A protocol for evaluating computer systems for application in a physician’s office

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In this paper we present some of our experiences in the development of protocols for the evaluation of manual and automated medical information systems. The objective of this work has been to determine the feasibility of implementing computer technology in the office practices of private practicing physicians in Clackamas County, Oregon.

In order to effectively resolve our major objective, we established two primary tasks, namely:

- Evaluation and Documentation of Existing Manual Systems
- Evaluation and Selection of a Computer System.

These tasks, although inter-related are presented in the two sections of this paper.

BACKGROUND

On June 1, 1973, the Physicians Association of Clackamas County (P.A.C.C.) received a federal grant to determine the feasibility of cost-effective automation in the physician’s office. The project, which subsequently came to be known as the Health Information Management Study (HIMS), was started on September 1, 1973. The HIMS Project is directly responsible to the P.A.C.C. Grant Committee, which in turn reports to the P.A.C.C. Board of Trustees.

P.A.C.C. was established in 1938 and is sponsored by the Clackamas County (Oregon) Medical Society. This dispersed Health Maintenance Organization (HMO) offers prepaid group coverage with service provided on a fee-for-service basis. In addition to a prepaid plan providing free choice of providers, P.A.C.C. has a “Protecting Circle Plan” which lists specific physicians, optometrists, physical therapists, pharmacies, medical laboratories, hospitals, convalescent hospitals, and home health care agencies providing services under the plan. These providers are scattered throughout the county which is largely rural. To minimize costs to the patient the physicians of P.A.C.C. use local control and peer review. All underwriting losses are shared by member physicians.

P.A.C.C. member physicians, recognizing that communication problems exist because of the dispersed nature of their practices, felt that an improved information system needed to be implemented. This conceptualized system would provide them access to the same kind of information they would have if they all practiced in one building with a centralized record system with easy access to one another. Such a system would improve the quality of care delivered in several ways. For example, duplication of services would be minimized. Physicians would have readily available access to information needed in a consultation or referral, thus improving physician-to-physician communication; a physician seeing a patient in a facility outside his own office would have the information available which was needed to provide the best care possible. It was felt that an automated medical information system would permit this kind of flow of information among participating physicians. With this in mind, P.A.C.C. physicians, in conjunction with Battelle, sought and received funding for such a research effort.

A major goal of this research effort was to provide an accurate comparison of current information systems and related costs to any future automated system. A format has been developed by HIMS which provides for a complete and logical description of an ambulatory medical practice. The format starts with a general description of each of the eight medical practices and includes detailed system descriptions and volume and cost statistics.

The HIMS project concerns itself with those ambulatory health care facilities located in Clackamas County and which are members of P.A.C.C. It was not feasible to document all facilities involved; therefore, a sample was selected to represent the total group. The selection criteria used in the project included the number and specialties of the physicians in the facility, the patient volume, and the proximity to other medical facilities. The sample medical practices selected represented a cross section of the popu-
DOCUMENTING THE MANUAL SYSTEM

Orientation and system description

The initial step in the HIMS documentation protocol was for an engineer to assume the role of a patient. This approach provided familiarization with the functions of a doctor's office and helped develop a positive rapport with the staff. While being processed as a patient through the health care facility, the engineer took notes concerning the flow of the patient and his associated information. The flow of information "triggered" by the patient was then converted to a patient-information flow diagram. This diagram, which utilized standard flow symbology, was instrumental in breaking down the medical practices into their basic "systems". Experience in Clackamas County suggests that a basic group of eight systems always exist in a medical practice. Figure 1 reflects their relationship to the total system, the medical practice.

It was our early judgment that five of these systems (shown shaded in Figure 1) were likely to be immediately affected by any automation of information. These five systems were subjected to detailed examination and documentation.

Protocol for detailed description

There are nine elements in our description of each of the five systems in each medical office:

1. System Definition and Objective
2. Flow Process Explanation
3. System Input Triggers
4. System Input
5. System Output Triggers
6. System Output
7. Physical Characteristics
8. System Problems

Figure 2 is a flow diagram of how we complete these elements and ultimately pull together an integrated system description. While content of these elements is obvious in several cases, some explanations are necessary.

Input and Output Triggers—elements 3 and 5—were events which caused a system to need or yield information, respectively. The input of a system was defined as the entire information received and processed by it. Somewhat differently, the output of a system is the transfer device or instrument of communication containing information produced by the system. An example of a system output is a listing of one physician's scheduled patient encounters for a given day.

The physical characteristics element included system location, storage media and preparation method of the records, accessibility, labeling, and methods used to arrange or store the records. Also considered were time relationships between information receipt, filing and retrieval,
and the retention criteria for a document in any given record keeping system.

A problem list of the shortcomings of a given system was made for each facility. The problems were those identified by the physician, his personnel, and the individual doing the documenting. While this list was not exhaustive in each case, the collective list of problems was of significant value while examining automation alternatives.

**Measurement and analysis**

Thus far in our documentation, all efforts were centered around verbal data. Hard statistical and financial data were collected to form a solid data base for future comparison. Determining the cost of an office system included allocating staff and physician time to each of the defined systems, allocating floor space to each system, and allocating all expenses according to man-hour wage, overhead, or direct assignment.

The HIMS approach to man-hour allocation involved interviews with management and staff. A spread sheet was set up for all those employed (including physicians) at the office during the year, and every effort was made to accurately assign the hours worked to the appropriate office systems encountered in an ambulatory medical facility. The physician was encouraged to log all of his time, including personal time, to allow a more complete analysis of his time utilization.

Once the man hour assignments were determined, a floor plan of the clinic was obtained. At this point, as much floor space as possible (usually about two-thirds of the total) was allocated to the various office systems. The remaining (unassigned) floor space, which consisted of waiting rooms, rest rooms, and hallways, was then allocated to the systems in direct proportion to the previously assigned floor space. For example, if Patient Care areas amounted to 50 percent of the directly assigned area, then 50 percent of the remaining (miscellaneous) area was assigned to this same system. Careful evaluation and a little inductive reasoning provided reasonably accurate allocations of office areas where more than one system was in operation.

The next step was to assign dollar values to the physician and staff time and floor space allocations. A copy of the annual (audited) financial report was the reference. This report reflects all expenses, and normally presents them in a detailed manner sufficient for immediate incorporation in the cost allocation effort. If an expense was attributable to one or more identifiable systems, it was appropriately charged to them. If, however, the expenses were rather broadly based (e.g., rent, fire insurance), they were assigned to the office systems in direct proportion to the assignment of floor space.

Volume statistics are equally as important as cost information when documenting any facility. Together, they provide the data necessary for evaluation of change. In pursuit of statistical data, HIMS first sought secondary sources where statistics had already been tabulated for other purposes. Since the practices we were working with did not tabulate many statistics, a plan to collect data from primary sources was then designed and carried out.

The primary objective of the collection effort was to determine the volume of patients seen during a given period. The patient medical record (including active and inactive files) was selected as the most acceptable source for these data. Information pertaining to the description of the population served was also collected at marginal additional cost. This additional information included patient characteristics (e.g., address, sex, insurance, date of birth), encounter information (e.g., date, graphics, second party involved), and report information (e.g., date, type, source).

In the HIMS effort many alternatives were considered concerning the method of sampling. It was decided that systematic sampling would be the simplest for data collectors to administer, and would not involve serious distortion of the statistics. The selection was done by counting patient records and taking every nth record, with n being the inverse of the sampling rate for that office.

HIMS discovered that great care had to be taken when designing data collection forms which met the needs of both data collectors and those involved in tabulating the data. For the data collectors, the fields on the forms were arranged in the sequence that the collector would encounter the information, when going through the source document. The forms provided adequate space for writing legibility and accurate reading by tabulators.

The importance of accuracy was impressed upon the collectors, and checks on the quality of the data were conducted regularly to keep errors at a minimum. Though the sampling methods were fairly rigid, individual judgments were unfortunately made by data collectors in some instances.

The data resulting from the HIMS statistics collection effort was entered into the computer at Oregon State University. File management programs were written in FORTRAN to extract and sort data from each of the files so that continuity of information about a given patient could be maintained. No patient names were used; patient numbers were assigned to maintain data organization.

Once the cost, volume and general statistics were gathered and tabulated, there were almost infinite possibilities for analysis. However, the present needs were for system costs and for several basic volume and growth statistics. All the collected data is stored on magnetic tape for possible future use.

**Discussion of problems**

 Probably the most serious problem facing the Industrial Engineers working on this project was the obvious meaning of “cottage industry”. There are approximately 140 physicians in Clackamas County working out of nearly seventy offices. The largest clinic in the county presently is made up of five physicians of various specialties. Thus, the size alone of these practices suggests the problem of a lack of internal documentation and standardization. While
many similarities were found when comparing systems of different offices, many more differences were documented. As would also be suggested by the relatively small size of these practices, statistics are neither needed nor maintained. Thus, the engineers were working in a “virgin” territory, relatively untouched by computers, systems experts, or professional managers.

Faced with this environment, the HIMS staff carried out plans to “soften” the blow of systematic analysis in these offices. With the obvious long range goal of automation clearly understood by the office staffs, the age old operational problems of the “efficiency expert” were anticipated. Meetings were held with over sixty office personnel which thoroughly explained and discussed HIMS. The net result was a definite “supportive” attitude that has persisted throughout this study.

The extensive physician involvement in this study was somewhat unique. This fact relates to the history of this study, which has the unique aspect of a group of physicians seeking out technical assistance in the area of automation, instead of the far more common reverse situation. Truly, the HIMS project represents a combined medical/engineering approach to problem solving in the medical environment.

While many other problems have been faced, one very interesting one has occurred, against which no known cure exists. Members of the medical profession are, at times, impulsive. This trait, combined with the intensive, deliberate exposure to automation occasioned by HIMS has resulted in “overpriming” some physicians. Several problems occur as a result of this situation. Examples experienced by HIMS include efforts by one physician to have a local computer service organization obtain a franchise for one system he had seen, since he decided unilaterally that system he had seen, was for him. He felt HIMS would take too long to study the offices before implementing a system. Another difficulty is the waiving of interest and support that occurs when the engineers finish documenting one office and move into another. This “withdrawal” of interest is not easy to restore, and can breed discontent throughout a medical group. HIMS practice to date has been to seek a careful balance between educating the physician in the applications of computers, necessary to obtain his judgment on potential value of the new system, and not educating him, which tends to alienate him and cause negative support.

Summary

The protocol presented in this paper can and has provided a comprehensive picture of private medical practices. It functions best in a cooperative mode, with the benefits being a mutual education of medical and systems personnel alike. Some traditional systems analysis problems do occur, but our experience indicates that they tend to be soluble to a high degree, possibly due to the higher than average education level of the personnel involved.

COMPUTER SYSTEM SELECTION

Selection constraints

Before proceeding to the topic of developing a system selection protocol, we should point out some of the constraints that we imposed on ourselves during the program. The most significant was the requirement that the system be largely composed of off-the-shelf components, especially the system software. We have been and continue to be far more interested in utilizing the best of available hardware and software than we are in developing new innovations to be tested. As a second constraint we elected to pursue an incremental, or modular approach to implementation as has been suggested by Dr. G. O. Barnett.1 Our purpose in this case was to provide a basic system which could be implemented at a reasonable risk (as opposed to a “total” system), but one which would provide a reasonable degree of open-endedness so that it could be substantially expanded. Third, we set out purposefully to involve physicians and physicians’ office staff in every major (and many minor) analysis, design, and implementation decisions. Since the ultimate acceptance or rejection of the system will rest on choices made by these people it is not just prudent, but necessary, to learn how to utilize their skills in assisting with the selection process.

Selection methodology

The methodology (protocol) developed for use in selecting a computer system is based on comparing the performance of modern medical computer systems against the requirements developed for P.A.C.C. The protocol includes four major elements which are:

- Definition of System Performance Measures
- Analysis and Specification of Requirements (Modeling)
- Performance Analysis of Available Systems
- System Selection.

This methodology is broadly comparable to that surveyed recently by Timmreck. He defines the four steps as (1) analysis and specification of need, (2) request for proposals, (3) validation of proposals including system performance measurement and (4) actual system selection. It may be contrasted with selection criteria reported by Raymond and Giebink. There are several major differences between our methodology and most others.

First, the system performance measures have been defined for a broad class of medical computing systems, namely real-time systems suitable for a geographically diverse group of physicians in a combination rural and suburban setting.

The second difference in this methodology is that the definition of system performance measurement elements
are presented from several different viewpoints; namely, the user, the computer scientist, and the business manager. The advantage to the user of this type of protocol is that he can develop an understanding beyond the technical performance of the system. Additional information gained includes a measure of the type (or style) of vendor he is dealing with, for the user's acceptance of the system, for its expansion capability, and the many other factors that are a part of the total commitment involved in owning or using a computer system for medical applications.

Third, we should stress that the selection process is not a simple four step process. It is a recursive process that must be repeated and refined. While we consider the basic four steps to be essential to every computer selection, we also recognize that each step can be approached in a simple manner or in a great deal of depth. We cannot, for example, tell every user that they should examine their requirements in the depth that we have at P.A.C.C. It would not, for example, make any sense to spend $50,000 selecting a $20,000 system. We can suggest that performance measurement elements and a system model should always be established prior to any commitment to lease or buy either a computer system or service. It is left to the individual user to determine the depth of investigation and analysis appropriate to his particular needs.

**System performance measures**

Performance measures are a set of measurable elements that characterize the system being considered. Performance measures should not be confused with performance specifications. By defining a set of measures we are simply generating a glossary of elements that are indicators of the performance of computer systems. Specifications are specific performance criteria which are used to describe the desired system in terms of the measurement elements.

The performance measurement elements derived for P.A.C.C. are shown in detail in Appendix A of this report. Six major categories of measurement have been selected. They are:

- Vendor Overview
- Systems Performance
- Applications Performance
- Start-up and Expansion Capability
- User Interface Performance
- Cost.

Vendor overview is intended to provide background information on each prospective system supplier. We have not set specific standards of acceptance in this area, but expect the information to be useful to P.A.C.C. in becoming familiar with each specific company. Information collected for each vendor includes:

- Corporate Profile
- Product Profile
- Health Care Experience.

Systems performance measurements are indicators of the fundamental design capability of the system. The use of evaluation criteria in this area can be eliminated or limited to a subset of the elements presented in some selection processes. This is especially true for a medical group that is selecting a system to solve a specific, well-defined problem such as taking patient-histories. In such a case, the evaluation may be carried out based on the quality of the applications programs, the user interface, cost, etc., without regard for the design of the system.

System design is an important element in any comprehensive information system, especially one that will have a county-wide impact as contemplated at P.A.C.C. Comprehensive, multiple-user systems are complex dynamic systems which must be flexible in design and operation, easy to maintain, and provide the necessary hardware and software support so that they can be modified to meet new and expanding needs. If existing systems are so designed that they do not meet the needs of the specific medical community where the system is to be used then the basic system design is a critical factor and should be considered. If the application is fairly simple and well proven then a prospective user of the system does not have to be so cautious.

Systems performance is characterized by the basic design of the hardware and the system software available to the user. The major elements are:

- Hardware Capability
- Programming Languages
- Operating System
- Data Base Management
- Utility (Support) Programs
- System Upgradability
- System Support
- Stage of Development.

Applications programs are the elements of the computer system that actually solve the end user's problems. It is the applications program that must be most closely tailored to the specific user's needs and demands. Many examples of computer system failures can be directly traced to applications programs which solved the wrong problem or solved the right problem in an inferior manner (e.g., at an excessive cost for the task). It is of vital importance that those who design the system (the computer types) and those who use the systems (physicians, nurses, business staff) work together in the analysis of application requirements, design, and use. It is extremely helpful to have access to a physician with a background in computers to act as the intermediary for these two groups.

Examination of available applications should focus on the scope, or breadth, of applications available and on the specific performance of applications packages. The following classes of applications are being implemented or considered at P.A.C.C.:

- Practice Management
- Business
Start-up and expansion capability is of prime concern to the prospective user of a medical computing system. He must develop a plan for the effective implementation of a proposed system. It is desirable for the user to minimize his risk and capital expenditure by selecting the minimum hardwar/software system that can be implemented to solve his current problems. At the same time, the system must be large enough to be capable of expansion to meet long range growth (both in the number of users, in the various types of applications programs, and in the population served). It can be as much of a mistake to install a large system which is grossly under utilized as it is to install a small system that cannot be expanded to meet all of the important design needs.

We are suggesting that the best approach is one that permits the modular expansion of the hardware/software system as the capabilities of the system expand. Our approach to this problem is to model both the full scale system and a start up system where the full scale system will meet the needs of our total user group (the physicians of Clackamas County, Oregon), but the start up system will begin with a small group of physician offices (say 7 or 8).

The growth and acceptance of medical computing systems depends largely on the establishment of effective man-machine communications. In a larger sense, the success of the system depends on the performance of the user interface with the system whether that involves a user at a terminal, or a user attempting to change the system (via programming or administrative action), or a user attempting to understand the system (training and documentation). The performance of the system from the user's viewpoint can be measured in terms of (1) What is used (hardware), (2) How it is used (communication/display elements), (3) How information is protected (security), (4) When it can be used (hours of service), (5) How well people like it (human factors design), and (6) How well it is documented. The performance elements are listed as follows:

- User Equipment (Hardware)
- Communication/Display Elements
- Security
- Hours of Service
- Human Factors Design
- Documentation and Training.

The cost of a medical computing system should be treated very carefully by the prospective buyer. Computing systems are not like conventional instruments such as X-ray machines and the like. They are complex and dynamic systems that require long term investments in personnel and expansion. Costs will vary substantially based on whether the user elects to purchase a computer service rather than installing his own system. In either case, estimates should be made for one-time costs and for the costs of recurring items. Design, implementation, testing, operation, and maintenance costs should also be calculated. Both personnel and facility costs should be added which will include terminal operators, central computer operators, programming staff (if any), management, and maintenance. Facility costs should not only include the facility to house the computer, but required improvements (power, air conditioning, etc.) and a cost associated with the space required for the terminal in each user's office.

Analysis and specification of requirements

Having defined the system performance elements we next begin to define performance requirements for each element. These requirements then become our model for the desired system. It is very useful to define two types of requirements: mandatory and desirable. In our case, we were able to reduce our analysis of vendor systems from a large number to only a few by the mandatory requirement that the system perform its major tasks on a real-time basis.

Requirements were established largely by the P.A.C.C. Grant Committee working with HIMS staff engineers. Inputs to the effort included (1) data from the documentation effort described earlier in this paper, (2) observations of office practices and problems by HIMS staff engineers performing the documentation effort, (3) a comprehensive Delphi Survey of physicians to determine their perceptions of information processing problems and their respective priorities, (4) a similar Delphi Survey of nearly 300 physician employees, (5) site visits to a number of medical computer installations, (6) limited evaluations of several systems that were demonstrated on a limited scale at our site, (7) a review of vendor literature, and (8) review of the current open literature concerning medical computing systems.

The results of the Delphi indicated that both physicians and their employees consider insurance claims processing, private billing, and internal control of both medical and financial information to be of highest concern. To a lesser degree physicians were concerned with inter-office communications. There was very little perceived need for some of the classical medical computing applications. The results of this study coupled with the documentation has led us to the following conclusion. The source of the underlying operational problems of office practice can be largely attributed to the current structure of the medical and financial records system. Moreover, if the data contained in these records were organized and stored in a manner that promoted effective retrieval and use of the information required for (1) insurance and private billing, (2) medical care, and (3) physician-to-physician communications then many of the current (and costly) redundancies of personnel and services could be reduced.

The next major task undertaken was to translate these
Performance evaluation

Performance evaluation of currently available systems requires three steps:

- Identification of Systems
- Analysis of Systems
- Selection or Evaluation.

One of our continuing efforts has been to identify candidate systems for evaluation. A variety of techniques were used, some successful, some not. The least successful was the preparation of a letter to vendors describing our general needs. The most successful were references from people in the industry and identification in the open literature. Initial identification was followed by telephone inquiry and if the system appeared suitable, by a site visit. At this point we established a screening process against our mandatory criteria. The following requirements were used:

- The system must be primarily a real-time system. Some applications (such as billing) can be run off-shift, but data entry must be on-line.
- The system must be capable of supporting up to 100 physicians in a time-sharing mode and in a diverse geographic environment.
- The system must have a background of established performance.
- The system must provide applications software.
- The applications must support both business and medical functions.

Only four systems survived the initial screening process. The secondary screening process utilized the detailed standards developed by the HIMS staff, the Grant Committee, and Battelle. Side-by-side comparisons were made for each system which resulted in the elimination of two more systems. In order to again refine the process, the final two vendors were asked to submit proposals for consideration. In addition, the Grant Committee reviewed the requirements and established the four most important elements which are listed as follows in descending order of importance:

- Cost
- Scope of Business and Medical Applications
- Human Factors Design
- Hours of Computer Coverage.

It should be pointed out that we did not systematically develop a weighting scheme for evaluation, largely because of the difficulty in assigning weights to all of the elements. Rather, we used the workshop meetings to develop a relative weighting scheme for selected elements based on interaction between the workshop participants.

The final evaluation which resulted in the selection of a preferred system consisted of the repeat of the side-by-side comparison of each system plus the development and presentation of a complete set of cost breakdown sheets for each system which included a broad variety of lease, purchase, depreciation choices.

SUMMARY

We have presented a protocol for the systematic analysis and selection of a computer system for a diverse medical community. The process involves physicians, physician employees, industrial engineers, and computer scientists working in a collaborative atmosphere. As a result, a large sample of the medical community of Clackamas County is prepared to implement a computer based information system in 1975.

REFERENCES

APPENDIX A—SUMMARY OF TECHNOLOGICAL/COST EVALUATION ELEMENTS

I. VENDOR OVERVIEW
   A. Corporate Profile
      1. Parent Company
      2. Data Founded
      3. Number of Employees
      4. Employee Skill Mix
      5. Number of Active Customers
      6. Length of Customer Service
      7. Profitability
      8. Sales Volume
   B. Product Profile
      1. Type of Product(s)
      2. Completeness of Product Line
      3. Market Segment Serviced
   C. Health Care Experience
      1. Installed Systems
      2. Staff Experience
      3. Source of Medical Input

II. SYSTEMS PERFORMANCE
   A. Hardware Performance
      1. Type of Hardware
      2. Configuration
      3. Central Processor
      4. Memory
      5. Major Peripherals
      6. Data Communications
   B. Programming Languages
      1. Language Types
      2. Programming Ease
      3. Standardization
      4. Portability
      5. Efficiency
   C. Operating System
      1. Type of System
      2. Scheduling
      3. Number of Tasks/Partitions
      4. System Compatibility
      5. Security
   D. Data Base Management
      1. Type of System
      2. Structure
      3. Access Techniques
      4. Security
   E. Utility (Support) Programs
      1. Diagnostics
      2. Program Development Tools
      3. Other Available Programs
   F. System Upgradability
      1. Age
      2. Production Status
      3. Upward Compatibility
      4. Ease of Program Conversion
   G. System Support
      1. Vendor Support
      2. Maintenance Requirements
      3. Operation Requirements
      4. Space Requirements
      5. Power and Cooling Requirements

H. Stage of Development

III. APPLICATIONS PERFORMANCE
   A. Practice Management
      1. Statistics Reporting
      2. Peer Review
      3. Budgeting
   B. Business
      1. Aged Accounts Receivable
      2. Daily Transactions
      3. Post Accounts (Close Books)
      4. Trial Balance
      5. General Ledger
      6. Payables
      7. Dictionaries
      a. Consumer
      b. Vendor
      9. Subsidiary/Special Accounts
      10. Edit (all other applications)
   C. Health Care
      1. Medical Records
      2. Scheduling
      3. Patient Histories
      4. ECG Analysis
      5. Diagnosis
      6. Laboratory
      7. Pharmacy
      8. Drug Interaction
      9. Training/Education
   D. Insurance
      1. Third Party Claims
      2. Third Party Receipts
      3. Claim/Receipt Justification
   E. Communications
      1. Message Switching
      2. Transferring Files
      3. Accessing File Subsets

IV. START-UP AND EXPANSION CAPABILITY
   A. Minimum Break-even Configuration
   B. Expansion Capability

V. USER INTERFACE PERFORMANCE
   A. User Equipment
      1. Input Devices
      2. Output Devices
      3. Miscellaneous Devices
   B. Communication/Display Techniques
      1. Interaction Protocol
      2. Response Time
      3. Error Control
      4. System Failure Recovery
   C. Security
      1. Responsibility
      2. Security Schemes
      3. Violation Detection
      4. Audit and Reporting
D. Hours of Service
   1. Daily
   2. Nights
   3. Weekends

E. Human Factors Design
   1. Operator Acceptance
   2. Language Requirements (Special Encoding)
   3. Training Time
   4. Space Requirements
   5. Convenience of Use
   6. Office Disturbance

F. Documentation and Training
   1. Systems
   2. Applications
   3. User

VI. COST
   A. Time Shared Access
   B. Owning the System