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Conventional film mammography has several technical limitations which reduce its effectiveness, most of which can be overcome by full-field direct digital mammography (FFDDM). This research investigates an important application of digital breast imaging: telemammography, the electronic transfer of digital mammography images to remote viewing sites. This should permit radiologists with great interpretive expertise to manage and read in real time *all* mammography examinations in a multiple-site practice, an approach superior to either deferred interpretation by expert readers or real-time interpretation by general radiologists. During Year 1 of this project, we installed the first of two FFDDM imagers and developed the infrastructure of a telemammography chain between two distant sites. By showing that telemammography technology can be developed for routine clinical operation, and that real-time off-site management and interpretation of a general-radiologist mammography practice by mammography specialists is feasible as standard operating procedure, we expect to establish telemammography applications of digital radiography as both valid and useful. The application of these procedures to routine mammographic examinations should bring to bear the expertise of mammography specialists at the community-practice general-radiologist level. This should benefit all women undergoing mammography in the future.

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Edward A. Sickles MD 10/8/97

PI - Signature Date

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INTRODUCTION

Current attempts at controlling breast cancer concentrate on early detection by means of mass screening, using periodic mammography and physical examination, because ample evidence is now available to indicate that such screening indeed can be effective in lowering the death rate.

Screen-film mammography has several technical limitations which reduce its effectiveness, most of which can be overcome by full-field direct digital mammography (FFDDM) [1,2]. The principal theoretical advantage of FFDDM comes from decoupling image display from the image receptor. This permits the digital image to be captured electronically, stored digitally, and then manipulated, analyzed, and displayed however, whenever, and wherever it is needed. Practical applications of FFDDM currently under development include: real-time image display, post-acquisition image enhancement, image archival and retrieval, dual-energy subtraction imaging, computer-aided diagnosis, and computer-aided instruction.

This research will investigate still another application of digital breast imaging: teleradiology mammography, or telemammography [1,2]. Electronic transfer of digital images to remote viewing sites can be accomplished almost as rapidly as between the standard display workstation and computer storage. Radiologists who work in several different offices or hospitals will be able to monitor and interpret examinations that are carried out in a nearby or even at distant location or locations. This will permit those radiologists with the greatest interpretive expertise to manage and read in real time *all* mammography examinations, an operational procedure far superior to the alternative of choosing between deferred interpretation by expert readers or real-time interpretation by general radiologists [3,4]. In addition, mammography screening in mobile units will be made more efficient, not only by overcoming the need to transport films from the site of examination to the site of interpretation, but also by permitting image interpretation while patients are still available for repeat or additional exposures. Telemammography can also be used to facilitate second-opinion interpretation, in effect making world-class mammography expertise immediately accessible to community-practice radiologists. Finally, digital image transmission can be the cornerstone upon which multi-site teaching conferences are built, from applications as simple as the simultaneous conduct of teaching rounds among the nearby hospitals that participate in a residency training program to intercontinental multi-institution conferences supported by satellite transmission of digital mammograms.

The majority of the clinical activities of the breast imaging service at our institution take place in the Breast Imaging Section of UCSF/Mt. Zion Medical Center, staffed by full-time breast imaging specialists. Additional mammography examinations are done at the UCSF/Parnassus Ambulatory Care Center (ACC), staffed by general diagnostic radiologists. During the conduct of this study, the UCSF/Mt. Zion Medical Center will serve as the site of great interpretive expertise, whereas the UCSF/Parnassus ACC will be a satellite site staffed by general radiologists.

By demonstrating that [a] telemammography technologies can be developed for routine clinical operation, and [b] that real-time off-site management and interpretation of a general-radiologist mammography practice by mammography specialists is feasible as standard operating procedure, we will help to establish telemammography applications of digital radiography as both valid and useful. The application of these procedures to routine mammographic examinations should contribute to more efficient and higher quality breast imaging, by bringing to bear the expertise of mammography specialists at the community-practice general-radiologist level. This should benefit all women undergoing mammography in the future.

BODY

1. Overall Goals

During the first year of this project, goals were set to accomplish the development of telemammography infrastructure and to start collecting patient examinations. The tasks of infrastructure implementation involve (1) creation of a telemammography network, (2) installation of the first (of two) FFDDM units at UCSF/Mt. Zion Medical Center, (3) development of a digital mammography display workstation (DMDW), and (4) integration of the above-described systems. Patient examinations involve the imaging of selected patients with FFDDM, to the extent that infrastructure implementation can proceed. These goals include all of the items listed in Tasks 1 and 2 of our Statement of Work.

During the next two years of the project, after installation of our second FFDDM unit at a different clinical site (UCSF/Parnasssus ACC) and completion of the telemammography infrastructure to incorporate this site into the imaging network (months 13-24), our overall goal is to complete three telemammography study protocols: telediagnosis, teleconsultation, and telemanagement (months 22-36). The telediagnosis protocol tests the clinical effectiveness of telemammography by comparing the interpretation of transmitted FFDD mammograms versus interpretation of conventional screen-film mammograms. The teleconsultation protocol tests the clinical effectiveness of digital mammography consultation between general radiologists and expert breast-imaging radiologists, using selected difficult mammography cases. The aim here is to evaluate the ability of telemammography to facilitate real-time consultation between on-site general diagnostic radiologists and remotely-located expert breast-imaging radiologists. The telemanagement protocol tests the effectiveness of remote real-time interpretation and management of digital mammography examinations by expert breast-imaging radiologists (versus real-time on-site interpretation and management of conventional screen-film mammograms by general diagnostic radiologists). If telemanagement succeeds, this will permit the replacement of on-site general radiologists with remotely-located expert breast-imaging radiologists.

2. Accomplishments During the First Year of the Project

The first year of the project (September 1996 - September 1997) involved the planning, purchase, integration, and testing of FFDDM system components, including the Fischer Imaging Corp. Senoscan FFDDM imager with Q/A capture computer (used to control the patient examination process), two high-resolution 2.5K x 2K FFDDM display workstations, and the telemammography ATM network. The first few patient examinations also were performed during this period.

2.1 Infrastructure

2.1.1 Cabling

Fiber optic cables were used for the telemammography network, to utilize high speed ATM technology. Existing fiber optic cables provide the basis for the local area and wide area ATM network. At sites where there were no existing fiber optic cables, we contracted with UCSF campus networking services to pull the fibers according to our specifications. The wide area network connection was established using the newly developed UCSF OC-12c Sonet Ring. Figure 2.1.1 (see page 15) shows a detailed diagram of the cabling infrastructure.

2.1.2 Networking

ATM technology was used to accommodate the high bandwidth requirement of this project, since the size of each FFDDM image is approximately 46 Mbytes. The main networking components are two FORE ASX-200BX ATM switches (one located in the UCSF LRI and the other located 2 miles away at UCSF/Mt. Zion Hospital), and the newly established UCSF OC-12c Sonet Ring. The ATM switches are configured with one OC-3c network module fabric containing four ports. One of the four OC-3c ports is reserved for the wide area network connection to the UCSF campus Sonet Ring. Each host requires an ATM host adapter card. A FORE SBA-200e host adapter card was used for this requirement. Currently there are three hosts connected to the ATM network: a Fischer Imaging Corp. Q/A workstation and two high-resolution 2.5K x 2K FFDDM display workstations. One display workstation is located in the UCSF Laboratory for Radiological Informatics (LRI) and the other is in the Breast Imaging Section at UCSF/Mt. Zion Medical Center. A Konica Model Li-21 Laser Film Imager is attached to the display workstation in the Breast Imaging Section using an ethernet port. Figure 2.1.2 (see page 16) illustrates the networking infrastructure.

2.1.3 Communication Protocol

Images associated with a patient examination are captured by the Q/A workstation through a Fischer Imaging Corp. data channel. Images then are automatically transmitted to the display workstation, after the technologist verifies acceptable image quality. DICOM protocol communication is used to transfer FFDDM images over the ATM network, which is configured to use Classical IP. A hard copy of the image can be made using the Konica Laser Film Printer, by issuing a DICOM-protocol print-server command from the display workstation.

2.2 Digital Mammography

2.2.1 Installation

Installation of a Fischer Imaging Corp. Senoscan Full Field Direct Digital Mammography (FFDDM) imager at UCSF/Mt. Zion Medical Center was completed in June 1997. The Q/A capture computer sits on top of the imager and is used to control the patient examination process. An ATM host adapter was installed in the Q/A capture computer for writing data to the network. The entire Senoscan system was bolted to the floor in accordance with State of California seismic codes.

The Konica Model Li-21 laser imager was installed in the Breast Imaging Section at UCSF/Mt. Zion Medical Center in August 1997. The soft copy display workstation was installed in the Breast Imaging Section at UCSF/Mt. Zion Medical Center in September 1997.

2.2.2 Training

Bonnie Grear is the technician hired to conduct patient examinations. Training was required to familiarize her with the Fischer Imaging FFDDM system. Representatives from Fischer Imaging provided basic instruction on how to power the system on and off, how to reboot the system, login names and passwords, basic file system layout, how to bring up the applications, and how to capture, manipulate, annotate, send, and archive an examination.

Images are viewed using the display workstation developed by the UCSF LRI. Basic training on how to select a patient and how to display, manipulate, scale, and magnify the images was provided to both Bonnie Grear and the breast imaging radiologists at UCSF/Mt. Zion Medical Center by the LRI staff.

2.2.3 Practice

A test phantom was used to simulate a patient examination. Using this phantom, Bonnie Grear practiced entering patient information, capturing an image, manipulating the contrast and brightness, and transmitting the image to the display workstation. The contrast and brightness are of particular interest since these values are saved in the image header and later used for display. If the contrast and brightness are adjusted properly, the breast imaging radiologist will not have to adjust these parameters, therefore reducing the time involved in image interpretation. This will be especially important in conducting the teleconsultation and telemanagement portions of our protocol, both of which involve real-time interpretation of digital mammograms.

2.3 Digital Mammogram Data Flow

Digital mammograms captured by the FFDDM travel through a Fischer data channel into the host memory of the Q/A workstation across the S-BUS. Once in memory, the digital mammogram is sub-sampled and displayed on the console monitor. The minified image has a resolution of approximately 600 x 800 pixels. The technician may adjust the contrast and brightness of this image to assess its quality. If the image quality is good, the "accept" button on the Q/A workstation is selected. Otherwise the image is rejected and another image is obtained. If the accept button is pressed, the mammogram is automatically transmitted to the display workstation through the ATM network, using DICOM protocol communications. Once the image is received at the display workstation, it is queued and transmitted to the peer display workstation located at the UCSF LRI through the Sonet Ring, using DICOM protocol communications. Figure 2.3 (see page 17) is a diagram illustrating the data flow.

2.4.1 Hard Copy

Images may be printed in hard copy format using the Konica Model Li-21 laser film printer. The printer is attached through a SCSI port to a PC computer, which acts as a DICOM converter. The PC computer receives images in DICOM format from the display workstation using the DICOM protocol Print Service Class and converts the images to a native format for printing. The display workstation and the PC computer are attached to a local area ethernet network. A graphical user interface (GUI) program loaded on the display workstation controls the printing process.

There are two methods which can be used to match the appearance of the images in soft copy format: (1) selecting the one of seven pre-programmed look-up tables in the Konica laser printer which best matches the characteristics of the monitor, and (2) use of the contrast and brightness values in the DICOM header for printing.

2.4.2 Soft Copy

Images can be viewed in soft copy format using the mammography display workstation. The display workstation utilizes the SUN Ultra-SPARC II platform with two 2.5K x 2K Data Ray monitors, two DOME MD5-SBX boards, one 200 MHz CPU, and 384 M-bytes of memory. The display workstation has the following features:

(1) A DICOM image server process, which runs continually in the background. Images can be transmitted to the display workstation in DICOM format from any node connected to the ATM network.

(2) A local database which records information about the patient examination. Attributes such as patient name, hospital identification number, examination date, and birth date are useful for retrieving the examination for a particular patient. A description of the projection of the image (craniocaudal, mediolateral oblique, etc) is also saved in the database. This description is used to set the output rectangle of the image, so relevant image labelling information will be displayed. A patient list GUI provides easy point-and-click scrolling of current patient examinations and their images.

(3) Image manipulation features include pan and scroll, window and level, a continuously scalable magnifying glass, zoom and fit window capabilities, and a quick full-resolution function. Using the left mouse button the image can be positioned on the screen. With a click of the right mouse button, a small pop-up menu appears with a set of tools for adjusting the window and level, the image scale buttons for the magnifying glass, and the patient list. Images may be displayed in 1:1, 2:1, or 4:1 format, using the two 2.5K x 2K display monitors. The quick full-resolution feature is activated by a middle mouse button click on an image that is displayed in 2:1 or 4:1 format, to instantly expand the image to full resolution in 1:1 format. A second click on the middle mouse button returns the image to its original display layout.

2.5 Patient Study

2.5.1 Patient Selection

This research project involves normal and abnormal mammography cases. During the first year, our focus was on selecting abnormal cases with subtle mammographic findings, to test the telemammography infrastructure at expected limits of performance. We chose these cases as we interpreted conventional mammography examinations at UCSF/Mt. Zion Medical Center. Informed consent was obtained from selected patients, who then underwent FFDDM examination. As of September 15, 1997 (end of Year 1 of the project), we have completed FFDDM examination on 10 patients. We are continuing to conduct FFDDM examination on selected patients, as required to complete the infrastructure testing in our protocol.

2.5.2 Preliminary Image Quality Study

All images were viewed through the DMDW. For all FFDDM examinations, the (subtle) abnormal findings initially identified at conventional film mammography have been readily identified on the DMDW (soft copy), using the provided image display and manipulation features. In most cases, the soft copy display of an FFDDM image has somewhat superior image quality to its corresponding conventional film mammogram. Studied lesions include masses and clustered microcalcifications, the two most common mammographic features of breast cancer. We have also printed the images of two patients using the Konica laser imager (50-micron resolution). The printed image quality is comparable to that of its corresponding conventional mammogram, except that the breast is slightly smaller on the laser-printed film than on the conventional film mammogram.

2.6 Administrative

2.6.1 Programmatic Meetings

Three programmatic meetings were held, on October 16, 1996; on October 20, 1996; and on July 15, 1997. The first meeting was a kick-off meeting at UCSF in which the execution of the project was planned. The second meeting was held at Fischer Imaging Corp., Denver, CO to arrange for delivery of the Senoscan FFDDM imager. The third meeting was held at UCSF, with participation of Fischer Imaging representatives, after delivery of the Senoscan imager, to discuss operation of and training for the imager. The minutes for these three meetings are incorporated into this report, as an Appendix.

2.6.2 Research Team and Recruitment

Edward A. Sickles: Principal investigator. Dr. Sickles is responsible for all clinical aspects of the project, and also has overall responsibility for the execution of the project.

H. K. Huang: Co-principal investigator. Dr. Huang is responsible for the overall technical aspects of the project, and as liaison with manufacturers to install and contribute equipment to the project.

Shyh-Liang (Andrew) Lou: Dr. Lou works on this project as a technical investigator and serves as the coordinator to establish the real-time telemammography chain. He is responsible for the reliability and upgrading of the telemammography chain, including hardware and software. He also is involved in the design and implementation of the DMDW and in database management.

David R. Hoogstrate: Mr. Hoogstrate works on this project as a system engineer. He and Dr. Lou ensure that the digital network equipment and cabling is in place and functioning. Mr. Hoogstrate is also responsible for digital mammogram data flow from the FFDDM to the display workstation. All utilized software packages, including DICOM communication, database design, and digital mammogram display, are developed by him and Dr. Lou.

Robert Gould: Dr. Gould supervises all major imaging equipment installations for the Department of Radiology at UCSF Medical Center. In this project, he is responsible for the installation of the FFDDM unit and for testing the physics of FFDDM image quality.

Steven Frankel: Dr. Frankel is a senior breast imaging radiologist at UCSF. He is responsible for determining the "truth" (results from tissue diagnosis or long-term imaging observation) for all FFDDM cases. He also is responsible for assisting in patient selection, obtaining informed consent from patients, and in conventional mammography and FFDDM image analysis.

Research Fellow (Drs. Eric Rosen and Karen Hunt, during Year 1 of the project): this position is filled by breast imaging radiologists who assist in patient selection, obtaining informed consent from patients, and in conventional mammography and FFDDM image analysis.

Albert W. K. Wong: Mr. Wong is a senior system engineer. He is recruited in this project to conduct the software development for the mammography file server and related database tasks.

Adams Weinberg: Mr. Weinberg is a student in the Bioengineering Joint Graduate Program at UC Berkeley/UCSF. He is recruited to this project to assist Dr. Lou and Mr. Hoogstrate in DMDW development.

Bonnie Grear: Ms. Grear is an ARRT-certified and California-licensed mammography technologist, with more than 25 years' experience performing conventional mammography examinations. Her responsibility is to conduct the FFDDM patient examinations, to maintain patient records, and to act as liaison between UCSF and Fischer Imaging Corp. in the maintenance of Fischer FFDDM equipment.

Mohammad Jahangiri: Dr. Jahangiri was responsible for the early stages of DMDW development, working with Dr. Lou and Mr. Hoogstrate. He returned to the University of Virginia to complete his radiology residency training in June 1997.

3. Difficulties Encountered During the First Year of the Project

During the development of our telemammography infrastructure, we have encountered several unexpected situations, which have somewhat delayed the progress of our project (although we still have completed our required Year 1 work [Tasks 1 and 2 in our Statement of Work]). In addition, there are a few technical difficulties with the FFDDM imager and the DMDW that we have not yet overcome.

3.1 FFDDM Imager Installation: Delay in Pulling the Optical Fibers

To complete the chain of our telemammography ATM network, we had to use a UCSF network service organization, Enterprise Network Services (ENS), to pull fiber cables. Our requested service to ENS was about several fiber cable pulling and patching within UCSF Medical Center as well as UCSF/Mt. Zion Hospital (Medical Office Building 1). The ENS subcontracted this service after putting it out to bid. However, the bidding process took more than three months, ultimately delaying the installation of the Fischer Imaging Senoscan imager at UCSF/Mt. Zion Medical Center.

3.2 FFDDM Imager Installation: Second-Generation Imager

We also experienced another delay to the installation of the FFDDM imager, related to substitution of a significantly improved (second-generation) image acquisition system by Fischer Imaging Corp. Since the Senoscan imager brought to UCSF/Mt. Zion Medical Center was the first-ever second-generation imager installed by Fischer Imaging, they experienced several unanticipated difficulties with detector assembly mounting, x-ray source and detector alignment, optical density adjustment, and image quality verification. The installation took about two months longer than expected. However, the installed system enjoys many imaging advantages over the first-generation imager that could have been installed more promptly. (1) Both dynamic range and overexposure tolerance are increased by a factor of eight. (2) Standard mode pixel size is reduced from 64 microns to 54 microns. (3) Electronic magnification mode is added, which results in pixel size of only 27 microns with a field-of-view of ¼ the area of normal mode. (4) Modulation transfer function is improved at all spatial frequencies, by eliminating the optical fiber taper required by the type of charged couple devices (CCDs) employed in the first-generation imager. (5) Field of view is increased from 18 cm x 24 cm to 22 cm x 29 cm, thereby allowing for inclusion in the image field of larger breasts. (6) Detector assembly thickness in the region contacting the chest wall is reduced from 11 cm to 5 cm, thereby facilitating improved patient positioning during breast compression. (7) Power of the acquisition computer is greatly increased to process digital images much more rapidly, thereby facilitating the real-time interpretation of FFDDM images that is crucial to the success of the teleconsultation and telemanagement portions of the project. We strongly believe that the improved performance of the second-generation FFDDM imager is much more important to the ultimate success of our project than the two-month delay in installation has been in slowing our progress.

3.3 Missing Pixels in Digital Mammography Images

This problem relates to the drop-out of image pixels when digital mammogram data are transmitted from the FFDDM imager to the capture computer. Fortunately, the problem does not occur frequently; unfortunately, it also does not occur consistently.

When it happens, the capture computer system hangs up, which results in lack of completion of the mammogram to be stored onto disk. The only apparent pattern to this type of failure is that mammogram corruption always happens right after the previous mammogram has been sent out via the ATM network. We have brought the problem to the attention to FORE (the ATM network manufacturer). One of the suggested solutions from FORE is to upgrade our ATM software device driver. We are currently in the process of upgrading this device driver, and plan to test the upgrade by taking multiple FFDDM images of our mammography phantom.

3.4 Insufficient Memory in the DMDW for Simultaneous Display of Multiple Images

This problem relates to the increase in memory required to display the larger field-of-view images produced by the second-generation Senoscan imager. To fully utilize the larger image area, Fischer Imaging Corp. has changed the image matrix from 4,095 x 5,120 to 4,095 x 5,625. This change alters the size of an image file from 40-Mbyte to 46-Mbyte per digital mammogram. The increase in image file size directly affects DMDW system memory capacity. Our current memory configuration is based on the previously valid 40-Mbyte per digital mammogram image file size and the capability to display simultaneously a maximum of 8 images. Currently, we have 384 Mbytes of system memory installed in the DMDW. We plan to solve this problem with two approaches. First, we will eliminate the unnecessary step of computer system environment setup. Second, we will purchase more system memory. These steps should overcome the problem.

4. Publications and Presentations

The following publications and presentations document some of the progress achieved during the first year of the project.

Lou SL, Sickles E, Hunag HK, Cao F, Hoogstrate D, Jahangiri M. Full-field direct digital telemammography - preliminary. SPIE Proc Med Imaging 1997; 3035:369-379.

Huang HK, Lou SL, Sickles EA, Hoogstrate D, Jahangiri M, Cao F, Wang J. Technical issues in full-field direct digital telemammography. *In* Lemke HU, Vannier MW, Inamura K, eds. Computer assisted radiology and surgery. Amsterdam, Elsevier Science, 1997:662-667.

Huang HK. Digital mammography: a missing link to a totally digital radiology department. Invited presentation, 15th International EuroPACS Meeting, Pisa, Italy, September 25-27, 1997.

5. Other Related Funded Projects

The following related funded research projects also contributed to some of the progress achieved during the first year of this project.

"A Digital Breast Imaging Teaching File"
September 1994 - September 1997
PI: Sickles, Co-PI: Huang
Sponsor: US Army Medical Research and Materiel Command (DAMD17-94-J-4338)
This project contributes to the display concept of digital mammography.

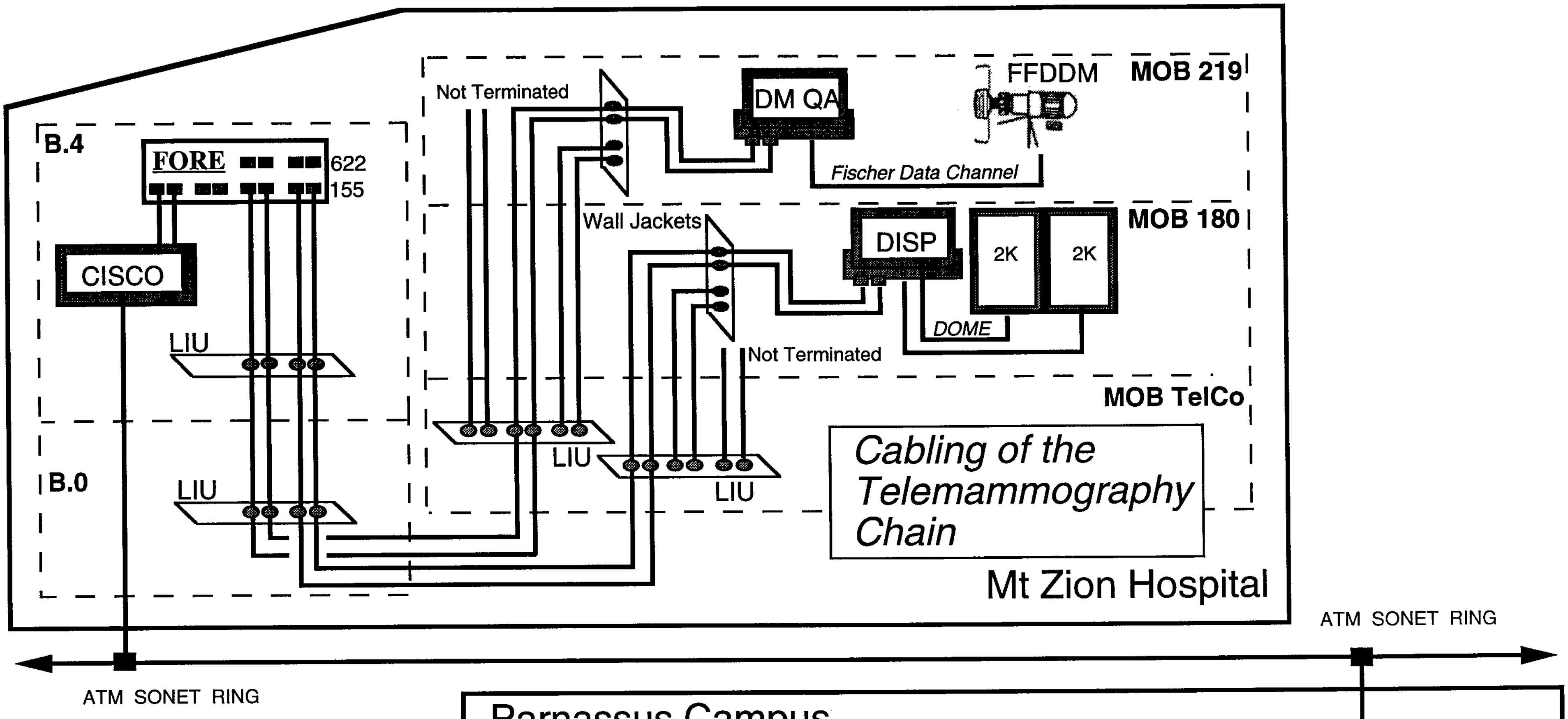
"Real-Time Telemanagement of Mammography Examinations"
July 1995 - June 1998
PI: Huang
Sponsor: California Breast Cancer Research Program (1RB-0148)
This project contributes to the concept and implementation of the telemammography chain.

"High Performance Tele-Imaging Infrastructure for Collaborative Health Care"
September 1996 - December 1999
PI: Huang
Sponsor: National Institutes of Health (N01-LM-6-3547)
This project contributes to the ATM, WAN, and LAN, as well as the infrastructure design of teleconsultation.

"Laser Film Imager for Mammography"
July 1997 - indefinite (equipment support)
PI: Huang
Sponsor: Abe Sekkei, Japan
This project contributes to the hard copy output of digital mammograms.

CONCLUSIONS

Work on this project is proceeding on schedule, despite several unanticipated delays. After completion of Year 1 of this project, we have installed the first of two full-field direct digital mammography imagers, developed a digital mammography display workstation, and developed the infrastructure and begun the clinical use of a telemammography chain between the Breast Imaging Section at UCSF/Mt. Zion Medical Center and the Laboratory for Radiological Informatics at UCSF/Parnassus Medical Center, two miles apart. Preliminary results demonstrate that the image quality of digital mammograms (soft copy display) is comparable if not somewhat superior to that of conventional screen-film mammograms. By the end of this project, we expect to demonstrate that [a] telemammography technology can be developed for routine clinical operation, and [b] that real-time off-site management and interpretation of a general-radiologist mammography practice by mammography specialists is feasible as standard operating procedure, thus helping to establish telemammography applications of digital radiography as both valid and useful. The application of these procedures to routine mammographic examinations should contribute to more efficient and higher quality breast imaging, by bringing to bear the expertise of mammography specialists at the community-practice general-radiologist level. This should benefit all women undergoing mammography in the future.

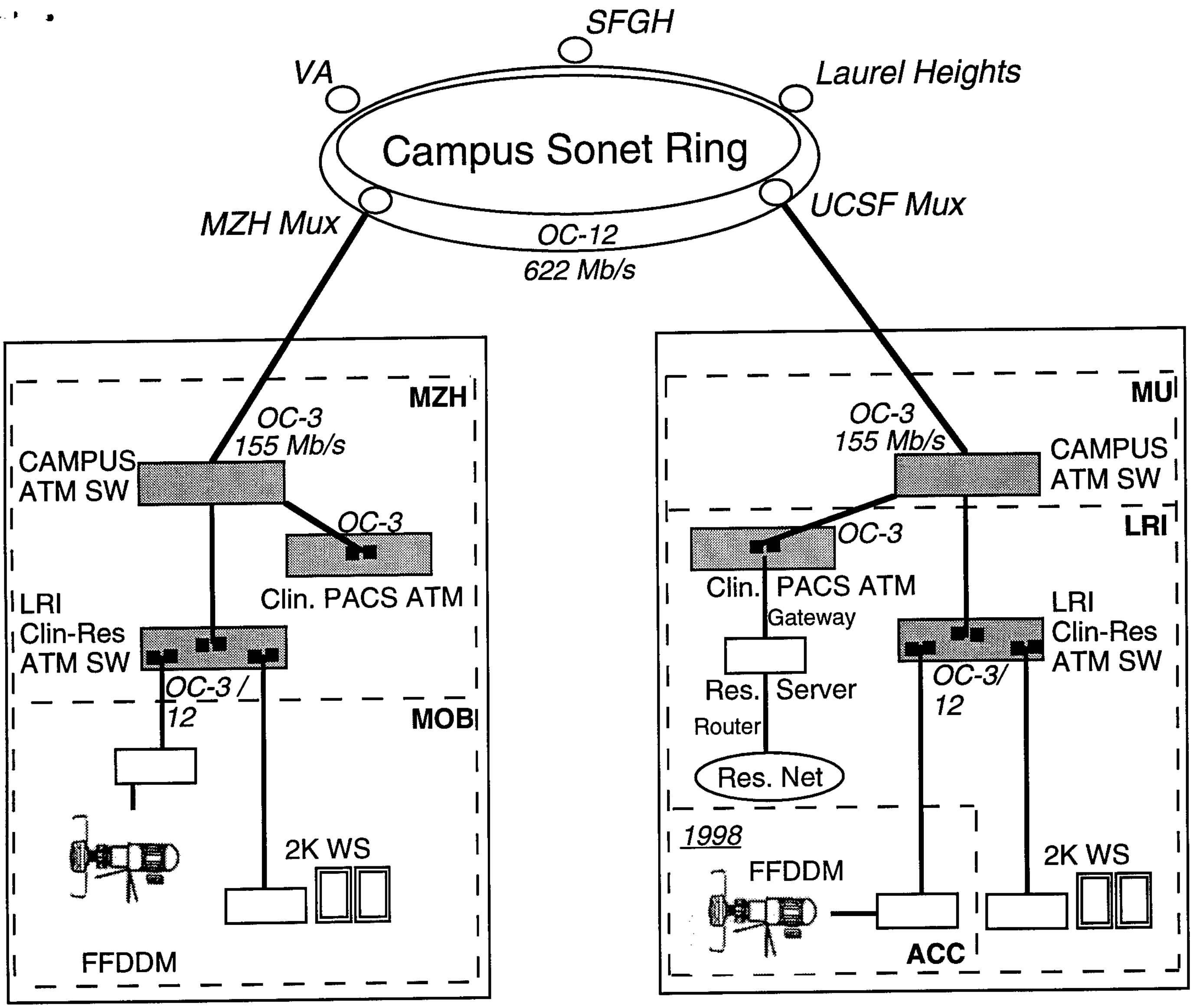


FFDDM: Full-Field Direct Digital Mammography
DM/QA: Digital Mammo QA Station
CISCO: L1010 ATM Switch
LIU: Lightguide Interface Unit
FORE: ASX-200BX ATM Switch

MM Fiber Optic Cable

SC ST

Figure 2.1.1 -- Cabling



LRI WAN/LAN ATM Network

MOB: Medical Offices Building
ACC: Ambulatory Care Center
LRI: Laboratory for Radiological Informatics
MZH: Mount Zion Hospital
MU: Millberry Union

Figure 2.1.2 -- Networking of the Telemammography Chain

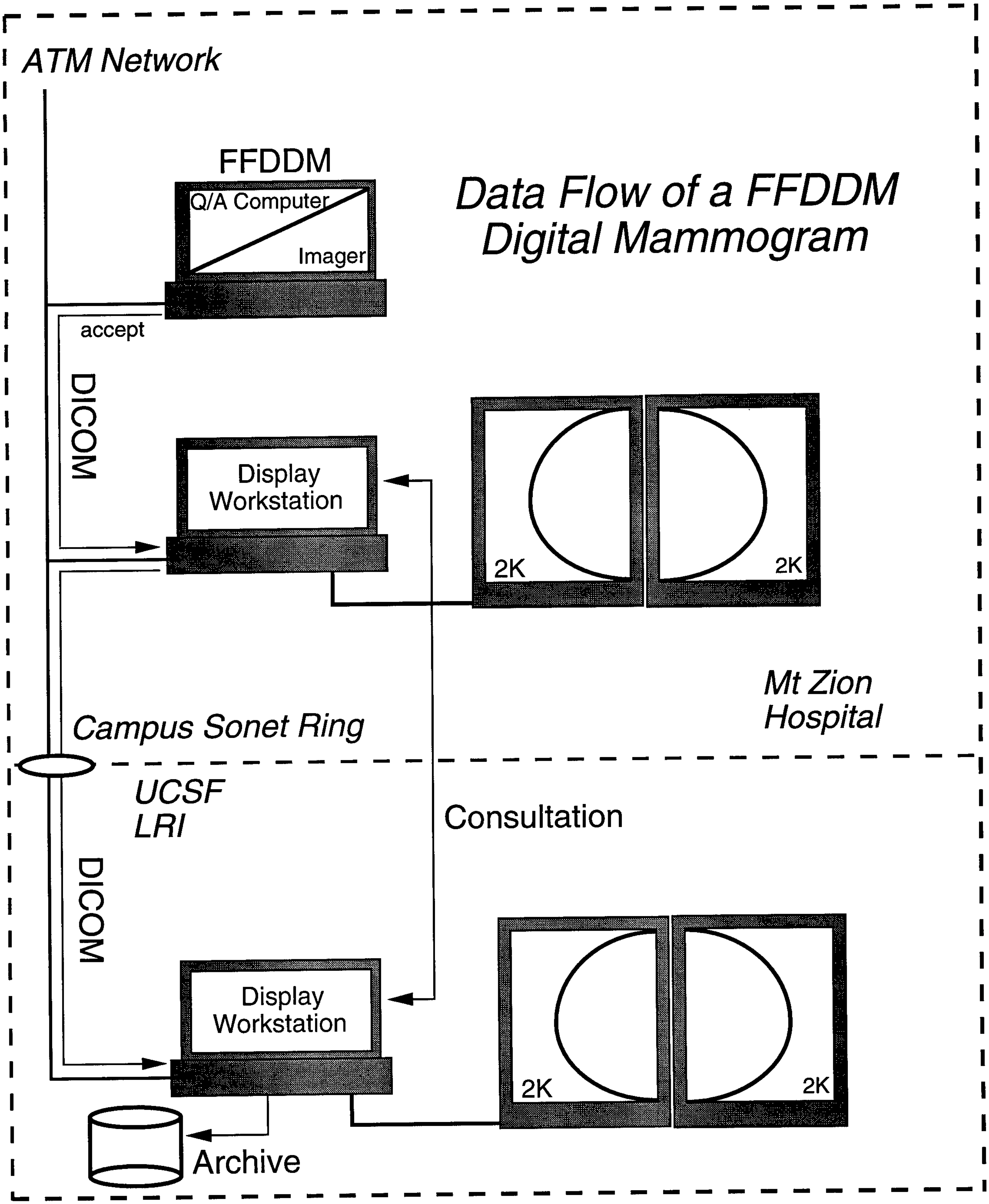


Figure 2.3 -- Data Flow of a FFDDM digital mammogram

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APPENDIX

The following four pages contain the minutes of the three programmatic meetings held during Year 1 concerning the operation of the project.

ARMY FFDDM CONTRACT KICK-OFF MEETING

10/16/96

MINUTES

Attendance: Bernie Huang, Edward Sickles, Andrew Lou, Fei Cao, Jianguo Zhang, Laura Snarr, Steve Frankel, Eric Rosen, David Hoogstrate, Mohammad Jahangiri, Bob Gould

Introductions

- Discussion about equipment and Bernie's site visit to Fischer Imaging in Denver, CO Monday 10/21.
- Workstations and locations
- Technologist and protocols: We will hire 1 full-time tech or several part-time equivalents. We don't have to hire him/her until we need a person.
- This is a three-year contract: The first six months is to set up the full-field direct digital mammography system (FFDDM) at MZH during months 1-6. During months 7-12 we will be establishing the chain of tele-imaging (see insert on task descriptions).
- A new 2K display station is being assembled. The equipment is new and up-to-date - Sparc Ultra 2 and DOME Board. We will use ATM technology
- The image database will consist of 600-800 patients.
- The question of a printer was discussed
- We will be performing teleconsultation and telemanagement: the day-to-day monitoring of mammography off-site.
- The question of S. Frankel's move to the VA was discussed. He is currently at VA but will still be there 4-5 days/month.
- The second FFDDM system is scheduled for September 1997.
- We are allowed to change protocols from time to time. We can also change the sequence of work with an explanation to the agency.
- There is a slight chance that the Breast Imaging Section may move to the PAvillion Building. It will be a new building. This building has good cabling.
- Access to the MZH Medical Office building in the evening: The least desirable solution is to go to the security office at MZH and they will walk you in. We are working on getting a key to the breast imaging suite.

- Installation: Dave Gannon (415) 885-3514 is the building manager. We need the plan from Fischer. Then we should give everything to Dave. Andrew will help. Fischer wants to send it to us by RSNA.

- We have funds for parking and local transportation. Save all receipts and give to Laura for reimbursement.

- We will have meeting every quarter.

HKH 10/23/96

Meeting with Fischer Imaging Summary
October 20,21, 1996
Denver, Colorado

Andrew Lou (415-476-5055) and H.K. Huang (415-476-6044) went to Fischer Imaging on 10/20-21/96. There was a dinner meeting on 10/20 and a full day meeting on 10/21. Mike Tesic, Greg Jeffrey, Stacy Maydew, and Michele Piccaro from Fischer were presented. Morgan Nields, President of Fischer, was also there briefly. The followings are topics of discussion:

1. Physics of Full-Field Direct Digital Mammography (FFDDM) - We learned the concept of Time Delay and integration, and the new CCD array technology. The new system will be using four CCD arrays with a dead space between them of only one pixel (100 microns ?), no fiber optics is needed. We also saw the prototype unit with demonstration.

2. Data output from the FFDDM - DICOM 3.0 will be used, a copy of the data format was obtained. Michele will send us some sample images on tape. Fischer will deliver the system with the UltraSparc 2 as the acquisition computer. We will use the ATM for data transmission.

3. Display of images from the FFDDM - Fischer only supplies one 2K monitor, we will develop our own display station with two monitors. We may be able to use some of their GUI.

4. Hardcopy output - Kodak 8x10 4K x 5K, and Polaroid Helios were discussed. As of now, there is no film printer at Fischer.

5. Storage - Fischer is not developing the long term storage. We will develop it with a data base management system.

6. Compression - No plan in Fischer, we will try to implement a lossless method during data acquisition if possible.

7. We met Fischer's site planner engineer, Peter Criscione (303-452-6800-ext 4745) , he will be responsible to give us the room specification requirements of the FFDDM during the next week. We will then proceed at our end to prepare the room through Dave Gannon (415-885-3514), building manager of the Physician Office Building, MZH.

8. We discussed the PO with a conference call with Anthony . We agreed that the PO, the price, and payment plan would be identical to our grant proposal(see Kick-off Meeting Minutes). We will prepare one PO for the first system now, and a second during the next Army Contract year. The payment will be stretched to three years as planned. The first system is expected to be delivered in mid-December.

9. We will receive the system with a new imager. This new design will be the final, Fischer does not expect any major changes in the next few years.

10. After the installation, the maintenance will be local, upgrade will be from Fischer headquarters.

11. We also discussed the possible collaboration in InfoRAD during the forthcoming RSNA.

12. We discussed the future close collaboration between Fischer and LRI on developing the FFDDM for filmless operation. Fischer will visit us on December 16, we will make arrangement for them to give a presentation.

Telemammography Project Meeting

July 15, 1997, MOB Mt. Zion Hospital
4-5:15pm

attendance: Ed Sickles, Mike Tesic, Bonnie Greer, Ruth Grafton, Bob Gould, Bernie Huang, David Hoogstrate, Andrew Lou

1. Mike Tesic: Introduction. Discuss the general progress of the FFDDM in Fischer.
2. Sickles: 3Y project funded from Sept. 96-Sept 99.
3. Safety and radiation regulations: Issues before patient study
   - The patient study has been approved by the IRB
   - About 200 MR radiation dosage/scan
   - Gould: For radiation safety, we can use standard phantom. He will invite Mark Howe from UCSF Safety Office to participate in the measurement
   - UL requirement
   - Physics measurements: plan on three schedules: 7/24-25; 7/31; 8/4
   - Safety: Gould will work with Fischer to obtain the radiation measurements. Wait for Fischer to complete its internal measurements
   - Training: week of 8/11, 1/2 day regular. Grafton will train Bonnie. Pat Campbell and Grafton will stay on sometime to continue supervising.
4. Patient population: approximately 4~6 patient eligible per day. Bonnie and Ed Sickles will recruit volunteers from this group.
5. Network: WAN and ATM completion. D. Hoogstrate passed out two network drawings
   - OC/3: 4 MBytes/sec disk-to-disk, routinely
   - OC/12: 40 MBytes/sec (memory-to-memory), experimental LAN
6. Display: Hardware of two new 2K WSs are ready. Andrew feels that preliminary software will be ready for displaying mammograms in two months. Andrew and David will try to install a temporary system at MOB during the first clinical test.
7. Laser Film Printer: Received the first images from Abe Sekkei today. It is a little moderately under exposed. Two copies are in Dr. Sickles' possession. Gould will look for a place to put the printer, Bernie will provide him with the schematic and specifications.
   - The printer should be connected to the new WS.