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THE UNITED STATES AIR FORCE HOSPITAL SYSTEM

Ronald A. Creamer

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August 1968

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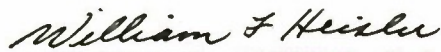
FOREWORD

This paper was originally prepared in February 1965 and submitted formally to the USAF medical research and development activities of the Air Force Systems Command for consideration. As a direct consequence, the author was invited to present his proposal to the Commander of the Aerospace Medical Division (AMD), whereafter agreements were made to blend the medical expertise of AMD with the system engineering talent of the Electronic Systems Division (ESD). Support for the project grew and a new name, "HAVE MEDICO," was adopted for the project.

The author expresses special appreciation to Colonel Frank L. Ayres, then Director of the 416L/M Air Defense System Program Office from which this paper evolved, whose urging, encouragement and solid support permitted the proposal to grow to a recognized project status.

This report has been reviewed and is approved.


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ABSTRACT

This paper describes in general terms a concept for introducing computers to all USAF medical facilities. It defines in depth the functions, applications and growth potential which can accrue within the USAF Hospital System. It also describes additional benefits possible on a regional and world-wide basis which could evolve from connecting the hospitals to a communication network. Research potentials of the system are also projected.

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I. INTRODUCTION

The purpose of this proposal is to conceive and develop a hospital system for the Air Force which will assist the Air Force medical community by transferring the burdensome tasks of information retrieval from doctors, nurses, medics and hospital administrators to a data processing system. The system will also serve as a research tool to researchers within and external to the Air Force.

II. GENERAL SYSTEM DESCRIPTION

A. General - The core of the automated hospital system, a high capacity digital computer (possibly an array of smaller computers), will be located within the Aerospace Medical Division complex at Brooks AFB, Texas. Satellite computers, located at each of the Air Force hospitals (throughout the world) will be netted to the central data processing function, affording a two-way flow of information between the hospital satellites and the core. The central computing function will also be connected to other major computers, such as that of Military Airlift Command and those of other government agencies. Dispensaries and outpatient clinics not having full hospital status will have a smaller data processing unit tied to the nearest hospital satellite unit. A simplified block diagram of this system appears in Figure 1.

1. Central Computing Function - The central data processing mechanism will be a data bank with a rapid-access information retrieval feature. It will consist of large bulk storage units, sophisticated control units and a large number of input/output channels.

a. The random access storage of the computer will have highly rapid access time. In addition, the central control computer will be tied to other governmental computers containing pertinent data, permitting information to be cross-told back and forth between these systems, thereby increasing the data bank of all interconnected machines via this data-sharing arrangement. The central unit will be utilized extensively in the areas of hospital administration, research, and medical records; however, Figure 2 lists the many additional services that it will provide.

2. Satellite Computer - The function of the satellite computer will be far more comprehensive than a mere facility-dedicated device. It will be a regional central computer which will service dispensaries and outpatient clinic remote units within its consultant region, connecting them not only to the central information retrieval network but also providing them with a local data bank of important regional information. Within the hospital itself, the satellite data processing unit will be used extensively in intensive care monitoring, data acquisition and reduction for EEG-EKG-X-ray and laboratory analysis, diagnostic assistance, medications, reports, hospital administration, regional epidemic analysis and regional disaster control. A list of potential applications appears in Figure 3.

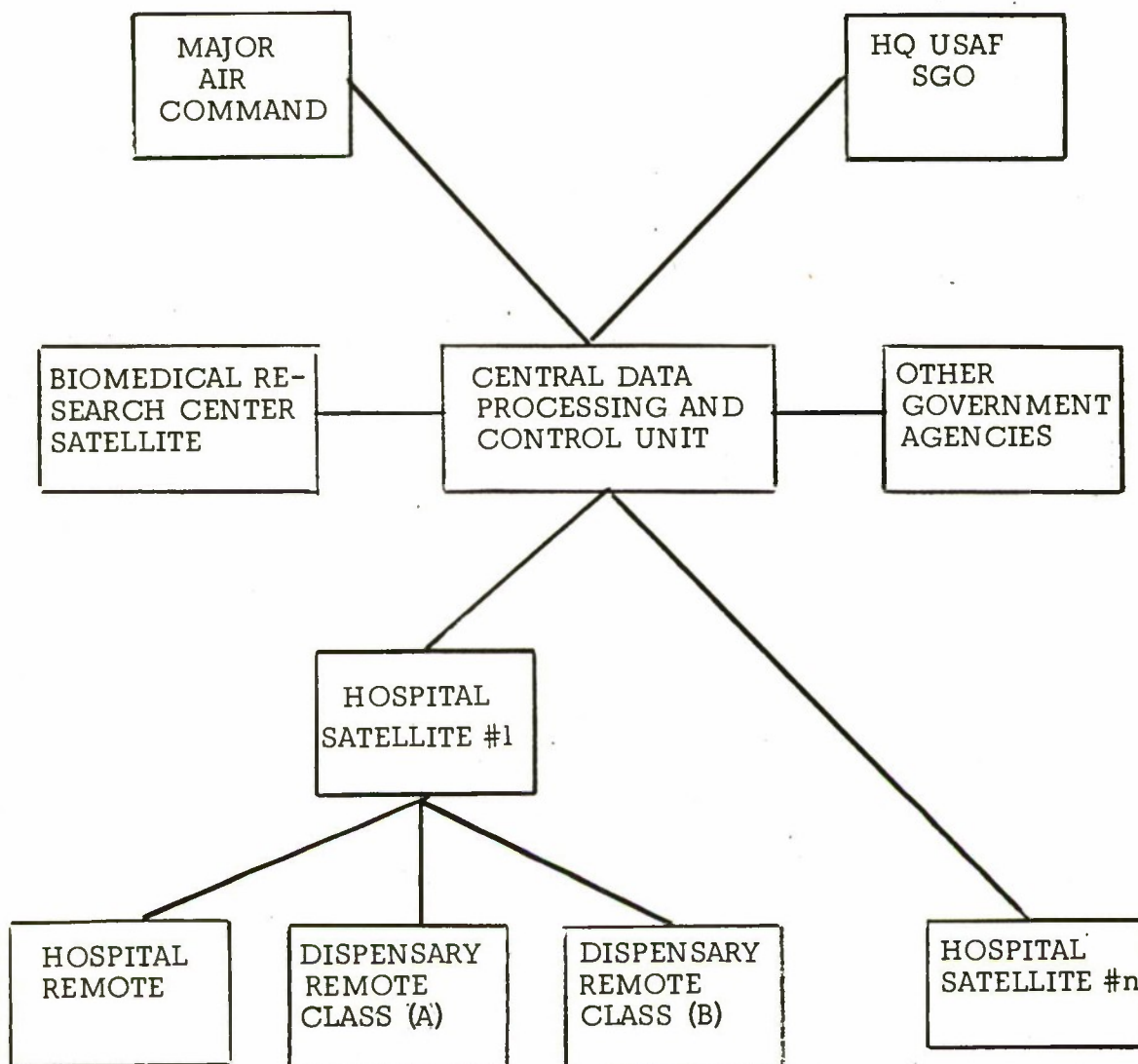


FIGURE 1. SIMPLIFIED BLOCK DIAGRAM OF THE NETTED HOSPITAL SYSTEM

DATA BANK (CENTRAL)

MEDICAL RECORDS

REPORTS

CODES

PROCEDURES

PERSONNEL

FORMULARY

INVENTORY

DIET PLANNING

EPIDEMIOLOGY

DISASTER CONTROL

TRANSPORTATION & TRANSFER

EDUCATION & TRAINING

RESEARCH

LOGISTICAL PLANNING

SCHEDULING

FIGURE 2. CENTRAL COMPUTER FUNCTIONS

3. Remote Computer - This computing unit will be the smallest among the system levels and will be serving small hospitals, class A and class B dispensaries. It will be tied to the nearest hospital having a satellite computer, and it will have access to the central computer through this satellite, thereby benefiting from access to each.

The services provided to the dispensary by the remote computer are similar to many of those provided by the hospital computer, but are not as numerous (see Figure 4). These would involve some diagnostic assistance, medications, laboratory analysis, reports and hospital administration. Reduction and interpretation of the more complex medical data will be referred digitally to the more capable regional military consultant center.

4. Dedicated Department - Oriented Computer - During the 1970 decade, it has been forecast by experts in the computer design and manufacturing industry that the manufacturing costs in computers will decrease sharply in comparison to what they are today. For this reason, it is conceivable that the implementation of small, low-cost, dedicated computers in hospital laboratories and departments might be more economical and provide more utility than the time-sharing of a central processing unit. Specialized computations and data reductions for each department within the medical facility would relieve that burden for the facility's central computer and thus reduce the cost of it. Results and compilations of the localized dedicated computers would be sent to the facility computer for consolidation and distribution. The system reliability potential of the multi-computer approach is another important advantage.

III. DETAILED SYSTEM DESCRIPTION

A. Introduction - This section delineates in more depth the functions, applications, and growth potentials of the Automated Hospital System. Many of these functions, to different degrees, can be utilized at each of the system levels (i. e., department levels, dispensary remote, hospital or research center satellite and the central unit).

B. Medical Data Retrieval - The term "medical data retrieval" involves the access to statistical and empirical data which, when made available to the medical professional, assists in obtaining a current and comprehensive picture concerning a patient or group of patients in a minimum amount of time.

1. Medical Records are among the more important data records. The advantages of having rapid access to personnel/dependent medical records are manifold. First, there is a distinct advantage in having USAF personnel medical records located permanently in the central computer. As changes occur in the individual's medical history, these changes are reflected immediately by their insertion into the dispensary remote or

LABORATORY INSTRUMENTATION & ANALYSIS	RADIOLOGY
MEDICAL RECORDS	ADMISSIONS & DISPOSITIONS
PATIENT MONITORING	PHARMACY
DATA BANK (REGIONAL)	SURGERY
DISASTER CONTROL (REGIONAL)	EPIDEMIOLOGY
LOGISTICS	DIAGNOSTIC ASSISTANCE
DIET PLANNING	TRANSPORTATION & TRANSFER
SCHEDULING	INVENTORY
REPORTS	PERSONNEL
BED CONTROL	RESEARCH & DEVELOPMENT (AMD LABS) (SUCH AS AMF)
EDUCATION & TRAINING	

FIGURE 3. SATELLITE COMPUTER FUNCTIONS

SCHEDULING	PHARMACY
ADMISSIONS & DISPOSITIONS	INVENTORY
REPORTS	DIET PLANNING
MEDICAL RECORDS	LOGISTICS
LABORATORY	DISASTER CONTROL
TRANSPORTATION & TRANSFER	BED CONTROL

FIGURE 4. REMOTE COMPUTER FUNCTIONS
CLASS A AND B DISPENSARIES

hospital satellite, and eventually into the master medical/dental record at computer central. There may still be a necessity for retaining a transient medical/dental record, at least for the sake of maintaining a file on those items which cannot be stored digitally. With an up-to-date medical record located in computer central, lost transient records would not be painful in hospital administration or, even more real, in terms of the repetition of a complete series of inoculations, treatments, X-ray or laboratory procedures; this would be avoided, because the master record in the central computer would contain all of this information. Another advantage would be the rapid availability of medical records in an emergency. For example, one can easily conceive of USAF personnel or perhaps dependents who are geographically displaced from their hospital region (albeit by temporary duty, vacation or forced landing at an alternate landing field) and who experience a situation which requires immediate hospitalization and treatment at the nearest dispensary or hospital. The hospital or clinic, utilizing the individual's identification number (hopefully his social security number), could issue a priority request through the hospital system network and receive the individual's medical record within seconds. Should the time requirement for the record be less critical, a normal request would ensure receipt of the record within a few minutes. Treatment under such a time-constrained situation can be made with far greater confidence.

2. Epidemic Recognition and Control can be expedited by the pooling of doctor-diagnosed information at the remote, satellite and central computer level. As cases are diagnosed, trends can readily be determined, and depending upon the seriousness of the spreading disease, bulletins can be dispatched accordingly. Another advantage to such a pooling of diagnoses will accrue if physicians are able to draw, in virtual real time, upon the experience of other physicians as to the effectiveness of various treatments of the disease in question. This will particularly apply to the many nondescript, nebulous diseases which are affecting an unusually large segment of the people. A consideration, which is somewhat more distant in probability of occurrence, but nevertheless conceivable, is the first occurrence of a rare communicable disease in a particular region. Where there is question about a particular disease which is alien to the region of occurrence, a request for information on the suspected disease might result in a reply to the effect that there has been a minor outbreak of the disease in an area from whence the affected patient has recently traveled. On the other hand, if this case were the first to be noted in any region, it would serve as a precedent with which other cases might be correlated at some later time. This conception gathers more credence upon considering that the pressures of the modern age to travel and the facility with which one can travel increase the likelihood of an unusual disease affecting a particular region without warning. Diseases emanating and spreading from Southeast Asia are classic examples of this.

3. Laboratory reports, EKGs and EEGs contain a great deal of data, the reduction of which can be arranged in the order which is convenient for review or analysis by a physician. Such a format can be arranged within the hospital satellite computer by prudent software (computer programming). The main advantage of this approach will be to relieve the burdensome task of information retrieval and data reduction from the physician in order that his talents might be better utilized on the interpretation of data and forming decisions concerning diagnosis and treatment. Computer-aided pattern recognition and image processing techniques can also be applied beneficially to the field of radiology.

C. Research - The potential uses for the Automated Hospital System as a research tool are seemingly boundless. Research centers which are tied to the hospital network will have access to a wealth of medical and psychological data.. The arduous task of manually reviewing stacks of records and gleaning selected data from each record to build a sample space for statistical inference purposes can be avoided and made entirely automatic by employing routine computer programming techniques. It is here that the computer displays its enormous value to the researcher. The establishment of a data base which would normally require many man-months of effort can be done in minutes by the computer with more accuracy, and with a much larger sample size if deemed necessary.

1. Medical Research is made easier by having access to the Automated Hospital System, and can be conducted without the many inconveniences which can be encountered in a civilian environment, particularly in the area of controlling the environment. Within this environment, extensive research can be conducted on the cause, treatment and prevention of cancer, stroke and heart diseases as well as children's diseases, diabetes and many others. It will also be possible to conduct research on the treatment of combat or accident-sustained wounds and injuries. Aerospace physiological research may also be conducted. The analysis and treatment of alcoholism, narcotic addiction or even the habit of smoking can be performed. The development of countermeasures against the effects of biological, radiological or chemical warfare can be accomplished from satellite laboratories. Research involving veterinary medicine can be directed toward the inoculation and control of the diseases of domestic animals; and it can also be oriented to the protection of personnel against hostile insects, reptiles and animals.

2. Psychological Research is another area that can capitalize on the quasi-controlled environment of the Automated Hospital System. A center which conducts psychological research will possess a satellite computer which will be netted to the central computer. This center could perform a wide variety of research including mental health, motivation analysis, and education, as well as efforts which include the study of combat effects. The analysis and treatment of the classic psychological disorders can be addressed. Human factors efforts involving the improvement of education of USAF personnel (training) and their dependents

(federally-required schooling) are possible. Also under the human factors heading would fall the study and application of conditioning and motivation. Battle stress analysis might yield insights which would increase the effectiveness of our combat forces (aircrew members and their ground-based support operation). The system could also be used for the evaluation and control of the use of free medical service.

D. Physiological Monitoring - Physiological monitoring concerns the constant vigilance of a patient's condition. The hospital satellite computer can be designed so that it can perform the task of intensive care monitoring for a number of patients in critical condition within the hospital. It can report to a central location (such as the nurse supervisor's station) such data as blood pressure, pulse, body temperature, respiratory rate, etc. (Manned space flights have already demonstrated that the instrumentation of a human for monitoring is indeed possible). It can also be programmed to alert (aurally, visually, or both) the nurse supervisor of important changes in the patient's condition; these alerting devices can also be used to signify that prescribed medication is due, overdue, or has been administered to a patient. The latter application can be adapted to all patients within the hospital and not exclusively to the intensive care patients. There are other applications that are indirectly related to intensive care monitoring. The computer can be programmed to provide valuable assistance to the surgeon before, during, and after an operation. Pre-operative assistance, for instance, can be used to assist the anesthesiologist and surgeon in the planning of the patient care before, during and after the operation. The computer can also be made to evaluate and troubleshoot any complicated equipment which is used during the operation. The computer can also be made to evaluate and troubleshoot any complicated equipment which is used during the operation, and it can provide instant notification when any equipment shows unreliable performance, or when patient response is drifting beyond tolerable limits.

E. Hospital Administration - The Automated Hospital System will offer many advantages in the area of hospital administration. Its outstanding advantage is that it can perform a broad variety of administrative tasks on a 24-hour per day, 7 day per week basis.

1. Personnel Management at the Command, Region, Hospital or Dispensary level will be simplified by this system. The whereabouts, capabilities, experience, scheduled rotation or separation dates and other pertinent data on doctors, nurses and medics can be stored and retrieved quickly. Should a patient at one facility require the specialized professional services of a physician in another area, this information can be utilized to get these two together with minimum delay.

2. Facility adequacy for a specialized use can also be placed in storage and retrieved quickly. In the example given above, the getting together of the ailing patient and the specialist is not wholly satisfactory unless a specialized facility which is required is available. The computer will be capable of responding to a facility request by suggesting a location where the patient and the physician can meet and effect a suitable solution to the ailment.

3. Inventory Management can be greatly simplified with a computerized system and a logical arrangement of data. The availability of medical supplies to a facility, whether an outpatient clinic, dispensary or hospital, is vital to the timely treatment of disease or injury. A dynamic record of supplies, equipment and furniture is made possible by the automated hospital network. More frequent than rare is the case of a shortage of blood. Should a facility require blood of a rare type, and should there be none at the facility's blood bank, the system would respond to a request issued to the network by furnishing information concerning the location of the nearest blood or nearest registered donor. It would also suggest means of transporting the blood or donor to and from the local blood bank.

4. Scheduling information can be stored and retrieved automatically with proper programming. Notice of scheduled booster shots, annual physicals, altitude chamber physiological training as well as the scheduling of recurring appointments for dependents (periodic obstetric/gynecology appointments, therapeutic treatment, etc.) can be read out automatically to a clerk for mailing.

5. Diet Planning and Control is a function that can operate at all system levels. At the central computer level, the diet codes and standards can be established and disseminated to the subordinate elements of the system. Furthermore, overall USAF hospital budgetary estimates and provisioning requirements utilizing the central computer as a focal point for satellite inputs, can be established. The hospital satellite will have a more dynamic role in diet planning and control. In addition to conforming to the USAF standards in the routine hospital diet, it will also be able to adapt to a particular case wherein a special diet is required (tailored metabolic research). A dietician who is responsible for the diet of a particular group of patients could be made aware, immediately, of any important changes in food preparation dictated either by a physician locally or by a change bulletin at the central computer level (such as the notification that a particular bread dye substance contains elements which cause intestinal disorder).

6. Admission of New Patients is sometimes hampered by the non-availability of beds in a particular facility. Bed availability and control is the kind of local operation easily adapted to satellite computer retrieval. Pre-planned contingency printouts can assist the hospital administrator to hasten the resolution of an overcrowded hospital problem.

7. Combat Zone Hospitals are unique in their problems for a number of reasons. The nature of the patient's ailment is markedly different from that of a peacetime, zone of interior (ZI) hospital. Secondly, the flow of patients is much higher. Finally, since no one knows where the next war will be waged or the next battle fought, the facility planning, manning and equipping of combat zone hospitals is shortchanged by circumstance. In such an environment, the variables which lend to confusion can, to some extent, be minimized by the systematic real time adaption of the combat hospital system to the fluctuating environment. By melding casualty requirements with considerations of supply availability, medical personnel availability and transportation, the gathering of life supplies and casualties to a safe adequate facility can be made more probable. Furthermore, by inserting a complete description of a patient's ailment into the hospital system, the primary hospital to which the patient might be traveling will be given more time to prepare for the patient's needs in advance of his arrival.

8. Disaster Control is a function which will benefit by the Automated Hospital System because of the system's ability to adapt rapidly to the situation. The effects of natural disasters such as floods, tornados, hurricanes, earthquakes or fires can be alleviated by the rapid transfer of medical supplies and personnel to the impacted region from adjacent regions. Rapid response to the specific needs of the hospital is made possible by the system. Contingency plans will ensure that the more important necessities such as electric power, pure drinking water, food and heat are available to the affected hospital and the Air Force installation itself. If the disaster were the result of a nuclear war, there would be no assurance that the hospital system's communication lines would be functioning; therefore, regional autonomy would likely occur, placing more reliance upon the satellite or remote computer within the isolated area.

9. Rehabilitation Time of a patient is an area of interest not only the administrator but also to the doctor, researcher and patient. Utilizing the system as a basis, accurate estimates as to the length of time a patient will be incapacitated by a particular disease can be made by the system, and it will have a wealth of statistical data to back up the estimate. This information will be particularly useful to the hospital administrator who needs a bed for a new patient, and the squadron commander who must know when the patient will report back for duty.

III. SUMMARY

The preceding pages are an expression of a concept which can be developed in considerably more depth. Many of the applications of such a hospital system are not original concepts, and there are in

fact dozens of universities and hospitals which are doing original work of major significance in many of the areas discussed in this paper. There are, however, some applications which are original in this paper. The concept of tying all USAF hospitals together into a gigantic network is one of these. The implementation of this ambitious but classic system engineering effort is feasible considering that extremely complex systems - SAGE (Semi-Automatic Ground Environment, the North American air defense system), BMEWS (Ballistic Missile Early Warning System), and the NORAD COC (NORAD Combat Operations Center, space warning and air defense nerve center for North America) to mention a few - are already operational. This effort gives the Air Force the opportunity to furnish society with a system of full-time mercy with both war and peacetime utility. Should the USAF Hospital System prove to be successful, it would be difficult to limit the concept with its humanitarian appeal to an exclusively USAF System, as other DOD agencies or the Public Health Service would likely be interested.

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Command Systems Division Electronic Systems Division L G Hanscom Field, Bedford, Mass 01730		2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	
		2b. GROUP N/A	
3. REPORT TITLE THE UNITED STATES AIR FORCE HOSPITAL SYSTEM			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) None			
5. AUTHOR(S) (First name, middle initial, last name) Ronald A. Creamer			
6. REPORT DATE August 1968		7a. TOTAL NO. OF PAGES 12	7b. NO. OF REFS 0
8a. CONTRACT OR GRANT NO. IN-HOUSE		9a. ORIGINATOR'S REPORT NUMBER(S) ESD-TR-68-310	
b. PROJECT NO.			
c.		9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
d.			
10. DISTRIBUTION STATEMENT This document has been approved for public release and sale; its distribution is unlimited.			
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY Electronic Systems Division, Air Force Systems Command, United States Air Force, L G Hanscom Field, Bedford, Mass. 01730	
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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT