX A
<u>Computing Vignettes</u>

Delayed success in computer science

The costs inherent in not providing the resources needed to support the research of the faculty is illustrated by a story about a young assistant professor in Mathematical Sciences at Rice in the early seventies. Coming to Rice with a Ph.D. in applied mathematics, he was interested in computer science, particularly in the design of compilers. He obtained an outside research grant of $5,000 to support his computing and proceeded to try out some ideas. His work quickly ran up a computer bill of $8,000, and he was locked out from using his account. He tried to argue that he was less than half of the way through his project, and that Rice should help to support his research by donating the time already used and allowing him to pay for another $5,000 worth with his project's grant. His request was denied. The experience was so discouraging that he retreated into purely theoretical work for the next four years. The theoretical work was sufficiently well received that he was eventually tenured. Once tenured, he took a sabbatical at IBM. During the time at IBM he was given virtually unlimited computing power and therefore was able, once again, to actually test some of his ideas. With the ability to actually implement and test his approaches, he made great strides in terms of both theory and design. Ideas that sounded good in theory but which didn't pan out in practice were discarded or appropriately modified. As a result, the contribution to theory was sharpened and the contribution to practice was made substantial. Of course, now his work is so well known that obtaining money for appropriate computing power to pursue his ideas is no longer a problem. The real point of the story is that he lost 4 to 5 years of his career. He would have reached where he is today even sooner if computer support in the seventies had been viewed as an investment in the future of a promising young faculty member.

As much as Rice has to gain through a major investment in computing, it has even more to lose if it doesn't.

Shepherd School research computing needs

The research computing needs of the Shepherd School fall into two departments, each with specific research requirements.

These are Musicology and Composition. It is important to mention that these needs apply to the students of these departments, as well as to the faculty. And an underlying assumption is that as they become more acclimated to the technology, new and perhaps unexpected applications will arise.

Musicologists at Rice, although members of a School that stresses performance, do academic research comparable to their colleagues in the School of Humanities. They do research in a wide variety of areas, publish articles and books, review other scholars' books, deliver papers and symposia, and apply for Humanities funding (from NEH, APS, ACLS, and others). Indeed, tenure and promotion depend on a steady flow of this material. Obviously, there is a great need for high quality word processing, including access to laser printing. Many publishers demand camera-ready copy. However, there is also a need for sophisticated graphics capability--essentially the visual and aural reproduction of music, much of it not available in any easily accessible form. These do not simply make their papers look better, they are integral to the research itself.

This is a rapidly emerging resource that our faculty not only utilize but contribute to.
The composers need publication-quality reproduction of their music. The software that currently exists is truly revolutionizing the entire industry, and the graphic representation of scores has advanced from pen and ink processes begun in the 9th century to the most modern technology in about 5 years. At first, just taking advantage of this technology will be a major advance in their professional lives. Ultimately, as familiarity with the systems and access to them grows, the way in which they compose will itself change. This is the most exciting research application: an alteration of the creative process itself. They will have much more efficient editing capabilities, and powerful feedback systems that will give them greater flexibility in what they write, increase their productivity, and improve the quality of their work.

The availability of research computing equipment will as a matter of course affect every music student. In this, as in many fields, it is impossible to separate research from teaching. This is especially true in musicology, but it is also true in composition. The effects on the music theorists will be slower in coming, but when new software is available, this too will change.

The equipment needed by the faculty of the Shepherd School for their research consists of high level personal computers, such a Macintosh II, plus some MIDI equipment like keyboards. It is important to have a relatively large screen and good sound quality.

Computer use for historians

Although historians publish essays, reviews, and articles, generally speaking the medium on which scholarly reputations are based is books. The advent of the personal computer has greatly improved the ability of historians to write these books. It takes a scholar from three to ten years to write a good booklength study. This lengthy process includes internalizing the relevant literature, doing research at libraries and archives, and writing the text. All of these processes are amenable to computerization. Instead of the large number of note-cards, pieces of paper, and scratched out notes to oneself, if the historian can begin his/her research with a personal computer equipped with a hard disk, all the relevant information needed for the project can be stored in a fashion that permits ordering, reordering, retrieval, and adjusting over the lengthy period that the project is under way. The computer is particularly important to the historian because the writing of a book of historical scholarship is not a linear process, but one of outlining, filling in, running down leads, backtracking, rewriting, and so forth. It is precisely this sort of text processing that a personal computer can simplify.

Most historians do not need a big number-crunching machine. What is needed is a moderately fast machine (a 286 machine is fine) with a hard disk of 40 mb, a good word processing program that accommodates footnoting, bibliographical manipulation, outlining, and indexing, and a sophisticated but flexible data base program that allows variable field lengths, easy creation of new fields, and good browsing, search, and recall capacities. In addition, the active historian needs a compatible laptop (such as the Z-88 being touted by the ACLS) for use in libraries and archives where the original research is done. Naturally, each scholar needs a draft-quality printer and access to a high quality printer. Some specialists have to interact with data bases and mainframes, but this is not a widespread need.

Reflection seismology

In 1983 the W. M. Keck Foundation made a grant to establish a program in reflection seismology at Rice. The grant included an equipment grant that allowed the Department of Geology & Geophysics to buy an ELXSI computer with a detached array processor--a computer system of sufficient size and speed to do the number crunching involved in reflection seismology. Only with the promise of a seismic processing system in hand was the university able to hire faculty with expertise in this area.

Since 1984, the reflection seismology group, including A. W. Bally, then head of the department, N. R. Hill (1984-86), Alan Levander (1984-present), Dale Sawyer (1988-present), and Manik Talwani (1985-present), has been heavily funded by the National Science Foundation and other sources. They have processed over 750 km of seismic profiles. They have constructed structural models for the San Andreas transform region, the Canadian Arctic Islands and Appenines, the Brooks Range in Alaska, some parts of southern Alaska, and the Atlantic margin off the coast of South Carolina. The machine has also been used for research and computing by other members of the Departments of Geology & Geophysics and Mathematical Sciences. Rice is a member of the IRIS project, a nationwide effort sponsored by the National Science Foundation.

The ELXSI has since been supplemented by several Sun Workstations, which provide graphics terminals and take some of the computational burden from the ELXSI.

In 1984, an undergraduate major in geophysics was started. The ELXSI is used in all of the upper level geophysics courses. As Levander puts it, "There would not be a major without the machine." Indeed both the undergraduate and graduate students need experience in seismic computing before entering the commercial world. Even in current market conditions, when the demand for scientists and engineers in the petroleum industry has fallen, Rice graduates are in heavy demand.

There are continuing costs involved with maintaining this computer environment. Maintenance of the hardware and seismic software costs on the order of $110,000 per year. In addition a staff person is needed to provide support. The machine is now four and a half years old, and the needs of the group are about to go beyond the capabilities of the ELXSI in its current configuration. At least for short time periods, much higher speed is required (say 10 to 20 mflops). What is needed is a high performance machine that can be shared by several science departments.

Space research on the Rice mainframe

Rice University, under the direction of the Air Force Geophysics Laboratory and the Air Weather Service, is developing a Magnetospheric Specification Model for operational use. This computer model will be used by the Air Force and NOAA to protect satellites from hazardous fluxes of energetic ions and electrons that engulf geostationary and polar orbit satellites during magnetic storms. The model requires a large mainframe computer to compute energetic plasma fluxes throughout the magnetosphere. It consists, so far, of over 5000 lines of code and, in its present form, takes about 8 hours to run on the Rice AS9000. A team of eight Space Physics and Astronomy faculty, senior research scientists, and graduate students have been working on the development of the computer code for about two years. It is estimated that the model will take another four years to complete and ultimately cost over $1 million. This project, like other modeling projects in the university, has need of a large, modern, high-speed mainframe computer.

Microcomputers in space research

Space probes and Earth satellites, which operate for many years, produce large quantities of data on the space environment. One such satellite, Helios 1, has been in orbit about the sun since 1974. A data set, consisting of six years of hourly averages of plasma data from Helios 1, is being analyzed by Professor John Freeman of the Department of Space Physics and Astronomy using an IBM PC. This plasma data file from Helios 1 is nearly 10 Megabytes in size. A typical pass through this data set takes about five hours. However, the low cost of processing large quantities of data on the microcomputer makes it practical to try many different statistical analysis techniques. As a result, Professor Freeman has made significant findings which were missed by the science team doing the original analysis. Microcomputers have become an indispensable tool for space research.

Computational chemistry

J. S. Hutchinson was brought to the Rice Chemistry Department in 1983 to meet the challenges of the rapidly emerging field of theoretical chemical dynamics. His studies apply numerical and computational methods to address fundamental questions concerning how a molecule undergoes a chemical reaction following exposure to laser radiation.

During his time at Rice, Hutchinson and his students have enjoyed the benefits of an excellent computing environment. The components of this environment include substantial access to the university mainframe via generous grants of computing time, use of minicomputers and workstations acquired through externally funded grants, access to supercomputing capability off campus via the university network, and assistance from a talented support staff at ICSA.

The beneficial effects of this environment on Hutchinson's research productivity and visibility are apparent. His group has moved to the forefront of research in the theory of photochemical processes in laser fields, producing nearly two dozen publications in the scientific literature in the past five years. Three graduate students have completed doctoral dissertations, and four more are working towards their degrees. Importantly, five undergraduate students have participated in the research in Hutchinson's group, four of whom subsequently entered into graduate research programs. Two of these students are coauthors of major scientific publications. Finally, and notably, the computing environment at Rice has made it possible to attract adequate sustaining research funding, including grants from the National Science Foundation, the Petroleum Research Fund, the Robert A. Welch Foundation, and the Houston Area Research Center.

Computing in the Jones School

Professor Randy Batsell of the Jesse H. Jones Graduate School of Administration uses the computer in both his research and teaching. His primary area of research is in the development of mathematical models of choice behavior. These models are capable of predicting choices that will be made by groups or individuals from offered sets of alternatives. They are used, for example, by companies to design new products and develop strategies for their introduction, by politicians to develop campaigns, by planning agencies to design transportation systems, and by builders to design homes.

Development of these models first requires specification of the structure of the model. (This activity is creatively analytical, and does not involve computing.) Once a model structure has been specified, however, one takes data and parameter estimation software and finds a solution for the model's parameters that best fit the data. Typically, however, the models are new, and software must be written to estimate the parameters. Therefore, Professor Batsell's primary use of the computer in research is the programming of software to estimate parameters for new models of choice behavior.

Professor Batsell's secondary area of research is in human-computer interaction. Research in this area constitutes studies of how individuals interact with computers and software. The goal is to understand enough about how individuals use computers that software and hardware can be made easier to use and render users more productive. In this activity, computers are first used to collect and store data, and then to analyze it.

Most of Batsell's teaching consists of helping students learn how to use data to make better decisions. The data can be preferences about products, employee attitudes toward work, cost data about a manufacturing process over time, etc. -- whatever data a manager can use to make better decisions. In this process, students use the computer to store and transform data, graph data and models for visual inspection, and test hypotheses.

When he came to Rice in 1980, the computing environment was exactly what Professor Batsell needed. There was a large mainframe with all three software packages that he typically uses to analyze data. There were also two collections of callable subroutines that he could incorporate into his own code designed to estimate parameters for models. Use of the computer in his research often involved calling up the computer from home at late hours to take advantage of price reductions during off-peak times. Since 1980 the computer has only been down twice when Batsell tried to use it in this manner. Compared to computers that he has used in the same manner at two other Universities which were down about 20% of the time, he considers this to be incredible performance. When he had problems during the daytime and staff were on duty, the staff was always helpful and almost always able to solve his problem immediately. In Professor Batsell's experience, the computer operators have always tried to minimize how long users have to wait for their output and so they place it in the bins very soon after it comes off of the printer.

Batsell's experience in using the computer in teaching was equally satisfactory. To carry out their assignments, students would go to the computer center and run analyses. When they had problems, they reported that the staff was helpful and almost always able to resolve the problem quickly. They did note a difference in the knowledgability of full-time staff acting as consultants versus part-time staff acting as consultants, but that would be expected.

Over the last few years, Batsell's use of computers in teaching has migrated to micros and so, except for an advanced class in Marketing Research, his students no longer interact with the mainframe. His research computing, however, is still done almost exclusively on the main-frame and, except for some problems associated with the elimination of TSO, the level of performance continues to be exceptional.

At the same time that the mainframe operation continues to satisfy his needs, there is more and more support for microcomputing on campus. Batsell and his group have received a great deal of help and support in: (1) writing applications for donation of microcomputers, (2) making decisions about what software packages to buy, and (3) training.

Based on his needs and his computing experience to date, the computing support Professor Batsell has received has been exceptional.

APPENDIX B

Research Uses of Computers

The appendix lists many of the major ways in which computers can help support research. For each support activity the section first defines the purpose of the support. Then the benefits of the support are described.

Computer Uses Related to Communication

ELECTRONIC NETWORKING

Purpose: To exchange ideas, software, data, analyses, graphs, and papers with colleagues at Rice and other Universities.

Benefits: 1) Reduces turn-around time between sending and receiving.

2) Reduces time spent on the part of the sender to print, package and ship.

3) Provides opportunities to collaborate with faculty at other institutions -- collaboration that would not take place without the network.

4) Provides access to data bases created at other locations, e.g., the Stanford Linear Accelerator, the Fermi Lab, NCAR, and MSRC.

5) Makes possible easy, interactive remote access to more powerful computers.

LITERATURE SEARCH

Purpose: The search for, and retrieval of, published (and unpublished) material on particular topics.

Benefits: 1) Makes it possible to search by category and thus find material that would not otherwise be found.

2) Saves time in that one can obtain the material immediately, rather than make numerous trips to libraries.

Computer Uses Related to Data

DATA COLLECTION

Purpose: The control of experiments, and the collection of data from an experiment.

Benefits: 1) Sometimes computers are used to control an experiment because in engineering this corresponds to the control of equipment and in the field of psychology it corresponds to making decisions based on subject input that alter what is done next. Both of these applications are examples of things that, because of the required speed, computers can do, but humans cannot.

2) Since most data are analyzed by computer, real-time data storage on a computer at the time of the experiment saves the step of preparing and entering the data for analysis.

DATA MAINTENANCE

Purpose:
The storage, editing, merging, sorting, and general maintenance of data.

Benefit:
Data maintenance is an unglamorous application of the computer, but without the ability to store, edit, merge and sort data on a computer, little research would get done in areas as diverse as Economics, Biology, and Space Physics.

GRAPHING OF DATA

Purpose:
To present raw data in a form that can be visualized.

Benefit:
Sometimes the researcher can see patterns in graphs of raw data that are not easily discernible in data analysis, so the ability to see visual representations of the data can lead to new ideas and hypotheses.

PARAMETER ESTIMATION

Purpose:
To estimate parameters in models.

Benefit:

The creation and building of mathematically precise models, which often contain parameters to be estimated, is the goal of a great deal of research activity. Such work depends on one's ability to take a model specified with parameters, and, given data, estimate those parameters. Parameter estimation tasks that could not be done by hand can be accomplished interactively with computers.

Computer Uses Related to Modeling

SOLVING EQUATIONS, SYMBOLIC MANIPULATION

Purpose:

The usefulness of many models depends on one's ability to find solutions to their specification equations.

Benefit:

Just as parameter estimation could not be accomplished without the computer, the solving of complex differential equations and the derivation of complex algebraic solutions by symbolic manipulation simply would not be possible without modern computing.

SIMULATION

Purpose:

Once an equation is solved, or a model's parameters are estimated, it is often useful to systematically vary its solution across some range and see what new phenomena are predicted. Thus, simulation is essential for determining the limits of theoretical models, and for predicting phenomena that are difficult or impossible to measure, experimentally.

Benefit:

Like parameter estimation, simulation is an activity that cannot be done, except on a very small scale, without a computer.

HIGH SPEED VISUALIZATION

Purpose:

High speed visualization can be described as the computer drawing pictures of some phenomena of interest.

The pictures can be computer-generated renderings of a physical model or a concrete analogue to a mathematical model.

Benefits: 1) When we can clearly picture something in our mind, we can internalize it more concretely. High speed visualization allows the researcher to "see" the phenomena (s)he is studying, but it does it in a tiny fraction of the time it would take to build a physical model.

2) Because high-speed visualization can be accomplished so fast on a computer, the computer allows the researcher to actually visualize simulated changes in the modeled phenomena. Picturing the dynamics of a phenomena often leads to a better understanding of that phenomena.

3) High speed access to remote interactive computing.

Computer Uses in Document Preparation

Purpose:
To prepare papers for publication

Benefits: 1) With the advent of word processors and laser printers, high-quality documents can be easily entered, modified, and printed by anyone with only moderate typing skills.

2) The ease with which text and graphics can be integrated into a single document has noticeably improved the quality of papers and reports.

3) The final draft can be submitted for publication electronically. This completely eliminates the errors inherent in manual typesetting, and reduces the need for proof reading.

Computers to Study Computing

There is one computer use that is unique to a particular discipline and should therefore be described separately. In the field of computer science, computers are used to study computing. The organization of systems, the design of compilers and other computing software are studied by simulating and comparing the performance of various approaches. In a sense, simulation is used, but the approach is sufficiently unique to warrant a separate description. Without computers to study computing, few advances could be made in the field of computer science.

APPENDIX C

Campus Interviews

In this appendix are listed the interviews conducted by members of the Research Computing Subcommittee in the fall of 1987.

DEPARTMENT	COMMITTEE MEMBER(S) RESPONSIBLE
Anthropology	Dick Grandy
Art and Art History	Dick Grandy
Biochemistry	John Hutchinson
Biology	John Hutchinson
Chemical Engineering	John Polking and Mary Wheeler
Chemistry	John Hutchinson
Civil Engineering	John Polking and Mary Wheeler
Computer Science	Don Johnson
Economics	Robin Sickles
Education	Robin Sickles
Electrical and Computer Engineering	Don Johnson
English	Dick Grandy
Environmental Science and Engineering	John Polking and Mary Wheeler
French and Italian	Dick Grandy
Geology and Geophysics	Don Johnson
German and Russian	Dick Grandy
Health and Physical Education	Randy Batsell
History	Dick Grandy
Linguistics and Semiotics	Dick Grandy
Mathematical Sciences	Mary Wheeler
Mathematics	John Polking
Mechanical Engineering and Materials Science	John Polking and Mary Wheeler
Military Science	Randy Batsell
Naval Science	Randy Batsell
Philosophy	Dick Grandy
Physics	John Hutchinson
Political Science	Robin Sickles
Psychology	Robin Sickles
Religious Studies	Dick Grandy
Sociology	Robin Sickles
Space Physics and Astronomy	John Hutchinson
Spanish/Portuguese/Classics	Dick Grandy

School of Music	Randy Batsell
School of Architecture	Randy Batsell