

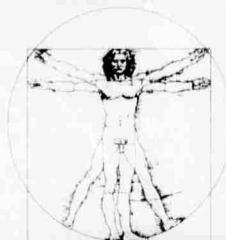
# Systems Analysis

## For a "New Generation" of Military Hospitals

Volume 3. Acquisition of Fixed Health Care Facilities

Final Report

AD722973



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SYSTEMS ANALYSIS  
FOR A "NEW GENERATION" OF MILITARY HOSPITALS

VOLUME 3  
ACQUISITION OF FIXED HEALTH CARE FACILITIES

FINAL REPORT  
TO THE ADVANCED RESEARCH PROJECTS AGENCY  
OF THE DEPARTMENT OF DEFENSE

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SYSTEMS ANALYSIS  
FOR A "NEW GENERATION" OF MILITARY HOSPITALS

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- VOLUME 2. REORGANIZATION OF THE BASE-LEVEL MILITARY HEALTH CARE SYSTEM
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### 3.1. INTRODUCTION

Military hospitals tend to become prematurely obsolete because they are built in accordance with outdated guidelines, they take an inordinate amount of time to plan, and they are inflexible to change after construction is complete.

Here we present improvements in acquisition procedures for military hospitals which, together with the adoption of advanced building methods, will result in a facility compatible with the demands of contemporary medicine while meeting the special constraints of military procurement and operational procedures. Had the recommended procedures been in effect in 1970, they would have reduced the \$60 million expenditure on construction of military hospitals by an estimated \$1.6 million.

Since the one certain characteristic of the future is that requirements for facilities and technology for buildings will change, we have emphasized the planning process more than the plans. To achieve the goal of upgrading the quality and utility of the military health care facilities and achieving demonstrable savings, we recommend the following:

1. That the DOD initiate an improved comprehensive systems management and design approach to the acquisition of health care facilities, embodying innovative features in the planning process, simplified review and approval procedures, and issuance of more detailed design and performance information to the Architect/Engineer and the building contractor.
2. That as an integral and fundamental component of the new planning process, a basic unit of measure--referred to in this report as a Planning Unit--be developed under the auspices of the SGO; the Planning Unit would incorporate cost, space and performance data, and would materially improve all planning, design, evaluation and decision-making procedures.
3. That the problem of early facility obsolescence be attacked by:

#### 3.1.1

- Adoption of modular building principles which facilitate reconfiguration.
- Initiation of a systematic information feedback procedure as an essential and continuing function of the acquisition process.
- More adaptability in planning and design, encouraging incorporation of new data and technology into every new project throughout its acquisition period.
- Use of computer-aided analysis to achieve better building layouts, taking explicit account of user requirements, site utilization, and economy.
- Use of long span roof and floor trusses to give unencumbered floor space and interstitial space for major building utility and service distribution.
- Adoption of multi-track scheduling for improved construction contracts, greater control over the project, and a shorter time span between design and beneficial occupancy.

Present acquisition procedures require two approvals at the OSD level (from the Hospital Planning Review Board) and one at the BOB level during the early planning stages. The information contained in documents associated with these approvals is largely tentative and undeveloped except for those elements which experience has taught influence budget approvals. The procedure is costly in terms of time and effort, and usually subject to substantial revision during the subsequent stages of the acquisition procedure. It is possible through introduction of Planning Units to streamline these procedures.

Development of a data bank contained in planning units for all departments of military hospitals is proposed. The Planning Unit is a standard module of area (approximately 1,200 square feet and is independent of department size), to which measurable quantities of performance output, cost, personnel and other resource inputs, and peripheral support requirements are assigned on the basis of experience. The assigned values would be derived from comparison of design criteria with actual performance of existing facilities. The information contained in the Planning Units would be kept current through continual feedback of information from operating hospitals.

Thus, once the performance needs of a new facility are identified (using present Base Planning Review Board procedures), information can be drawn from the data bank of Planning Units, and assembled as a detailed quantitative profile of the new facility. The resulting Project Summary Chart would assist in replacing both the present Project Proposal and the Preliminary Study documents with one proposal document, and would contain data sufficiently detailed and accurate to be used as a basis for Congressional budget review.

The second phase of the planning process follows the time-honored procedure of requiring an architect to interpret a written space program of requirements, matching his understanding of user needs to an intuitive approach to building design. We believe that it is possible to improve on this procedure by using computer assistance in analyzing and resolving conflicting requirements for the physical proximity of departments within the building and by using Form Diagrams as the preliminary description of the new building for the architect.

In the design phase modular principles can facilitate both design and, ultimately, construction. The modular concept in no way usurps the architect's traditional responsibility of designing an aesthetically congenial environment in a building of unique character. Designing a building amenable to internal change and possible external expansion during the facility life span does, however, call for new thinking.

Modularity in design makes possible overlapping the design phases with construction. This is called multi-track scheduling. In the construction phase work may begin up to four months or more prior to the issuance of final working drawings. A feature of the proposed building system is that detailed design of interiors can be left until later in construction.

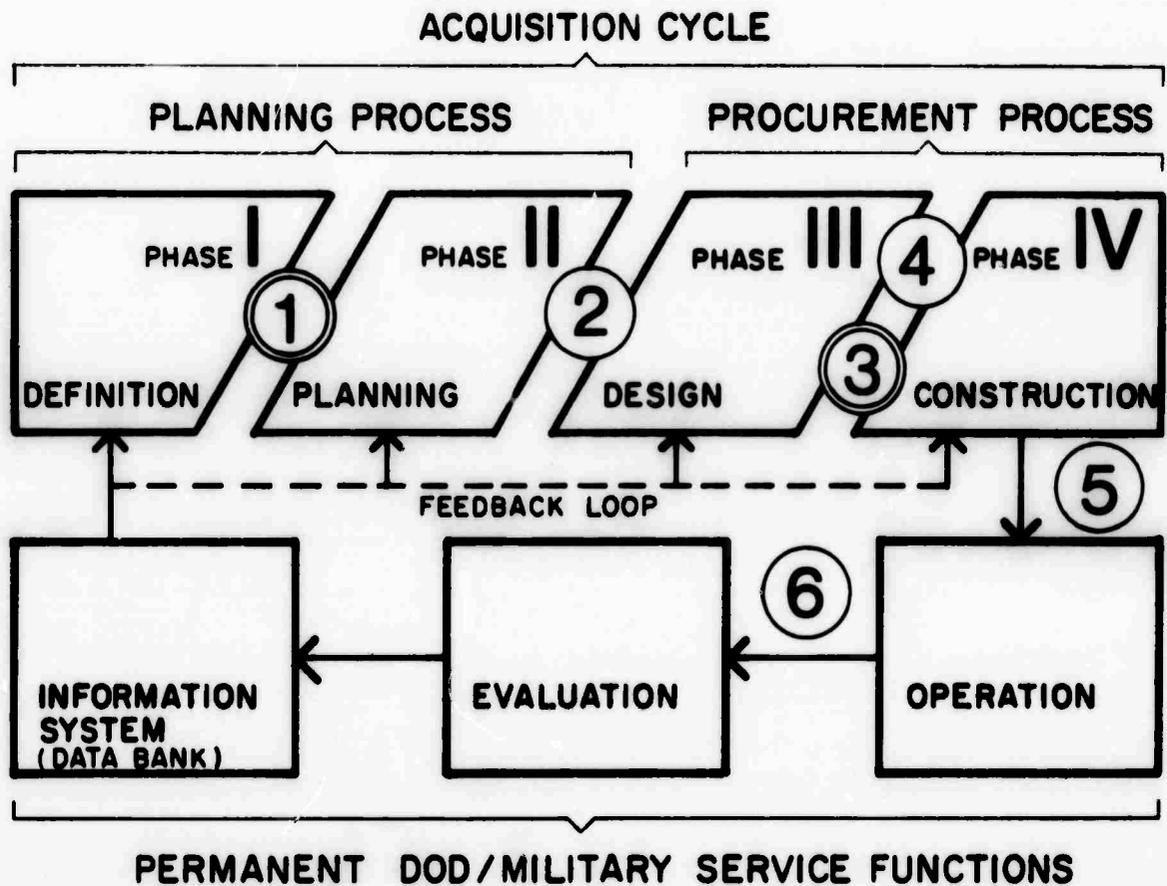
The role of computers in the new acquisition process is important but not essential. This obviously must be so, since military health care facilities have been designed quite satisfactorily without them. At the same time, computers offer a way of alleviating certain problems, especially those stemming from planning with insufficient information and long delays while detailed specifications are developed.

As a rule, computerizing a process already carried out manually turns out to be far more time-consuming and frustrating than it first appears. Computers demand meticulous attention to detail, and it is often the case that numerous details previously neglected must be dealt with. In addition, analysis of the process in which the computers will play a role often reveals inconsistency, irrelevance, inefficiency, or error in procedures performed manually. This has proved to be the case in reviewing the acquisition process for military health care facilities.

The improvements introduced in this volume are intended to take advantage of the capabilities of computers. However, with the possible exception of Form Diagrams, none of these improvements require the use of computers. Planning Units, performance records, and project summary charts can all be maintained and used without a computer. Nonetheless, they lend themselves to computerization, and their value is greatest when the system has been computerized.

In summary, the proposed Acquisition Cycle abandons the present linear procedure in which each new step is contingent upon completion of the previous step, and where all delays are cumulative. Instead, it proposes adoption of techniques that will eliminate many of the present steps and permit overlapping of the sequential phases. Adoption of the recommendations in this report can reduce the time span of the procurement period from the present 5-6 years to perhaps 3 years. The principal steps of the proposed acquisition cycle are listed in Figures 3.1.1 and 3.1.2.

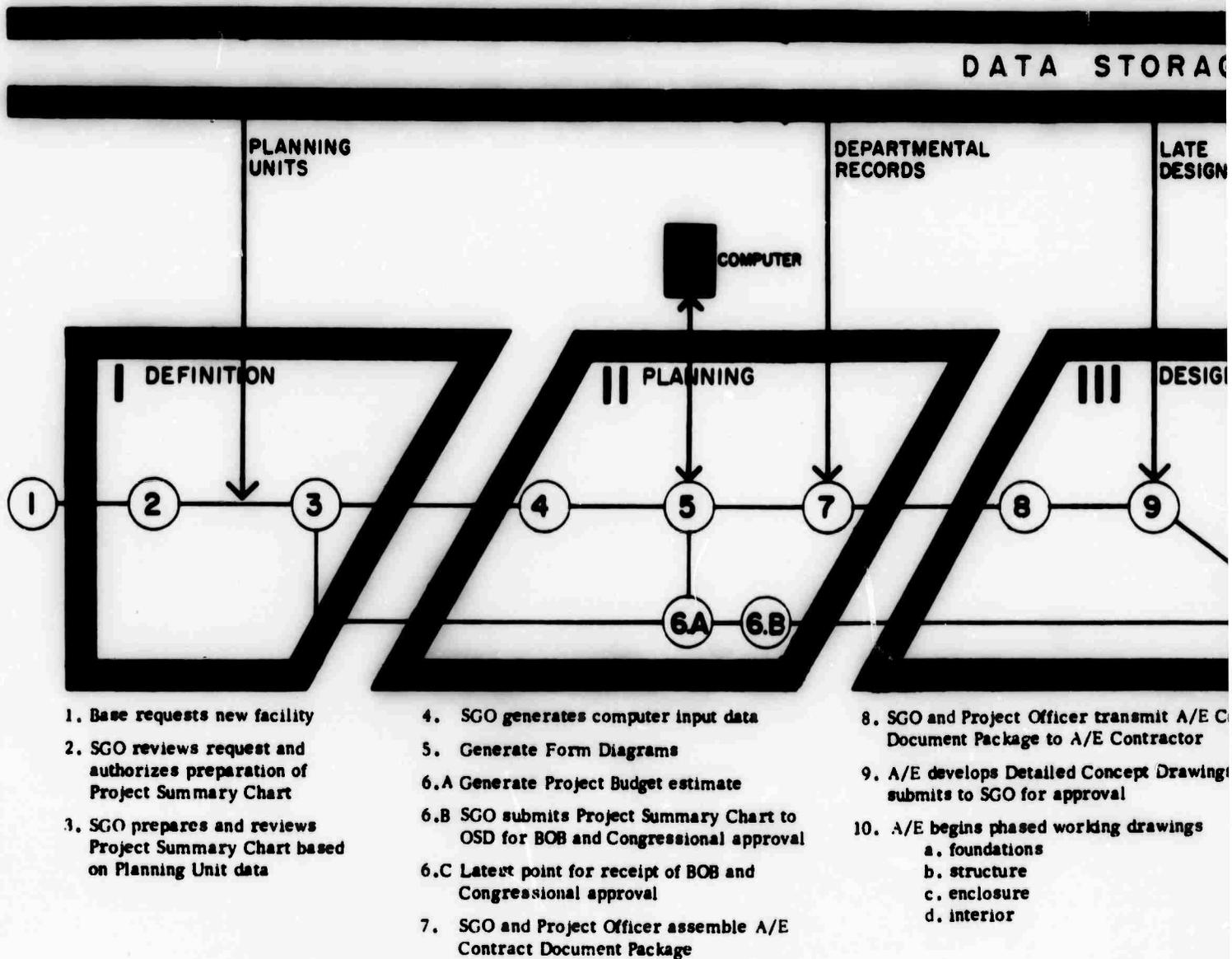
The majority of problems in procurement of military health care facilities are by no means peculiar to the military. The unique needs, capabilities, and resources of the military, however, place it in a most favorable position to lead a decisive attack on the problems. In planning this attack, our goal has been to achieve hospital facilities that will free medical personnel from present constraints on their work of providing the best possible health care for the military patient.



**DOCUMENTATION (Phase Objective)**

- 1)\* Project Summary Chart - Performance and budget estimate prepared by SGO for decision and submission to BOB, OSD, and congressional approval as part of the Project Proposal.
  - 2) A/E Contract Documents Package - Design instructions, Form Diagrams, and Departmental Performance Records prepared by SGO for Architect/Engineer.
  - 3)\* A/E Design Drawings and Estimates - Detailed Concept Plans and construction cost estimates prepared by A/E for SGO, OSD, BOB approvals.
  - 4) Working Drawings and Specifications - Prepared by A/E for phased construction contract bids and site construction.
  - 5) Acceptance Documentation - Formal facility acceptance for beneficial occupancy.
  - 6) Post Occupancy Evaluation & Operating Reports - Prepared by operating military bases and the individual military service for use in evaluation by DOD/SGO to update information system.
- \* Major approval steps

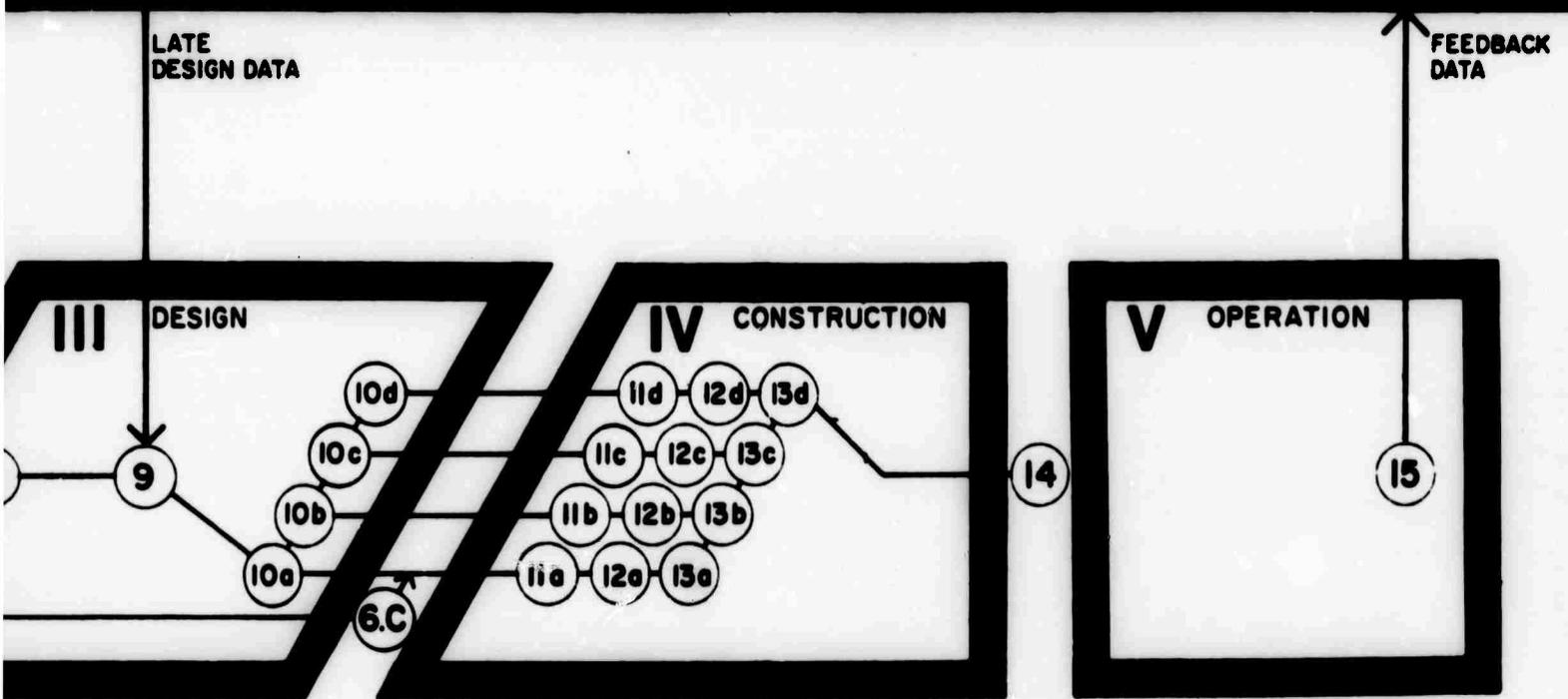
**FIGURE 3.1.1 SCHEMATIC OVERVIEW OF ACQUISITION CYCLE AND PERMANENT FUNCTIONS**



**FIGURE 3.1.2 PRINCIPAL STEPS IN**

A

**A STORAGE BANK**



Officer transmit A/E Contract  
to A/E Contractor  
alled Concept Drawings and  
r approval  
d working drawings  
s

11. Project Officer obtains construction bids and awards contracts on phased construction basis
  - a. foundation
  - b. structure
  - c. enclosure
  - d. interior
12. Off-site fabrication of modular building components
13. Site construction work

14. Acceptance of facility for beneficial occupancy
15. Periodic post-occupancy evaluation

**PRINCIPAL STEPS IN THE PROPOSED ACQUISITION CYCLE**

3.1.7

*B*

## 3.2. FINDINGS AND PROBLEM AREAS

### 3.2.1. INTRODUCTION

Findings in this volume are based on an in-depth study of the health care facilities at three military bases. They are March Air Force Base in Riverside, California, designed as a 200 bed hospital, the Wilson Army Hospital with 900 beds at Ft. Dix, New Jersey, and the 500 bed U.S. Naval Hospital in Jacksonville, Florida. Each hospital has extensive outpatient services. Other base hospitals were visited for familiarization. These included Andrews Air Force Base, Camp Springs, Maryland; Lackland Air Force Base, San Antonio, Texas; U.S. Naval Hospital, Beaufort, South Carolina; Oak Knoll Naval Hospital, Oakland, California; Womack Army Hospital, Fort Bragg, North Carolina; and DeWitt Army Hospital, Ft. Belvoir, Virginia.

The pattern of findings is similar at each base and reveals that facilities require a long period of development, averaging 6 to 7 years or more, from the identification of a need, through the facility planning and procurement phases, to beneficial occupancy. Facility space programs derived for the project proposal, and later detailed in the preliminary study become "frozen" into a fixed plan early in the acquisition process and tend to cause functionally obsolete hospitals upon beneficial occupancy. At the end of the preliminary study and after the DOD Hospital Planning Board's approval of it, the Surgeon General's Office requests the engineers to undertake the facility design and construction. The efficiency of the finished facility's operations is always found to vary from its planned performance capability, seldom matching the goals established in the planning criteria.

The acquisition process is somewhat similar for most military buildings. Procedural controls are established and enforced to assure the matching of funding with planning, to limit overrun costs. The controls further assure that the facility to be constructed, is the one defined in the project proposal and later developed in concept plans and working drawings. As the acquisition process proceeds, details of space requirements are

emphasized rather than functional programs. Hospital Commanders are, therefore, forever preoccupied with adjusting their physical plant to conform with changing health care patterns or to take advantage of new equipment and building technology.

The findings in this section are structured into two general areas. The first is the facilities' operational characteristics (Sections 3.2.2 through 3.2.4) and the nature of the facility's physical growth and change. The second area is concerned with the acquisition process (3.2.5), or means, used to plan and procure the facility. The former is derived from on-site investigation of the facility and the latter is derived from a study of policies, procedures and documentation required in the acquisition process. The basic questions being raised here are:

- Can health care facilities be built as flexible systems that respond to changing conditions of health care and technology?
- Can health care facilities be acquired, (that is, planned and procured), in an easier way, in less time, and at less cost?

The objectives of our recommendations are as follows: to improve the health care facility's ability to cope with growth and change; to take advantage of new technology such as industrialized building systems and prefabricated building components through modular design practices and modular planning; to reduce the amount of documentation required to define the proposed health care facility by using "Planning Units" and "Form Diagrams;" and finally, to reduce the total acquisition period through the use of multi-track schedules and systems management, rather than the current sequential steps.

### 3.2.2. OPERATIONAL CHARACTERISTICS\*

Health care facilities produced for military bases today often reflect outdated health care patterns and old mission needs. (The term facilities, as used in this report, is a generic expression of an assembly of resources to deliver health care, and includes the structure, equipment, manpower and supplies.) Facilities of the 1960's and before are traditional buildings which are definitized at an early stage--normally in preliminary studies. Frequently, the newly acquired facility on its opening day had outdated methods and was responding to past needs. An example is the 12-bed dispensary and outpatient clinic at Norton AFB, which serves a military population larger than that at March AFB with a 200-bed hospital and complete outpatient clinics. During the planning stage the need changed but plans for facilities did not. The arrangement which finally emerged, where facilities at March and Norton jointly serve beneficiaries in the area, is satisfactory, though a larger facility at Norton would have been preferable had plans been more flexible.

Information feedback on current and future needs is almost entirely excluded once the concept plans are begun, to avoid changing the Military Construction Program Budget.

In evaluating hospital operations against their planning criteria, it is observed that the BOB Circular A-57, "Review of Proposed Construction or Acquisition of Federal Hospitals and Domiciliary Homes," and DOD space planning criteria for hospitals (Directive Number 6015.6, "Technical Military Health and Medical Facilities Requirements," and its references) can and should remain, if properly updated, the most important guides for use in the planning process and review of Fixed Health Care Facilities (FHCF) in the Department of Defense.

Although some of the analysis in this section is directed at the basic content of these documents, the main remarks are concerned with the actual use of this information for facilities development. These remarks are concerned with the planning and procurement

\*The possibility is recognized that certain parts of this section might be dated, especially in the area of organizational improvement which is taking place within the DOD, and the work of the individual military services in "new criteria development."

phases during which time the information in the criteria become relevant. The process of continually updating this information with feedback from the operation and maintenance characteristics of existing facilities is of concern to planners and designers (as users), and to administrative, executive, Congressional, or permanent task forces of the DOD Hospital Planning Review Board as reviewers. The organizational mechanism to keep these criteria updated requires a more centralized SGO effort, in addition to revised reporting procedures.

### 3.2.2.1. Forecasting of Future Work Loads

From an examination of the work load projections as shown by the "Basis for Design for the 200 beds (175 operating beds) Composite Medical Facility for March AFB," (Revised January, 1961), it appears that there is a very wide gap between the projected planning documentation statements and the actual work loads found in operating reports for the calendar year 1968.\* A random survey of some of the departmental operations shows the following:

<b>Clinical Laboratory:</b>	Projected Work Load	Approx. 120,000 Tests/Year
	Actual Work Load	Approx. 240,000 Test/Year (1968)
<b>Diagnostic Radiology:</b>	Projected Work Load	Approx. 60,000 Film Units**
	Actual Work Load	Approx. 110,000 Film Units (1968)
<b>Pharmacy:</b>	Projected Work Load	Approx. 125,000 Prescr./Year
	Actual Work Load	Approx. 300,000 Prescr./Year (1968)
<b>Outpatient Visits:</b>	Projected Work Load	Approx. 100,000 Visits/Year
	Actual Work Load	Approx. 230,000 Visits/Year (1968)

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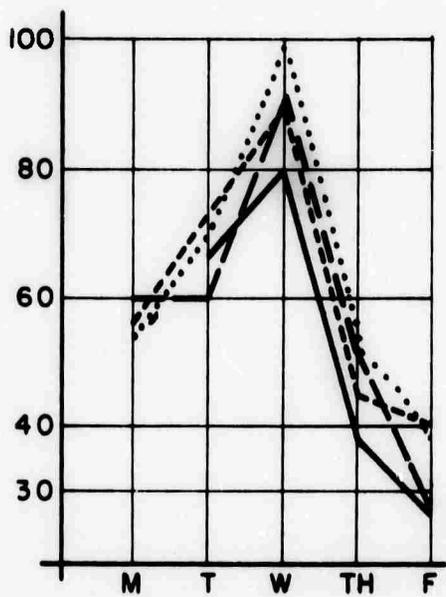
\*See also Volume 8.

\*\*Projections of Radiology Work Load are in Exams/Year. Further assumptions in the same document indicate a ratio of 2 Films per Exam. Total number of Exams projected was of 20,000 Exams/Year. A generous allowance for error (20,000 Films/Year) has been assumed here to arrive at a meaningful comparison between projected and actual work load.

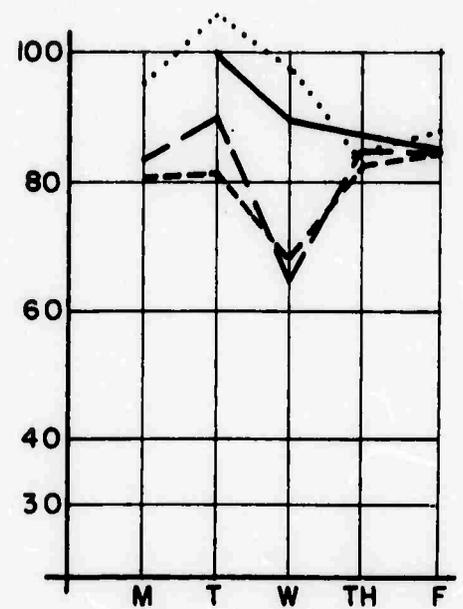
It is obvious that work load forecasting has been, at least in this case, of dubious reliability. (Forecasting of projected work load is shown to be one-half of actuals, in most cases.) In the case of March, only minor changes were made to update the facilities' operational nature between January, 1961, and its opening in June, 1965, four and one-half years later. The same sort of situation was found in all the other hospitals visited.

Additions to the March AFB Hospital are already in the planning phase, less than five years after the start of its operation in June, 1965. It is worth mentioning that the effectiveness of the facility, after its alterations in the early 1970's (payoff vs. cost), can never equal the functional effectiveness of original new construction. The alteration programs might be very effective within a particular department, but cannot avoid generating an increasing strain on the present staff, patients, logistics systems, on the administrative and general support services, and on the utility systems. March was designed as an individual fixed facility with a particular form and shape and was never planned for future expansion. Most hospitals designed and constructed in the 1960's suffer from the same characteristics. The conflict is between long-range hospital need, and the short-term assignments of management, administrative and Congressional personnel who are primarily concerned with "today's" problems.

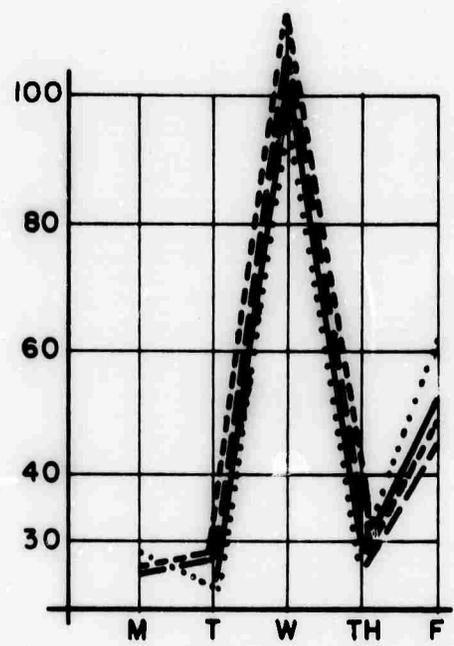
It was also found that most of the Space Planning Criteria provided by the DOD directives and Circular A-57 are based on average work loads. Although it is recognized that military hospitals have a higher degree of control over the scheduling of patient loads, it is known that medical departments are highly susceptible to seasonal, weekly or daily variation in work load as shown in Figure 3.2.1. We are not fully informed of how variable facility operating behavior has been used in setting standards, but it does not appear to be reflected in the operating procedures for updating current planning criteria.



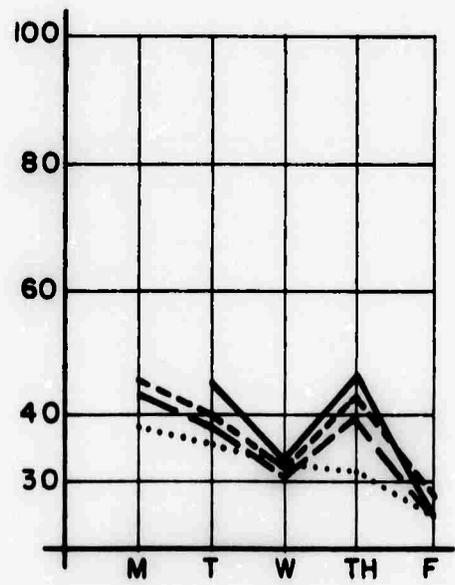
ORTHOPEDICS



PEDIATRICS



OBSTETRICS



SURGERY

\_\_\_\_\_ 1st week    ..... 2nd week    - - - - 3rd week    \_\_\_\_\_ 4th week

FIGURE 3.2.1 MARCH AIR FORCE BASE, AVERAGE PATIENT CENSUS OF FIRST FOUR WEEKS OF APRIL AND SEPTEMBER, 1969

### 3.2.2.2. Fixed Health Care Facility Gross Areas and Cost Estimating

The distribution and intensity of work loads determine the net areas of space requirements. At the project proposal step, in order for a project to be accepted in the five-year program, total departmental space requirements are determined in increments as small as 10 square feet, or less than 1% (e.g. linen closets); in other cases, spaces are determined by increments as large as several thousand square feet (e.g. nursing units). Approximately 40% of the remaining space (i.e. circulation and equipment) is determined as a percentage of net area.

For the purpose of cost estimating in project proposals today, reliable data on the total area of the projected health care facility is considered to be indispensable. It would appear inconsistent to be extremely accurate in predicting net area requirements, then use measures of a totally different level of accuracy to project the additional 40% of space requirements, and to follow this by applying an average price per square foot (or to check it with an average price per bed). It has also been observed, in the DOD criteria and preliminary study documents, that allowances for flexibility (contingency), are allowed at .75% of the total projected gross areas, e.g. 750 square feet per 100,000 gross square feet. It is not clear how this allowance contributes to the building flexibility later in the operational phase, or conversely, what interpretation of flexibility could be satisfied by this allowance.\*

\*There are several questionable points in regard to the percentage of net areas which are used to determine allowances for mechanical, circulation, partition spaces, covered walks and flexibility. Allowances for mechanical spaces, for example, have been determined to be equal to 7.9% of the total net usable area. Such criteria have been used for March AFB 200 beds in 1960. The same criteria apply for U.S. Naval Hospital, Oakland, California, 650 beds, 1963, and for the Naval Hospital, Pensacola, 310 beds, 1968. We do not believe that such criteria can be valid for ten years in consideration of a greater demand for mechanical installations, and be consistently applied to facilities of different size, geographical location, etc. Cost estimates are generated on the basis of cost per square foot, but this approach makes no allowance for the type of space.

The present planning process, which seeks to arrive at the definition of a facility's size and resources to cope with a health care delivery program, proceeds from the particular (linen closets and nursing beds) to the general (gross space requirements) using a factor today of 1.6 to 1.8 to expand net space to gross space and average cost factors. The reverse going from the general to the particular is more appropriate when estimating facility (resource) needs against program. The probability of decay in the validity of particular requirements over time is high, (e.g., Norton AFB outpatient clinic which responded to an outdated mission requirement). Decisions about relatively small components and specific requirements (linen closets) of any hospital system should obviously be delayed until late in the final design period.

The greatest demand for information is during the actual design process; building programs in general limit themselves to specification of detailed quantities of space: design is, in addition, strongly concerned with quality of space; quality and quantity of space are non-separable entities which should be considered during the procurement period rather than during the planning period.

In summary, it is recommended that detailed space layout and design should occur during the procurement phase rather than the planning phase. This is discussed later, in Section 3.4. The present detailing of building specifications at the project proposal step does not appear to result in accuracy in area estimating; it does, however, tend to freeze the final building program at an early stage, and once concept plans are drawn, functional change is discouraged until after beneficial occupancy.

### 3.2.2.3. Updating Criteria

From an examination of past records, i.e. the Post Occupancy Evaluation (POE) reports and the Project Proposal, it is clear that the programming of new facilities is, to a high degree, predicated on rather incomplete information. For example, in a report "Applicability Study USAF Manpower Determinants for Medical Functions, 1601st USAF Dispensary," Norton AFB, California, March, 1969, it is shown that projected need for new facilities is made on the basis of existing records, but does not consider that on the average, 264 outpatients are turned down each day because the existing facility is unable to handle the overload. Appointments are made only for the next day.

Although changes do occur in planning criteria, the cycle for incorporating change seems to be slow, and the degree of experimentation with relatively new concepts is quite limited. For example, the BOB Circular A-57's last principal update was in 1968 and some portions have not been updated since 1960.\* Further reasons for outdated planning criteria can be found in the lack of an adequate and responsible feedback mechanism. For example, the Post Occupancy Evaluation reports, now used by the Air Force, if properly structured and standardized, could provide high quality feedback information. The present POE is concerned mainly with the analysis of physical building performance as understood from an engineering (structural, mechanical, etc.) standpoint, but it makes no attempt to evaluate quality and quantity of work output.

The main functional elements of the facility are evaluated separately without examining the department interrelationships for efficiency. No clear frame of reference is established against which hospital performance can be measured. Comments and evaluation are therefore dependent upon the particular abilities of the individual observer and his own frame of reference as derived from his knowledge of official criteria.

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\*DOD Directives are attempting to compensate for this, but the organizational capacity available to carry on the monumental task of evaluation and update is small.

### 3.2.3. HISTORY OF GROWTH AND CHANGE

#### 3.2.3.1. History of Capital Additions to the March Air Force Base Hospital

- June, 1965      Construction complete at 130,000 square feet for 200 beds and outpatient services at a cost of \$4.5 million.
- 1966            Addition of an emergency generator station at 500 square feet at a cost of \$135,381.00.
- 1974            Proposed expansion additional clinical facilities, supporting service and the Flight Surgeon's Clinic 44,000 square feet at \$2.4 million.
- 2000            Projected estimates would add 60 to 70% additional space to house dental clinic and dental laboratories, warehousing, additional outpatient clinics and an additional light care unit. This expansion is contingent on policy decision on the more or less use of CHAMPUS and treatment of retired military personnel. The population of retired military personnel is expanding rapidly in Southern California.

#### 3.2.3.2. History of Capital Additions to Walson Army Hospital

- Jan., 1960      Original construction including a contractor-installed equipment completed (nine floors, 500 beds for 386,756 gross square feet of area at a cost of \$8,603,907). This addition provides a total capacity of 896 beds.

- Mar., 1967 Clinic addition of 33,618 gross square feet at \$1,285,982. Additional wing for air evacuation of 6,292 gross square feet at \$128,000.
- 1960-1970 Miscellaneous capital additions including a ventilating system, a sterilizing system, new lavatories, new circuits, and crash bars on doors at \$383,139.
- Mar., 1970 Scheduled date for contract award for six-story addition over existing one-story air evacuation wing at rear of building--230 beds--completion scheduled for February, 1972 at \$3,500,000.
- June, 1970 Contract still not awarded because lowest bid received was \$4,300,000 and plans are currently stalled. This bid excludes six additive items: construct and install elevator number 10; masonry with plaster partition and ceilings plaster on metal lath; wall coverings over plaster; parapet walls of masonry with stone coping; parking for automobiles.

### 3.2.3.3. History of Capital Expansion to Jacksonville Naval Hospital\*

- Dec., 1967 Completed and dedicated as a 400-bed hospital on a 400-bed chassis. Area is estimated at 235,000 square feet for \$7,200,000. Total bed capacity with this new facility is 500 beds.
- 1970 Modifications from opening to May 25, 1970 include approximately 86 to 100 projects at an average cost of \$400-\$600. These projects serve to correct deficiencies to make the hospital fully operational. Total cost approximately \$46,500.

\*Data from Hospital Administrators and NAVFAC Division Office in South Carolina.

**Modifications in progress:**

- Install water storage tanks and hook-up lines for distilled water to selected areas at \$5,723.
- Soundproof offices in administrative areas on second deck at \$5,944.
- Alternate transformer was deemed necessary for the hospital by the Commanding Officer, Southeast Division, Naval Facilities Engineering Command, at \$47,890.
- Minor repairs and repainting. This project is considered premature and caused by considerable plaster damage due to leaking windows and the use of poor quality paint by the contractor, at \$63,000.
- Planned modifications include over 31 projects of varying size ranging in cost from \$200 to as high as \$450,000 for a Recreation Facility. For further details, see the separate report on this hospital.

It is necessary to understand the relationship between structural degeneration and functional obsolescence in buildings. In the curve in Figure 3.2.2, structural degeneration is shown as an index of structural performance. The curve of structural performance starts at a high point of maximum structural performance and decays with time. At some time during the life of the building, this curve will approach the minimum satisfactory level of structural performance. But if the building is repaired, (i.e. maintained somewhere above minimum structural performance level), structural performance will never be raised to its original level. If the structure is demolished and rebuilt, the curve will begin again at a higher level of structural performance due to improvements in construction methods.

Functional obsolescence as shown in Figure 3.2.3 also falls off but in a series of steps, each indicating the introduction of a new procedure or technique which suddenly lowers the functional effectiveness of the plan.

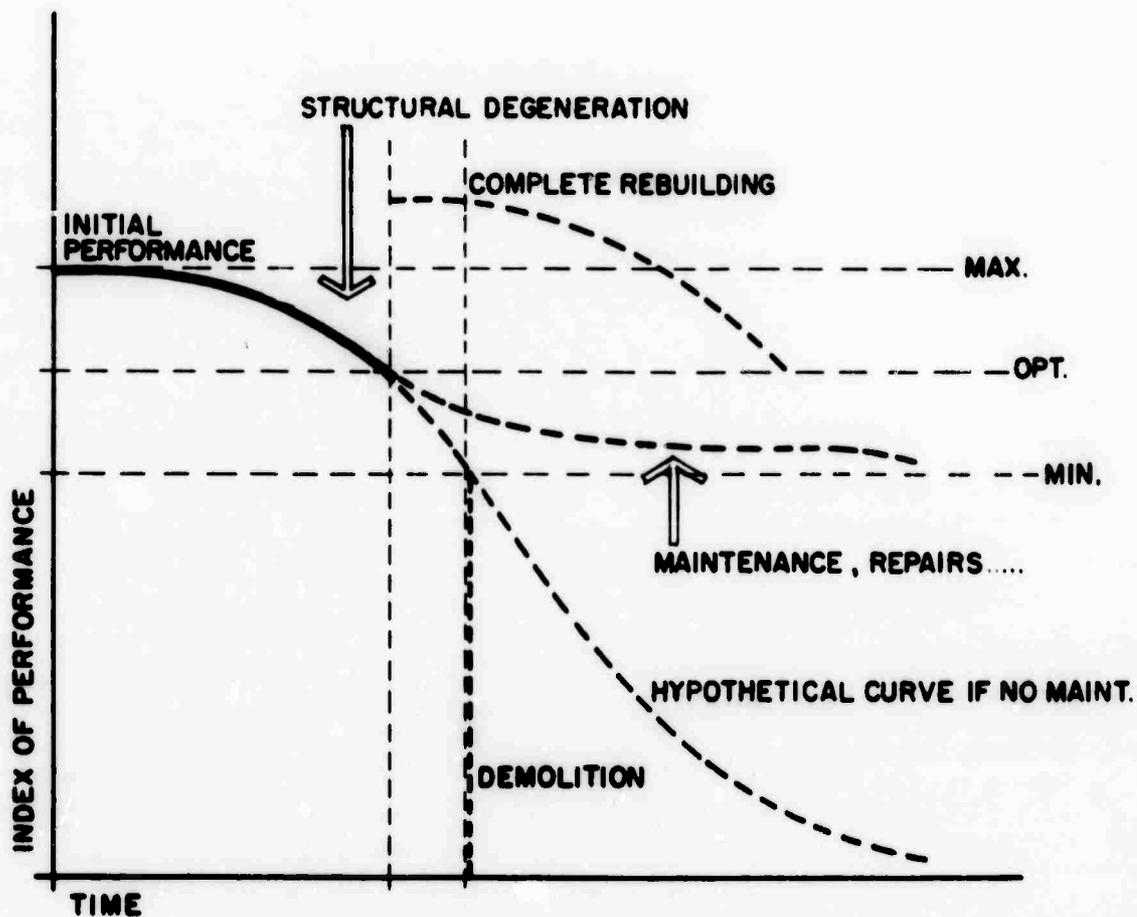
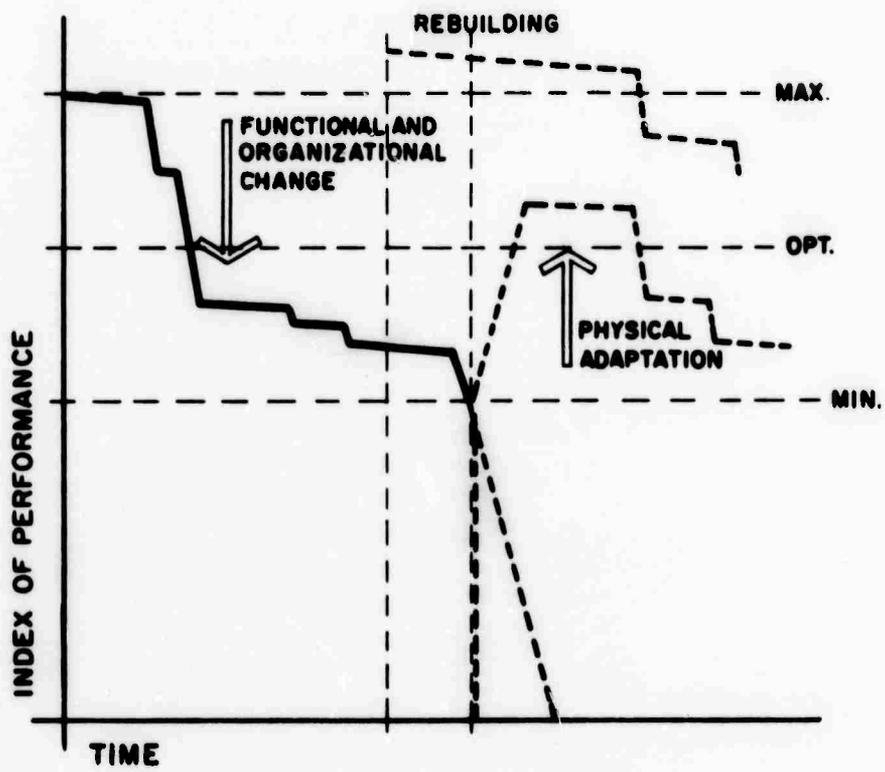


FIGURE 3.2.2 DEGENERATION OF PERFORMANCE



**FIGURE 3.23 FUNCTIONAL OBSOLESCENCE**

The first difficulty of such curves lies in devising proper indicators of structural and functional performance. Without these we shall be unable to determine when a building becomes obsolete. The normal range of life span for a hospital is figured at approximately 50 years.\* Equipment deteriorates much more quickly, usually in five to seven years. Large air conditioning systems last about 20 years, as do elevators. Today's trend is for buildings to contain more and more mechanical equipment, thus tending to reduce their useful life. Clearly, then, internal mechanisms are more likely to cause the downfall of a large and complex building than the building structure.

It seems likely that the economic life of a hospital based upon these depreciation rates, lies somewhere between 40 and 50 years, and should certainly not be more than 60 years. Abel-Smith and Titmuss<sup>1</sup> estimated this as the probable economic life for a hospital in their discussion of the cost of the British health service in 1956. However, by limiting the heavily serviced areas we may be able to confine the high obsolescence rates to small zones of the hospital, allowing differential aging in various parts of the building. For example, an operating theatre could reasonably have a life of 20 years and a ward area might well last 30 years providing it is not too heavily serviced.

The disparity between structural degeneration and functional obsolescence raises practical problems in that buildings remain structurally sound long after they are functionally obsolete. A building which is functionally obsolete after five years usually lasts fifty. In the past, functional change occurred slowly and buildings could be pulled down as they became obsolete. Now, with changing social habits and advances in technology, almost every building becomes obsolete long before it is ready to fall down.

The hospitals and health care facilities at the military bases visited were designed as one-time structures. Yet it is pointed out

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\*By military planning standards and for average depreciation allowance set by The Internal Revenue Service.

in the previous discussion that functional change is evident and likely to increase, and that growth in the facility size is a foregone conclusion. The more closely a design is tailored to a particular function, the more quickly it becomes out-of-date and obsolete. It is therefore necessary that planning consider future expansion, and that buildings be designed to adapt to change as discussed in Section 3.4.1. A design narrative\* for the David Grant Hospital at Travis Air Force Base, Fairfield, California indicates that the concepts of growth, change and adaptability are being considered in the DOD.

Physical obsolescence comes about through age, rusting, rot, deterioration and all other things that affect the strength and weatherability of a building. The rate of obsolescence varies for different structures. Complex structures such as hospitals or research laboratories become obsolete at the rate of 3-20% per year. The more complex the program, the faster the obsolescence.

Causes of obsolescence include:

- Physical aspects of the building,
- Changing medical and nursing practices,
- Patient expectations change,
- Socio-economic changes,
- Environmental change--the mission of the military base,
- Changes in codes and laws,
- Changes brought about by availability of disposable items.

It was found that hospitals with basic plants that were more than 20 years old need extensive new mechanical services before they can be fitted with up-to-date surgeries, X-ray suites, laboratories, central sterile services, and computer centers.

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\*A design narrative is a general document written for medical facilities in the Air Force. DOD has recognized the value of this approach to planning in Instruction 4270.1, 17 November 1967, "Defense Construction Criteria Manual."

#### 3.2.4. BUILDING TECHNOLOGY

The principal military hospitals investigated were designed and constructed by conventional methods. Little use was made of modular systems or industrialized building systems. Construction was performed mostly on-site by using material delivered to the site and then assembled by standard construction trades. The factors preventing the use of systems building technology were the local and Federal building codes and union opposition.

It became clear that working drawings were not prepared on a modular grid, that performance specifications were minimal, and that traditional cut and fit methods of assembly on the site predominated. The pre-fabricated components were the fixed equipment: reinforcing steel bars, building panels, windows, doors and smaller parts.

The building and management technology found were considered to be time tested, having worked well in the past, but being unnecessarily rigid today. Buildings were designed around a one-time program and lacked any future expansion possibilities. March Hospital, for example, was known prior to its erection to be inadequate in size. Yet it was designed as a fixed and rigid shape. The designer's lack of understanding about the long-term operations problems of growth, changing health care patterns and maintenance, has introduced constraints which are forcing higher maintenance and alteration costs today. One specific example at March was the crushing of base cove and plaster by floor polishers banging into it; this will require a special project of \$100,000 or more for curb repair.

There was an apparent lack of technical information flow from post-occupancy reports into planning and design manuals.

There are hospitals today--McMasters University; Greenwich, England and the VA at San Diego--that have taken a major step toward maximum use of current technology of interstitial space, modularity, a recognition of growth and change, and systems buildings. The cost of these facilities initially is higher, but is later offset by lower maintenance and alteration costs.

Finally there appears to be a communication gap between SGO ideas on what a hospital should be and eagerness of the engineers to pass the responsibility of design onto the A/E firm.

It takes four documents to arrive at a budget figure for the DD 1391: the proposal, preliminary study, concept plans and 30% working drawings. It appears that both parties--the SGO and engineers--are working on opposite teams rather than joining together in a planning effort. The Navy recognizes this problem and has placed an MSC officer in NAVFAC and NAVFAC is placing a CEC officer in the SGO.

The space program listing does not appear to be a sufficient vehicle of communications and it is for this reason that affinity matrices and design guide lines are being advanced by the SGO. However, the A/E becomes a dominant force and can soon overcome the ideas given to them; vis-à-vis the form of the 1960's, sometimes described as a "matchbox-on-a muffin," changed little during the decade.

### 3.2.5. HEALTH CARE FACILITIES ACQUISITION PROCESS

The planning and procurement of Fixed Health Care Facilities rests primarily with the operating military base commanders. It is their responsibility to recognize health care facility deficiencies when their level of health care delivery fluctuates from operating norms established by higher level directives. Health care delivery in this instance, recognizes the need for coordinated resources and ethical professional practice for system effectiveness.

Deficiencies are constantly accumulating as a result of plant deterioration, changing technology and patterns of health care, manpower training and retraining requirements, and changing base missions.

For planning and acquiring new (or modified existing) health care facilities, there is a recognized process established by DOD Directive 6015.17 which is implemented by each individual military service. For an overview of the acquisition process, a network flow of its activities is presented in Figure 3.2.4. This is the process for a single new facility, a sub-system acquisition, or an alteration over \$500,000. At any one time in an individual base health care system, there are multiple projects in being and all the functions of planning, programming, design, construction and operations are occurring in parallel as shown in Figure 3.2.5.

For a single new acquisition, the process is normally confined to a linear path. That is, each step and document must be completed and approved prior to originating the next step. The minimum normal acquisition period from programming to the point of beneficial occupancy is from six to seven years. Most projects (see Tables 3.2.1 and 3.2.2) take longer as a result of competing for limited funds during the planning period. Under the multi-track scheduling, proposed in Sections 3.4 and 3.5, the procurement period can be less than 3 years.

The Congressional funding process requires the DOD to establish the cost of their health care facilities with great care. The Deputy Assistant Secretary of Defense (Installations and Logistics) requires development of 30% final working drawings before making an estimate.

It is assumed that this level of detail will ensure that estimates will accurately reflect the eventual bid price, though actual bids are received not less than 13 months from the submission of the program to the Bureau of the Budget and Congress, (as scheduled on the Milestone Chart, Figure 3.2.6). Because so much time elapses between estimating and bidding, the estimates are frequently in error.

Not only is the estimate likely to be in error, but it is time consuming and cumbersome as well. It takes five documents to comply with current requirements: 1) project proposal, 2) preliminary study, 3) concept plans, 4) preliminary (30%) working drawings, and 5) the construction bid, which responds to a contract bid package of plans, specifications and general contract provisions. The cost of documentation preparation is estimated at 18% of the construction cost in professional fees and requires approximately 360 man-days of SGO and base personnel time as shown in Table 3.2.3 (not including the management fee of 8-12% to handle the project construction administration by the military engineers). It appears that the four documents leading to Congressional Review and funding authorization could be reduced to one if the information used to support proposal preparation were better organized and easier to retrieve. Sections 3.3.2 and 3.3.3 propose a methodology for achieving this reduction.

For the sake of comparison, the acquisition period for a number of public building projects is shown in Table 3.2.4. The current period for military hospitals is the longest, being six years or more. The Public Building Service estimates that their period can be reduced, for example, by 50% or more times by using multi-track scheduling. It is estimated that three or four years for the military facility acquisition period is possible.

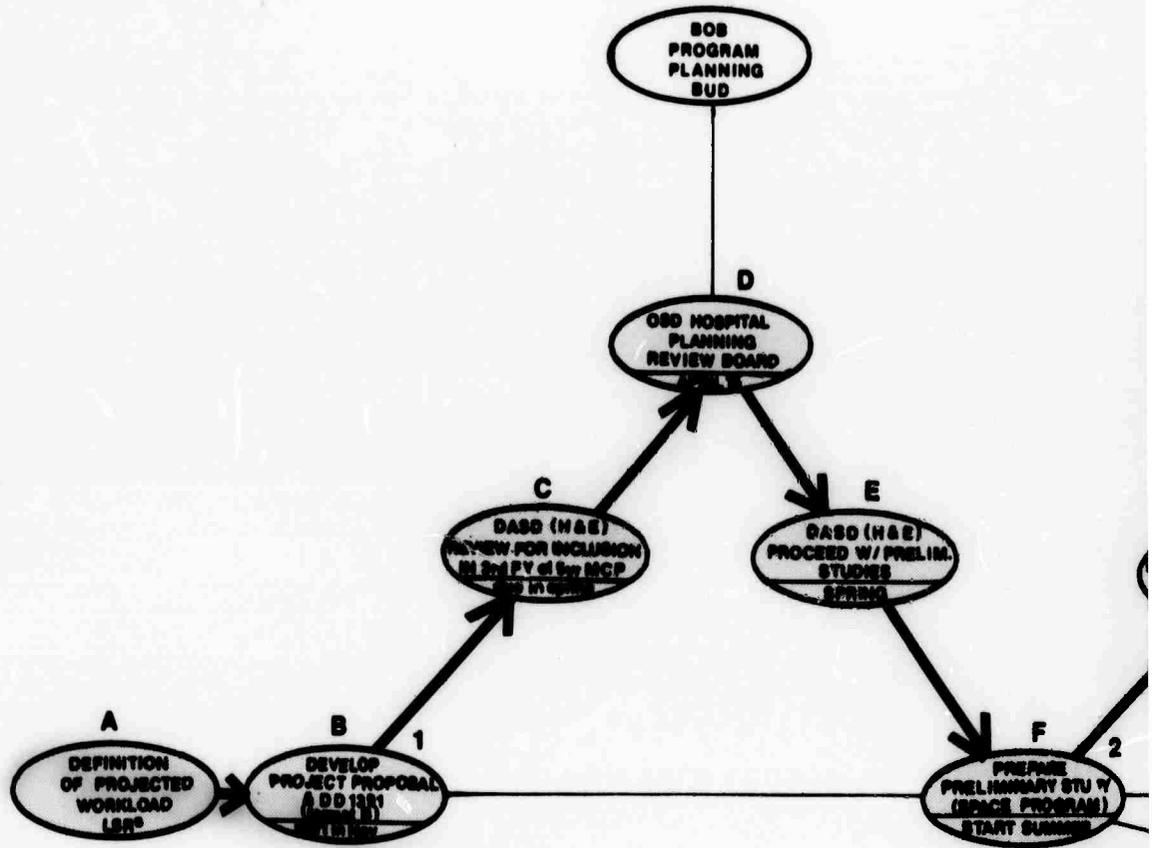
A review of former studies completed for DOD has brought to light the fact that previous approaches to designing new hospitals have been concerned largely with development of sophisticated equipment and related supporting services. It must be recognized that a building is quite different from equipment in its characteristics. This statement is illustrated in the following comparison:

	<u>EQUIPMENT</u>	<u>FIXED FACILITY</u>
<b>RESOURCES</b>	High priority within DOD	Low priority within DOD
<b>DESIGN &amp; DEVELOPMENT</b>	High cost in relation to end product	Low cost. End product predictable
<b>TECHNOLOGY</b>	Sophisticated "One cycle end product"	Standard
<b>DESIGN OBJECTIVES</b>	Permanent through time Clearly identifiable Preproducible prototype	Change through time Unclear--no existing feedback One-of-a-kind products
<b>DESIGN CONSTRAINTS</b>	Clearly identifiable	Partially identifiable
<b>PERFORMANCE SPECIFICATIONS</b>	Clearly identifiable Permanent through time Rel. low mainten.costs (change of parts easy) Obsolescence criteria clearly establishable  Restricted type of use Operation cost low	Partially identifiable Change through time Low maintenance costs (change of parts difficult) Obsolescence criteria not clearly establishable  For many uses (present and future) Operation cost very high
<b>SOCIAL &amp; PSYCHOLOGICAL CONSIDERATIONS</b>	Low priority	High priority
<b>ENVIRONMENTAL CONSIDERATIONS</b>	Generally related to highly specialized activities	Only partially related to highly specialized activities

**FINANCING  
(BOB / CONGRESS)**

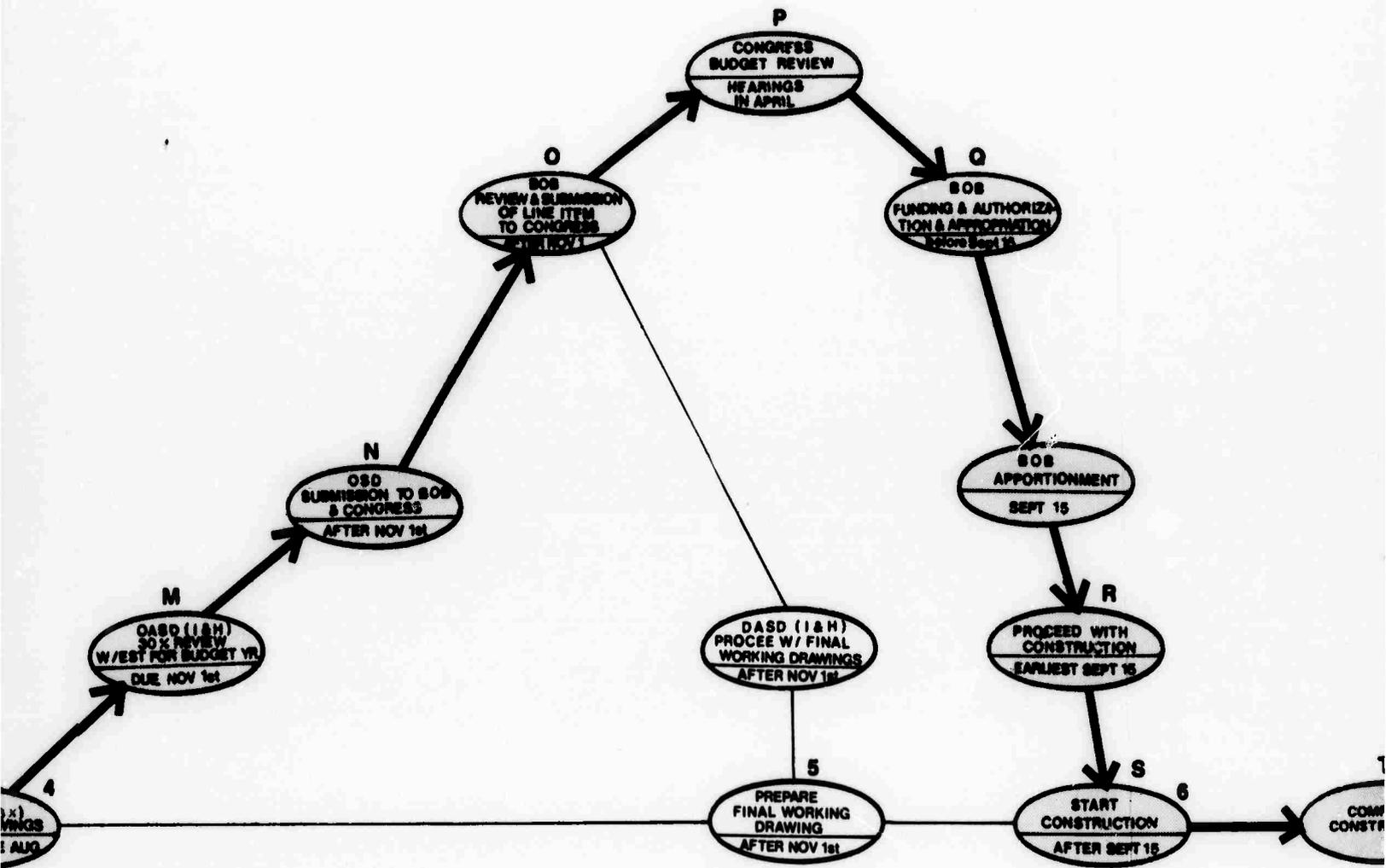
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(REVIEW & APPROVALS  
FOR MCP)**

**MILITARY  
SERVICE  
(PLANNING & FACILITIES  
ACQUISITION)**



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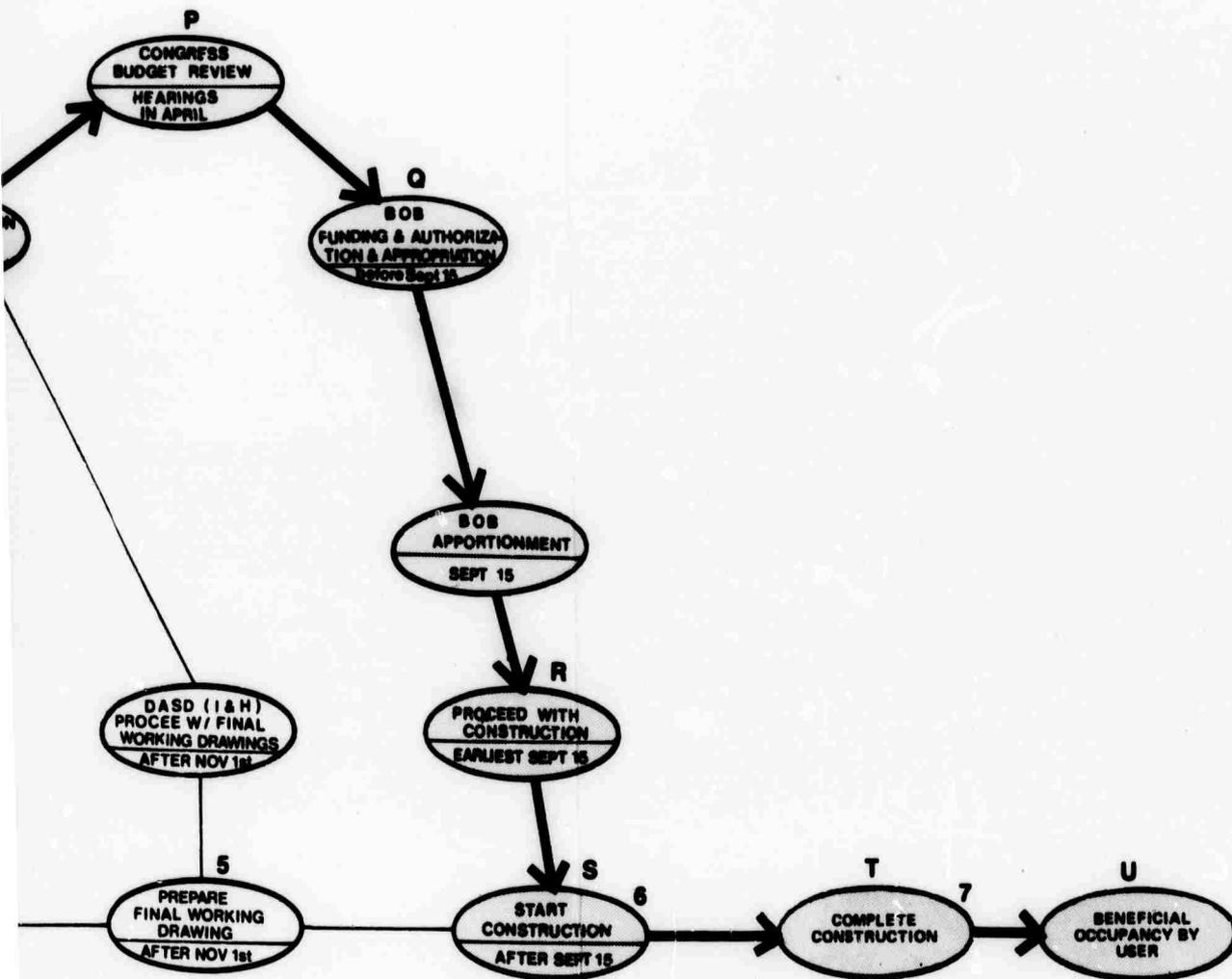




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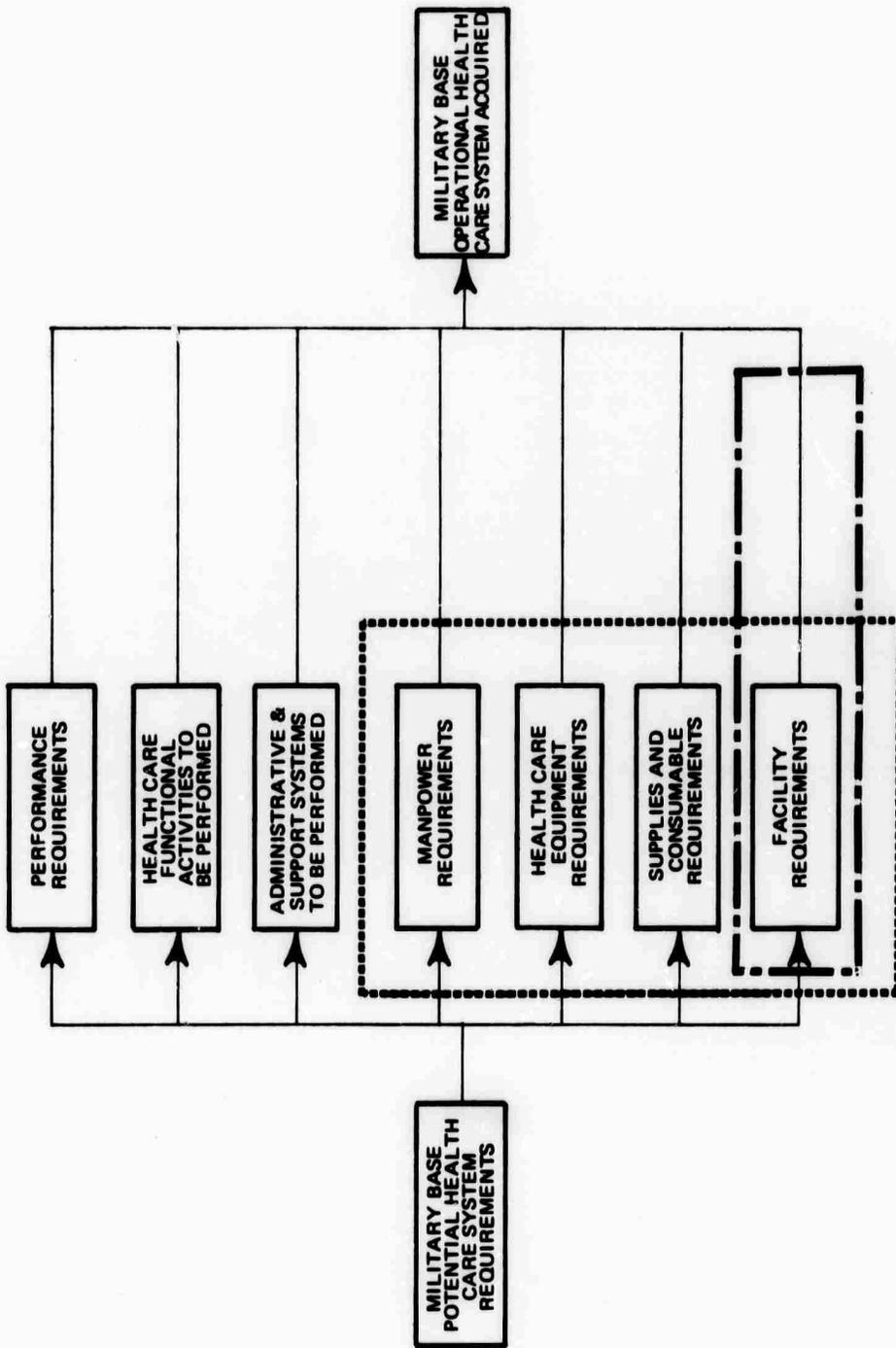
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**FIGURE 3.2.5 CONCEPTUALIZATION OF FIXED HEALTH CARE FACILITIES ACQUISITION PROCESS**  
 The process concerns independent trades of resource acquisition rather than an integrated process.  
 Each resource category is independent and is pursued in the same manner.

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TABLE 3.2.1

PROJECT ACQUISITION HISTORY FOR THE MARCH AFB HOSPITAL

Description:	General Regional Hospital for the Air Force in Southern California; 175 operating beds and 25 beds for temporary expansion.
1958	Project proposal prepared and discussions held on this project at March AFB.
June, 1960 In-house	Preliminary study developed.
1961	Concept plans prepared.
1962	Preliminary working drawings.
Apr., 1963	Start construction
June, 1965 7 Years	Complete construction and beneficial occupancy TOTAL ACQUISITION PERIOD

TABLE 3.2.2

PROJECT ACQUISITION HISTORY OF MARCH AFB MODIFICATION  
AND ALTERATION PROJECT

**Description:** Additional clinical space for the outpatient care department and the Flight Surgeon Clinic—44,000 square feet at \$2,293,000.

**June, 1963** Facility inadequacy discussion. It was known  
**In-house** in 1963 that the faculty was undersized and the Flight Surgeon's Medicine Department was excluded.

**Sept., 1967** Preparation of preliminary study and project  
**In-house** proposal

**Fall, 1969** Revalidation of preliminary study.  
**In-house**

**Dec., 1969-** Preparation of concept plans.  
**June, 1970**  
**A/E Firm**

**Nov., 1970** Complete 30% preliminary working drawings.  
**A/E Firm**

**Jan., 1974** Start construction  
**Contractor**

**Jan., 1976** Complete construction and beneficial occupancy.

STEP, ACTIVITY & DATE	1st FY ONDJFMAMJ	2nd FY JASONDJFMAMJ	3rd FY JASONDJFMAMJ	4th FY JASONDJFMAMJ	5th & 6th FY JASONDJFMAMJ	7th FY JASONDJFMAMJ
B Develop Project Proposal (Nov)	■					
D OSD Hospital Planning Review Board (Apr 15)	■					
E Prepare Preliminary Study (Jun)		■				
H OSD Hospital Planning Review (Oct 1)		■				
J Prepare Concept Plans (Jan 15)		■				
K DASD (I&H) Budget (Aug 15)			■			
L Prepare Prelim Working Drawings (Aug)			■			
M DASD (I&H) Budget Review (Nov 1)				■		
Q/P Congressional Hearings (Apr)				■		
Q Funding Application to DOD (Sept 15)					■	
S Start Construction (Sept 15)					■	
T Complete Construction (2-3 years)						■
U Beneficial Occupancy (within 30 days)						■

Data taken from Figure 3.2.7  
 Ref: DOD 6015.17  
 Dated September 1, 1969  
 (Draft Revision)

FIGURE 3.2.6 MILESTONE CHART FOR EXISTING ACQUISITION PROCESS

TABLE 3.2.3  
 PRODUCTS DEVELOPED DURING ACQUISITION PERIOD AND THEIR ESTIMATED COST OF PREPARATION

Products	Cost in Man Days or Percent of Construction Value (6)		
	SGO Personnel	Base Personnel	Software Contractors, A/E's Consultants, etc.
Logistic Support Requirement (software)	20-60 (3)	5	
Project Proposal -- DD 1391 for Health Care (software)	3 (2)	-	
Preliminary Study--Space Requirements (software)	5	1	
Feasibility Study to determine adequacy of plant (software) (1)	(2)	5	1 % (2)
Program for Design/Design Narratives (software)	15	2	
Concept Plans & Revised DD 1391 (software)	5	30	1.5%
Preliminary Working Drawings (30%) (software)	5	20	1.5%
Final Working Drawings (100%) (software)	15	20	4 %
Construction and Equipment Procurement (hardware)		100	
Contracts--during acquisition period (software)	30	-	11% (4)
Management Reporting--during acquisition period (software)	50	20	
Post Occupancy Evaluation Report (software)	5	5	
	153 Man Days (5)	208 Man Days (5)	18%

Note: Total costs are not coordinated through a central accounting system to give total costs of facilities planning. Estimates are difficult to obtain and vary greatly from project to project.

- (1) Not carried out in all cases. Special studies, i.e. Walter Reed Hospital, David Grant Hospital, Travis AFB.
- (2) Base engineers may make a statement in the prepared DD 1391.
- (3) Lower number is used in addition.
- (4) Cost of construction management.
- (5) Professional--excludes secretarial and support personnel.
- (6) All man days are estimated as a result of discussions held with the three services.

TABLE 3.2.4  
FACILITY ACQUISITION PERIODS

<u>Type Project</u>	<u>Acquisition Periods</u>	
	<u>Current</u>	<u>Proposed</u>
Military hospitals	6-7 years	3-4 years
Hill-Burton Hospital Project	4-5 years	same
HEW Research Building	4-5 years	same
Barrack Project*	3-4 years	same
PBS Office Building*	4-5 years	2 years

\* Public Building Service of the General Services Administration

### 3.2.6. CONCLUSIONS

The present acquisition process works, but it contributes to early functional obsolescence, is burdensome, time-consuming, and overloaded with constraints. It requires excessive documentation for presenting and justifying need. The process could be improved by incorporating recommendations summarized in Section 3.1 and described in greater detail in subsequent sections. Findings and problem areas are summarized below:

- The activities during the acquisition period are sequential and not overlapped. It takes from six or more years to produce a health care facility.
- Freezing design early in the acquisition process prevents the developing facility from accommodating changing conditions of mission, health care patterns and technology.
- Emphasis in planning is on details of individual room space requirements, rather than on overview of functional and departmental space programs. Planning proceeds from the particular to the general.
- Hospital commanders are continually faced with problems of adapting the physical plant to conform to changes in health care patterns and new technology.
- Current facilities are inflexible and adapt with difficulty to changing conditions. Costs of modifying facilities are excessive.
- Planning criteria are scattered (separate manning tables, space requirements and operations characteristics), and require better coordination.

- There appears to be a wide gap between the projected planning documentation statements and the actual work loads found in operating reports. Space planning criteria are based on average work loads.
- Current documentation, (i.e., project proposals and preliminary studies) for modifications, additions or new facilities, is inadequate. Frequently additional feasibility studies are ordered to validate proposals and evaluate existing facilities. Criteria for validating the condition of the existing plant are frequently stated in terms of physical structure rather than its performance and operational effectiveness. Operating data requires a feedback mechanism and format in order to bring it before a central evaluation group or task force. The objective is to update planning criteria and information.
- The field of industrialized buildings is developing at an unprecedented rate as a result of market demand for low cost buildings. Health care facilities programs have not exploited their benefits.
- Convertibility has a greater priority in terms of contingency planning than growth and change, though the latter are at least as important.

### 3.3. THE PROPOSED PLANNING PROCESS

#### 3.3.1. INTRODUCTION

The Planning Process proposed here is part of a longer acquisition cycle and has two definitive phases. The purpose of the first phase is to identify and define the needs of a military base for new or upgraded Fixed Health Care Facilities in a way that allows those needs to be rationally evaluated when compared with the operational needs and budgetary requests of other bases. The second phase is concerned with developing a clear profile of the physical facility to be designed to satisfy the need. Each phase contains significant departures from existing methodology.

The principal new feature of the first phase of the Acquisition Cycle--Definition--is a comprehensive data storage bank based partially on BOB and DOD criteria, partially on past and current experience with existing military hospitals, and partially on new developments in the state-of-the-art (i.e., medical science and technology, construction materials and methods, new and experimental hospital facilities outside the military purview, etc.). The data will be systematically stored and continuously updated with regular reports from operating hospitals, surveys of the literature, and other sources to serve as a basis for evaluating the novel features of new hospitals. The evaluation program is discussed in Section 3.7 as a future research and development function.

The proposed data bank varies from existing data records in the format and content of the recorded data. An analysis of the size, resource inputs, costs, and functional performance of all hospital elements (including administrative, logistics and support departments), for every military Fixed Health Care Facility will be placed in the data bank, and updated at regular intervals with information from operating hospitals. For purposes of easy manipulation of this information, either for comparative analysis, upgrading criteria, or synthesis of new facility needs, the data are to be reduced to a common module of area independent of department element size, known as a Planning Unit.

The Planning Unit, discussed in Section 3.3.2, relates functional objectives for medical treatment to the modular planning and design of the hospital building. Expressed as a standard module of occupied building area, the Planning Unit derives from an arbitrary but proven building grid of 4'x4"--sixty-four such grid elements furnishing a space Planning Module of (nominally) 1,200 square feet. The various element inputs (resources personnel and costs), and appropriate output performances (case loads, treatments, clean sheets, etc.), are then related directly to the 1,200 square-foot area to achieve a comparative unit of measure. Capital and operational costs are then estimated for this data.

Planning Units would be initially assembled, stored, and periodically updated by the SGO, and kept in a common central planning data storage bank. Storage could be on tape, microfilm records, or "hardcopy" records in conventional files.

Retrieval of Planning Unit data for assessing new facility needs would normally be by requesting the number of Planning Units required to accomplish the projected number of case loads (expressed in Standard Work Units) for a given hospital department. For example, a given number of surgical procedures per year would call for a surgical department of, say, 3.5 Planning Units in the proposed hospital. As well as knowing that the resulting surgical department would occupy 4200 square feet of hospital floor space (3.5 x 1200), typical departmental operating costs, staffing, logistical, and support requirements would also be immediately known.

A summation of all the departments in a proposed hospital, together with their developed Planning Unit data, would be assembled in a Project Summary Chart (Section 3.3.3) and standard adjustment factors applied for project location and time. This chart permits fast and concise assessment of the scope, cost, and functional capability of the proposed facility. The level of detail is such that base review board personnel can study and, if appropriate, modify their request before submitting it formally to the SGO; at the next level, the request can be evaluated in detail as a required budget appropriations, and relationship to other proposed and existing facilities for the fiscal year, compared on a regional planning basis;

finally, if the SGO concurs with the base request, the Project Summary Chart would become a key substantiating document in the Health Care Facility Proposal for requesting budget approvals from OSD, BOB and Congress. Preparation and evaluation of the Project Summary Chart data concludes the first phase of the planning process.

The second phase of the planning process begins with the decision to request Congressional approval for the project. The SGO will initiate preparation of two sets of documents: a Health Care Facility Proposal, and the documentation required for a full and detailed briefing of the Architect/Engineers. The compilation of these documents constitutes the principal goal of the second phase; it calls for a significant departure from the present methodology in preparing proposals and space program information, furnishes mission-oriented budget information for Congressional consideration, and is much more extensive and definitive in the information it imparts to the A/E contractor.

It is proposed that the essential elements of the initial concept design studies, presently made by the A/E contractor, be computer-generated from functional input data supplied by the SGO. These studies pertain primarily to the physical relationship of hospital elements. (A review of computer programs potentially applicable to this task is included in Section 6.5.) This activity is not strictly dependent on Planning Units and can be used with existing space program criteria pending development of the Planning Unit data bank. Analysis of departmental relationships, study of alternative building forms, and locating the building relative to the site for a variety of input criteria are discussed in Section 3.3.4. The computer printouts showing this information are called Form Diagrams. (See Figure 3.3.1 for diagrammatic explanation.)

Functional resolution of the hospital floor layouts generated by the computer provides a visual impression of the building form (based on operational requirements), prior to architectural inputs. Thus, the Form Diagrams, together with the Project Summary Chart, (and even a tentative artist's rendering, if necessary) can be submitted to Congress for budget approval prior to any work by the A/E contractor. This earlier request for budget approval permits much more efficient use of the time (about 13 months) taken up in the Military Program Review Cycle, and

### 3.3.3

Arthur D Little Inc

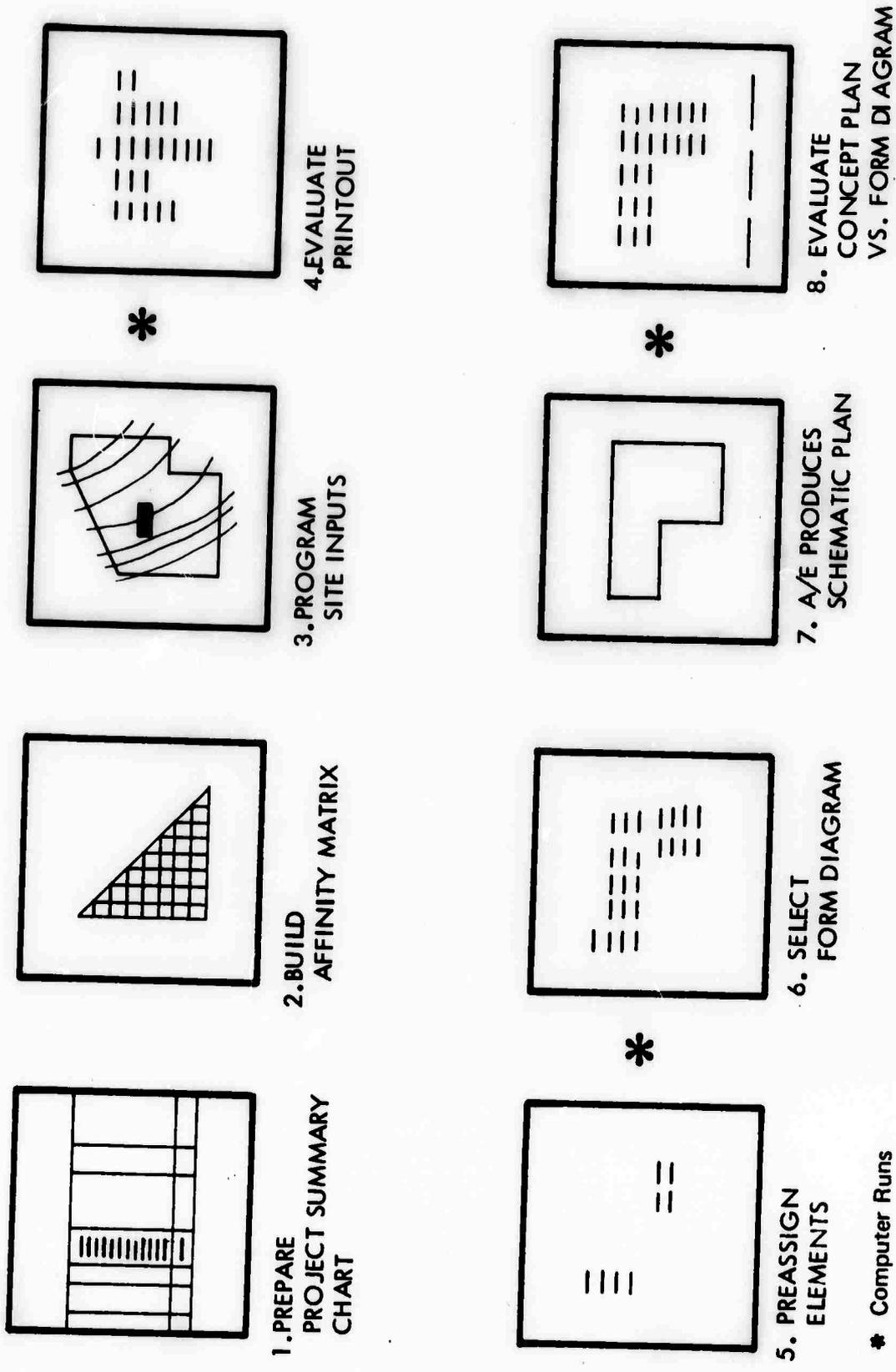


FIGURE 3.3.1 GENERATION AND USE OF FORM DIAGRAMS

is one of the key factors in reducing the overall acquisition time.

The A/E Contract Documents Package will contain several different Form Diagrams, offering the A/E designer a choice of sub-optimal resolutions of the planning criteria, departmental relationships, and site studies. Inclusion of the Form Diagrams with the information supplied to the A/E contractor will enable him to prepare Detailed Concept Plans and cost estimates approximating the present 30% final working drawings without requiring formal preliminary approvals (Section 3.4.2).

It will be apparent from the above comments that the computer-generated Form Diagrams are important inputs to both the Health Care Facility Proposal and the Architect/Engineers Contract Documents package. The data base for the computer program producing Form Diagrams includes both site survey information and information developed from the Project Summary Chart. Functional relationships are expressed in an Affinity Matrix (Section 3.3.4) and are prepared by the SGO showing the desirability of hospital elements proximities.

Another important component of the A/E Contract Documents (though largely irrelevant to the Health Care Facility Proposal) will be a file of Departmental Performance Records. These are records retrieved from the data storage bank showing plans of similar-sized departments in existing military hospitals. Also included are updated data on the suitability of the space allocation for the required work output, cost factors, access and egress affinities, staffing and support needs. The designer will not be expected to copy these plans in the new facility, but, together with the Form Diagrams and a delineation of standard operating requirements criteria, they should enable him to arrive at an early design concept of high functional efficiency, unique to the requirements of the project.

The documentation included in the Health Care Facility Proposal and the A/E Contract Documents Package (preparation of which concludes the principal objectives of the third phase of the Acquisition Cycle) is delineated in Section 3.5.2.

Principal benefits of the proposed new planning process include:

- Development of concise, mission-oriented proposal documents and estimates.

### 3.3.5

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- Development of definitive A/E design instructions.
- Preparation of functionally efficient building forms and floor plans.
- Incorporation of latest and best available planning and operational data from all sources including all existing Fixed Health Care Facilities.
- Significant reduction in the acquisition period, and the review and approval procedures.

3.3.6

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### 3.3.2. THE PLANNING UNIT

The proposed Planning Unit is a convenient means of storing, updating, and retrieving specific information about the cost, staffing and functional performance of occupied floor space in a military hospital.

The need for such a "yardstick" is well known to all involved in hospital planning and operation, and has been given formal expression in an Air Force letter dated 29 November 1968, which reads in part, "the Department of Defense has directed that a 'data bank' be established-- (to) store data and generate OSD reports and analyses." The Planning Unit is responsive to this need, integrating cost and performance data with spatial requirements.

Primary uses of the Planning Units are as follows:

- To help generate a detailed and accurate definition of a proposed new Fixed Health Care Facility.
- To furnish projected cost data substantiating requesting for budget approvals.
- To provide a direct means of relating medical functions to the design of the physical facility which houses them.
- To provide a normative base against which performance and cost data from existing hospital departments can be measured and compared.
- To create a data format capable of evolutionary change to keep abreast of current technology.

The present basic source of planning criteria for military hospitals is BOB Space Planning Criteria, Circular No. A-57, supplemented by DOD directives and individual SGO criteria. These criteria as revised and

supplemented still seem to be the most valid and best guiding data for the military hospital designer. We propose that the BOB/DOD Space Planning Criteria terminology, hospital element categories, space and performance data be used as the primary inputs for Planning Units. (We also propose, in a later section, that the Planning Unit's capability for comparison of ideal criteria with actual performance be used to update the specified criteria creating a feedback loop for greater currency of the criteria as applied to new facilities). Additional Planning Unit inputs would come from other public health agencies, private hospitals, the construction industry, and the broad fields of medical science and technology.

The reason Planning Units are proposed here is that existing data and planning criteria are scattered and uncoordinated with medical functional performance records. Even in a single document, such as the BOB Criteria, the information becomes cumbersome to retrieve and translate into efficient building layouts. Planning Units, on the other hand, are designed to be easy to manipulate when creating a precise functional profile of a proposed facility (Section 3.3.3) easy to translate into modular building Form Diagrams (Section 3.3.4) and easy to conduct post-occupancy performance analyses. Also, since the data bank of Planning Units will be established using existing BOB Criteria inputs, comparative evaluation of the performance of new generation hospitals with present facilities will also be possible.

In short, the Planning Unit is a compact unit of space planning criteria, cost, staffing, and other input data, quantified for a particular hospital element. It has a constant though shapeless floor area (1200 square feet of space is recommended as a convenient size and is based on 64 grid units having a normal dimension of 4'-4"), permitting ready translation to physical space planning and design. All other information pertains to the overall departmental size, cost, support requirements and functional characteristics of the hospital element, statistically pro-rated to the 1200 square foot datum.

As an interim step between the written criteria and quantified abstracted data of the Planning Unit, it is proposed that all hospital

elements be designed for "ideal" departmental configuration, without specific project-peculiar constraints. These plans can then be analyzed for developing basic cost data for the Planning Unit, equipment location and traffic flow information for inputs to the A/E Contractor, and visual (qualitative) comparison with Departmental Performance Records from existing hospitals. The layouts would be developed in considerable detail showing in, say, a surgery the optimum equipment requirements, scrub areas, operating rooms, staffing needs and supplies storage. Besides generating data for the Planning Units, these plans will be used as guidance documents for the A/E Contractor and will assist SGO staff in evaluating the detailed concept plans.

Typical Planning Units are illustrated in Table 3.3.1. Establishment of a data bank containing Planning Units for all hospital element categories is proposed in Section 3.5.3. The format is set up for computer data processing.

Planning Units information typically comprises the following:

- 010 ELEMENT. This is the standard BOB/DOD criteria description of the department with suffix indicating size category where applicable.
- 020 WORK LOAD. This is the work load in standard equivalent units per year as specified in BOB/DOD criteria for the size and type of department, pro-rated to the 1200 square feet Planning Unit datum.
- 030 INTERIOR ENVIRONMENT COSTS. These figures are current best estimates as of the end of the last fiscal year. (All Planning Unit data is updated annually.) They are based on detailed cost estimates for the "ideal" plan, analysis of recently constructed projects, manufacturers' price lists, published construction figures, and review of current bids.

MILITARY BASE--HOSPITAL			
010			
DEPARTMENT GROSS AREA NUMBER OF PLANNING UNITS			
		TOTAL	PER P.U.
020	WORK UNITS RANGE (Exposures/Yr.)		
030	INTERIOR ENVIRONMENT COST		
031	Interior Construction Costs		
032	Equipment Costs		
033	Exterior, Structural, Mechanical & Additional Circulation Costs		
	TOTAL ACQUISITION COSTS		
040	PERSONNEL		
041	Physicians		
042	RN		
043	Other Nursing		
044	Other Professionals		
045	Non Professionals		
050	LABOR COSTS		
051	Physicians		
052	RN		
053	Other Nursing		
054	Other Professionals		
055	Non Professionals		
060	SUPPLIES COSTS		
061	Linen		
062	Provisions (Food)		
063	Drugs		
064	Medical Supplies		
065	General Supplies		
070	BLDGS & GRNDS OPERATION COSTS		
071	Utilities		
072	Maintenance		
073	Housekeeping		
074	Other		
080	MISCELLANEOUS		
090	OPERATING COSTS TOTAL		
	OPERATING COST PER WORK UNIT		

Table 3.3.1 DEPARTMENTAL PERFORMANCE RECORD

031 CONSTRUCTION. This includes the installed cost of all floors, walls, partitions, ceilings, doors, windows, hardware, finishes, lighting, electrical, HVAC, and rough plumbing runs in the building volume defined on plan by the 1200 square foot area, and in section by the distance between finished floors including interstitial space, but not including the building structure or mechanical equipment.

032 EQUIPMENT. This includes the delivered and installed costs of all major medical equipment, fixtures, and furnishings within the building volume.

040 PERSONNEL. This is the FTE staffing requirement for the Planning Unit, pro-rated from Directive recommendations for the size and type of department.

041 PHYSICIANS

042 RN's

043 OTHER NURSING

044 OTHER PROFESSIONAL

045 NONPROFESSIONAL

(Note: These personnel categories may be further subdivided as necessary.)

050 LABOR COSTS. These are total figures for each category as of the end of the last fiscal year, apportioned to the 1200 foot module, and derived from the data furnished by all military Fixed Health Care Facilities in the Annual Health Report of the Command.

- 051 MD LABOR COSTS PER YEAR
- 052 RN LABOR COSTS PER YEAR
- 053 OTHER NURSING LABOR COSTS PER YEAR
- 054 OTHER PROFESSIONAL LABOR COSTS PER YEAR
- 055 OTHER NONPROFESSIONAL LABOR COSTS PER YEAR
  
- 060 SUPPLIES. These include pharmacy, laundry, general storage, etc.
  
- 070 MAINTENANCE and CUSTODIAL. Including HVAC, utilities, housekeeping.
  
- 080 OTHER. Reserved for costs not included in the above categories.
  
- 090 TOTAL OPERATING COSTS. The sum of the costs, shown in 050 through 080.

It should be noted that all of the Planning Unit data are applied to the 1200 square foot datum area and not to the entire department. Thus, if a surgery were sized at three Planning Units (i.e., 3600 square feet), the work load, personnel and costs shown on the Planning Unit would all be multiplied by three to obtain the total department figures. It is also worth noting at this point that although the Planning Unit has a specific area, it is not limited to any particular shape or plan; the figures are applicable to a wide range of departmental configurations.

All Planning Unit cost figures are for a selected zone of the country as of the end of the previous fiscal year. For the cost program/budget estimating purposes, these figures must be adjusted by factors applicable to the area in which the facility is located, and for the construction, the projected increase for the estimated date of awarding construction contracts. Functional data are from BOB criteria, and personnel data from the application service directives. All data are updated by processing and evaluating information from operating hospitals (Figure 3.3.2)

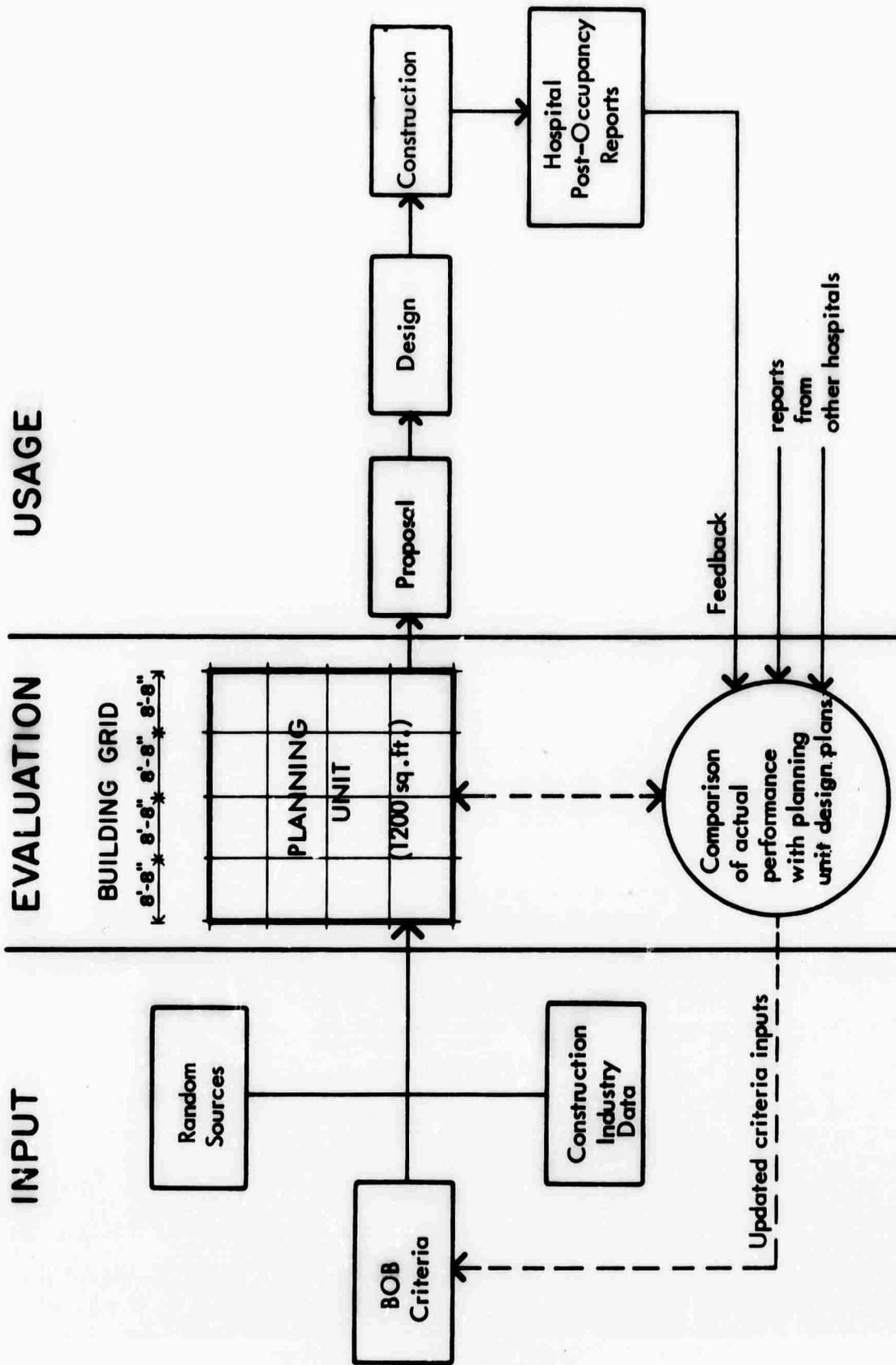


FIGURE 3.3.2 DERIVATION AND USE OF THE PLANNING UNIT

and from random input sources.

Planning Unit data represent the estimated current norm for a new military Fixed Health Care Facility. In practice, few, if any, hospital departments would return performance records congruent with the data. A deviation from the norm is to be expected, as was pointed out in the findings discussed in Section 3.2. All existing military hospital records can easily be reduced to Planning Unit proportions, however, for the purpose of making a comparative analysis. (See Tables 3.3.2 and 3.3.3 for a comparison of selected hospital departmental performances at Jacksonville Naval Base and March Air Force Base.) Once a sufficient number of military hospitals are analyzed and compared with the Planning Unit data in this way, it will be apparent whether the BOB/DOD criteria from which data are derived is a realistic document. If it is not, the Planning Unit analysis will reveal how the criteria should be changed to conform with operating hospital experience. (This is represented schematically in Figure 3.3.3).

The method of measuring the components of the hospital element structure is described in more detail below.

#### 3.3.2.1. Output

The output consists of measuring the amount of work performed within the department. It is usually possible to find a practical way of measuring the output and of relating it to a basic unit of measurement.

A number of studies in this area have already been carried out both by DOD and other hospital agencies. The methods for assessing standard work load values are, by necessity, empirical since they can only be based upon assumptions. For example, the number of standard procedures which may be conducted in a surgery department is determined by:

- the fluctuation of work load distribution,
- the number of hours per day the operating rooms are used,
- the patient preparation techniques peculiar to the institution,
- the techniques used for room clean-up,

JACKSONVILLE		RADIOLOGY ELEMENT OPERATING DATA AS OBSERVED IN 1969	
010	RADIOLOGY		
DEPARTMENT GROSS AREA NUMBER OF PLANNING UNITS		3,854 sq. ft. 3.2 P.U.	
020	WORK UNITS RANGE (Exposures/Yr.)	TOTAL 90,000 WU	PER P.U. 28,000 WU
030	INTERIOR ENVIRONMENT COST	\$ 64,500 + EC	\$ 20,800 + EC/3.2
031	Interior Construction Costs	64,500	\$ 20,800
032	Equipment Costs	EC	EC/3.2
033	Exterior, Structural, Mechanical & Additional Circulation Costs	\$139,000	\$ 44,700
TOTAL ACQUISITION COSTS		\$203,500	\$ 65,500 + EC/3.2
040	PERSONNEL	10	3.12
041	Physicians	2	
042	RN	-	
043	Other Nursing	-	
044	Other Professionals	8	
045	Non Professionals	-	
050	LABOR COSTS	\$ 86,000	\$ 27,000
051	Physicians	\$ 30,000	\$ 9,850
052	RN	-	
053	Other Nursing	-	
054	Other Professionals	\$ 56,000	\$ 17,150
055	Non Professionals	-	
060	SUPPLIES COSTS	\$ 43,800	\$ 13,800
061	Linen	-	
062	Provisions (Food)	-	
063	Drugs	-	
064	Medical Supplies	\$ 43,800	\$ 13,800
065	General Supplies	-	
070	BLDGS & GRNDS OPERATION COST	\$ 26,300	\$ 8,200
071	Utilities	\$ 13,400	\$ 4,200
072	Maintenance	\$ 6,950	\$ 2,250
073	Housekeeping	\$ 4,950	\$ 1,550
074	Other	\$ 1,000	\$ 330
080	MISCELLANEOUS	-	-
090	OPERATING COSTS TOTAL	\$156,100	
OPERATING COST PER WORK UNIT		\$1.76	

Table 3.3.2 DEPARTMENTAL PERFORMANCE RECORD

TABLE 3.3.3  
DEPARTMENTAL PERFORMANCE RECORD

MARCH AIR FORCE BASE		RADIOLOGY ELEMENT AS SPECIFIED IN BOB CRITERIA FOR PROJECTED WORK LOAD (1960-1965)		RADIOLOGY ELEMENT AS BUILT (1960-1965) FOR PROJECTED WORK LOAD		RADIOLOGY ELEMENT OPERATING DATA AS OBSERVED IN 1969		IDEAL RADIOLOGY ELEMENT AS REQUIRED FOR OBSERVED WORK LOAD (1969)	
010 RADIOLOGY		3,650 sq. ft. 3.05 P.U.		2,530 sq. ft. 2.11 P.U.		2,530 sq. ft. 2.11 P.U.		5,750 sq. ft. 4.8 P.U.	
DEPARTMENT GROSS AREA NUMBER OF PLANNING UNITS		TOTAL	PER P.U.	TOTAL	PER P.U.	TOTAL	PER P.U.	TOTAL	PER P.U.
020	WORK UNITS RANGE (Exposures/Year)	45,000 WU 75,000 WU	15,000 WU 25,000 WU	45,000 WU 75,000 WU	21,000 WU 36,000 WU	113,000 WU	53,500 WU	105,000 WU 135,000 WU	22,000 WU 28,000 WU
030	INTERIOR ENVIRONMENT COST	\$ 63,500 + EC	\$ 20,800 + EC 3.05	\$ 42,500 + EC	\$ 20,800 + EC 2.11	\$ 42,500 + EC	\$ 20,800 + EC 2.11	\$ 99,500 + EC	\$ 20,800 + EC 4.8
031	Interior Construction Cost	\$ 63,500	\$ 20,800	\$ 42,500	\$ 20,800	\$ 42,500	\$ 20,800	\$ 99,500	\$ 20,800
032	Equipment Costs	EC	EC/3.05	EC	EC/2.11	EC	EC/2.11	EC	EC/4.8
033	Exterior, Structural, Mechanical & Additional Circulation Costs	\$136,000	\$ 44,700*	\$ 94,200	\$ 44,700*	\$ 94,200	\$ 44,700*	\$215,000	\$ 44,700*
	TOTAL ACQUISITION COSTS	\$199,500 + EC	\$ 65,500 + EC 3.05	\$137,700 + EC	\$ 65,500 + EC 2.11	\$137,700 + EC	\$ 65,500 + EC 2.11	\$314,500 + EC	\$ 65,500 + EC 4.8
040	PERSONNEL	8	2.62	8	3.78	14	6.65	14	2.82
041	Physicians	1		1		2			
042	RN	-		-		-			
043	Other Nursing	-		-		-			
044	Other Professionals	6		6		11			
045	Non Professionals	1		1		1			
050	LABOR COSTS	\$ 51,600	\$ 17,200	\$ 51,600	\$ 24,400	\$ 93,000	\$ 44,500	\$ 93,000	\$ 19,350
051	Physicians	\$ 15,000	\$ 5,000	\$ 15,000	\$ 7,100	\$ 30,000	\$ 14,200	\$ 30,000	\$ 6,250
052	RN	-	-	-	-	-	-	-	-
053	Other Nursing	-	-	-	-	-	-	-	-
054	Other Professionals	\$ 31,600	\$ 10,500	\$ 31,600	\$ 14,800	\$ 58,000	\$ 27,400	\$ 58,000	\$ 12,100
055	Non Professionals	\$ 5,000	\$ 1,700	\$ 5,000	\$ 2,360	\$ 5,000	\$ 2,360	\$ 5,000	\$ 1,080
060	SUPPLIES COSTS	\$ 30,000	\$ 10,000	\$ 30,000	\$ 14,200	\$ 51,000	\$ 24,200	\$ 51,000	\$ 10,200
061	Linen	-	-	-	-	-	-	-	-
062	Provisions (Food)	-	-	-	-	-	-	-	-
063	Drugs	-	-	-	-	-	-	-	-
064	Medical Supplies	\$ 30,000	\$ 10,000	\$ 30,000	\$ 14,200	\$ 51,000	\$ 24,200	\$ 51,000	\$ 10,200
065	General Supplies	-	-	-	-	-	-	-	-
070	BLDGs & GRNDS OPERATION COST	\$ 6,700	\$ 2,250	\$ 4,500	\$ 2,250	\$ 4,400	\$ 2,250	\$ 9,900	\$ 2,250
071	Utilities	\$ 1,800	\$ 620	\$ 1,350	\$ 620	\$ 1,350	\$ 620	\$ 3,000	\$ 620
072	Maintenance	\$ 900	\$ 295	\$ 650	\$ 295	\$ 650	\$ 295	\$ 1,460	\$ 295
073	Housekeeping	\$ 3,500	\$ 1,175	\$ 2,400	\$ 1,175	\$ 2,400	\$ 1,175	\$ 5,440	\$ 1,175
074	Other	-	-	-	-	-	-	-	-
080	MISCELLANEOUS	-	-	-	-	-	-	-	-
090	OPERATING COSTS TOTAL	\$ 88,300	\$ 29,400	\$ 86,100	\$ 40,800	\$148,400	\$ 70,050	\$153,000	\$ 31,800
	OPERATING COST PER WORK UNIT		\$1.46		\$1.43		\$1.32		\$1.35

\* It accounts for all costs of Building due to 2.4 P.U.

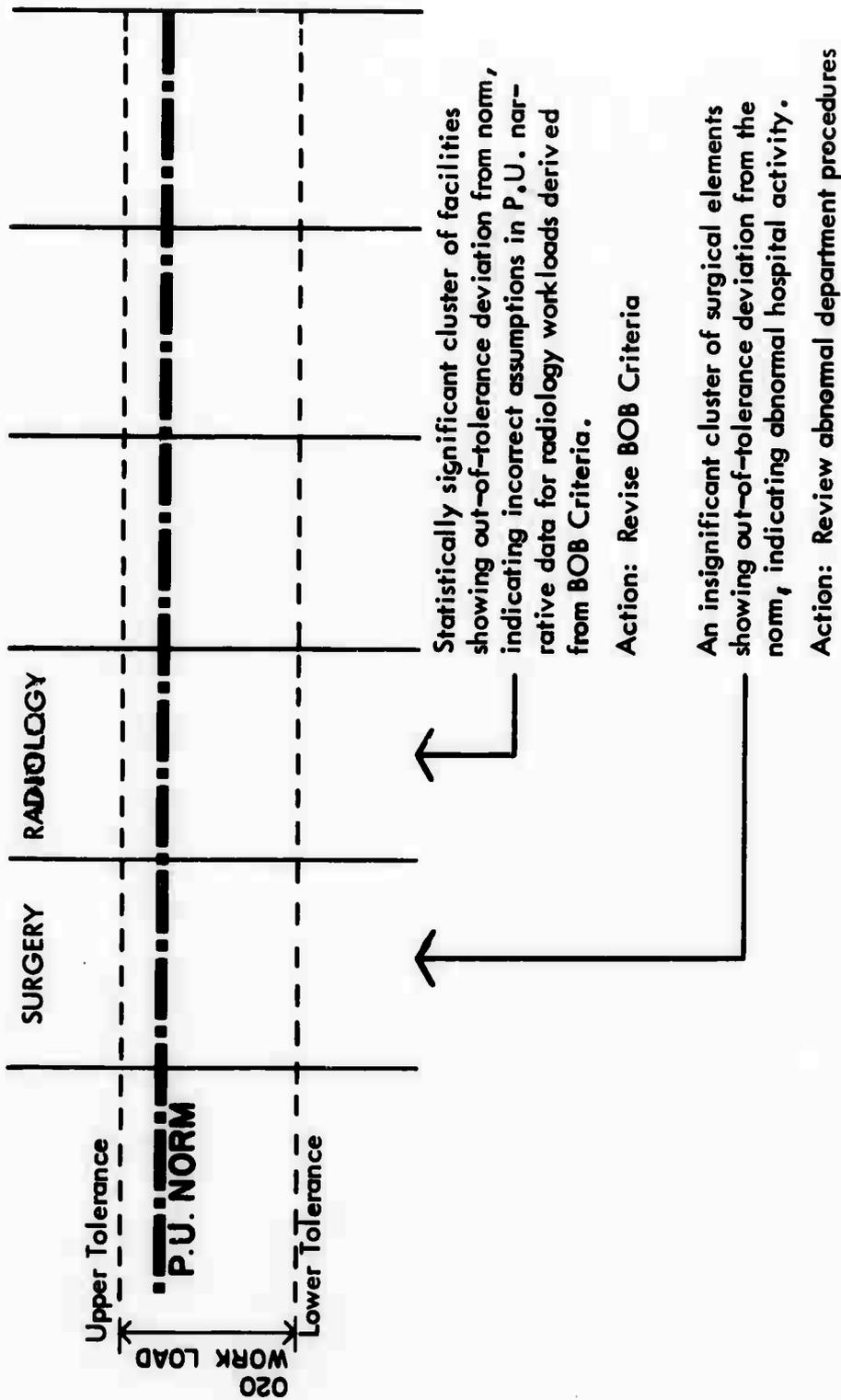


FIGURE 3.3.3 P.U. SUMMARY ANALYSIS

- the quality of the scheduling system,
- the actual performance of the surgical staff,
- the size of the unit.

It is recognized that only a few departments are designed to satisfy primary, direct health care needs; the size and scope of other departments depend, to a certain degree, on the size of the primary departments, such as inpatient and outpatient. Consequently, it is necessary to follow a definite pattern in determining the total scope and size of the institution. (See Section 3.3.3.)

#### 3.3.2.2. Input

As well as measuring output, the resources and their implications must be understood to satisfy any given set of needs. This understanding will generate better decisions, better planning and design. Less time will be spent due to more concise quality information. The planner will be able to predict future costs, personnel requirements, training programs, etc. The systems programmer will also be able to better evaluate the function of support facilities and the interrelation between departments.

#### 3.3.2.3. Space Descriptors

Space and size and configuration (of process flow) are the key elements used to bring together all the preceding information. Output and resources are expressed as functions of quantity of space.

The particular configuration of each hospital element affects its performance only moderately. (This is demonstrated in Tables 3.3.2 and 3.3.3 which develop Planning Unit data for two different Radiology Departments--Jacksonville Naval Base and March Air Force Base--with insignificant variation in the resultant figures.)

Although configuration does not materially affect Planning Unit data, the size of the hospital element definitely does. This non-linear effect

of increasing size on performance output, resource inputs, and other factors is recognized in the BOB criteria. Whether the present BOB categories of department size are satisfactory or even realistic is one of the comparative analysis tests proposed for the Planning Unit. Initially, separate Planning Units should be developed for each departmental size category as suggested in the criteria. Later, additional or different size categories may prove more meaningful.

It is recommended that all elements of the existing military hospital be analyzed to yield Planning Unit performance data on size (expressed in number of Planning Units), and its correlation to output (expressed in standard procedures), operational and capital costs, and staffing. (See Section 3.3.5, Departmental Performance Records.) The data on actual departmental performance thus developed could be summarized (Figure 3.3.4) for direct comparison with the Planning Unit data hypothesized from BOB criteria and other sources. Derivation of the summary sheet shown in Figure 3.3.4 is shown schematically in Figure 3.3.5.

#### 3.3.2.4. Implementation

The planners today lack a modular communication link with the engineers, and this is considered to be the major contribution of the Planning Unit. The next step is to establish the task force and assign its responsibility for defining and systemizing the procedures for producing Planning Units. The following task would be to produce Planning Units.

The task force composition should include two architects, two industrial engineers with operations research capability and an understanding of hospitals, a systems analysis and a business or hospital administrator. Consultant services for medical, dental, cost estimating, statistics, and special problems will be required.

It is estimated that Planning Units can be developed for most functional elements in military hospitals in a year's time. This could be accomplished through a task force of selected SGO planners and assigned to the DOD Hospital Planning Review Board. The budget for this task force should include funds for systems analysis and data processing. The outcome of

NUMBER OF PLANNING UNITS	2	3	4	5	6	7	8	9	10	n
<b>WORKLOADS # OF STANDARD PROCEDURES</b>										
a to a <sub>1</sub>	<input type="checkbox"/>									
a <sub>1</sub> to a <sub>2</sub>		<input type="checkbox"/>								
a <sub>2</sub> to a <sub>3</sub>			<input type="checkbox"/>							
a <sub>3</sub> to a <sub>4</sub>				<input type="checkbox"/>						
a <sub>n-1</sub> to a <sub>n</sub>										<input type="checkbox"/>
<b>OPERATIONAL COSTS/P.U.</b>	b <sub>2</sub>	b <sub>3</sub>	b <sub>4</sub>	b <sub>5</sub>						b <sub>n</sub>
<b>CAPITAL COSTS/P.U.</b>	c <sub>2</sub>	c <sub>3</sub>	c <sub>4</sub>	c <sub>5</sub>						c <sub>n</sub>
<b>STAFFING:</b>										
PHYSICIANS PER P.U.	d <sub>2</sub>	d <sub>3</sub>								d <sub>n</sub>
RN	e <sub>2</sub>	e <sub>3</sub>								e <sub>n</sub>
OTHER NURSING										
OTHER PROFESSIONAL										
NON PROFESSIONAL										
<b>TOTAL COSTS</b>										
Operational	2b <sub>2</sub>									nb <sub>n</sub>
Capital	2c <sub>2</sub>									nc <sub>n</sub>

FIGURE 3.3.4 DEPARTMENTAL SUMMARY SHEET

3.3.20

DEPARTMENTS  
OF COMPARABLE  
SIZE  $\pm 4$  P.U.'S

$\pm 6$  P.U.

$\pm 8$  P.U.

$\pm 10$  P.U.

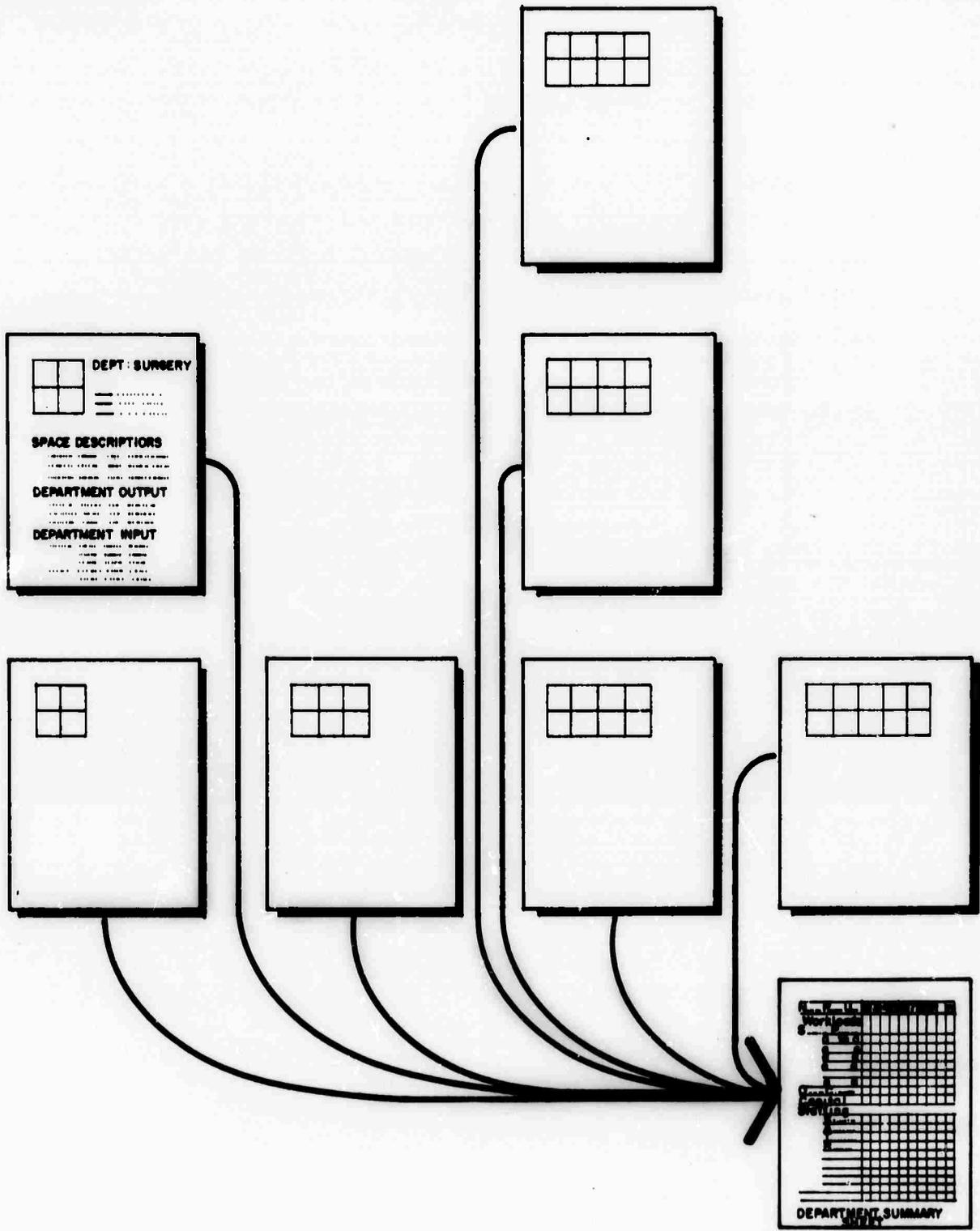


FIGURE 3.3.5 GENERATION OF DEPARTMENTAL SUMMARY SHEET

the task force would be the establishment of a Planning Unit data bank (manual or automated). If automated, storage media (tape, cards, etc.) could be duplicated for SGO and geographical distribution for use by local base planners.

In summary, the Planning Unit can be considered as a yardstick used to measure performance. First, it reduces existing criteria to a modular unit, next it incorporates new information from all pertinent sources, and finally it updates the criteria with comparative analysis of feedback data from operating hospitals. It is essentially a compound unit of measurement, correlating relevant physical and operational aspects of each of the hospital elements.

### 3.3.3. THE PROJECT SUMMARY CHART

The Project Summary Chart is the key document generated in the first phase of the Acquisition Cycle for the preliminary health care facility proposal. It brings together all of the medical mission needs (for a proposed new project), as identified by the Base Planning Review Board, expressed in Planning Units; summarizes the Planning Unit data to give total staffing figures, support requirements, and operating costs; adds projected structural, mechanical, and site development costs to the sum of the departmental construction costs; and applies adjustment factors for time and zone to give a concise, but detailed, capital cost estimate.

Together with the Form Diagrams generated concurrently (Section 3.3.4) the Project Summary Chart becomes the major summary of the final Health Care Facilities Proposal and provides an overview of the proposed facility detailed in its functional elements, staffing and supplies requirements, costs, and performance capabilities, but still flexible in terms of its architecture (no A/E Contractor inputs have been developed at this stage of the Acquisition Cycle). Thus, the early resolution and physical organization of detailed elements results in an adaptable, but clearly discernible overall profile. When this capability of the Project Summary Chart and Form Diagrams is used in conjunction with a standard specification of modular building components (Section 3.4), it enables a realistic construction cost program and budget estimate to be developed in the Acquisition Cycle's first phase, considerably advancing the point where Congressional approval may be requested and, consequently, shortening the acquisition time.

There are two major steps in the compilation of a Project Summary Chart; the first is concerned with developing a functional profile with generic cost data, while the second is specifically concerned with generating budget estimates peculiar to the particular project under consideration.

- The assembling of the appropriate Planning Units by type and number to satisfy the identified medical mission requirements. It is assumed that initial statements of need will be given in terms of Primary Patient Service, i.e., patients, patient/day

care, outpatient visits, projected emergency loads, etc. These needs will determine requirements for a first nucleus of facilities (Clinics, Inpatient Units); these, in turn, will determine the work loads of all Medical Support facilities, i.e., diagnostic and treatment facilities. The projected Primary Patient Services and Medical Support Departments together determine the requirements for Ancillary Support facilities, and finally, all three will generate requirements for General Services, i.e., Administration, Dietary, Maintenance, etc. (This assembly order is shown schematically in Figure 3.3,6) . . . The sequential assembly of Planning Units for each of the above, choosing the appropriate size according to work load capability (Figure 3.3.4) and multiplying by the number of Planning Units required for each department, terminates the first step.

The information assembled in the above first step must now be processed to determine the desired physical relationships of the various hospital elements within a feasible building form. It is strongly urged that computer assistance be employed for this work (see Section 3.3.4) to achieve rapid and efficient conversion of the Planning Unit module to a physical building format without the lengthy intervention of architectural studies. Computer printout Form Diagrams can then be evaluated by the DOD Project Officer to provide the project-peculiar information needed to complete step two of the Project Summary Chart.

- The purpose here is to adjust the generic departmental cost data amassed in Step One to suit the particular requirements of the project. The sum of the Planning Unit construction cost columns 031 and 032 (Table 3.3.1) is multiplied by factors recognizing the following series of building and site constraints:

1. Inter-departmental circulation. (Note: inasmuch as intra-departmental circulation area is included in the Planning

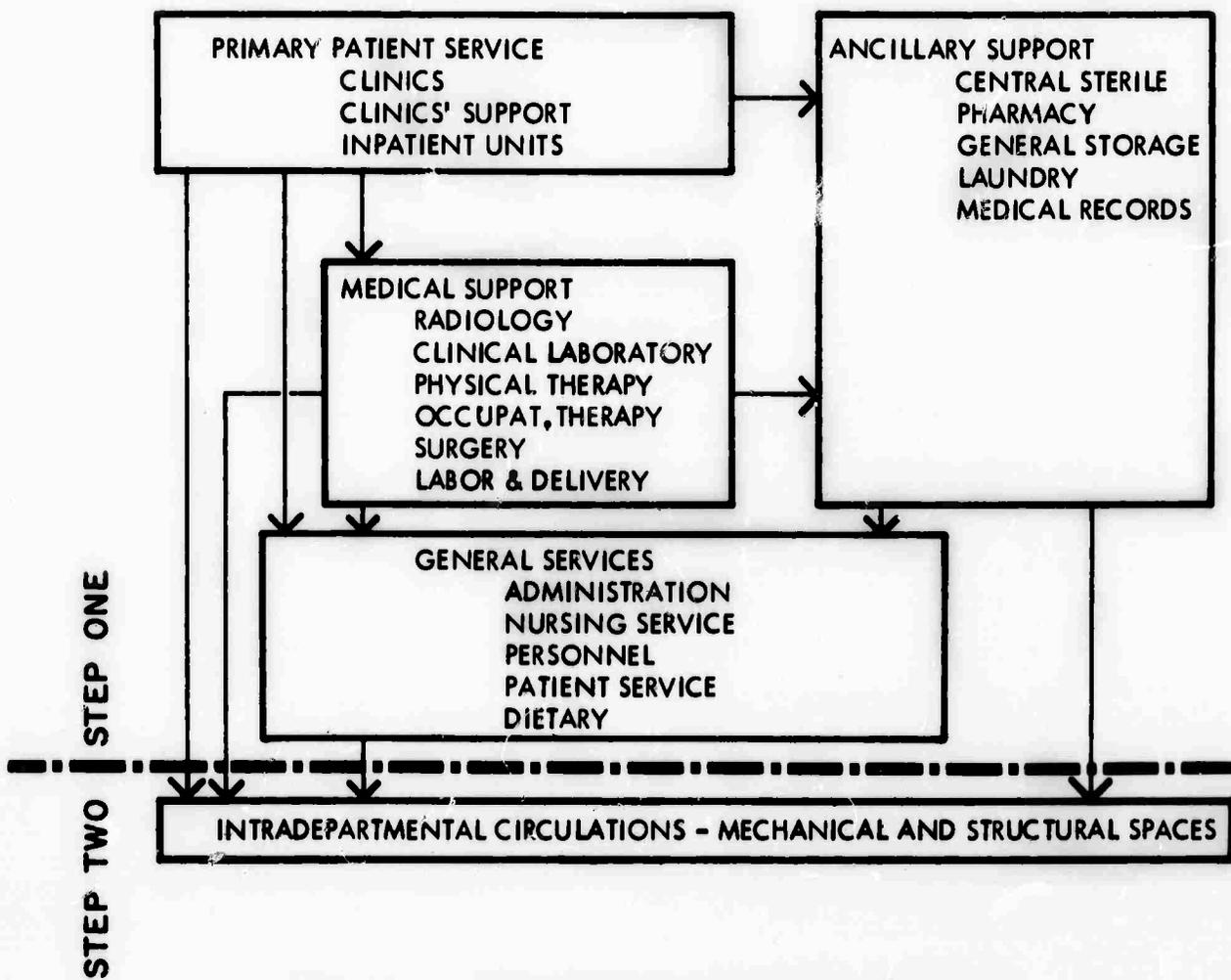


FIGURE 3.3.6 PROJECT SUMMARY CHART ASSEMBLY SEQUENCE

Unit data, this will only be for major corridors and vertical movement between floors, resulting in a much smaller factor than the 1.6 presently used in the BOB Criteria.)

2. Building form. This cost factor will be determined by evaluation of the Form Diagrams, number of floors, and application of cost principles derived from the use of standard modular building components for the hospital's main structural and mechanical system.
3. Site constraints. This factor may be applied if evaluation of the site survey suggests that abnormal conditions exist which might affect delivery of materials, construction methods, etc.
4. Location zone. A standard construction costs adjustment factor for the location of the project if different from the Planning Unit datum cost base.
5. Time factor. This is a projected increase in construction costs from the datum base time to the anticipated date for receiving bids.

Initially, the Project Summary Chart (a typical Project Summary Chart is shown in Table 3.3.4) is expected to be generated by the SGO Project Officer for evaluation by the Base Planning Review Board. Should he decide, on the basis of the assembled data, to modify the original definition of departmental need, or amend the scope of the facility, the effect of such changes on the complex network of interrelationships between hospital elements can quickly be determined. (The Project Summary

MARCH AFB 1970

ELEMENT	WORK LOAD	NR PU	COST ENVR	PERSONNEL					OPERATING COST					
				MD	RN	ON	PR	NP	LABOR	SUPPLY	MAINT	OTHER		
Clinic Medical	138	1.2	24,200	6										
Surgical	40	.6	12,100	2										
Orthopedic	14	.8	16,100	2										
Dematology	5	.3	5,800	1										
Psychiatric	8	.3	5,800	1										
Pediatric	80	1.2	24,200	2										
Obstetric	50	1.0	19,300	3										
Urology		.7	14,000											
EENT	31	1.3	26,000	2										
Flight		1.6	32,100	12										
Dentistry		.4	8,100	15										
Emergency		.9	18,000											
Nursing Light	40	10.0	168,200											
Interim	68	17.4	292,000											
Intensive	20	5.8	96,300											
Obstetric	16	4.6	76,100											
Pediatric	16	4.0	61,200											
Nurseries	104	1.2	22,500											
Laboratory	10000	1.7	32,000	3										
Radiology	18000	1.8	42,500	2										
Surgery	8	3.6	101,200	1										
Delivery	3.3	1.7	32,700											
Physical Therapy	97	1.3	22,200											
Pharmacy	477	.9	17,600											
Central Sterile		1.6	35,200											
Supplies & Storage		6.7	83,000											
Administration		8.4	138,200											
Patient Activities	160	1.6	26,600											
Maintenance		.9	12,400											
Food Services	340160	4.9	122,000											
Employees	230	1.8	27,300											
Plant		4.8	66,200											
Circulation	95	14.0	23,800											
TOTAL INTERIOR ENVIRONMENT		109.0	1,704,900											
STRUCTURE & SHELL			3,921,270											
TOTAL			5,626,170											

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Table 3.3.4 PROJECT SUMMARY CHART

Chart's capacity for demonstrating change within the hospital system is discussed later in this section.)

Within the SGO, the clear delineation of performance, staffing, and cost requirements of the proposed facility assists in the comparison and evaluation with the requirements of competing requests in the same fiscal year. Again, the effect of modifications to the original request can readily be determined.

Once the decision to proceed with the proposed project has been made, the Project Summary Chart has two principal functions:

- It becomes the basic data document in the Health Care Facility Proposal for consideration by OSD, BOB, and the Congress, (Section 3.5.2).
- It provides the basic functional (program) information in the A/E Contract Documents Package, and through its cost program information, gives the architect a working breakdown of the budget limitations within which he is required to design.

It will be apparent from the above that the Project Summary Chart is the pivotal document in the Acquisition Cycle, matching generic hospital element information Planning Units from the data bank with project-peculiar information regarding site requirements and building form to achieve a specific (but adaptable) quantitative profile of the proposed facility.

Use of the Project Summary Chart is not limited to the Planning Process portion of the Acquisition Cycle. It has already been noted that the Project Summary Chart possesses characteristics for evaluating the effect of change in one specific area of the hospital system upon the rest of the elements and components of the system. This is due, primarily, to the modularity of the Planning Units which comprise the main format of the Project Summary Chart. To understand this better, it is necessary to consider how the Project Summary Chart differs from the existing method of summarizing project requirements.

Expressed simplistically, the component information needed to define a proposed facility is presently assembled "vertically." That is, net departmental floor areas are aggregated and multiplied by circulation and other factors (amounting to some 40% of the whole) to arrive at the gross total facility floor area; staff, equipment, capital and operating costs are similarly summarized in terms of the gross total facility requirement. But present methodology does not permit a "horizontal" evaluation between departments; that is, the amount of, say, capital cost, or laundry, for the proposed size of surgery cannot be directly compared with the proportion of the cost, or laundry requirement, for, say, radiology. Thus, the effects of a change in one on the others cannot be examined with any precision. The Planning Unit, on the other hand, is a common unit of measure for departmental components (space, capital cost, personnel, supplies, support requirement, operating costs), and therefore its use on the Project Summary Chart permits "horizontal" comparison--and interrelationship--as well as "vertical" summation.

The relationship that exists between each departmental component is not particularly complicated, since no high degree of accuracy is called for in measuring these relationships. It should be noted however, that the number of interrelationships between these components is high. For example, to establish the change in relationship between the surgery and the laundry support logistics due to an increase in surgical work loads calls for following a complex procedure to achieve accurate results. Although such changes are complex, they are not difficult, consisting mainly of establishing linear relationships between several characteristics of each department. An increasing number of patients in surgery would affect such other departments as personnel and administration, as well as housekeeping.

Similarly, the distribution of work loads in any given facility is not constant throughout the year because hospital occupancy varies seasonally. Peaks and valleys exist even within a 24-hour time frame, when the variation in work load demand is quite high. Such variation in work load has direct bearing on space utilization, cost, staffing, and so on, and should be well understood by the hospital planners and the hospital management.

Again, the modular breakdown of departmental performance and its relationship to support and other components on the Project Summary Chart is helpful in analyzing such variations. Although the implications of increased demand on hospital resources are reasonably well understood at the present time, they are never computed in depth. The amount of time needed to carry out such computation is formidable indeed without first reducing the components to a common module, and even when Planning Units elicit such a module on the Project Summary Chart the data could best be manipulated if it were computerized.

We do not recommend computer generation of Project Summary Charts as an initial implementation step. The above discussion points out, however, the potential advantage of computer assistance in manipulating Planning Unit data to examine the effects of work load fluctuations on a monthly, weekly, or hourly basis, rather than the present annual forecasting method. The Planning Unit and Project Summary Chart may be viewed as steps towards the eventual computerization of the data bank, furnishing much more flexible component data than the present gross summations of annual facility requirements.

In summary, the Project Summary Chart helps to achieve the following system objectives:

- To reduce the time gap between the identification of need and the beneficial occupancy of the completed facility.  
(This is of fundamental importance because the assumptions upon which a hospital is based change extremely quickly. At present, by the time a Fixed Health Care Facility begins operation, its functional design is between four and six years old.)
  
- To generate rapidly and expediently a clear functional and cost profile of the proposed facility, capable of accepting both detailed change and major alterations in scope of the facility function and medical mission capability.

- To provide a definitive means of assessing new requirements and scheduling changes in existing facilities without creating imbalance in departmental relationships.
- To upgrade the quality and quantity of information contained in the Health Care Facility Proposal, and the A/E Contract Documents, with an emphasis on operational capability rather than building hardware.

The Project Summary Chart develops input information leading to the generation of Form Diagrams which, in turn, feed back information for the refinement and completion of the Project Summary Chart data.

#### 3.3.4. COMPUTER-AIDED FUNCTIONAL ANALYSIS

The preceding section touched on the desirability of using computers sometime in the future for generating all of the information in Project Summary Charts, and manipulating their data for more efficient scheduling of activities and operational space utilization in the Fixed Health Care Facility; such computer assistance is not, however, one of our immediate recommendations.

Computer assistance is advocated as an inherent part of the Planning Process, in translating the modular quantified needs of the facility (as expressed on the Project Summary Chart) into a Form Diagram showing the same needs in terms of their spatial requirements and relationships in a proto-building form.

Form Diagrams are needed:

- To help generate more accurate project-peculiar cost data in the second step of the Project Summary Chart, enabling a detailed proposal to be developed without the need for A/E Contractor inputs.
- To help develop a visual, as well as a functional and quantitative, profile of the proposed facility, sufficient to satisfy the requirements of approving agencies without "locking into" an architectural solution so early in the Acquisition Cycle.
- To assist in subsystem development.
- As a more definitive means of communicating the functional needs of the facility to the A/E Contractor.

The latter point is probably the most crucial, and is worth examining more closely. There is a gap between the work of hospital planners and architectural designers. This gap (between SGOs and engineers) is inadequately bridged at present by written programs—usually rather lengthy volumes of

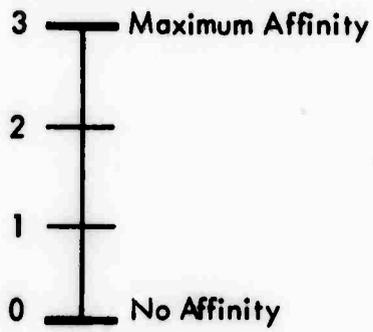
words, figures, facts and diagrams—which attempt to communicate the needs, constraints and criteria of the project.

One of the problems is that the sheer volume and complexity of the planning data defies rational synthesis into anything approaching optimum solution by a human being. Such factors as the interrelationship of hospital elements, site constraints, legal codes, safety requirements, and construction limitations must all be wrestled with simultaneously. Since this is obviously impossible, design solutions far from the optimum resolution of need are considered acceptable. Until the advent of the computer, there was little or no other choice, but today much more efficient (though still sub-optimal) solutions are attainable.

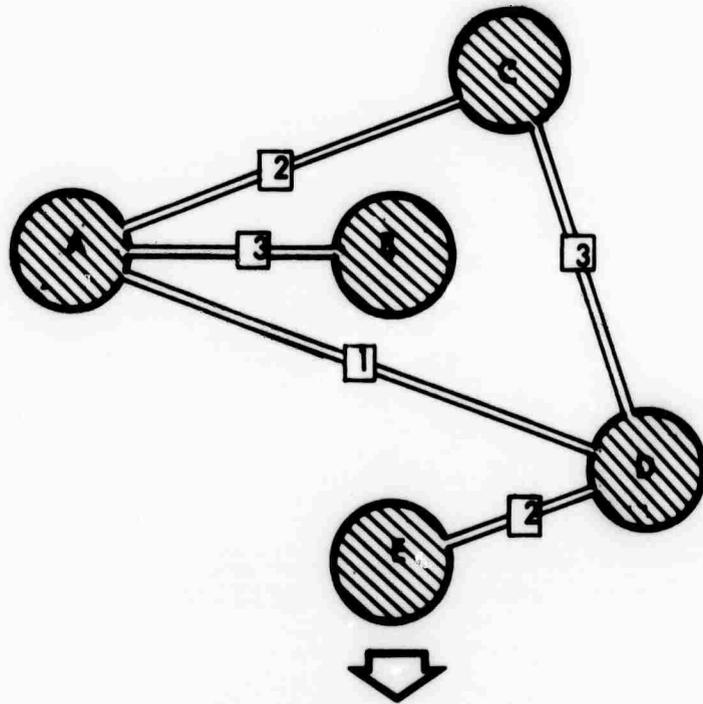
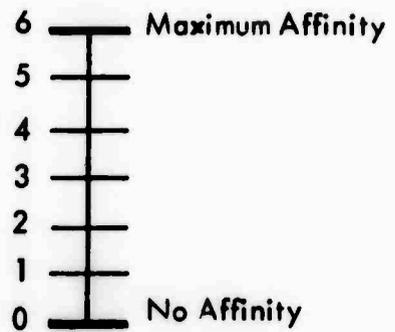
The initial problem is to give some sort of order to the functional interrelationships between hospital elements. One method of doing this is the "affinity matrix." (A matrix expresses the same information as the better-known "bubble diagram" but is more versatile and efficient.) A diagrammatic example of an affinity matrix is shown in Figure 3.3.7. The matrix is used to determine, for each pair of elements represented in the columns and rows, the importance of immediate adjacency for these two elements relative to all other relationships. A scale of 0 (no importance) to a maximum number (absolutely essential) is employed. The optimum solution is to place each element adjacent to every other element. Since this is impossible, the matrix defines the sequence of adjacencies so that the designated priorities are observed.

One of the problems still unresolved in using affinity matrices is the inability to combine all the criteria into a single affinity value. Many relations can be expressed for each pair of elements, resulting in many different matrices, each describing the relationship in terms of one factor (e.g., the flow of materials, information, or personnel between departments, structural similarities, commonality of utilities requirements, etc.). Such independent analysis of relationships can yield very accurate and meaningful matrices, but leaves the problem of combining these into a single value unsolved. (It is, of course, the objective to obtain a single figure representative of physical proximity.) A direct quantitative combining of the affinity values is not recommended

**AFFINITY SCALE**



Any continuous scale can be used:



**RELATIONSHIP DIAGRAM**

Elements  
The numbers between the elements represent the required degree of affinity between elements

A	-				
B	3	-			
C	2	0	-		
D	1	0	3	-	
E	0	0	0	2	-
	A	B	C	D	E

**AFFINITY MATRIX**

**FIGURE 3.3.7 THE AFFINITY MATRIX**

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since there is no single measurable unit between them other than cost; therefore, human judgment is required for the rationalization of a single value representing the most desirable physical relationship of each element pair with all others in the final layout. In the present instance, this judgment should be made by SGO personnel experienced in hospital planning and operation. The elements on the affinity matrix are derived from the Project Summary Chart.

The affinity matrix and hospital element descriptions now become basic inputs to the computer. The size of an element is defined in terms of Planning Unit modules which are identical in volume and are assumed here to be square unless otherwise noted. Other features are added to this core input to make the program more realistic and usable, including site information, legal codes, structural and functional requirements, and dimensional data.

For each set of input data, a number of Form Diagram solutions will be generated. A typical Form Diagram is shown in Figure 3.3.8 (other examples of Form Diagrams, generated as a hypothetical solution to the requirements of the March AFB hospital facility, are shown in Section 6.6). Elements are identified by code letter, each printed letter representing one Planning Unit module of floor area occupied by that particular department.

It should be emphasized that this type of computer program is only a manipulative tool to assist the planner and can never replace him. The program has been designed to be highly flexible allowing the planner many options and many ways to manipulate in order to attain desired results, with immediate systematic evaluation of a proposed design's effect on functional efficiency and costs.

The Form Diagram is a major step in bridging the gap between planning and design. It overlaps these two functions to confront the building layout problem with the broadest possible front of experience and understanding between planners and designers. Traditionally, the work of the planner is complete when the written program is delivered to the designer. The designer alone makes the compromises and judgments imposed by the constraints of physical configuration. Inasmuch as many

**FLOOR PLAN FOR LEVEL 3 - SOLUTION NUMBER 2**

	1	2	3	4	5	6	7	8	9	10
1							ACC	ACC	ACC	ACC
2		CL1	CL1	CL2	CL2	CL2	ACC	GRP	GRP	ACC
3		CL1	CL1	OP2	CL2	OP2	ACC	HAD	FFA	ACC
4		AV1	RAD	RAD	OP2	OP2	ACC	FFA	HAD	PAR
5		FOD	FOD	SUR	SUR	SUR	ACC	HAD	HAD	PAR
6		FOD	CLA	CLA	OP1	OP1	ACC	HAD	MEC	PAR
7		FLA	FLA	LIB	OP1	OP1	ACC	MEC	MEC	PAR
8			SFA	SFA				MEC		ACC
9										ACC
10								ACC	ACC	ACC

**FIGURE 3.3.8 TYPICAL FORM DIAGRAM**

of these compromises involve functional efficiency and modification of criteria, their resolution should be multi-disciplinary rather than "loaded" in the direction of building expediency. This balance is, to a large extent, achieved with Form Diagrams. An example of how a hospital is designed from Form Diagrams<sup>2</sup> is shown in Section 6.6. In the present instance, it is proposed that Form Diagrams be generated and evaluated by the (construction-oriented) Project Officer from matrix inputs developed by the (function-oriented) SGO planners.

A survey of six computer programs addressing plant layout problems is given in Section 6.5. These programs are used for assisting planners and designers in hospital layout problems, are an important step in the direction of the ideal system described above. The computer programs have been designed and used as part of the planning process for civilian hospitals, but are easily adaptable to the special requirements of the military.

### 3.3.5. DEPARTMENTAL PERFORMANCE RECORDS

The proposed Planning Process is part of a continuing cycle in which operational needs are translated through design to physical work environments, tested for functional efficacy, and the results of experience in an actual work situation fed back into the basic planning criteria to upgrade the quality of the data bank's original source material. The vehicles for transmitting feedback information from operational hospitals are the Post Occupancy Reports and Annual Health of the Command Reports. The data from these documents must then be collected and recorded in a format compatible with the stored criteria. It is proposed that Departmental Performance Records will provide a format for recording and storing information from operating hospitals in direct parallel with the "ideal" departmental layouts and Planning Units used as inputs for a proposed new facility. In effect, the Departmental Performance Record provides a direct comparison between the theoretical ideal and the pragmatic end result of planning criteria.

The expected variance between Planning Unit anticipated performance data and measured end results has been discussed in Section 3.3.2. It has also been pointed out that work output and support requirements are, to some extent, subject to unquantifiable variables such as the inherent abilities of individual staff members; to this extent, the recording and analysis of individual hospital departmental performance must be particular to the place and time, rather than "generic" as is the case with the ideal layouts and Planning Unit data.

Nevertheless, there are sufficient military Fixed Health Care Facilities capable of returning high quality data to the SGO for statistical methods to be applied for purposes of comparative analysis. Once again, the Planning Unit provides the common yardstick with which to measure performance, not only against the ideal, but in comparison with other similar departmental components.

It is proposed that Departmental Performance Records should contain identification of the base, facility and department in addition to the following information:

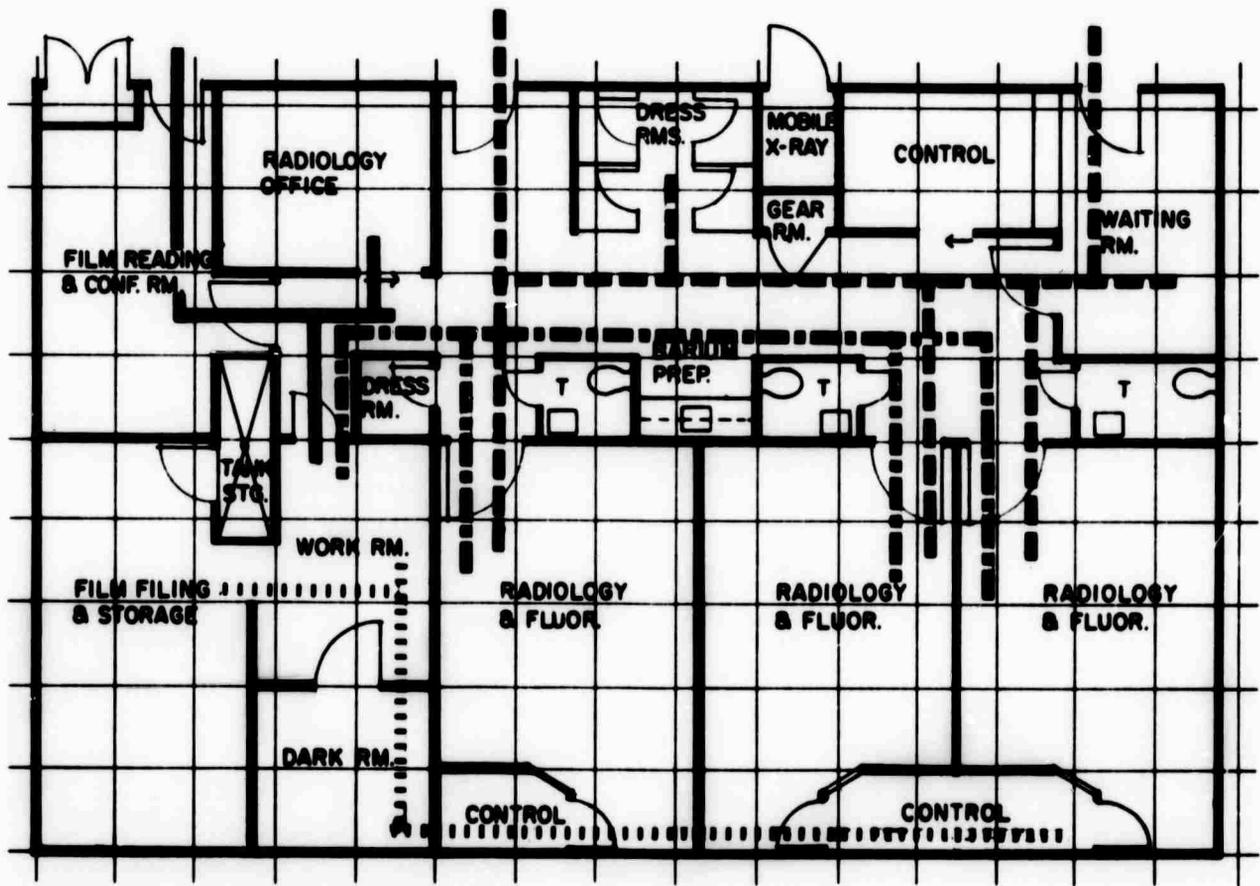
- A plan of the departmental layout showing principal dimensions, equipment locations, utilities requirements, access, egress and traffic flow patterns, special storage requirements, materials handling patterns, and identification of adjacent departments.
- Totals for the gross occupied floor area, interior environment construction cost, equipment cost, pro-rated share of building structure and mechanical cost, and total departmental capital cost.
- The actual cost figures for the preceding items, proportionally increased or decreased for applicability to the 1,200 square foot Planning Unit module. (Also shown will be the figures as originally estimated, and as modified by subsequent additions or changes.)
- Departmental work output in annual total number of procedures (and types of procedure), and the same reduced to Planning Unit module data.
- Total Full Time Equivalent numbers and categories of personnel working in the department, annual labor costs by category and departmental total, and all of these figures reduced to Planning Unit data.
- Total types and costs of the supplies used by the department, and the same reduced to Planning Unit data.
- Total types and costs of utilities and maintenance requirements by the department, and the same reduced to Planning Unit data.
- Total department operational costs, and the same reduced to Planning Unit data.

In short, the Departmental Performance Record should be a concise summation of the departmental configuration; estimated, actual, and

modified construction and equipment costs; work output; personnel and support requirements; and annual operating costs. All of the data should be expressed both in departmental totals and as applicable to the 1,200 square foot Planning Unit module to permit easy comparison with the ideal, and other actual departments of similar size. A typical Departmental Performance Record was shown in Table 3.3.3 in combination with Figure 3.3.9. This particular record serves as data input for the development of the radiology planning unit.

Departmental Performance Records would be stored in the SGO data bank, updated annually, and copies issued as appropriate for design guidance in the A/E Contract Documents Package.

Additional studies for other functional elements are shown in Tables 3.3.5, 3.3.6, and 3.3.7.



- PATIENTS' CIRCULATION FLOW
- RADIOLOGISTS' " "
- TECHNOLOGISTS' " "
- .....** FILM " "

NET	AREA	1835 S.F.
PARTITIONS & CIRCULAT.	AREA	695 S.F.
GROSS	AREA	2530 S.F. 2.11 P.U.

GRAPHIC SCALE 0 2 4 6 8 10 FEET

**FIGURE 3.3.9 DEPARTMENT PERFORMANCE RECORD – RADIOLOGY (LAYOUT) MARCH AFB**

JACKSONVILLE		CLINICAL LABORATORY AS BUILT 1963-1968 OPERATING DATA AS OBSERVED IN 1969	
010	CLINICAL LABORATORY		
020	DEPARTMENT GROSS AREA NUMBER OF PLANNING UNITS	5,728 sq. ft. 4.78 P.U.	
020	WORK UNITS RANGE (Exposure/Yr.)	TOTAL 582,000	PER P.U.
030	INTERIOR ENVIRONMENT COST	\$163,000 + EC	\$ 33,800 + EC
031	Interior Construction Costs	\$163,000	\$ 33,800
032	Equipment Costs	EC	EC/4.78
033	Exterior, Structural, Mechanical &		
034	Additional Circulation Costs	\$214,000	\$ 44,700
	TOTAL ACQUISITION COSTS	\$377,800	\$ 78,500 + <sup>EC</sup> <sub>4.78</sub>
040	PERSONNEL	25	
041	Physicians	3	
042	RN	-	
043	Other Nursing	-	
044	Other Professionals	22	
045	Non Professionals	-	
050	LABOR COSTS	\$196,889	
051	Physicians	\$ 45,000	
052	RN	-	
053	Other Nursing	-	
054	Other Professionals	\$151,889	
055	Non Professionals	-	
060	SUPPLIES COSTS	\$ 65,340	
061	Linen	-	
062	Provisions (Food)	-	
063	Drugs	-	
064	Medical Supplies	\$ 65,340	
065	General Supplies	-	
070	BLDGS & GRNDS OPERATION COST	\$ 19,146	
071	Utilities	\$ 8,951	
072	Maintenance	\$ 4,633	
073	Housekeeping	\$ 3,302	
074	Other	\$ 2,860	
080	MISCELLANEOUS	\$ 4,725	
090	OPERATING COSTS TOTAL	\$286,700	
	OPERATING COST PER WORK UNIT		\$ .63

Table 3.3.5 DEPARTMENTAL PERFORMANCE RECORD

MARCH AIR FORCE BASE		CLINICAL LABORATORY AS BUILT 1960-1965 OPERATING DATA AS OBSERVED IN 1969	
010	CLINICAL LABORATORY		
DEPARTMENT GROSS AREA NUMBER OF PLANNING UNITS		2,055 sq. ft. 1.72 P.U.	
		TOTAL	PER P.U.
020	WORK UNITS RANGE (Exposure/Yr.)	180,000	
030	INTERIOR ENVIRONMENT COST	\$ 57,700 + EC	\$ 33,800 + EC
031	Interior Construction Costs	\$ 57,700	\$ 33,800
032	Equipment Costs	EC	EC/1.72
033	Exterior, Structural, Mechanical &		
034	Additional Circulation Costs	\$ 77,000	\$ 44,700
TOTAL ACQUISITION COSTS		\$134,700	\$ 78,500 + $\frac{EC}{1.72}$
040	PERSONNEL	20	1.16
041	Physicians	3	-
042	RN	-	-
043	Other Nursing	-	-
044	Other Professionals	17	-
045	Non Professionals	-	-
050	LABOR COSTS	\$252,175	\$148,000
051	Physicians	\$ 45,000	\$ 26,200
052	RN	-	-
053	Other Nursing	-	-
054	Other Professionals	\$207,175	\$ 12,500
055	Non Professionals	-	-
060	SUPPLIES COSTS	\$ 66,091	\$ 38,400
061	Linen	-	-
062	Provisions (Food)	-	-
063	Drugs	-	-
064	Medical Supplies	\$ 66,091	\$ 38,400
065	General Supplies	-	-
070	BLDGS & GRNDS OPERATION COST	\$ 5,777	\$ 3,380
071	Utilities	\$ 1,748	-
072	Maintenance	\$ 831	-
073	Housekeeping	\$ 3,198	-
074	Other	-	-
080	MISCELLANEOUS	-	-
090	OPERATING COSTS TOTAL	\$324,043	
OPERATING COST PER WORK UNIT		\$1.57	

Table 3.3.6 DEPARTMENTAL PERFORMANCE RECORD

MARCH AIR FORCE BASE		SURGERY AS BUILT 1960-1965 OPERATING DATA AS OBSERVED IN 1969	
010	SURGERY		
DEPARTMENT GROSS AREA NUMBER OF PLANNING UNITS		7,628 sq. ft. 6.35 P.U.	
020	WORK UNITS RANGE (Exposures/Yr.)	TOTAL 3,290 WU	PER P.U. 530 WU
030	INTERIOR ENVIRONMENT COST	\$182,000 + EC	\$ 28,600 + EC/6.35
031	Interior Construction Costs	\$182,000	\$ 28,600
032	Equipment Costs	EC	EC/6.35
033	Exterior, Structural, Mechanical &		
034	Additional Circulation Costs	\$ 298,000	\$ 44,700
	TOTAL ACQUISITION COSTS	\$480,000 + EC	\$ 73,300 + EC/6.35
040	PERSONNEL		
041	Physicians		
042	RN		
043	Other Nursing		
044	Other Professionals		
045	Non Professionals		
050	LABOR COSTS		
051	Physicians		
052	RN		
053	Other Nursing		
054	Other Professionals		
055	Non Professionals		
060	SUPPLIER COSTS		
061	Linen		
062	Provisions (Food)		
063	Drugs		
064	Medical Supplies		
065	General Supplies		
070	BLDGS & GRNDS OPERATION COST		
071	Utilities		
072	Maintenance		
073	Housekeeping		
074	Other		
080	MISCELLANEOUS		
090	OPERATING COSTS TOTAL		
	OPERATING COST PER WORK UNIT		

Table 3.3.7 DEPARTMENTAL PERFORMANCE RECORD

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### 3.4. DESIGN AND CONSTRUCTION

#### 3.4.1. INTRODUCTION

The previous Section has proposed a new methodology for the Planning Process, with the compilation by the SGO of definitive instructions for the Architect/Engineers as its culminating milestone. The Procurement Process begins with the Design Phase and the selection of an A/E contractor. He is given a briefing on the purpose and intent of the health care facilities project using information contained in the A/E Contract Documents Package.

The principal goal of both the Design and Construction Phases is to translate the developed planning criteria into a work environment fully responsive to the identified functional (operational) needs of the facility, and to build into the physical facility a capability for adaptation to the requirements of future unknowns. A discussion of functional obsolescence in existing facilities is contained in Sections 3.2 and 3.4.4; the same discussion covers the proposed alternative to the present hospital building techniques, the use of a modular standard building system with large structural bays, interstitial floors, advanced characteristics for interchangeability of building components and, ultimately, complete work environment units.

We recommend that all future Fixed Health Care Facilities be designed and constructed on a modular building systems basis, significantly advancing both the construction engineering technology (within the existing state-of-the-art), and the adaptability of the buildings to the user's needs. In general, the facilities project proposal requires that the permanent structural and mechanical components (e.g. long-span roof and floor trusses, interstitial utility spaces, and trunk utilities) be located at regular, pre-determined intervals providing a modular structural and mechanical framework and large unobstructed neutral floor areas within which departmental layouts with their partitions and sub-systems of utilities would fit, virtually as self-contained environments.

The long-term advantage of modular building systems is the intrinsic adaptability of such systems. If a major change in, say, treatment procedure

or equipment technology called for the replacement of a departmental unit, it could readily be changed without affecting a relocation of the fixed structural/mechanical network—the costly framework items containing utilities that preclude change in most existing facilities. Besides simplifying both major and minor reconfiguration of floor plans, the interchangeable (i.e. replaceable) characteristic of the more sophisticated modular components and the easy accessibility of mechanical equipment located on interstitial floors encourage highly efficient maintenance procedures.

Possibly of equal importance, consideration of the building as a system of compatible components and sub-systems, rather than a custom-built monolithic object, enables new and improved methods of construction contracting, design, and acquisition procedures to be adopted.

An improved acquisition procedure, the multi-track schedule, is discussed in Section 3.4.4. Multi-track scheduling is a proven, but relatively new, contracting procedure in which the traditional prime contractual responsibility and relationship to subcontractors is abrogated in favor of direct (DOD) Project Manager-(contracted) Construction Management relationships. Under this procedure, separate construction contracts are awarded by the Government in sequence for each of the principal fabrication and on-site construction activities, (e.g. Foundations; Structural Frame; Enclosure; Equipment; Interior Finish). Contracts are then managed under the auspices of the Construction Management function. Design is phased in accordingly.

Advantages of multi-track scheduling discussed in Section 3.4.4 include a reduction in the time between design and completion of the building for beneficial occupancy and a tendency to more efficient bidding, better selection of qualified contractors, and improved on-site control. An application of multi-track scheduling is found in the activity network in Figure 3.4.9.

The reduced time span of the multi-track scheduling process calls for architectural working drawings and specifications to be issued simultaneously as completed, rather than the conventional method of waiting until the complete set of working drawings for the entire project is approved and issued for prime contractors' bids.

Modular building systems also impose new constraints, and open new opportunities, for the A/E contractor. The concept of modular buildings and the acceptance of dimensional standards is much further advanced in Europe than in the United States. Some resistance to the idea is therefore to be anticipated from traditional construction contractors and designers. On the other hand, progressive designers in this country generally agree on the desirability of compatible industry standards for building components and equipment, and the economic weight of DOD procurement processes offer the best opportunity for attainment of this goal. (Establishment of military standards in the present instance would have probably further application to civilian hospital facilities.)

Design methodology is reviewed in Section 3.4.2. Aside from considerations of the physical structure, the computer-aided configuration of departments within a building form assigned to a particular site orientation also calls for new thinking on the part of the designer. Presently, the single most determining factor in hospital design has been the program statement that a Nurses Station serves a given number of beds; floor plans and the ultimate building form have all been developed by the designer around the nursing department from this easily manageable item of data.

The design methodology that we propose requires the simultaneous consideration of all the building's departmental and support activities, their individual spatial and resource requirements, desired physical relationship to each other, and possible future growth, obsolescence, or relocation. Several different resolutions of these needs in sub-optimal physical arrangements will have been computer-generated during Phase II, and are proposed as mandatory design inputs as the Form Diagrams component of the A/E Contract Documents Package. Again, traditional A/E contractors may resent losing control over this aspect of the Design Process, while progressive designers should recognize and welcome the computer's more efficient manipulation of data over the conventional intuitive design procedures. The sensitivities and benefits of the new design process are discussed in Section 3.4.2.

DOD organization and management of the new design and construction methods proposed here is discussed in Section 3.5.

Principal benefits include:

- Building adaptability to changing functional needs.
- More efficient maintenance procedures.
- Reduction of construction time span.
- Improved construction contractual procedures.
- Ability to accept updated design inputs.

### 3.4.2. MODULAR DESIGN

The A/E Contract Documents Package contains the following design (program) briefing information:

- A clear delineation of the location, scope, and purpose of the new facility.
- The size, estimated cost, function, and tentative physical relationship of all the hospital's component elements.
- Specification of a systems building methodology using a modular reference grid, long-span structural bays, interstitial floor spaces, and standard component construction.
- A multi-track scheduling methodology for the production of final working drawings and performance specifications.

The systems building design goal is to provide an unobtrusive structural envelope around the required gross "neutral space" floor areas, with optimum distribution of mechanical services convenient to all points in the neutral space area. Functionally, the neutral floor space is to be allocated to the hospital elements, generally as indicated on the Form Diagram, and with minimum distortion of the interface between neutral and structural building spaces.

Within the mandatory constraints of the specified modular grid and systems building methodology, the architect on the designers' team will be required to create an aesthetically pleasing hospital building design satisfying the criteria furnished with the A/E Contract Documents. He is to present his design solution in the form of Detailed Concept Plans (approximating 30% Final Working Drawings) and to support the design solution with a detailed cost estimate which will be forwarded to DOD for approval before proceeding with the phased development of Final Working Drawings and Specifications.

The A/E Contractor has the following design responsibilities:

- Electrical: trunk power runs, switching, lighting and connections.
- Architectural: aesthetics, materials, fixed equipment, costs.
- Structural: available techniques, soil tests, costs, performance.
- Mechanical: climate, surrounding utility systems, etc.
- Local conditions: available labor skills, materials, building systems.
- Special Consultants: on engineering, medicine, administration, supply and other functions.

The A/E Contractor will report to the DOD Project Officer, who will, in turn, maintain close liaison with the SGO.

#### 3.4.2.1. The A/E Contract Briefing

The A/E Contract Document Package contains a number of features that will be new (and initially disconcerting) to the designer who has been accustomed to receiving conventional space program criteria. Computer printouts, Departmental Performance Records, a modular grid coordinated with Planning Units, and specified constraints on the building methods and materials will all be seen (quite accurately) as an erosion of the architect's traditional role as creative master builder. As with systems management and engineering methods, systems building is essentially functional and goal-oriented.

It has been pointed out in Section 3.3 that the purpose of the A/E Contract Documents Package is to bridge the gap of understanding between the user's work environment needs and the architect's translation of those needs into a building design. Present methodology is slow, cumbersome, and fails to articulate work environment needs adequately in a "language" suitable for translation into building design solutions. The Planning Unit/Project Summary Chart/Affinity Matrix/Form Diagram continuum is a means of bridging the gap, each step defining need more tangibly in terms of design than the last. The Form Diagram, generated from SGO medical mission inputs and refined by the DOD Project Officer,

provides a three-dimensional visual analogue of the suggested hospital element relationships from which the building form is derived.

It will be important in briefing the A/E Contractor personnel that the purpose of the Form Diagrams be understood and that their role in the ongoing Acquisition Cycle be clearly defined. In fact, the systems building and design requirements are a true test of creative talent, calling for original thinking and sensitivity to unquantified human needs within the discipline of the system constraints. The designer's function is to transform computer-processed data into tangible environmental forms capable of stimulating sensitivity, abetting human activities, or merely pleasing the eye in a moment of relaxation. The tools, the techniques, and the times call, perhaps, for a new aesthetic.

The briefing process at a vital stage in a complex systems procedure cannot stop with the presentation of the A/E Contract Documents Package. The Project Officer will play an active part in the translation of the Form Diagram into architectural schematic drawings. When the designer achieves a schematic solution to his satisfaction, it will then be reconverted to a Form Diagram format in the computer so that its element relationship characteristics can be checked for compliance with the SGO requirements. The Project Officer's role at this point is to complete the task of bridging a gap from planning to procurement, reconciling the functional objectives with the design goal in a liaison/briefing capacity between the SGO and the A/E Contractor. This process ends with mutual agreement on the conceptual design solution.

Unlike the present methodology, in which the designer is required to prepare his concept plans from a written space program, the above process bridges the gap between the Planning and Procurement (Design Phase), enabling the designer to proceed almost immediately with the preparation of Detailed Concept Plans and working cost estimates.

#### 3.4.2.2. Detailed Concept Plans

Once the selection and refinement of the Form Diagram and outline specifications or subsystems is made into schematic plan format, the designer is ready to give detailed consideration to the implications of

the specified systems building. In terms of system documentation (see Section 3.5.2), the next milestone is to prepare and submit Detailed Concept Plans (30% Final Working Drawings) and cost estimates for approval by the base command, SGO and engineers.

Modular design (i.e. designing a building whose principal structural component features and subsystems conform to a preferred reference grid) is a developing methodology. The use of modular design grids is an essential feature in the planning and construction process that we propose; modularity is consistent, linking component of all the phases as well as the conceptual framework within which the completed hospital may be physically reconfigured to accommodate changing mission requirements.

It is this idea of designing a framework for an adaptable systems building rather than a finite object (a health care facility whose very appearance suggests permanence and certainty) that many traditional designers will find workable. One of the reasons many building systems given publicity in the past are yet to be realized, is that they were not based on a disciplined modular design system, but rather on a traditional representation of architectural ideas.

It is the purpose of the proposed planning and design effort to create military health care facilities that are inherently capable of adaptation, in order to meet unforeseen changes in mission needs. Conceptually, this is discussed in the Planning Process discussed in the previous section. Physically, it requires facilities to be constructed using removable and reusable building components, and a total systems building. There are A/E firms specializing in health care facility design that have had considerable success in using a 4'4" sub-grid which integrates all phases of the construction plans. Although actual savings have not been calculated in detail, considerable reduction in design and drafting time can be achieved. For example, using conventional design methods for a medium sized hospital, 80 standard-sized architectural drawings at an average of 130 man/hours per final sheet are required. In using modular coordination the number decreases to approximately 60 drawings at 95 man/hours per sheet, or a time saving of approximately 45%.

The 4'-4" grid was used to derive the Planning Unit area and is suggested to be a satisfactory grid for component and facility design in all future military health care facilities. Multiples of this grid can be used for almost all hospital element layouts. For example, two grid units will produce a typical hospital corridor of regulation width; 4 x 4 grid units will make up an economical two-bedroom section in a nursing unit; two grid units will make up a reasonable floor to ceiling height, and again, two grid units will make a good interstitial floor; the width of stairs can be expressed by three grid units; examination office layouts can be multiples of three grid units; and in terms of components, partition construction which is usually based on 4 x 8 panels readily adapts to the grid dimensions.

Modular design and standard component construction (sometimes referred to as "industrialized" building) has been successfully applied to the British government's hospital building program. Their experience, and its implications for the designer, is published in a series of Ministry of Health Design Notes.\* While the British needs and requirements differ in certain detailed respects from those of the DOD, the general principles of their methodology parallels the design and construction recommendations of this report. In summary, these principles are stated by their implications on systems building.

Systems building involves a large measure of fabrication in the factory, where work can be undertaken in a controlled environment. On site, organization aims at the quick assembly of finished components by the minimum labor force.

To enable components produced in several factories to fit together with a minimum of site labor, cutting and jointing, and to facilitate their combination with traditional and other on-site components, it is essential to ensure that the dimensions of the components are coordinated with each other. This coordination will permit the requirements of the designer to be reconciled with those of the manufacturer and constructor and the following benefits can ensue from a modular gridding:

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\*Prepared by the Ministry of Health, London, England.

- designs based on universally accepted dimensions can be more easily visualized and understood, particularly by the user
- the general content of drawings can be simplified and time saved by the designers in the preparation of contract drawings
- orders for components can be placed well in advance of need, thus creating the right conditions for effective control of production and delivery
- consistent use of a limited range of components will encourage controlled performance testing--modifications found necessary from their use in practice can be fed back to the designers and manufacturers, and incorporated in future phases of a program of buildings designed on the same dimensional principles
- the extension of factory production makes for more economic use of mechanical plant for construction assembly on site
- the location, spaces required and integration of mechanical engineering services is especially important in hospital buildings, and a technique of coordinating dimensions provides a simple dimensional frame of reference to accommodate these factors; mechanical services can therefore be related to the structure at an early stage in planning and this can lead to more standardization, with a consequent reduction of cost in design time and in the supply and installation of the services

- shorter ranges of components will permit early cost planning and experiment with new contractual methods
- with the establishment of standard ranges of dimensionally coordinated components, manufacturers are assured of continuity of production: building and engineering contractors are able to simplify setting out on the site and utilize to the full their skills in assembly methods; and the user has a finished product developed as a result of widely based cooperative studies and prototype testing.

The requirements basic to the use of systems building techniques are:

- a clear brief on the functional requirements which the building is to satisfy
- the use of preferred increments in the design of spaces and components
- the selection of a technique to relate components to each other
- the use of preferred dimensions in the design and production of ranges of dimensionally coordinated components and the variety reduction of all components
- administrative measures to ensure the effective use of these new techniques by architects, engineers, estimators and industry.

Finally, the adoption of a preferred reference grid for systems building will make it easier for the designer's team to work simul-

taneously. Because of the design module's dimensional constraints a mechanical engineer, for instance, knows that columns will appear at every  $n^{\text{th}}$  interval, enabling him to design trunk utilities without finding out later that foundations must be dug up to accommodate them. The following comparison of conventional and modular design procedures demonstrates this facility for a multi-disciplinary approach excluding approvals and reviews.

#### Conventional Design

1. Designer reviews area analysis and produces preliminary floor layout plans.
2. Structural, electrical, mechanical and other engineers advise on supporting systems.
3. Designer, with his team, produces schematic drawings.
4. Designer's team prepares concept plans.
5. After architectural working drawings are initiated, engineers begin with final working drawings.

#### Modular Design

1. Designer's team studies the A/E Contract Documents Package\* and decide upon a grid system which will satisfy requirements.
2. Designer's team produces schematic drawings.
3. Designer's team begins work simultaneously on concept plans.
4. After completion of each set of drawings and specifications which correspond to a construction phase, bids are secured.
5. same

\*The Form Diagram already gives a fair idea of the future shape of the building. (In the conventional process, the architect had to make a sketch in order to solicit contributions from the engineers.)

6. When all combined working drawings and specifications and remaining sections of the construction bid document are completed, bids are secured.
6. same

The simultaneous design effort of the designer's team derives the usual benefits of a team approach, and also reduces the design time. Construction can begin earlier, permitting more realistic contractor bids (see Section 3.4.3).

#### 3.4.2.3. Advantages of Modular Design

Modularity - beginning with the definition of functional requirements and proceeding consistently through the generation of the Form Diagram, development of Detailed Concept Plans, and preparation of final working drawings - means that localized changes can be made in the building plan (resulting from changes in technology or mission needs) without disruption of the work of the architect/engineer team. The advantages of modular design and conceptual flexibility may be enumerated as follows:

- Immediate response to program changes during the design phase, since the building structure and most of the mechanical system will not be affected.
- Reduction of errors in working and shop drawings; the A/E teams working simultaneously can constantly cross-check, uncovering discrepancies much earlier than is now possible.
- Faster verification of shop drawings; the dimensional relationship between the grid and the components results in shop drawings that are easier to read and cross-check.

This flexibility in modular planning and design means that the facility design, and even construction, can begin before all of the hospital's functional elements are planned in detail. This may be particularly advantageous where it is known that an improved care pattern or item of medical equipment (or an equipment subsystem) is soon to come on the market. The detailed hospital functional design need only be firmed up at the time interior partitions are ready for installation, providing the partitions conform to the overall building system module.

#### 3.4.2.4. Reduction in Construction Period

A study of the magnitude of the cost increases resulting from a decision to cut down areas of a facility (to stay within a certain budget) shows that additional facilities acquisition cost amounted to 3.2% of the DOD patient care costs, whereas personnel cost was 60%.<sup>7</sup>

To be more specific, if one reduces the clinic from 20 examination rooms to 16 (or 20%), a 10% increase in time schedule could still handle the same number of patients--with a slight loss of quality of care. This higher utilization of space would need more administrative and maintenance personnel, plus extra time for the medical staff. This can then increase staff cost by 8%. However, there are some savings, such as less area to maintain and fewer M.D.'s, bringing down the extra personnel cost to 5%.

<u>No. Patients</u>	<u>Area</u>	<u>Cost</u>	<u>No. Staff</u>	<u>Cost</u>
constant	-20%	-.64%	+5%	+3%

In other words, if one were to keep treating the same number of patients, an area reduction of 20% means a total construction cost reduction of .64%, but might very well mean a personnel increase of

5% (a very conservative estimate). This would mean a total cost increase of 3% or 4.5 times more expense as is intended to be saved.

But, in spite of all precautions, such as highly accurate cost estimating, it still can happen that a construction project has to be reduced in area. Reasons for this might be 1) a totally unpredictable labor or material situation (caused by strike or shortages), which will raise bids out of proportion, 2) sudden drastic changes in base population, 3) budgetary cuts at Congressional level. Designs established according to modular concepts allow these changes to take place without too much delay or diminished efficiency of functional relationships.

At present, it is often the case that because of a higher than expected bid at the initiation of the construction stage, the size of the facilities are reduced in order to remain within the previously approved budget. This can have several consequences:

- sometimes the cut will be made in the cost, and therefore in quality of the materials, resulting in higher maintenance cost during the operational period.
- sometimes the cut will be made in the mechanical systems, such as materials handling or air-conditioning, which means less efficiency and therefore higher operational costs.
- sometimes the cut is made in the supporting areas, such as administration, general storage, employees, etc., resulting in a lopsided situation where the medical staff is hampered by insufficient backup.
- sometimes the cut is made in the medical care areas, such as reducing the total number of beds, resulting in over-sized ancillary service or cramped inpatient quarters.

Reducing the outpatient areas has similar consequences: because of the strong interrelationship between number of patient visits to number of hours of operations, and size of staff to area of the clinic, a reduction in area will force the facility either to refer part of the patient load to other facilities or to run the clinic more hours, which means increased personnel cost.

If, however, a Fixed Health Care Facility is designed using modular design and building systems, these changes can take place with little delay or loss of efficiency of functional relationships. If construction has not begun, a reduction in area will cause shifts in element locations; but as the details will not change, elements can be reduced in size and relocated within the modular grid.

Generally, if a building cannot be completed and construction is well underway, modular design allows the hospital to operate with a minimum of loss of time and cost. Today, a major cut in programmed buildings, after construction, means either a massive "patch" job which requires new working drawings, or an imbalanced facility. The building is also too rigid and the design too specific to accommodate new functions. On the other hand, modular design ensures that the necessary relationship of elements be maintained. Even if the building envelope is completed, interchangeable components fitting into a modular grid will allow "last minute" relocation of elements. Thus, rather than cutting off a wing and eliminating, or disproportionately reducing, some elements, the designer can simply relocate elements in new, smaller proportions within the limited building area. Unfinished areas can then be closed off and new entrances and exits provided until funds become available to continue construction. At that time the building is still sufficiently flexible to assume a balanced new design scheme.

In summary, use of modular design is an essential component in the New Generation Hospital system. It ensures:

- adaptability of facilities to present and future change with less time/cost losses

- a capability for multi-track scheduling which shortens procurement period
- a better and balanced response to budget changes.

As a means of ensuring that the health care facility will have a specific degree of adaptability for future growth and change, and can be constructed within certain time limits, a set of performance specifications will be required. These performance specifications issued for the guidance of the A/E Contractor should include these criteria:

- a grid system to be used to simplify coordination and allow the fabrication of modular components.
- the structural bay size to be not less than 1,500 square feet to restrict the number of columns per area.
- all hard, medium and soft area which has a probability of future change to be connected to interstitial floors:
- integrated ceiling systems to be used to allow the independent location of partitions
- all area dividers that carry no special requirements for reasons of shielding or fire protection are to be made up of relocatable partitions
- the utility network to be organized along a modular grid
- exterior wall panels to be of component type to ensure easy removal in case of expansion
- select fixed equipment of component type which can be easily re-installed after changes

- all cabinet and counter work to be of modules that fit the chosen grid system.
- the structural horizontal members must be of a type which imposes minimum constraints on the utility system
- other features as required, i.e. material handling system, communication networks.

### 3.4.3. ADAPTABLE BUILDING SYSTEMS

#### 3.4.3.1. Functional Obsolescence

The physical requirements of a health care facility are met if the building can:

- a. Provide environmental protection and support for the medical mission without imposing undue constraints on the performance of health care practice.
- b. Accommodate future changes in user requirements even though the nature of these changes cannot be foreseen with any precision when the facility is built.

The ideal environment of a facility is dynamic. Constant change results from:

- a. Continuous improvement in treatment procedures.
- b. High mobility of population (patient load).
- c. Continual development of better equipment.
- d. Unpredictable policy decisions.
- e. Probability of vast improvements in the field of construction technology.

At present it is very costly, and sometime impossible, to accommodate changes. High operational costs still characterize treatment procedures, in part because the environment does not accommodate change, or because a remodeling program would be economically infeasible and not necessarily the optimum answer a year or two later. In fact, military Fixed Health Care Facilities are to some extent obsolete upon occupancy. What does this mean?

A building is considered functionally obsolete when it can no longer be used efficiently for its original purpose. This usually happens when the functions for which some or all of its internal elements are planned change after the building is designed or built. A building can become technically obsolete when its mechanical equipment, utilities and services

no longer accommodate the needs of the operational activities. Existing military hospitals, for instance, need extensive new mechanical services before they can be fitted with the latest surgeries, laboratories, central sterile services, computer centers, etc. None of the hospitals studied exhibited capabilities for easily accommodating such change.

There are construction methods and techniques that can lead to the completion of an adequate and adaptable Fixed Health Care Facility and which also result in time/cost benefits. As we have indicated, however, the building industry, on the whole, is characterized as being conventional and conservative. It could benefit from the pressure and influence of a large federal agency, such as the DOD, requiring an upgrading of construction technology to bring it into line with other U.S. industries. We recommend that all future Fixed Health Care Facilities should continue to incorporate advanced construction techniques (within the state-of-the-art), but at a faster rate.

This section also discusses systems building; that is, the integration at the construction level of design, manufacturing, site operations and scheduling into a disciplined method of mechanized production of buildings. Considering a hospital building as a constellation of compatible subsystems and building components will allow new and improved methodologies of construction, contracting, design and acquisition procedures to be adopted.

The long-term advantage of using systems building techniques is the intrinsic adaptability of the resulting facilities. This is maximized by the creation of flexible (expanding or contracting) sub-divisions of building space. These techniques require that building systems be as neutral as possible; neutrality is best achieved through standardization.

#### 3.4.3.2. Standardization

In the systems building approach, an entire Fixed Health Care Facility would be seen as an entity comprised entirely of interchangeable components which can be moved around easily or exchanged as the need arises. Clearly,

such complete interchange is not currently attainable and will not be achieved until building components and methodologies are standardized.

We propose that the DOD develop and establish standards of performance and industrial incentives having the following overall goals:

- a. Performance specifications for the entire hospital building.  
This includes: all major structural and mechanical components and interior partitions, ceilings, fixtures and equipment.
- b. Standardization of segments within a hospital, creating in effect total work environments amenable to change as a complete unit.
- c. Development of standard dimensional modules, enabling economical manufacture of high quality components for more than one facility in a single production run.

#### 3.4.3.3. Interstitial Floors

Versatility in use of space and utility services is a major factor in postponing the obsolescence of hospital facilities. Interstitial floors and long structural bays are two ways of providing flexibility in a building structure.

Large floor areas unobstructed by structural columns and free of major utility installations such as ducts, pipes, and conduits are essential for easy conversion of any part of a hospital to a variety of uses and arrangements, and to transposition of entire departments. Such loft-like flexibility also lessens the impact of inaccurate decisions about the location or size of services.

Clear health care delivery space requires that utility installations run above and below this space but not within it. Clear usable floor space is created by expanding the conventional utility space above sus-

pended ceilings into separate full-height utility floors. Such floors not only simplify initial installations and future modifications, but day-to-day maintenance can more easily be accomplished by equipment and plant engineering personnel. The horizontally placed utilities within the "interstitial floors" lead to vertical utility shafts placed on the periphery of the structural module, thereby freeing operating space from mechanical obstructions.\*

Long-span roof and floor trusses, used to reduce the frequency of columns in usable floor space, are also conducive to adoption of utility floors. Space within the deep trusses themselves will accommodate not only the ducts, pipes, and wiring normally found within the suspended ceilings, but also the major cooling, heating and air circulating units, electrical transformers for X-ray equipment and other utilities. Catwalks will pass through these trusses to permit day-to-day maintenance without disturbing the operations of the department below (no ladders or scaffolds will be necessary, nor will stacks of ceiling tiles clutter use areas during repairs or remodeling).

Full-height interstitial floors are probably not necessary at every level. If experience strongly indicated that future change is highly unlikely in an area, then reductions of interstitial floor heights can be used. (See Figure 3.4.1).

Interstitial floors carry some constraints:

- a. Special coordination is needed between the various disciplines--structural, mechanical, electrical--during the design process.
- b. Greater supervisory control is needed during construction. Frequently the extra (expansion) space provided is usurped by utility subcontractors, in the interests of more economical installation runs. Also, the first subcontractor to begin work may attempt to take short cuts, causing difficulty for subsequent contractors trying to

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\*An example of a hospital using interstitial floors is the Dominican Santa Cruz Hospital in California.

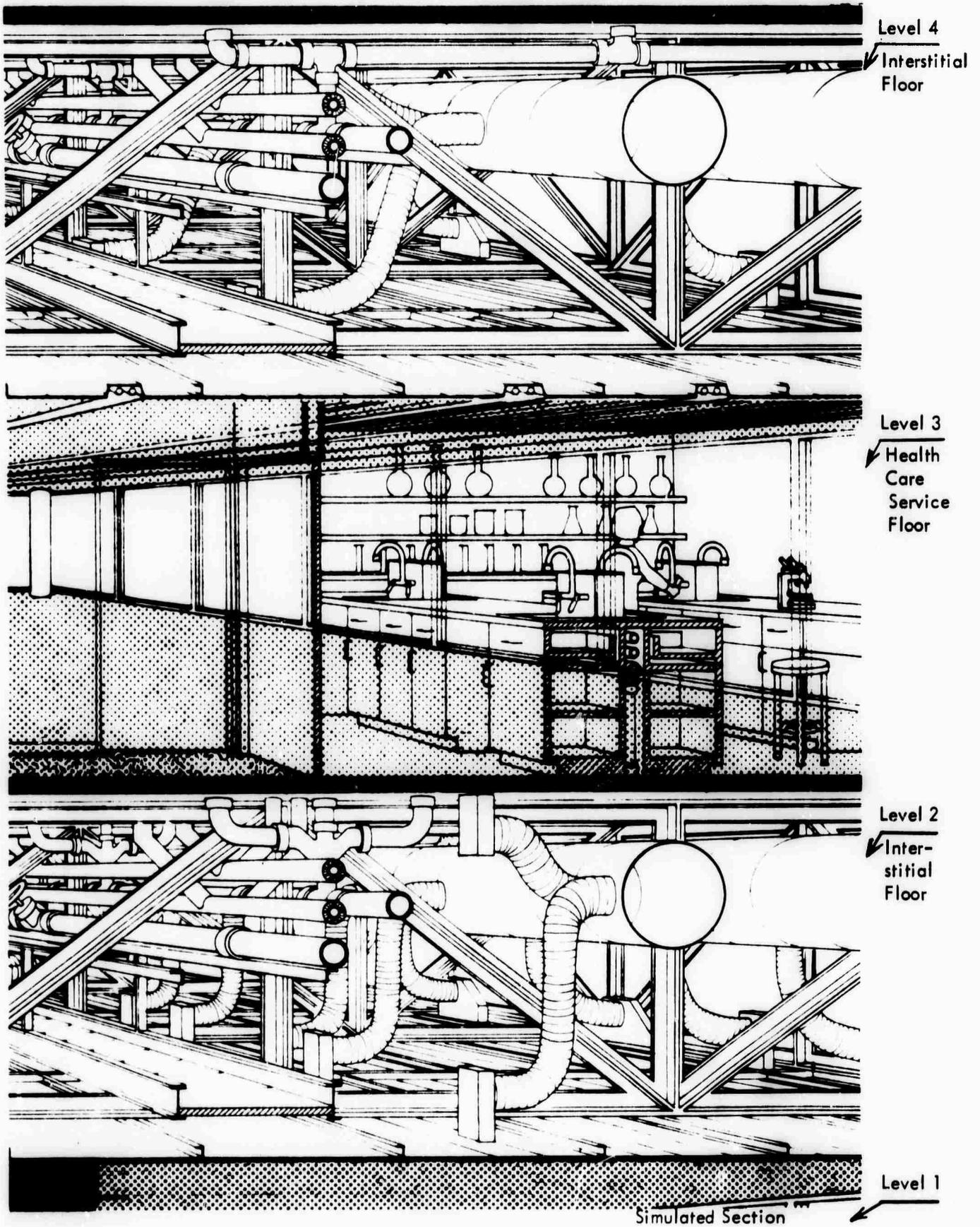


FIGURE 3.4.1 INTERSTITIAL FLOORS

3.4.23

follow their shop drawings. All subcontractors must adhere absolutely to the plan for effective long-term use of interstitial space.

Designers are considering decreasing the horizontal extent of interstitial space; the periphery of each intra-floor can be used for purposes other than mechanical and utility runs, such as laboratories, offices or storage rooms.

In some cases, longer than average structural spans and greater floor-to-floor height needed to provide interstitial floors may increase costs. These initial costs, however, are generally considered to be offset by the medium- and long-term advantages listed below. (For actual examples of cost savings see Section 6.7.)

- a. Potential reduction in operational costs through simplified maintenance and ease of repairs to mechanical systems. Access to the entire system, which is exposed in its own space 6 ft. to 8 ft. high, enormously simplifies repairs and regular maintenance procedures.
- b. Savings in operational costs through increased building flexibility. The ability to reconfigure usable floor space, and change mechanical services on interstitial floors with greater ease, brings about a reduction in costs for future reconstruction when labor and materials costs will be higher.
- c. Compatibility with multi-track scheduling, reducing design and construction time with consequent savings in inflationary costs. Separating structural and mechanical components of the building from primary use spaces facilitates delaying the decision-making time for final layout of floors until much later in the design process, while permitting site installation of the structural-mechanical grid before final floor plans are committed.

#### 3.4.3.4. Structural Spans

It is clear that the needs of a medical care facility are constantly changing. As a result, the function of space within the building changes too. If the fixed structural frame of a hospital building frequently intrudes on usable floor areas, space functions cannot easily be altered, and new needs must be subordinated to the limitations of the structure. If, however, a building framework provides only a few spatial interruptions (columns and utility shafts) changes will be less impeded. (See Figures 3.4.2 and 3.4.3.)

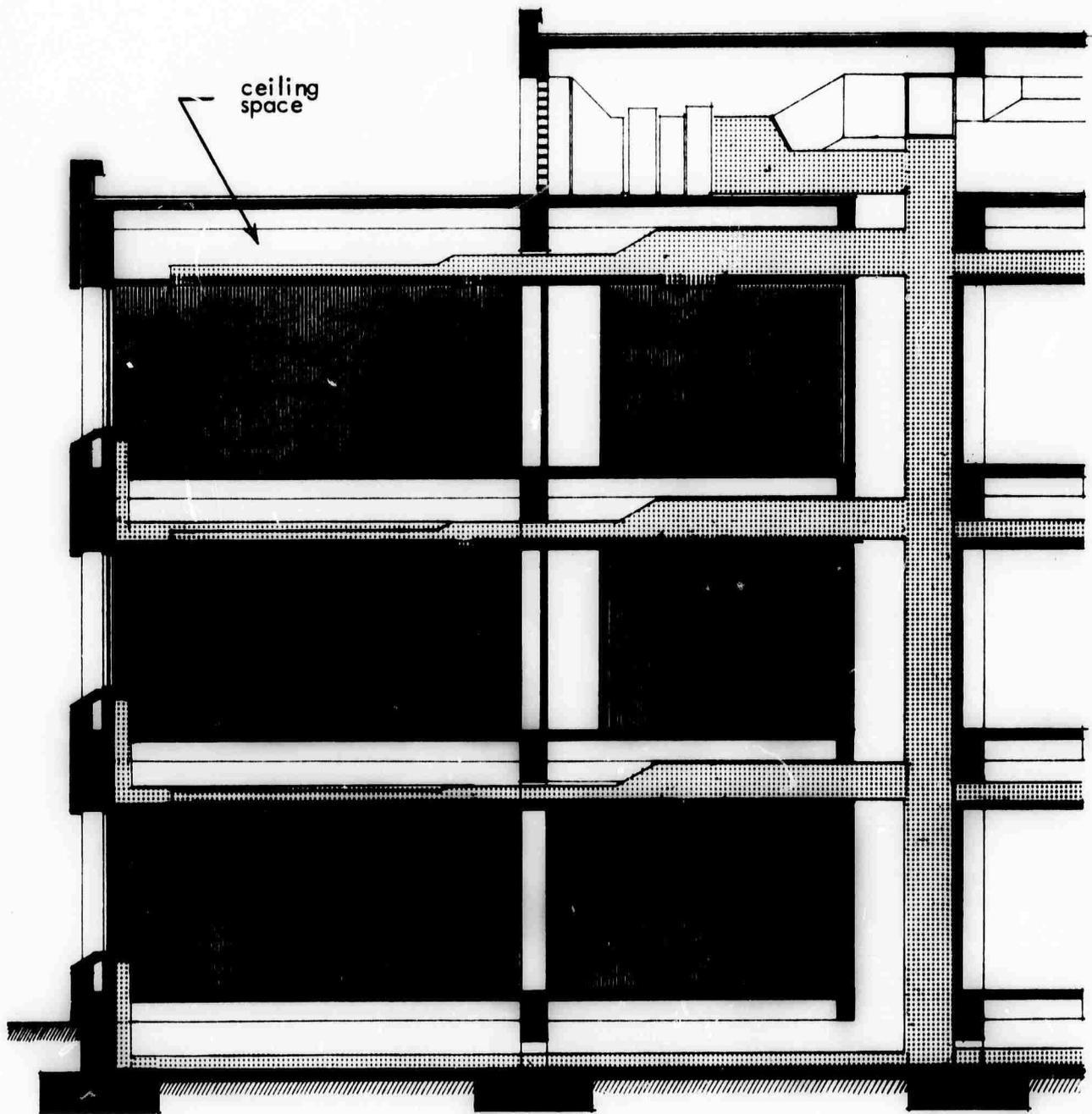
One way to achieve flexible (neutral) space is to introduce a long-span truss or space frame system. Large structural bays result in minimization of fixed vertical obstruction, allowing accessibility to services and large, flexible floor areas.

There are two possible schemes for long-span trusses which greatly expand space flexibility:

- a. Placement of vertical supports on the periphery of the floor space (with the mechanical services contained in interstitial floors.) This technique has already been used successfully in demountable parking structures (which, incidentally, are pure structures with no enclosures or partitions at all).
- b. Placement of vertical supports within the floor area in such a way as to create a modular division of floors compatible with the planned use of the space.

Several advantages accrue from large structural bays:

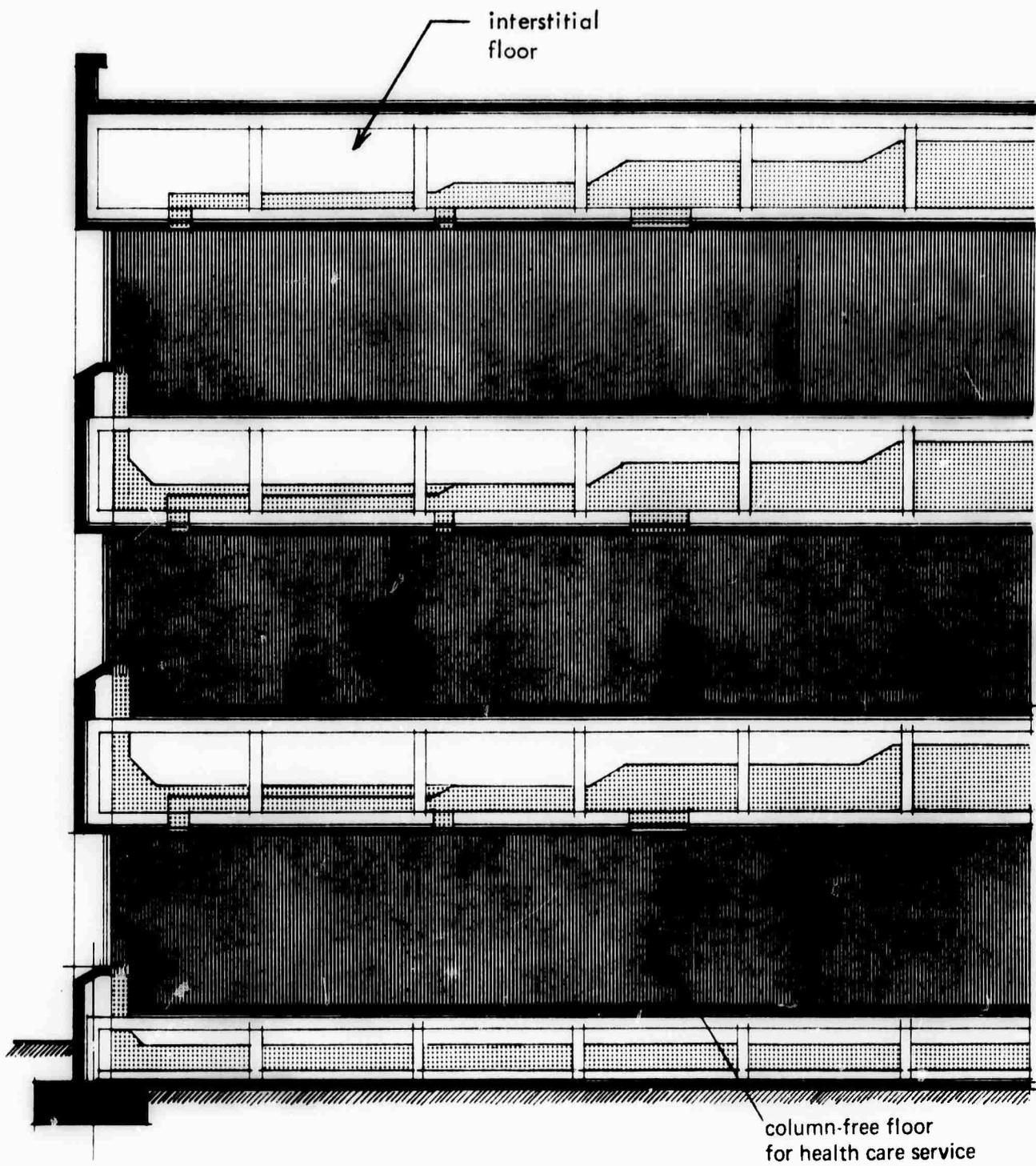
- If the mechanical services are organized on interstitial floors and modularly spaced vertical shafts, they will not prevent changes or intrude in operational procedures. In conventional structures, the cost of mechanical changes are often much higher than a department can justify.



-  Utilities
-  Assignable Space

**FIGURE 3.4.2 SECTION THROUGH BUILDING SHOWING  
A CONVENTIONAL MECHANICAL SYSTEM**

3.4.26



-  Utilities
-  Assignable Space

**FIGURE 3.4.3 SECTION THROUGH BUILDING SHOWING AN INTEGRATED STRUCTURAL/MECHANICAL SYSTEM**

3.4.27

- With the other building components, (e.g. partitions and equipment), being more adaptable, it is possible to plan a vertical access pattern that will relate to a great number of variations in horizontal circulation patterns.
- Demountable partitions (recommended for use in large structural bays) offset their higher initial cost (in some cases eliminated by prefabrication and faster construction), by lowering operational cost in allowing the most efficient patterns. (See Section 6.7.)
- Having this greater freedom in low equipment use areas opens the possibility of providing units which can be manufactured off-site and brought in fully equipped.

#### 3.4.3.5. Use of Reference Grids

To integrate the structural frame with the adaptable working environment components, it is necessary to adopt a technology for the dimensional coordination of space. In other words, the dimensions of functional elements within the hospital (rooms, departments, etc.) must be standardized. We propose that all the components of the new generation hospital be organized on a mutually compatible system based upon a modular grid. (Note: The planning units discussed in Section 3.3.2 proposes a standard grid of 4'-4".)

The technique of mesh or grid reference in the design and construction of buildings is not new. In general, grids have two principal functions:

- a. To define spaces and the general location of components.
- b. To define the detailed assembly of components.

The grid provides a discipline for accommodating both currently available materials and components and new components designed to preferred dimensions within a framework of space sizes. Standard modular building components are used with increasing frequency in Europe, and are gaining acceptance in this country with the development of building systems encouraged by federal programs.

Benefits of using a reference grid:

- Acceptance and use of a standard grid system ensures that components will always fit the spaces allocated to them, thus reducing to a minimum the possibility of one component infringing on the space which should be occupied by another.
- When space-function changes, there is no physical inhibition of relocating or interchanging components other than the structural frame.

3.4.3.6. "Hard", "Medium" and "Soft" Spaces

The complexity of the medical mission renders the goal of adaptability to change more attainable by some hospital departments than others. It is therefore convenient for planning and design purposes to categorize departments as "soft," "medium" or "hard" in their adaptability (i.e. their dependence on convenience or physical factors external to the departmental boundaries).

- "Soft" departments are virtually self-contained work environments that can be expanded or relocated with minimum disruption of the physical facility. An example of a "soft" department is Administration.
- "Hard" activities require an environment that is not easily expanded or relocated. An environment may be hard because: an activity requires much built-in equipment (such as a radiology or laboratory) or an activity that must be located in a specific area (i.e. emergency must be located near an entrance and exit).
- "Medium" departments are those requiring some special services or utilities, but whose relocation

is made easy by use of interstitial floor distribution systems, and departments with secondary priorities in physical location or proximity to other departments. ICU's are an example of "medium" departments.

#### 3.4.3.7. Space Dividers and Mobile Components

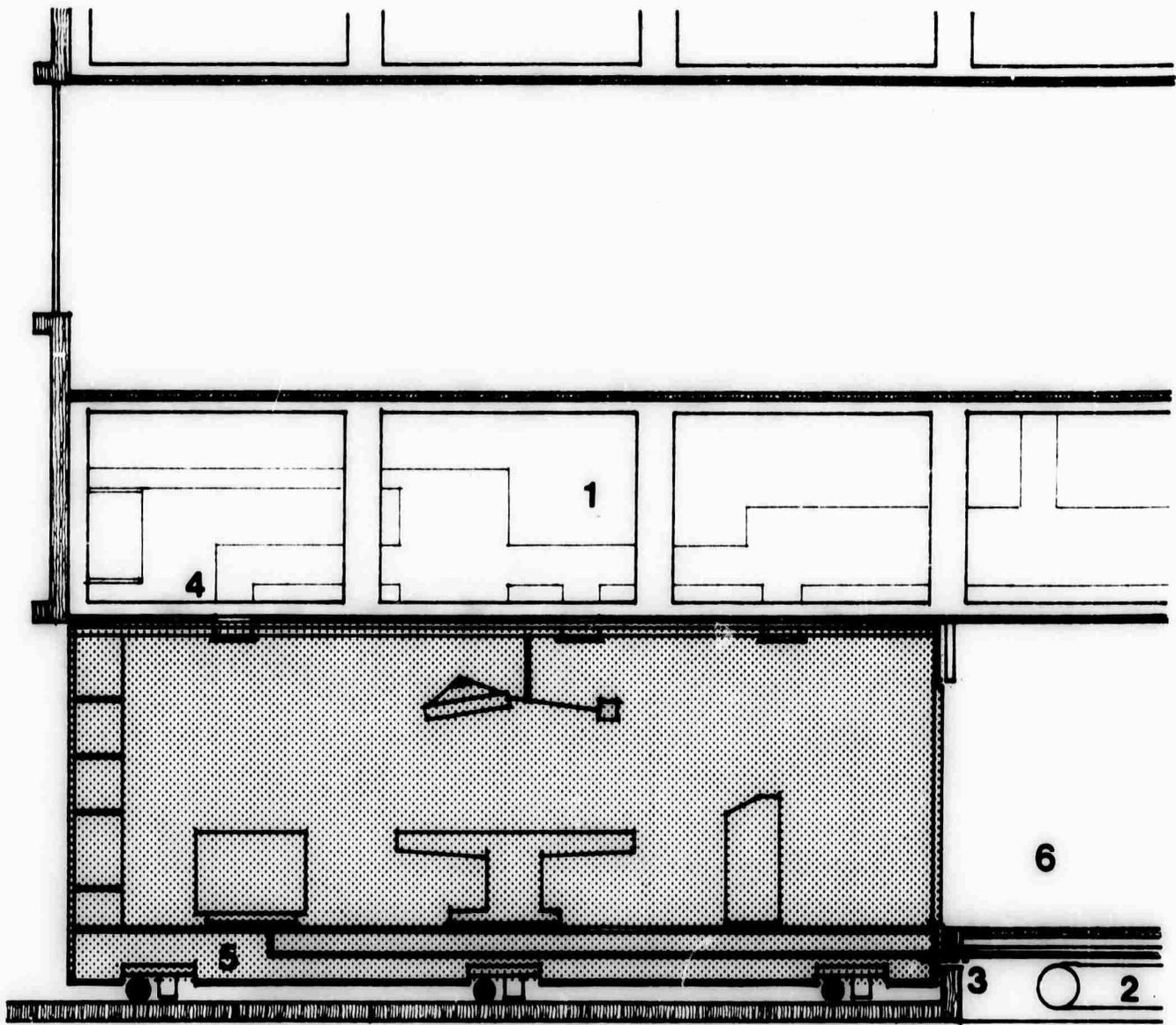
If an activity is fairly "soft," maximum flexibility of space is ensured by the installation of space dividers. All partitions and other service components such as benches, closets, etc. and movable equipment are standardized, allowing for maximum neutrality of space. Changes in "soft" environments can be made easily by using removable partitions and integrated lighting and ceiling subsystems together with standardized equipment which, if not mobile, is at least movable.

#### 3.4.3.8. Plug-ins

Maintaining flexibility in a "hard" area is more difficult, both because of stress on the utility distribution system and because of the fixed relationship of equipment. Components cannot be relocated as in soft areas. One possible answer to the problem of achieving adaptability in "hard" departments, such as surgery, laboratory or radiology, is the "Plug-in Unit." These units will require further study, and this topic is proposed as a future research and development study.

The plug-in is a fixed subsystem of related components making up an entire environmental work unit within the department. While individual components of the department cannot be moved, the entire work unit can literally be relocated whenever needs are altered. (See Figure 3.4.4) Recent examples of plug-in units are the removable surgery units in Great Britain which are used during hospital remodeling.<sup>6</sup>

In the United States, plug-in units have been used for several years. One of the largest examples is the 16-bed intensive care unit at the Candler Hospital in Savannah, Georgia. This plug-in unit measures



LONGITUDINAL SECTION

- 1 Fixed Structural/Mechanical Components
- 2 Major Waste Lines
- 3 Drain Connections
- 4 HVAC Connections
- 5 Mobile Base with Adjustable Height
- 6 Scrub Area

FIGURE 3.4.4 EXAMPLE OF SEMIPERMANENT PLUG-IN UNIT – SURGERY

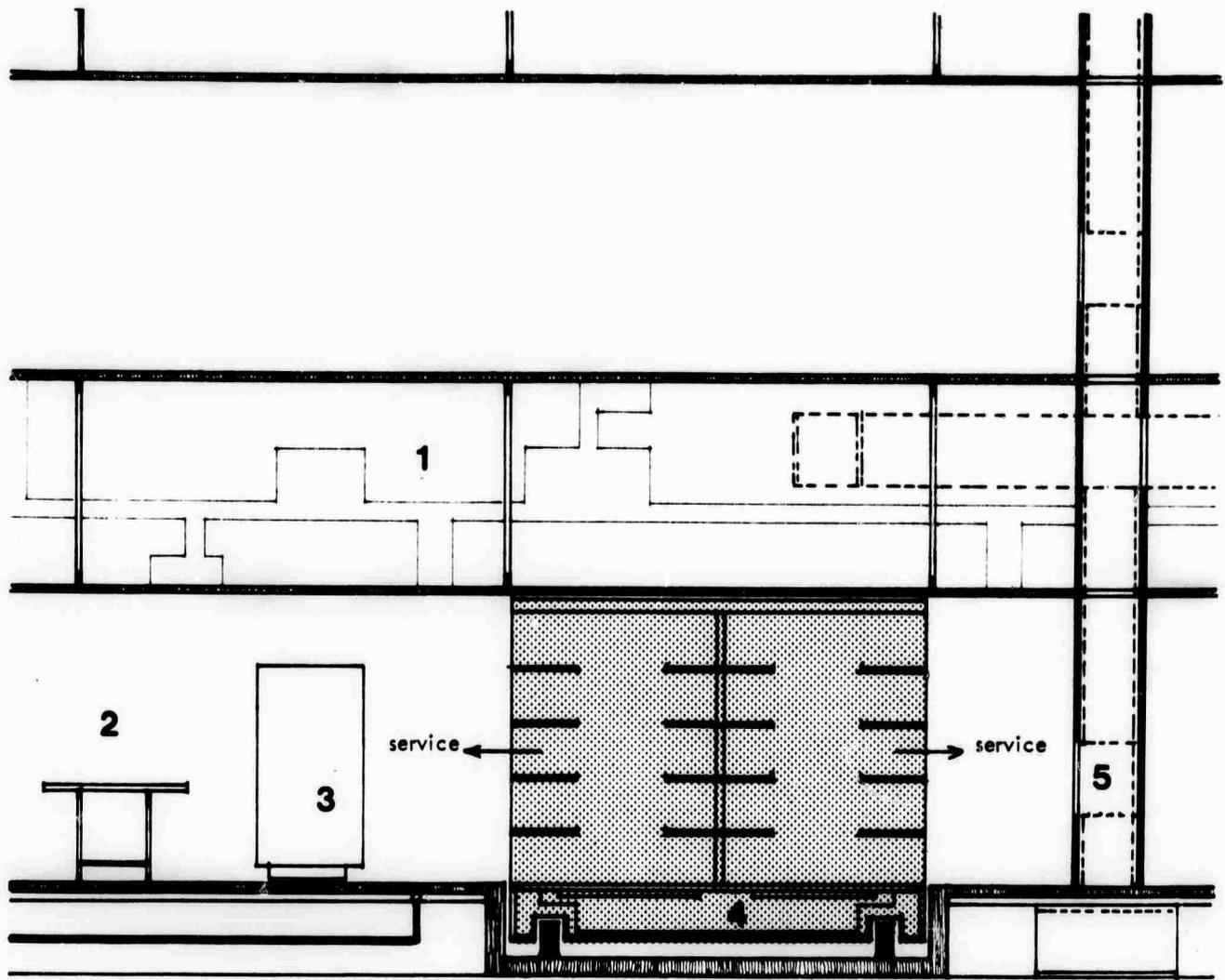
36 x 120 feet and was built and outfitted in Miami, from where it was shipped to its final location.

The plug-in unit concept offers the ultimate in flexibility and efficiency. Although still largely undeveloped, possible uses of these units are almost limitless. Plug-ins could be used to house activities requiring mobility such as a food storage unit for convenience food service. Many of these units could be located at strategic locations near different types of lounges and materials handling stations (see Figure 3.4.5). Such units offer potential cost savings as the product is only handled at the production center and at the consumption area, simplifying problems of receiving storage, preparation, space and staffing. The same type of unit could be used for linen and even pharmaceutical items.

Note: The plug-in unit concept can be expanded to accommodate emergency or examination. A unit could be quickly staffed and flown by helicopter or driven as a trailer to the scene of an emergency. This method has already been applied very successfully in California.<sup>21</sup> Treatment can begin at the site and continue during the flight back to the hospital, where it is dropped off and connected again. Patients may be picked up in a trailer-type unit and questioned or examined during the ride. If after arrival they are subjected to more intensive examinations, such as X-ray, the plug-in unit could serve as a waiting area.

#### 3.4.3.9. Modular Building Components

The state-of-the-art of modular industrialized building components in the United States is not as advanced as in Europe. While much of



TRANSVERSAL SECTION

- 1 Fixed Structural/Mechanical Components
- 2 Dining Area
- 3 Microwave Unit
- 4 Refrigeration Equipment
- 5 Materials Handling System

FIGURE 3.4.5 EXAMPLE OF MOBILE PLUG-IN UNIT – FOOD SERVICE

the technology developed for building systems outside the United States is applicable, building systems in the "new generation" military hospital should take advantage of the lack of existing U.S. methodology by:

- Postulating the various functional and user requirements for standard modular building components to be used in constructing military hospitals.
- Developing and establishing standards and performance specifications for a limited range of dimensionally coordinated components to be used in combination to meet the functional and user requirements postulated.

The selection of the preferred dimensions for components involves study of a number of factors, which are of varying significance for each component:

- Type of component.
- Functional requirements.
- Determination of sizes.
- Production factors.
- Variety reduction.

Type of component. Some components, e.g. partitions, windows, ceiling panels, etc., are commonly used in multiples, or in combination with each other and frequently in long runs, and thus require an inter-related range of preferred dimensions. Others can be employed singly and so can be considered initially in relation to their own specific space requirement, though their relationship to adjacent components should also be considered in design. Components such as structural beams need not be dimensioned to achieve the same degree of flexibility because of their function and conditions of use, but maximum correlation of sizes is still required to achieve variety reduction.

Functional requirements. Evaluation of the significance of this factor depends on the type of component. Examination of such considerations as sound properties, stability, weight, erection needs, articles to be stored in closets, doors wide enough to permit beds to pass, working weights for counters, and so on, are derived from anthropometric and other data.

Determination of sizes. Sizes should be determined initially from the results of study of functional requirements and then related to the preferred increments/ dimensions of the modular grids selected for the Fixed Health Care Facility.

Production factors. The significance of manufacturing problems can be established in consultation with manufacturers. Such problems include the degree of standardization capable of attainment in the factory, method of manufacture, costs of tooling up, handling, stockpiling, and transportation.

Variety reduction. To obtain the full benefits of building systems it is essential to achieve the minimum range of manufacturers' standard components (as distinct from components standardized for one or more hospital projects only), but which satisfy the maximum number of applications. This will require several stages of work: an assessment of the total range of components needed; consultation with manufacturers to establish economic runs; estimation of demand, etc. Components with a limited use in practice could be eliminated from the range with a minimum effect on the general aim of variety reduction of all components used in hospital building.

#### 3.4.3.10. Prefabrication

European experience has shown that modular building processes can take advantage of a large measure of component fabrication in the factory,

where work can be undertaken in a controlled environment; and of quick on-site assembly of finished components by a small but efficient labor force.

The construction industry in the United States has been slower to adopt methods of prefabrication. It has been said that buildings are too unique and complex for standardization of the components that would permit the economic feasibility of, say, automobile mass-production techniques. Quantity production is an important component of the success of overseas building systems techniques, however, and together with reduced construction time, has demonstrated significant time/cost savings.

An example of reduced construction time savings is demonstrated by Skarne of Sweden. The firm has produced 40,000 units of apartments, of which 50% have been produced outside of Sweden. The Skarne System 66, an "open" system of precast units, has reduced the building time from 10 months to 5 months.

It should, perhaps, be noted at this point that although Systems Building is relatively undeveloped in the United States, it is not new. Beginning with an experimental project by General Electric in 1942, a number of respected American companies have attempted to introduce prefabricated and unitized building systems to this country, including ALCOA, Monsanto Chemicals, and Allside Homes. All of these attempts proved economically unsound, and were abandoned. The principal reason for failure in each case was the materials and product sales-orientation of the companies making the effort without concurrent development of market acceptance. The American market is notoriously "independent" and resistant to the introduction of a common standard. In the present instance, however, it is proposed that the standards and specifications should come from the "market" (i.e. the DOD), and be issued for industry compliance. The potential of DOD as a customer for modular, prefabricated components manufactured to common performance and dimensional standards should provide the incentive for the successful introduction of large-scale building systems in the United States.\*

#### 3.4.3.11. Summary

In summary, the new generation military hospital building should be the highly adaptable end product of advanced building systems

\* See Health Service Design, Note #1, Department of Health & Social Security, Great Britain

techniques, incorporating:

- Structural and mechanical frame built to a modular grid layout, using long-span trusses with mechanical and utility runs in interstitial floor spaces.
- Components including interior partitions, equipment, and fixtures conforming to the modular design grid, but independent of the structural and mechanical elements to facilitate relocation.
- Plug-in units where necessary, to permit relocation of environmental work units with "hard" characteristics (in the late 1970's).
- Standard, prefabricated, modular building components fabricated especially to comply with DOD hospital building specifications.

### 3.4.4. MULTI-TRACK SCHEDULING

#### 3.4.4.1. Introduction

The cost of constructing buildings has been rising steadily in recent years, with the last twelve-month period showing an approximate 10 to 12% increase above the previous twelve-month period.\*8 There are methods and techniques that commercial builders are using which reduce the design and construction time, and maximize the use of other cost saving techniques. The Department of Defense has not followed a comparable course with regard to hospital construction but there is some indication that positive action is being taken to change the traditional practices. In this section we are recommending changes that would permit facility construction to take advantage of new practices to improve their track record in delivering facility on time. To provide these facilities, substantial modifications are suggested for improving the present contracting and management procedures. New federal legislation is not necessary in order to carry out most of these recommendations; however, reaching for optimum efficiency would be facilitated by legislative changes which would permit effective development of concept plans and working drawings, and would provide the necessary funds at the inception of a project acquisition.

The present scheduling practice for design and construction is sequential and arises out of traditional practice when hospital buildings were simple structures not requiring lengthy periods of development. Procedures have grown to be rigid and inflexible and limit the improvement of project delivery time. With the advent of new management and building technologies, traditional procedures can be changed to accommodate a shorter delivery time.

We are recommending an increase in the flexibility in both the design and construction phases by changing management and contracting techniques. A "project office" organization should be used, in which a project officer has the early assignment of a construction management subcontractor. With this organization, multi-track scheduling procedures can be implemented.

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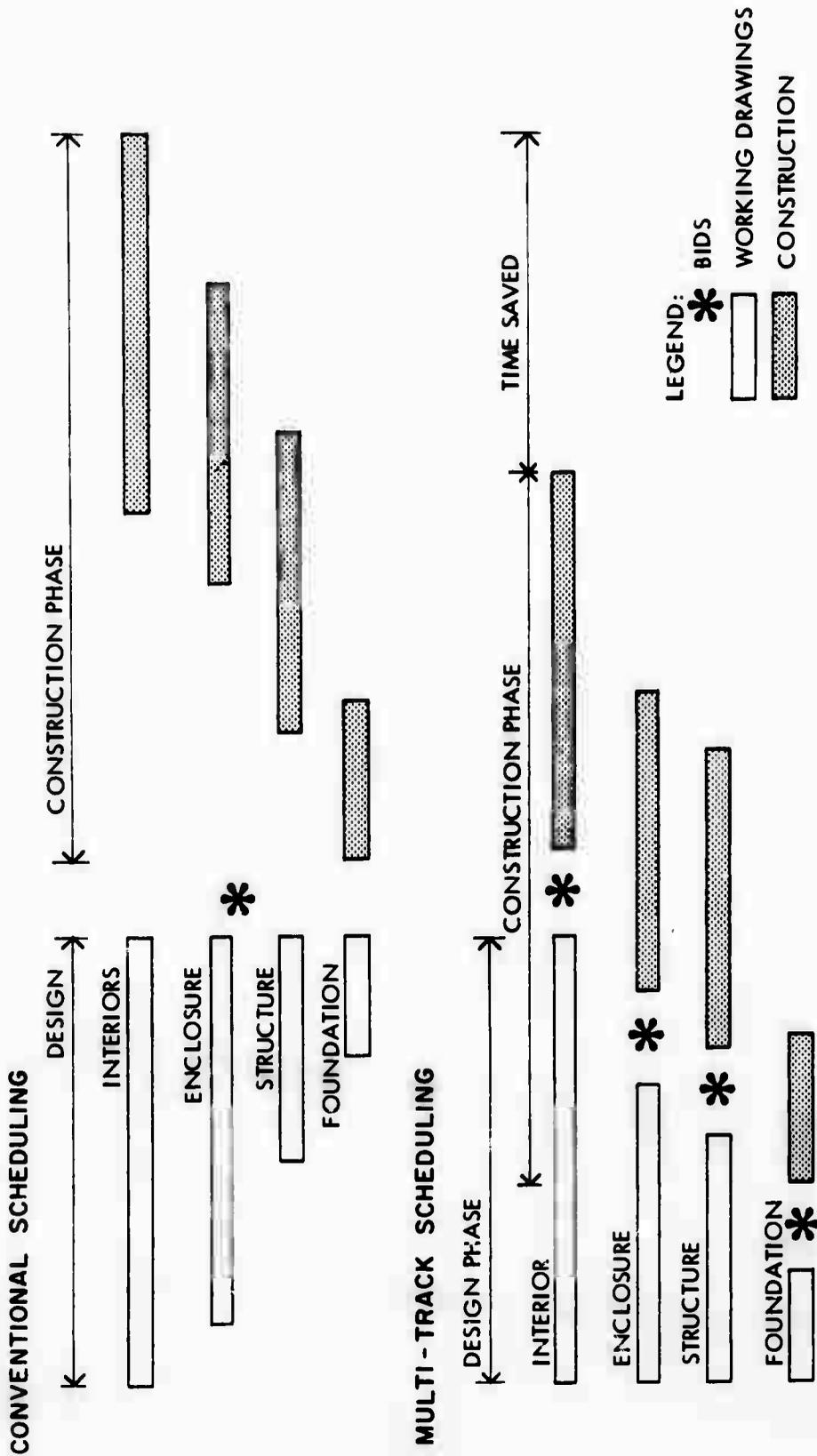
\*For graph of index, see Figure 6.7.2.

The project organization is described later in Section 3.5. An overview of multi-track scheduling is shown in Figure 3.4.6, and is compared with the conventional period. The assumptions are stated and four work packages are indicated for construction subcontracting. This is not to say that more or less packages may be needed. Essentially the design and construction phases are overlapped through the assistance of Modular Design described in Section 3.4.2. The resulting time savings are attributed to an early start in construction and the elimination of the sequential bidding period.

#### 3.4.4.2. Background

For projects where the total estimated construction cost is under \$200,000 and which involve augmentation or reduction in the number of nursing beds, the respective military service obtains approval of the preliminary studies from the Office of the Secretary of Defense (OSD). All projects \$200,000 and over, but less than \$500,000, require Office of the Secretary of Defense approval of the concept plans. Projects \$500,000 and over require Office of the Secretary of Defense approval of the results of all three design steps with preliminary (30%) working drawings, and these must be available to Congress should there be a call for them.

In the acquisition process of a military hospital today, there are four main steps for the preparation of software which include: the preparation of 1) concept plans, 2) preliminary (30%) working drawings, 3) final (100%) working drawings which include specifications, fixed equipment listings and a full quantity cost estimate, and 4) construction. (These steps are detailed in a network program in Figure 3.2.7.) Concurrent with facility acquisition is the parallel requirement of obtaining staff and the procurement of movable equipment and supplies in a timely manner so that an operating facility will result at the point of beneficial occupancy. During the design period, the respective Surgeon General project representative is responsible for working with an architect/engineer firm selected jointly with the construction agency.



**ASSUMPTIONS:**

1. Schedule is representative for the building structure only to the 5 foot building line
2. No change in construction period
3. No change in design period
4. Total development period shortened by overlapping
5. Not shown are further time and cost saving by using systems buildings and module design practice
6. Building utilities are a part of each work package

FIGURE 3.4.6 A COMPARISON OF CONVENTIONAL SCHEDULING WITH MULTI-TRACK SCHEDULING. BY OVERLAPPING DESIGN CONSTRUCTION START CAN BE EARLIER AND AS SOON AS THE FOUNDATION WORKING DRAWINGS ARE COMPLETED.

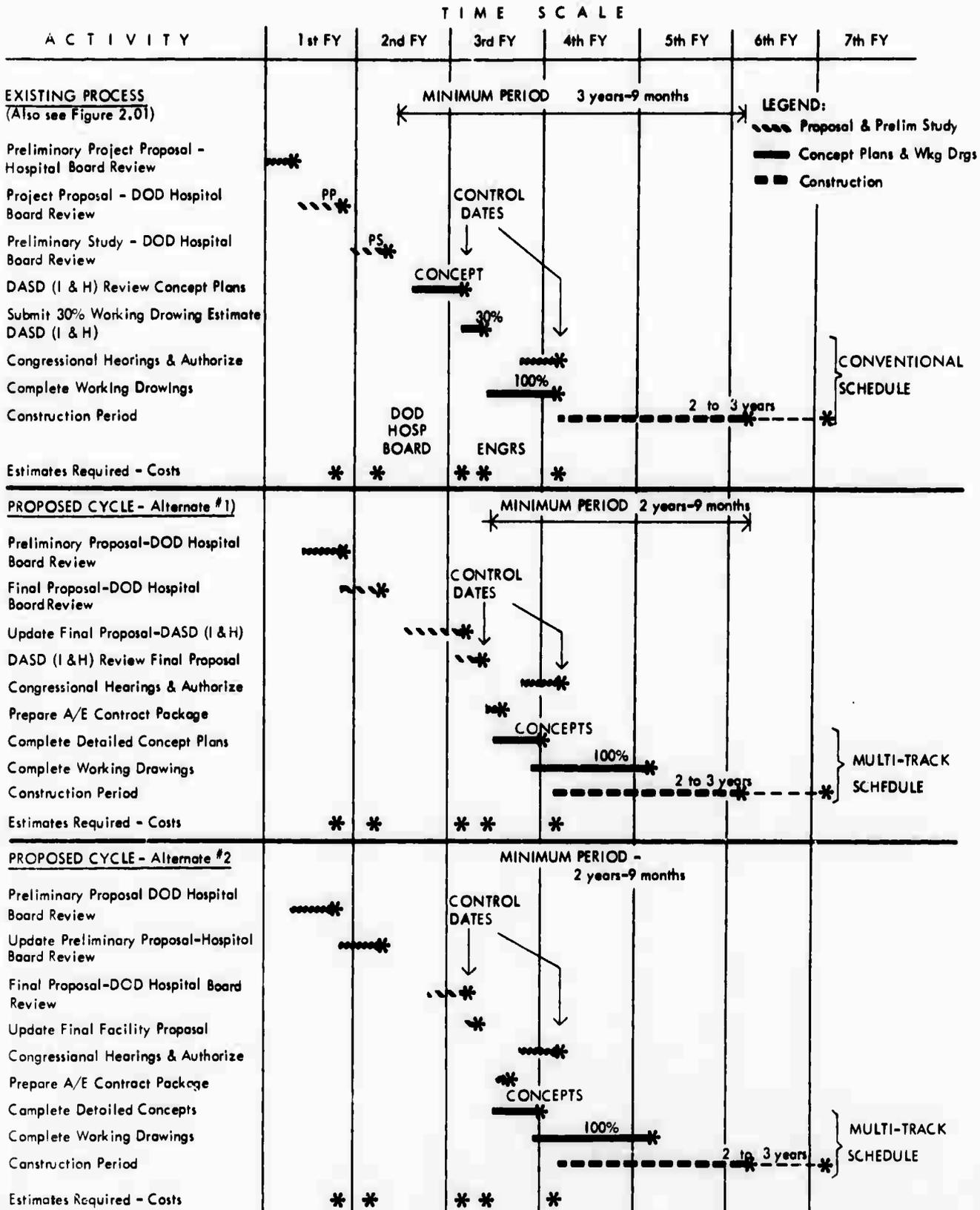
The steps for the existing acquisition cycle are shown in Figure 3.4.7 in the form of a bar/milestone chart. The present design-construction period is 3 years and 9 months, providing the approval and funding routines take place on time. In the proposed cycle in both alternates, the design-construction period is estimated to be 2 years, 9 months. Prior to starting the concept plans the functional elements are defined and the Form Diagram is developed. Few changes in functional space are approved after this step has been undertaken by the NAVFAC or OCE construction agencies.

The construction agency's experience has proven that up to 5% or more increase in cost can result because of functional changes during the design and construction period. Functional changes, especially, start a chain reaction of events causing changes to be made in utility systems (i.e., heating, ventilating and air conditioning, electrical systems, plumbing, material handling, etc.) and oftentimes, functional relocation which can effect building shape. As the architect/engineer firm has a negotiated fixed fee contract, they are reluctant to make changes. Thus, changes are usually made at the expense of the Government, with an increase in fee along with a build-up of frustrations by both parties, especially if changes predominate the latter part of the design period. In addition, if the estimate of the project exceeds the Congressional authorization, there is reluctance by the construction agency to query Congress for additional funding. When construction bids exceed funding limitations because of excessive changes, there are several alternatives for reducing the project cost:

- By cheapening the finishes, which eventually adds to maintenance costs,
- Eliminating high-cost mechanical material handling equipment,\* or
- Removing a portion of space (usually in the nursing service).

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\*The Veterans Administration experienced a cost growth in their San Diego Hospital--automated material handling equipment rose from \$2 million to \$3 1/2 million, and finally a decision at the administrative level was made to eliminate it. A trade-off analysis was not developed costing out a manual system.



**FIGURE 3.4.7 MILESTONE CHART COMPARING THE EXISTING ACQUISITION PROCESS TO THE PROPOSED ACQUISITION CYCLE USING THE MULTI-TRACK SCHEDULE**

In each case the hospital becomes an unbalanced system, and the operating staff is left with the problem for the next 10 to 20 years, and perhaps its remaining life, to bring the hospital into a balanced and responsive health care system. (See Section 3.4.2)

In the procurement of building and scientific equipment, fixed equipment is normally included in the construction contract while movable equipment is normally obtained through direct purchases. The military has a joint service publication entitled, "Construction and Material Schedule for Military Medical and Dental Facilities," which sets forth those items which should be included in the construction contract.

The cost of designing hospitals in the federal government varies widely. A facilities analysis was developed (Table 3.4.1)<sup>16</sup> showing cost data in four categories:

- Construction cost and other site costs,
- The cost of furniture and equipment,
- The cost of design by the architect/engineer firms, and
- Other design, supervision and overhead costs.

#### 3.4.4.3. Multi-track Scheduling

Multi-track scheduling\* is one of the major techniques used by private developers and their contractors to compress the time needed

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\*Sometimes referred to as simultaneous or fast track.

TABLE 3.4.1  
COST COMPARISON BETWEEN HOSPITALS

Category	Percentage of Total Cost			
	Military	VA	Five Civilian	Kaiser <sup>a</sup>
Construction Cost	60 to 76	62	67 to 77	78
Furniture and Equipment <sup>c</sup>	13 to 29	32	16 to 26	15
Design by an architect/ engineer firm	3 to 5	3	5 to 7 <sup>b</sup>	6
Other design, supervision, and overhead	6 to 8	3	0 to 2	1

- a. The Kaiser Hospital is set out separately from the other civilian hospitals in this and other schedules because it was the only hospital we reviewed for which no federal funds were involved.
- b. Includes costs of supervision of the construction by the architect/engineer firms.

The above percentages indicate that there is a considerable range in the cost of each of the elements, regardless of whether the cost data were for the military or for the civilian hospitals.

- c. With respect to furniture and equipment, some pieces of equipment were included in the construction contract and others were the result of direct purchases by the owner of the hospital. We were not completely successful in breaking out the cost of equipment included in the contract price because of reluctance or inability of some of the construction contractors to furnish the data. Since all the construction contracts involved either were advertised or the federal government was not a party to the contract, we did not have a right of access to the contractor's records. Consequently, the cost information that we were able to obtain was from the contractors on a voluntary basis and was not verified. In those instances where the contractor did not furnish all the desired information, to the extent practicable, we estimated equipment and site costs on the basis of such documents as architects' cost estimates.

With respect to comparing the costs of design supervision and overhead in constructing military and civilian hospitals, a special study report was prepared for the Department of Defense that states that these costs are greater for military hospitals partly because the military have administrative overhead items that have no civilian counterpart. The study report states that, for example, the organization, development, programming, and financing of civilian hospitals is primarily accomplished by citizens who donate their time and services.

to obtain new buildings. Multi-track scheduling calls for the overlapping of the various elements of design and construction (the project foundations, structure, enclosure, and interior work) to the maximum extent feasible. This requires close coordination between the architect and the contractor by the project officer since the early elements of the job will be under construction before completion of the total design. While this technique increases the risk of a high incidence of changes during construction, developers have not found this to be a significant problem.<sup>19</sup>

In multi-track scheduling, early elements of the project are designed and procured quickly in order to begin construction as soon as feasible. The network program on Figure 3.4.8 shows the overlapping of design/construction steps required to achieve facility development in a minimum period of time. The constraints in installing multi-track scheduling are at two control points: step F, where the health care facility proposal is due at DASD (I&L) by November 1, and the point where construction starts, step K (after September 15, when Congress and the Executive Branch has agreed to authorize and appropriate funds).

The radical departure from current design/construction practices begins at step I and continues through step P. These steps require the preparation of final working drawings, and include the normal administrative and technical reviews in parallel with construction bidding periods, rather than in sequence. Also, the space program for functional elements is delayed to accommodate changes in medical technology, equipment and new patterns of health care. It should be understood that functional size is known very early in the program, at step B, and that functional location is known at step D and its location is fixed at step H. Currently, space programs are developed as early as in step C and remain fixed until the completed facility is delivered to operating organization. The minimum period between step E, "concept plans," beginning in January, and step P, "completion of construction" for a typical 200-bed hospital could be as little as two years and three months, providing Congress authorized funds on time, there was no freeze on construction programs by the executive management, and the sequential review

periods moved rapidly. The maximum time can be much longer, up to three years and nine months or more from the start of concept plans, as shown in the Existing Cycle in Figure 3.4.7. Very large projects such as the Army's Walter Reed Hospital in Washington, D.C. and the David Grant Hospital at Travis AFB, California, fall into the latter category of extended periods of development, but these are special cases.

The assumptions for the two alternates in Figure 3.4.7 are that the DASD (I&H) will accept a Final Health Care Facilities Proposal (described in Section 3.5.2) rather than preliminary (30%) Working Drawings; that the apportionment procedures allow overlapping of design and construction; and that maximum use is made of building technology described earlier in this Section.

#### 3.4.4.4. Project Management and Management Control Systems

Multi-track scheduling requires 1) the use of network programming as a tool for control of activity start and finish times, 2) a project management organization and 3) a construction manager contracting system. Further changes beyond these are not considered at this time with the assumption that existing methods and procedures can be accommodated.

- CPM--This tool is ordinarily used by the construction portion of hospital projects. Directives for its use are contained in OCE publication "Engineer Regulation ER 1-1-11 Network Analysis System," (issued approximately 1967-68) and Naval Facilities Engineering Command publication, TSP 62 A, "PERT/Time Management Information System."
- Project Management--The overall organization composition and approach to project management is stated in the Section 3.5.1 and shown in Figure 3.5.2 as it related to the various phases of project development. In Figure 3.4.8 it would be appropriate to employ a Project Officer in step D

**MILITARY PROGRAM REVIEW CYCLE**

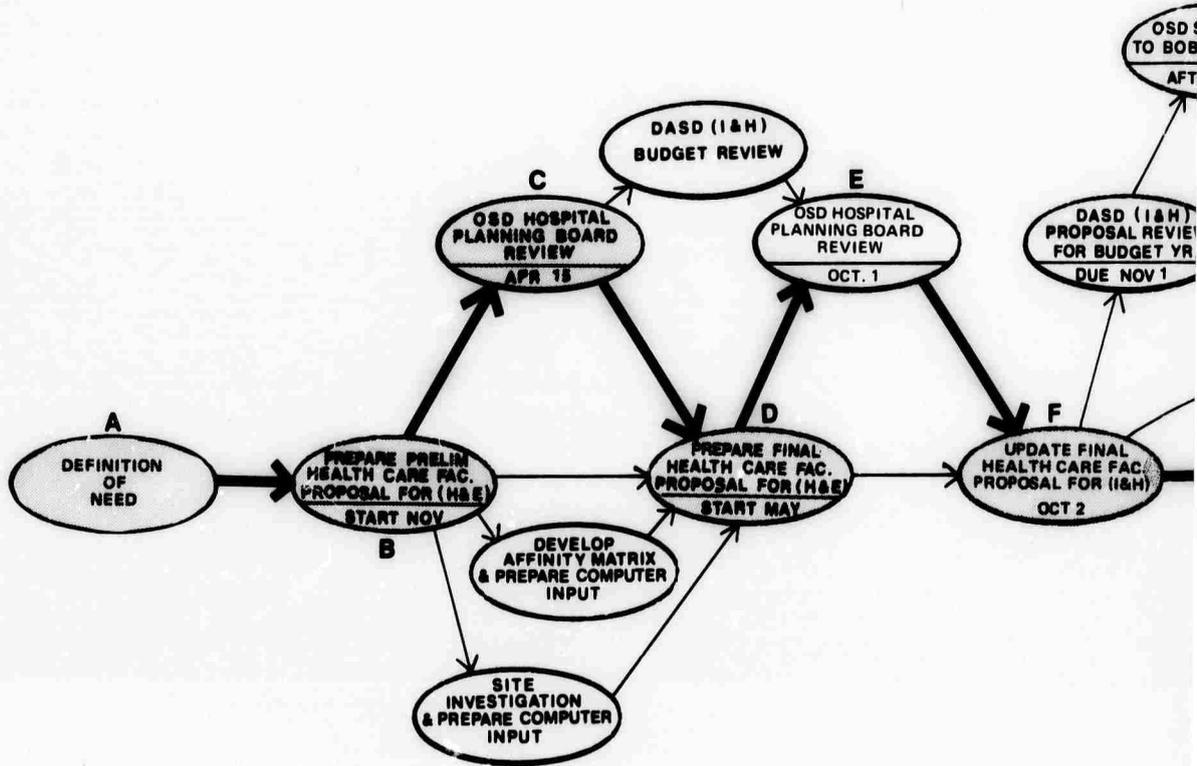
**FACILITY ADMIN.**

**FACILITY PROGRAMMING**

**DESIGN**

**OFF-SITE FABRICATION**

**ON-SITE FABRICATION**



**LEGEND:**

**CRITICAL PATH**

**NOTES:**

1. ACTIVITY "D" IS A JOINT ACTIVITY OF SGO & ENGINEERS.
2. A NEGOTIATED WORKING RELATIONSHIP BETWEEN DASD-H&E AND I&H USING THE FINAL PROPOSAL AS THE BUDGET JUSTIFICATION RATHER THAN 30% WORKING DRAWINGS CAN REDUCE THE REVIEW CYCLE BY 1 YEAR.

A

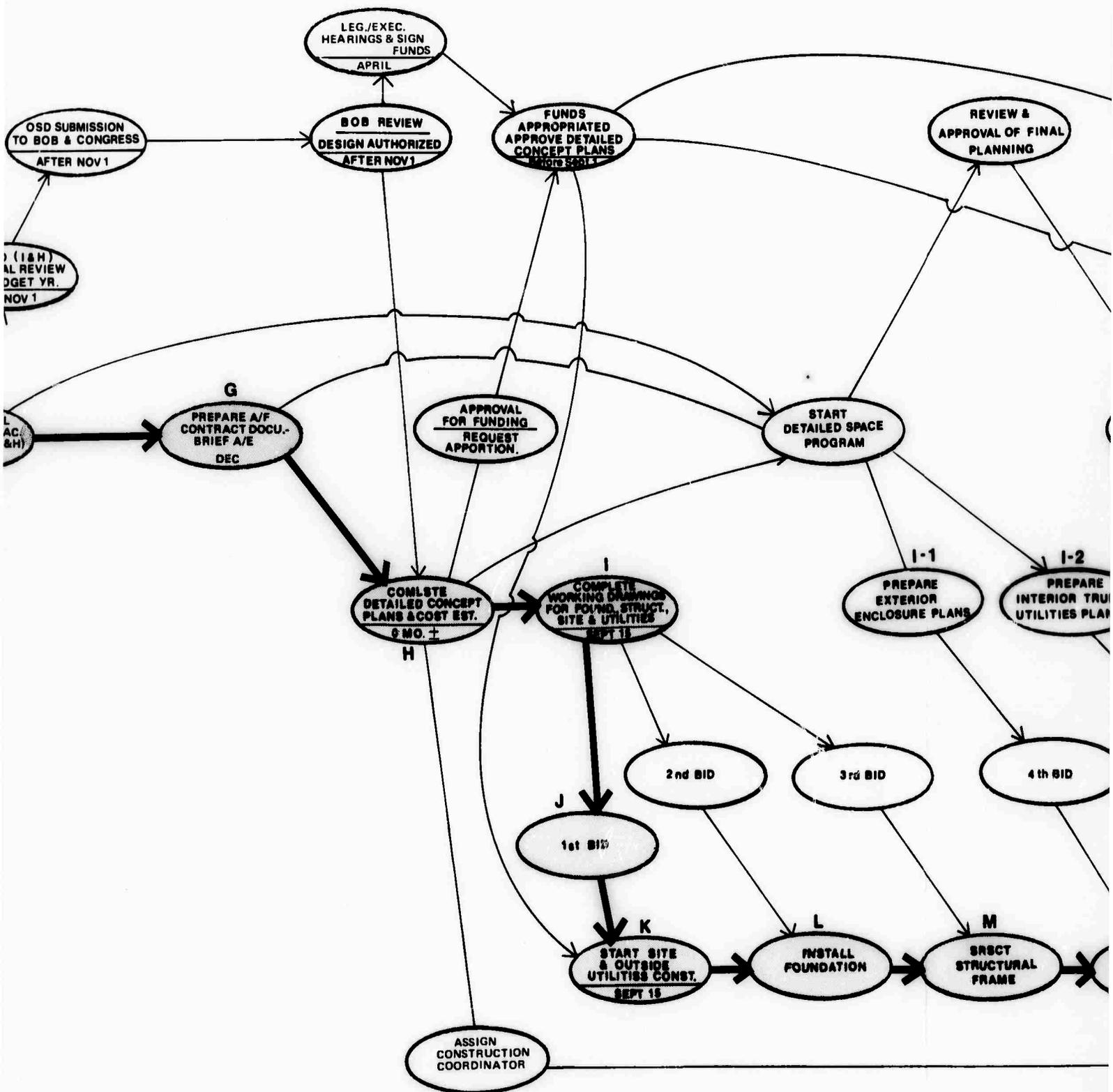
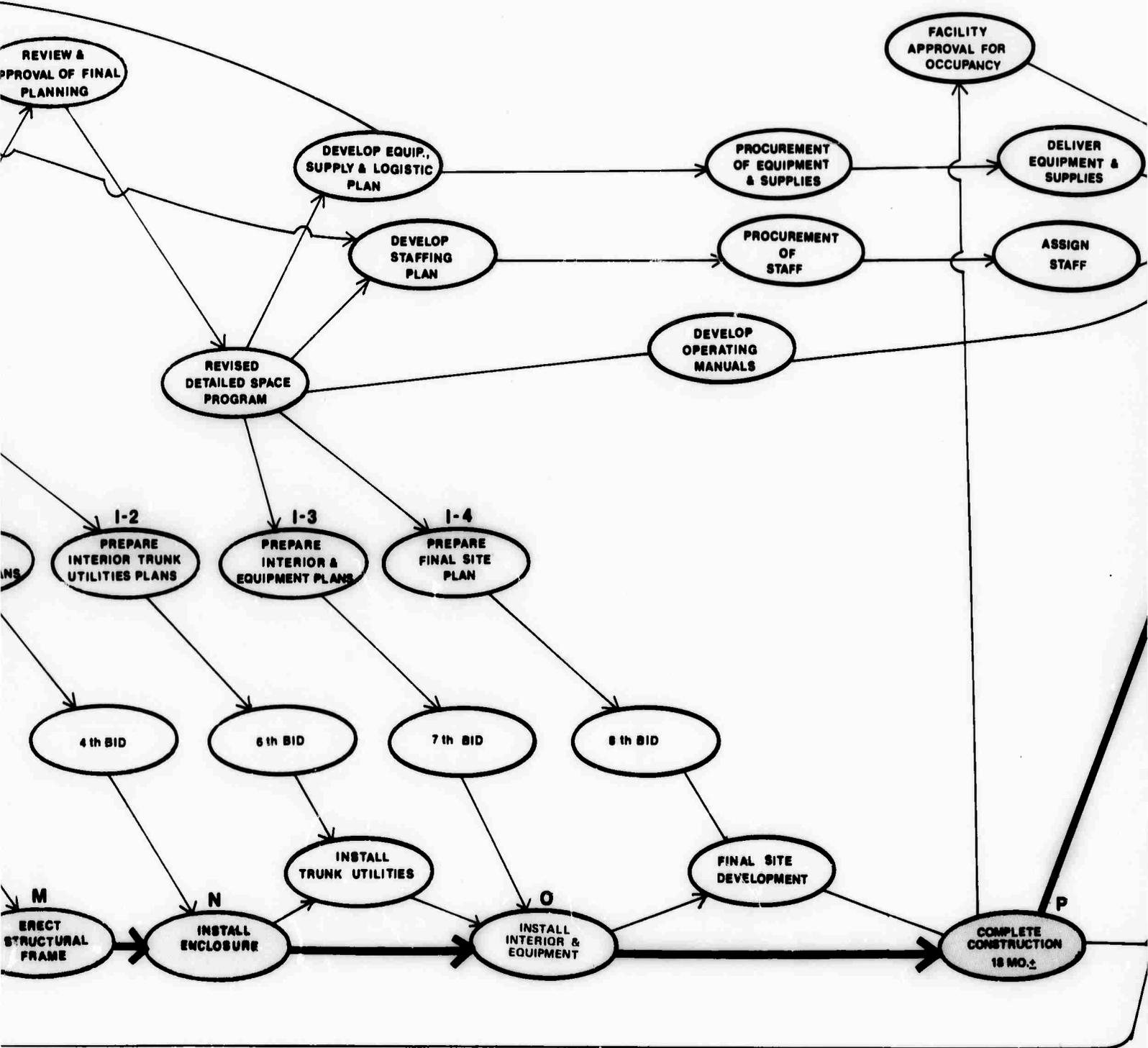


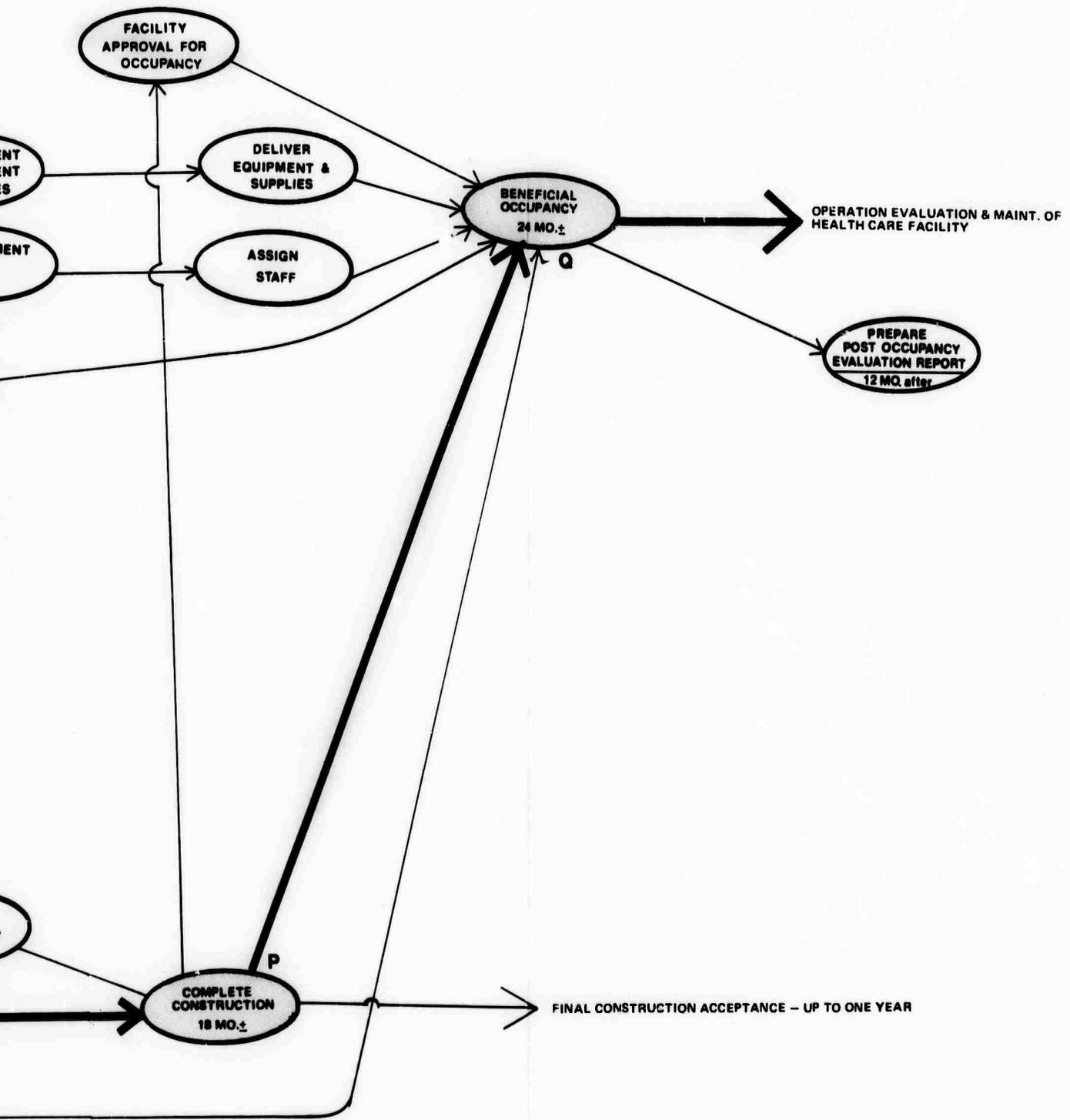
FIGURE 3.4.8 TYPICAL SEQUENCING OF ACTIVITIES FOR MULTITRACK SC

B



OR MULTITRACK SCHEDULING

C



D

where final health care facilities proposal and systems analysis work is accomplished. It is at this point the systems engineers and designers, and computerized applications such as those explained in Section 3.3.4, are engaged; then continue through step H, when the architect/engineer group has been selected to develop working drawings. The table of organization for project planning and acquisition (Table 3.4.2) recognizes that design/construction are in a phased schedule as shown in the activity network schedule, Figure 3.4.8.

Functions of the Project Officer include, but are not limited to, the following:

- Recommend the selection of the architect/engineer and negotiate the contract.
- Supervise architect/engineer.
- Review concept plans.
- Review working drawings.
- Make payments.
- Award construction contracts.
- Approve change orders.
- Arbitrate disputes.
- Assist construction manager in developing CPM.
- Report to service management.

TABLE 3.4.2

ORGANIZATION FOR PROJECT MANAGEMENT OF PLANNING AND ACQUISITION

General Functional Resources	Step D Facilities Proposal	Step H Detailed Concept Plans	Steps I-1 through I-4 Working Drawings and Specifications	Steps K through P Construction * of Facility
Project Officer	X	X	X	X
Systems Engineers	X	X		
Systems (architect) Designer	X	X		
Planning Consultant	X	X		
Cost Estimators	X	X	X	
Specification Writers			X	
Special Consultants	X	X	X	
Construction Manager				X
Architect/Engineer			X	
Construction Subcontractors				X

3.4.50

- Interpret contract.
- Approve inspection reports.
- Manage inspectors and office staff.

#### 3.4.4.5. Construction Manager Contracting

A construction manager is a prime contractor who will work with DOD and the design firm to formulate the project budget, furnish the designed with information on construction technologies and market conditions to ensure that a building design stays within budget, manage the procurement effort, supervise the construction of the building and provide, if desired, a wide range of other services. In order to discharge these responsibilities, the construction manager will be required to have a strong in-house capability which includes engineering, budgeting, cost estimating, scheduling, purchasing, inspection, management and labor relations, and personnel. The construction manager functions as a member of a team which includes a DOD hospital project manager and an architect/engineer firm. To carry out this contracting system, it is recommended that DOD qualify firms that desire to be considered for construction manager contracts. Concerns should be publicly invited to file their qualifications at DOD in advance of any formal proposals on a specific contract. It should be made clear that firms may submit a statement of their qualifications at any time for consideration in the same manner as architect/engineers. Solicitation of proposals shall contain a specified list of criteria which will be used to select the construction manager. Criteria may be used to include extent of previous experience.

For this service\* a negotiated fixed fee contract is preferred, but a lump sum fixed fee is probable. Fees range between 0.5 and 5.0%. Services performed under this contract include, but are not limited to, the following:

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\*The New York State Hospital and Mental Health Corporation is using this system to develop the \$125 million Lincoln Hospital and Mental Health Center. Turner Construction Company of New York City is acting as construction manager.

- Review work of architect/engineer and comment on it; suggest alternative solutions on products and materials.
- Solicit subcontractor bids; develop CPM schedule for entire contract.
- Process changes.
- Do site work, hoists, final cleanup and other minor tasks.
- Operate a field office.
- Establish and maintain the construction site.
- Coordinate progress of contractor and subcontractors.
- Investigate inspection reports.
- Assist in review of shop drawings.
- Expedite delivery of material and equipment.
- Review billings.

### 3.5. MANAGEMENT AND IMPLEMENTATION

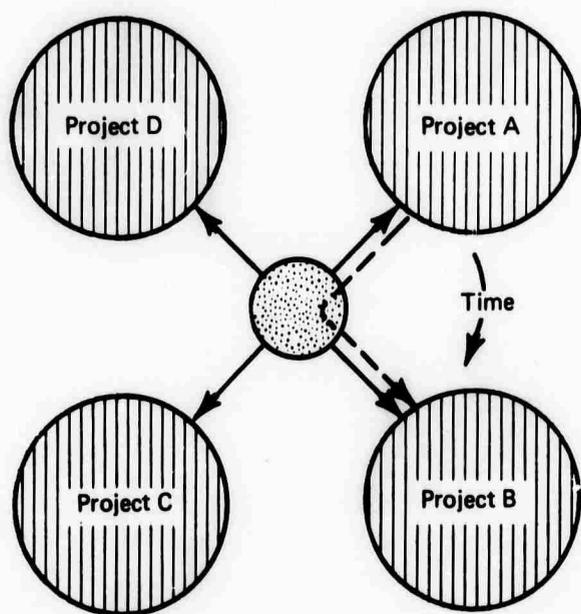
#### 3.5.1. MANAGING THE ACQUISITION CYCLE

This Section summarizes management responsibilities and work flow during the four phases of the Acquisition Cycle, the associated documentation, and the implementation of the report recommendations in the planning and construction of a prototype new generation military Fixed Health Care Facility.

In overview, the proposed Acquisition Cycle process encompassing definition, planning, design, and construction de-emphasizes the "custom project" aspect of new hospital procurement, substituting a central data bank of modular planning and design information having routine application to all military hospitals. The approach does not call for total reorganization of existing procedures, but the more centralized effort and greater degree of SGO activity and data input during the Planning Process portion of the Acquisition Cycle will call for re-allocation of personnel and resources. This re-allocation is shown schematically in Figure 3.5.1.

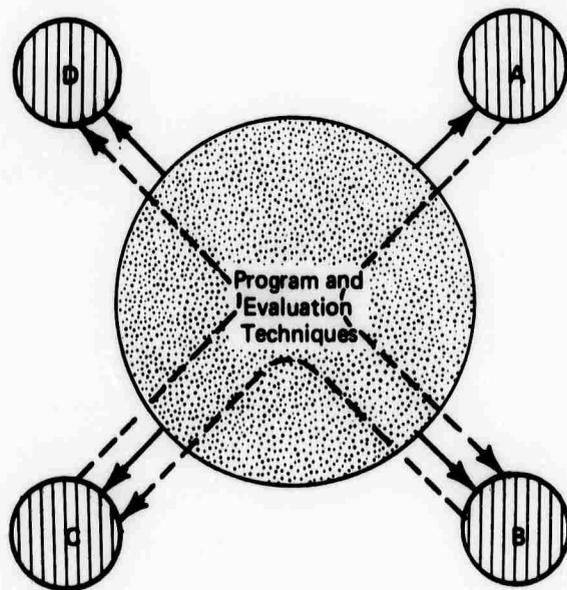
Currently, each military service has SGO facilities planning personnel centrally located (Army and Navy) or mostly decentralized (Air Force). Each service is working independently from their own central sources of information. This is illustrated by the existing procedure in Figure 3.5.1. It is recognized that to build a centralized information service, each service will be required to contribute to a common function of evaluation. The function as illustrated in the lower half of the figure will serve to organize operating hospital reports, post-occupancy evaluation reports and state-of-the-art information, synthesize it, and contribute to the central data bank.

A developed work flow chart, shown in Figure 3.5.3, indicates the individual steps at the four acquisition phases. Organizational responsibilities are shown schematically in Figure 3.5.2. This latter chart emphasizes the organizational functions and components necessary



Limited time spent on evaluation to produce DOD Planning Criteria. Excessive time in planning to arrive at construction program.

**EXISTING PROCEDURE  
-PROJECT ORIENTED-**



Minimize planning time but reallocate SGO manpower resources to the evaluation function to produce reliable planning data.

**RECOMMENDED PROCEDURE  
-PRODUCT ORIENTED-**

○ Areas designate comparative size of planning staff

● Programming and evaluation process

▨ Projects

--- Feedback

**FIGURE 3.5.1 RE-ALLOCATION OF ORGANIZATIONAL RESOURCES**

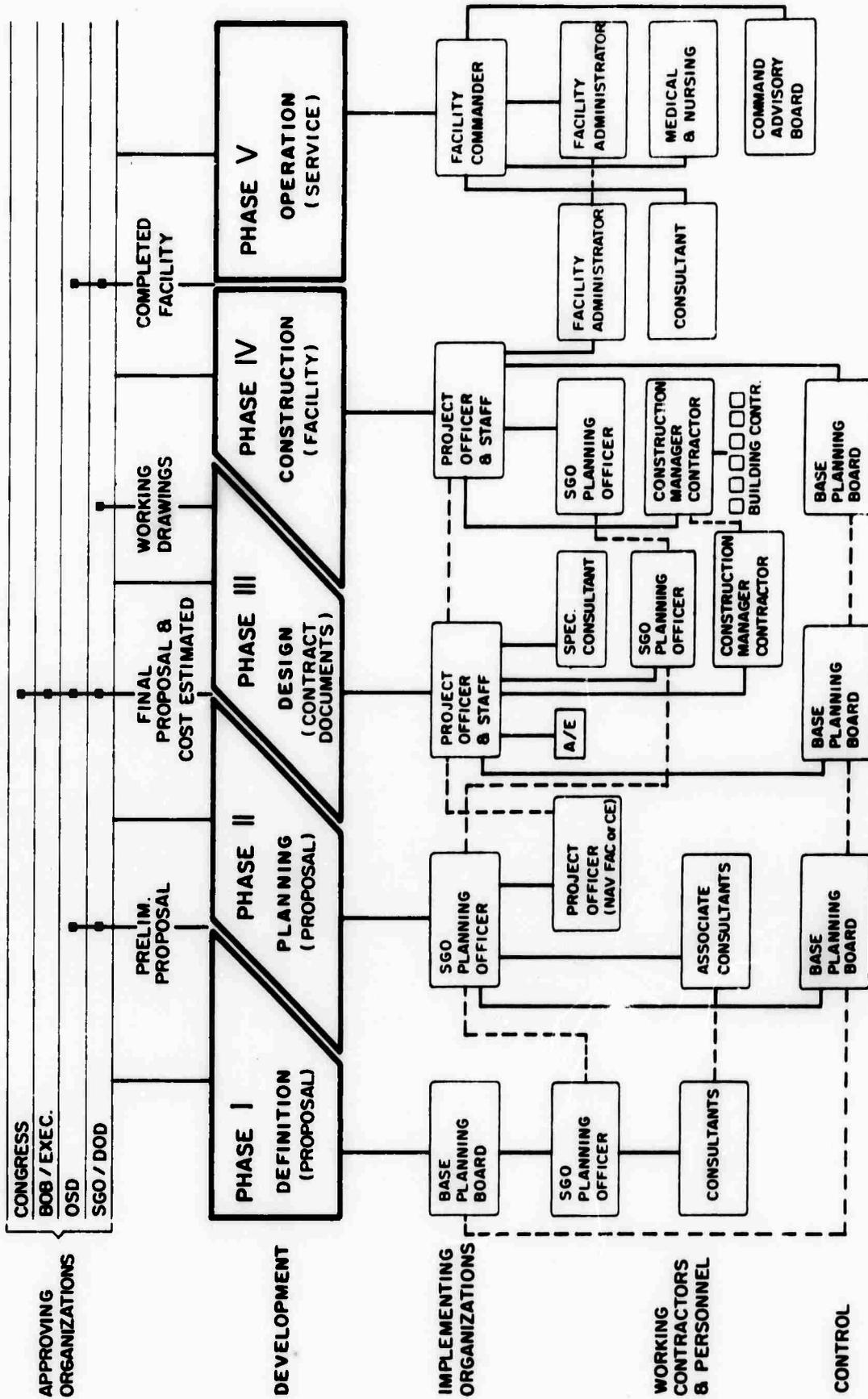


FIGURE 3.5.2 ORGANIZATION FOR IMPLEMENTING THE FACILITIES ACQUISITION CYCLE

to move a project through the acquisition cycle in a systems management fashion. Organizational components as shown in the lower half of Figure 3.5.2 change from phase to phase. Stability is provided by the Base Planning/Review Board during the acquisition period and then is transferred to the operating personnel.

No changes are contemplated in the present military operating Base Planning/Review Board procedures for identifying Fixed Health Care Facility needs, or the initiating proposal requests to the SGO's. A liaison officer from the SGO will be assigned to work with the base personnel in defining the scope, mission, and projected departmental case loads of the proposed facility. The liaison officer will have access to the central data storage bank with its latest current information on departmental performance in the form of Planning Units. From these he will assemble a Project Summary Chart during the Definition Phase giving a concise overview of the proposed facility showing all size, cost, staffing, logistics and support requirements for satisfying the identified needs. At this point, the Base Planning/Review Board may decide to re-examine the needs in view of the Project Summary Chart data, or to formalize their request to the SGO for the proposed facility as delineated.

The SGO hospital planning staff will now examine the proposed hospital function and budget estimate relative to all other requests for the fiscal year, and, using Project Summary Charts for all these requests, compare, evaluate and assess priorities. The request is next readied for submission by the SGO to OSD, BOB, and Congress for budget approval. A Project Officer will be assigned from the Corps of Engineers or NAVFAC to assist in the preparation of Form Diagrams and other data (pertaining to the building) required for inclusion in the Health Care Facility Proposal (see Section 3.5.2.)

While awaiting budget approval the SGO may proceed with preparation of the physical planning data that will be needed by the A/E contractor to design the building. Appropriate Departmental Performance Records of similar functional capability will be assembled from the data storage bank (see Section 3.3.5). At the same time, the Project Officer will prepare and assemble the written A/E contract documents, performance specifications, etc., (see Section 3.5.2).

The SGO Liaison Officer and the Project Officer will jointly select an A/E contractor, and thoroughly brief him on the purpose and intent of the A/E Contract Documents. The Project Officer will remain in close touch with the A/E contractor during his translation of the Form Diagrams into architectural schematic plans, obtaining, if necessary, additional Form Diagrams compatible with both the medical mission and the designer's sense of an appropriate building form.

The Project Officer next appoints a Construction Management contractor. As soon as the A/E contractor has developed his detailed concept plans and cost estimates, the Construction Management contractor is given the plans and asked to provide a second cost estimate as a check on the first. These cost estimates are then submitted by the Project Officer for the approval of DOD, OSD, and BOB. At the same time, the detailed concept plans are reviewed and receive design approval from the Project Officer and the SGO.

With receipt of Congressional budget approval and satisfactory cost estimates, the A/E contractor begins work on the final working drawings in the sequence required by the Phased Construction process. As drawings and specifications are completed, they will be issued by the Project Officer for competitive bids, and the building contracts awarded, again in accordance with the Phased Construction sequence. The work of scheduling fabrication, delivery, and on-site coordination of contractors will be done by the Construction Management consultant, reporting directly to the Project Officer.

The formal transition from the Construction Phase to beneficial occupancy for Operation will be jointly supervised by the Project Officer and the SGO Liaison Officer.

Summarizing the organizational responsibilities (shown schematically in Figure 3.5.2):

- Phase I (Definition) will be carried out by the Base Planning Review Boards and the SGO.
  
- Phase II (Planning) will be the responsibility of the SGO, assisted by a Project Officer from the Corps of Engineers or NAVFAC.

- Phase III (Design) will be accomplished by an A/E contractor reporting to the Project Officer, with liaison assistance provided by the SGO.
- Phase IV (Construction) will be supervised and coordinated by a Construction Management contractor reporting to the Project Officer.

Thus, the chain of responsibility for implementing the work does not differ widely from present acquisition procedures, but the activities within the Acquisition Cycle Phases and the overlap between the phases represent a significant departure from existing methodology.

It is also worth noting that the SGO planning process does not terminate with the compilation of the A/E Contract Documents Package; detailed planning of the proposed facility's logistical, staffing, and other operational needs continues throughout the later phases of the project. Updating of Planning Unit data in the storage bank is also a continuing process independent of the project. Both of these planning modes may furnish detailed or changed design input criteria throughout the development of the project.

### 3.5.2. DOCUMENTATION

#### 3.5.2.1. Present Documentation

Documentation for the planning and procurement of facilities is described in DOD directive 6015.17. The purpose of this directive is to define facility resource requirements in five specific documents responsive to health care delivery. The documents clearly respond to the present acquisition phases as shown in Table 3.5.1. Procurement and construction instructions are found in the manpower, material and construction organizations, but the burden of clearly defining facility needs rests with the Surgeon General Offices.

The second principal objective of documentation is to define funding requirements, compete for program position in the Five-Year Military (hospital) Construction Program, and convey the need for funds through the BOB to Congress. This objective, to seek funding, has had a marked effect on how the acquisition process is structured. As a result, the conflict arises between short range thinking of administrative and Congressional bodies and long range program demands. The DOD in 1961 introduced the planning, program, budgeting system (PPB) as a means for dealing with this problem.

The present documentation is still largely responsive to past short range planning attitudes, whereas the documentation proposed in this report places the emphasis on long range system operations, growth, and change.

#### 3.5.2.2. Proposed Documentation

During the course of this contract, the problem of documentation for facility acquisition was studied extensively for several other reasons than its response to long range planning. They are:

- Responsiveness to base health care need
- Quantity and quality costs of development

TABLE 3.5.1  
PRESENT DOCUMENTATION FOR FACILITY ACQUISITION

<u>PHASE</u>	<u>DOCUMENT</u>	<u>DESCRIPTION</u>
Planning	Project Proposal	Translates need into resources and costs.
Programming	Preliminary Studies	Translates need into resources and costs in more detail. Emphasis on Space Program.
Design	Concept Plans	Translates Space Program into layout and building form. Engineers principal response to the Surgeon General to show physical form.
Design	Preliminary (30%) Working Drawings	Converts concept plans into construction drawings and serves to harden cost working estimate.
Design	Final (100%) Working Drawings	Finalizes all thinking into construction requirements.

- Efficiency in acquiring facilities, and
- Content, coordination, and effectiveness.

The results of the study have generated recommendations that are found throughout this volume. A coordination of these recommendations as they especially apply to documentation is shown in Figure 3.5.3, Documentation Flowchart. This flowchart recognizes a group of centralized permanent activities comprising 1) the operations and maintenance of the completed health care facility, 2) an evaluation of its performance from continuous reporting and 3) management of the data bank containing planning criteria and planning units. All of these activities now exist in the Department of Defense/SGO organization(s). The efficiency of organizational effort to provide functionally current facilities, however, requires an improved organizational system and better operational procedures. Further study of an evaluation activity is outlined in Section 6.6.

Two important observations are made: the first is a recognition of the permanent activities and the second is the importance of and the need to make this activity more effective.

The second group of activities indicated in Figure 3.5.3 consists of the project-peculiar activities, required during the acquisition cycle. These activities are also continuing permanent organizational functions, but operationally decentralized. For example, implementation and planning are primarily military base oriented, while design and construction are functions of field offices of the engineers (OCE & NAVFAC).

The document flow in Figure 3.5.3 is a continuous cycle, initiated by drawing information from a current and well-managed data bank.

A list of the documents in the proposed system is given in Table 3.5.2. The major changes from present documents are 1) the Health Care Facility Proposal which combines the project proposal and preliminary study; 2) the A/E Contract Document Package which contains the Project Summary Chart (Section 3.3.3), Form Diagrams (Section 3.3.4), and specific instructions to the architect/engineers; and 3) the Detailed Concept Plans which combine the present concept plans and preliminary (30%) working drawings.

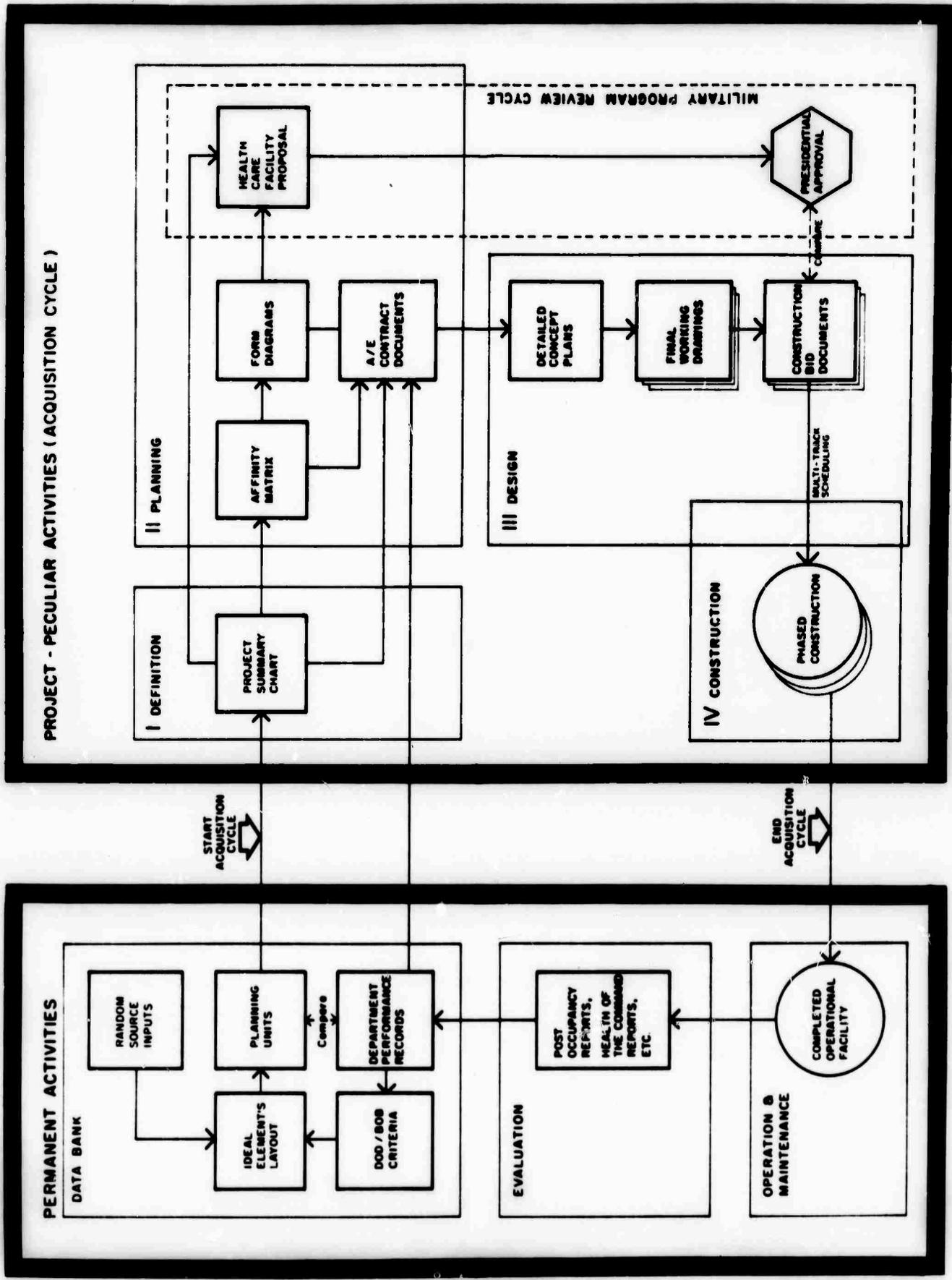


FIGURE 3.5.3 DOCUMENTATION FLOW CHART

TABLE 3.5.2

COMPARISON OF PRESENT ACQUISITION DOCUMENTS WITH PROPOSED DOCUMENTS

<u>PRESENT</u>	<u>PROPOSED</u>	<u>EXPLANATION</u>
Project Proposal Preliminary Study	Health Care Facility Proposal	Coordinated document containing the definition of the facility, its capital and operating costs and its expected performance. Used for two purposes: for obtaining authorized funds and resources procurement.
A/E Instructions	A/E Contract Documents Package	Instructions to the Architect/Engineers and includes facility definition, form diagrams and a list of references.
Concept Plans Preliminary (30%) Working Drawings	Detailed Concept Plans	An interpretation of the facility in layout, building shape, preliminary calculations, outline specification and cost estimates.
Final (100%) Working Drawings	Final Working Drawings	Construction requirements carrying Detailed Concept Plans to finished working drawings.
Construction Bid Package	Same	Contains plans, specifications and contract requirements in order to receive a responsive construction bid.

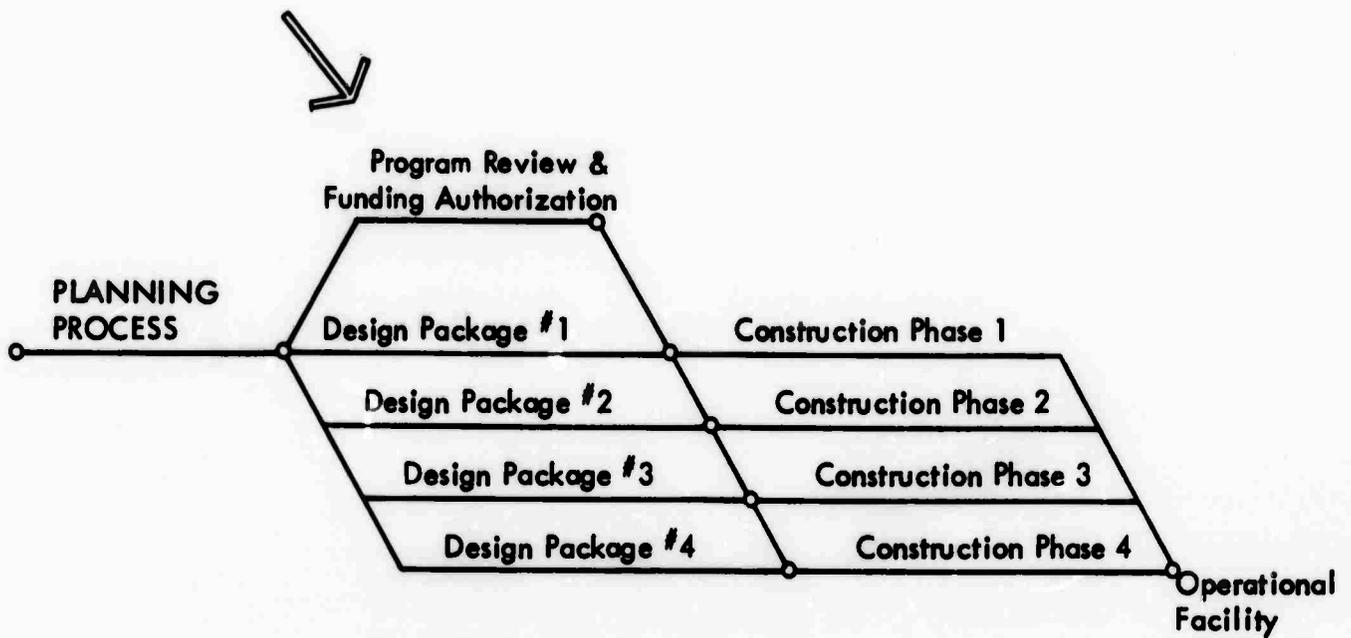
### 3.5.2.3. Health Care Facility Proposal

This document defines the facility, states its purpose and performance, justifies its need and provides an estimate of costs. It is the initiation of a coordinated effort to define resource requirements, i.e., buildings, equipment, staffing, logistics and administration for a proposed health care facility. It also sets forth systems needs, their effect on the existing resources inventory and tells what changes need to be brought about in the existing inventory and systems to cause integration, thus providing an efficient new system. Central planning criteria are used.

This document, after its completion, serves two purposes. The first is a justification for health care facility funding; it is the backup to the DD 1391 for inclusion in the Military Construction Program for the budget year and The Five Year Program. The second is information for facility design and construction. It is expected that both of these activities will be scheduled in parallel so that an apportionment request will have been filed for the first construction contract package. The apportionment can arrive in the budget office either prior to or at the same time as the appropriation; an overview of this action is shown in Figure 3.5.4.

The Health Care Facility Proposal will include the following parts:

- I. Project Identification
- II. Basis of Requirement, Mission, Population Served
- III. Programs, Inpatient Care, Outpatient Care including Dental, Teaching and Research
- IV. Project Summary Chart and Form Diagrams
- V. Sections Supporting the Project Summary Chart
  - Definition of facility size by planning units



**FIGURE 3.5.4 OVERVIEW OF MULTI-TRACK SCHEDULE FOR FACILITY PLANNING, REVIEW OF PROGRAM AND FUNDING, PROCUREMENT AND OPERATIONS**

- Staffing plan
  - Department performance requirements (existing and proposed)
  - Movable and fixed equipment notes
  - Operational requirements
  - Utility, material handling and other subsystems requirements
  - Existing (hardware) facilities--only those interfering and changing as a result of the new facility
- VI. Standard or general building specifications embodying modular building components, interstitial space and long spans--technical requirements for adaptable buildings
- VII. The Role of Existing or Proposed Community Health Care Facilities as they are able to interact with the new military facility
- VIII. Capital Budget & Operational Costs
- IX. Administration, Notes and References

Appendices--as they are required to support the proposal

3.5.2.4. A/E Contract Documents Package

The preparation of the document is a joint effort of the SGO liaison officer and the Project Officer.

The contents of this package include the following:

- Purpose, location, population group, and scope of project found in the health care facility proposal

- Project Summary Chart—described in Section 3.3.3, showing functions, space requirements and staffing
- Site Survey--topography and subsurface soil investigation; utility locations and indicated points of connection
- Form Diagrams--a set of alternatives as described in Section 3.3.4
- Reference documents and criteria; including access to the data bank through members of the project management staff (standard requirements)
- Building System requirements specifications as outlined in Section 3.4.2 and a description of facility constraints as they affect the building system
- Departmental and functional performance records (if any)
- Contract requirements including products, tasks, multi-track schedules and progress reporting (standard requirements)
- Administrative information relating to security clearance, access to the site; procurement of references; project organization and constraints
- Other pertinent information for a clear understanding of the A/E role relative to the Acquisition Process

It should be made clear that the A/E's role is that of a designer. The A/E Contract Documents Package provides information on alternative building shapes and internal department and functional relationships. Thus, the A/E does not need to become preoccupied with building shape and affinities and can devote his energies to systems, design and architecture.

### 3.5.3. IMPLEMENTATION

The next steps, needed to implement the recommendations of this report, fall into two general categories; the first is generally concerned with the Planning Process:

- Development of a systems data bank of planning criteria, and improved data processing procedures and programs.

The second category concerns the Procurement Process:

- Construction of a prototype New Generation Hospital using modular design principles, multi-track scheduling, and systems building.

The research, evaluation, and development activities to be implemented and contained in these two categories are outlined below. It is recommended that the work in the two categories be done in tandem; that is, construction of a New Generation Hospital should not await complete development of the new Planning Process. A completed facility, designed and built for optimum internal reconfiguration and adaptability (possibly to a higher degree than would normally be required, to allow experimental configuration), will provide valuable feedback input to the data bank's "ideal" layouts and Planning Unit data.

Implementation steps include the following activities:

#### 3.5.3.1. The Planning Process

- (a) Develop detailed plans of "ideal" hospital functions, based on BOB Criteria, DOD Directives, existing military and civilian hospital layouts, and random source information.
- (b) Analyze the "ideal" plans, BOB Criteria, DOD Directives, and random source information, to generate Planning Unit data.

- (c) Design the categories, coding and format of the Planning Units, and add the data generated in (b) to establish the initial Planning Unit
- (d) Assemble Departmental Performance Records (as recommended in Section 3.3.5), for all existing facilities.
- (e) Compare the data in the initial Planning Unit catalog with the Planning Unit data derived from an amalgam of the Department Performance Record information.
- (f) Revise the BOB Criteria, "ideal" plans, and Planning Unit data to conform to real world experience.
- (g) Develop criteria and a methodology for the generation of Affinity Matrices (Section 3.3.4), for optimum resolution of military hospital element proximity requirements.
- (h) Design a computer program specifically geared to the needs of military Fixed Health Care Facility planning.
- (i) Generate hypothetical hospital element configurations, and other experiments, for testing and evaluation in the prototype New Generation Hospital.

#### 3.5.3.2. The Procurement Process

- (j) Develop detailed Building System performance specifications.
- (k) Select a proposed Fixed Health Care Facility as the target prototype New Generation Hospital. Assign the engineer Project Officer.
- (l) Carefully select an A/E Contractor on his ability to work with modular principles and award him a special design and development contract.

- (m) Working closely with the A/E Contractor, and using Form Diagrams generated by the RELATE (or equivalent existing computer program), design the hospital to the specifications developed in (j), including long-span trusses, interstitial mechanical floors, standard components, and a preferred grid.
- (n) Select a construction management contractor and assign as his first responsibility the implementation of multi-track scheduling.
- (o) Evaluate the design for cost, construction time, and operational feasibility.
- (p) Working closely with the Construction Management Contractor, advertise, evaluate and award the construction bids. (Note: For the prototype hospital, the multi-track scheduling should overlap the preparation of working drawings.
- (q) Carefully evaluate the Phased Construction process.
- (r) Work closely with the SGO hospital planners in developing and carrying out configuration experiments in the completed hospital.
- (s) Working closely with the SGO planners, the A/E Contractor, and the Construction Management Contractor, evaluate the building performance, and develop new building materials criteria, dimensional standards, and performance specifications for a new set of components and equipment conforming to the preferred grid.

It is expected that existing SGO resources can be used to develop items (a) through (g) through a reallocation, at least temporarily, on a task force basis as depicted by Figure 3.5.1. The implementation would require an understanding and need for the action by the OASD (H&M) and OASD (I&H). Engineering/Construction skills should be part of the process.

Item (j) has been in the development stage in school buildings (SCSD in California) and is being tested in the HUD "Operation Break-through" program. The National Bureau of Standards is concerned with these programs. Also the Facilities Engineering Construction Agency of the Federal Department of Health, Education and Welfare is investigating building performance specifications for hospitals.

Items (k) through (s) can be carried out within existing regulations but existing procedures will require revisions to correspond to recommendations.

It is not the intention of the implementation of a prototype hospital to disrupt existing practice but to test a process and technology for a comparison with what is, before adopting new ideas.

### 3.6. COST ANALYSIS

#### 3.6.1. INTRODUCTION

It is difficult to analyze the costs associated with the innovations discussed in this volume, because most of the ideas are too new to have permitted much practical experience with them. Thus, savings attributable to them, or expenses associated with them, must rely to a considerable extent on judgment. In Section 6.7 we have examined the costs of several hypothetical redesigns of the hospital at March AFB in considerable detail, using the services of an independent professional cost estimator, and we have collected the opinions and estimates of a number of professionals in architecture, design, and construction; that information furnishes some of the basis for discussion of costs in this section.

In other cases, we have exercised our own judgment and provided as much supporting detail as is available. In general, we have tried to lean in the direction of conservatism in estimating savings attributable to innovations in the planning process, design, and construction.

#### 3.6.2. COMPARISON OF CONSTRUCTION COSTS AND OPERATING COSTS

From the functional cost analysis given in Section 1.6 it can be seen that annual operating expenses in military hospitals are comparable to their capital costs. In Table 3.6.1 we present the figures for the three hospital studies in detail.

TABLE 3.6.1  
CAPITAL AND OPERATING COSTS IN MILITARY HOSPITALS  
(thousands of dollars)

	FORT DIX (occupied 1960; addition 1964)	JACKSONVILLE (occupied 1967)	MARCH (occupied 1965)
Original Capital Cost	\$10,401	\$8,922	\$5,277
Replacement Costs <sup>a</sup>	14,900	9,810	6,500
Annual Operating Expenses <sup>b</sup>	14,992	6,753	5,935

3.6.1

Arthur D Little, Inc

- a. Converted from original costs to 1970 dollars using Engineering News Record's Building Cost Index given in Table 6.7.2 (Vol. 6); thus, costs shown represent replacement costs as of 1970.
- b. Annual operating expenses for FY 1969, including military salaries and costs of "free" services as shown in Section 1.6.

This comparison illustrates the well-known fact that operating expenses over the lifetime of a hospital completely dominate the original capital expenditure. Therefore, increases in capital expenditures which hold promise of reducing operating expenditures are usually justified. Unfortunately, as we remarked above, experience with new methods of design and construction is insufficient to demonstrate their impact on operations; but it is this fact which has led us to emphasize innovations in the planning process which relate operating needs to the building, particularly the use of planning units, modular design, form diagrams, and adaptable buildings.

### 3.6.3. BENEFITS AND COSTS OF DESIGN AND CONSTRUCTION INNOVATIONS

While many of the concepts introduced in this volume and in Volume 9 (Building Systems for Military Hospitals) have merit in themselves, their full value as parts of a systematic approach to the development of facilities is only realized when they are used together. Innovations in the planning process, especially planning units, modular layouts, and form diagrams, lend themselves to buildings whose structure reflects the modular form and whose construction facilitates adaptation to changing needs. Collectively, these innovations attack the current problems of military hospitals\*:

- Lack of flexibility to adapt to changes
- Long design and construction time
- High costs for construction

- Poor quality or poor performance
- Problems engendered by incompatible subsystems

#### 3.6.3.1. Planning Units and Form Diagrams

Planning units and form diagrams, as explained in Section 3.3, improve communications among the various participants in the offices of the Surgeons General, the Department of Defense, and the architects and engineers. To a degree, they transfer some of the design responsibility from the architect/engineer to the planning offices of the SGO's, so that potential savings on fees for the A/E appear as expenses to develop planning units and keep them up to date.

We estimate that the effort for developing and maintaining planning units would require about ten men. If this work were contracted for, the cost would be about \$400,000 annually. This figure is about equal to the estimated savings on the A/E fees, amounting to 0.75% of the annual new construction budget. The latter was \$55 million in FY 1970.

However, planning units and form diagrams make possible multitrack scheduling, discussed below, and help to make buildings systems more flexible by interspersing "hard" areas, where alterations are difficult, with "soft" areas where alterations are comparatively easy. This is accomplished through the use of a computerized layout program, as discussed in Volume 6, Sections 6.4 and 6.5.

#### 3.6.3.2. Modular Design

Modular design and building systems are beneficial because they provide standard solutions to many of the fitting and layout problems encountered in every building design. By providing zones for different parts of the

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\*These problems are enumerated and discussed in Volume 9, which uses the extent to which they are solved as evaluation criteria for various building systems.

structure and for various utilities, and by standardizing dimensions, they make the design problem for each new building that much easier. The design time can be reduced, because various teams can be deployed simultaneously and because there is less necessity for detailed verification to avoid incompatibilities (such as those between plumbing runs and heating ducts).

According to Rex W. Allen, Architects, San Francisco, who have made extensive use of modular designs in their practice, design time can be reduced by as much as 45%. To the extent that this saving in time can be applied to the A/E fee, a cost saving can be realized, amounting to an estimated 1% of the construction cost (A/E fees, as a rule, range between 6% and 8% of construction costs.)

As discussed earlier, military hospital construction projects frequently must be reduced in size because of limited funding. Under current procedures, where it is difficult to redesign the structure, cuts tend to be directed to specific areas of the hospital, rather than a balanced reduction. If, however, a fixed health care facility uses modular design and building systems, these changes can take place with less delay and less reduction in efficiency of functional relationships. The building can be more easily redesigned in a balanced way, because of the simplicity offered by reference grids and modular design.

#### 3.6.3.3. Multitrack Scheduling

One of the important benefits of planning units, form diagrams, modular design, and building systems is that the construction cycle can be shortened by overlapping certain phases of construction. Because many of the problems of coordination are reduced through modular design and building systems, it is easier to use more than one contractor for different phases of building construction. This has the advantage of enhancing competition, because more contractors are able to bid on portions of the job.

A shortened construction time can be expected to reduce costs in several ways. One is the inescapable fact of inflation and increasing labor rates. There is little reason to expect these contributors to high building costs to abate; their effects are normally built into construction bids. Over

the past three years, construction costs have been increasing about 12% per year. (See Figure 6.7.2 in Volume 6.) We have estimated that a three-year construction project could be reduced by perhaps nine months through multitrack scheduling. If the inflation rate is 12%, this yields a reduction in cost of 4%.\*

Another cost reduced by shorter construction time is that of services to be provided by the new facility. These costs may be explicit, as CHAMPUS costs would be, or they may be hidden in travel and transportation of patients to more distant facilities or in operations at a presumably obsolete facility. Estimating such costs as a general matter is not feasible, and we shall not attempt to do so here, but they are real costs which can be estimated in any specific situation.

Contributing to the feasibility of multitrack scheduling is the concept of using prefabricated components. The advantages are improved quality control and reduction of on-site labor. The latter might be presumed to reduce costs, but experience has been variable, and expected savings are often eaten up by transportation costs and labor union requirements. It is almost impossible to generalize, so we shall not count them as either costs or savings.

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\* To compute the effect of inflating costs on the total price, we proceeded as follows: Suppose that the level of expenditure, K, per unit time is constant if there is no inflation. When inflation occurs at a constant rate r, the level of expenditure is  $K(1 + rt)$ , where t is time from initiation of the project. Let  $C_c$  be the total cost for construction under conventional methods and  $T_c$  be the total time for construction.

$$C_c = \int_0^{T_c} K(1 + rt) dt = KT_c \left(1 + \frac{1}{2} r T_c\right)$$

(continued on next page)

#### 3.6.3.4. Adaptable Buildings

The concept of using building systems in conjunction with other innovations to the planning process goes a long way toward achieving the desired goal of constructing flexible buildings which can adapt to changes unforeseen during design. The importance of this benefit is hard to overstate; at the same time, however, it is difficult to be quantitative about its merit, because buildings built in accordance with the principles of flexibility discussed in Volume 9 do not have a long enough operating history to ascertain the impact on alteration costs. Nevertheless, it is possible to provide some estimates of the potential reduction in alteration costs.

As discussed in Section 6.7.12, the use of interstitial space may add to the cost of original construction. There is conflicting evidence in this regard: some people claim that construction costs rise when interstitial space is used, because the volume of the building is increased; others argue that this rise is cancelled or even reversed by reduced labor costs resulting from less interference among different

Under multitrack scheduling the level of expenditure per unit time must be higher to accomplish the same work in less time. Let  $T_m$  be the shorter period for construction under multitrack scheduling. Then, if there were no inflation, the level of expenditure would have to be  $KT_c/T_m$ . To account for inflation at the rate  $r$ , the level of expenditure is  $KT_c(1+rt)/T_m$ , and the total cost,  $C_m$ , is:

$$C_m = \int_0^{T_m} K \frac{T_c}{T_m} (1+rt) dt = KT_c \left(1 + \frac{1}{2} r T_m\right)$$

The ratio of total costs is

$$\frac{C_m}{C_c} = \frac{1 + \frac{1}{2} r T_m}{1 + \frac{1}{2} r T_c} = 1 - \frac{1}{2} r (T_c - T_m)$$

utilities, but they add that it will be a while before contractors become used to the concept and the savings they can realize. In any event, the change in construction cost occasioned by interstitial space is not large; we have settled upon a 5% increase as a fair estimate.

The effect on alteration costs must be estimated, because there is too little operating experience for firm figures to have been developed. The Veterans Administration has estimated a 50% reduction in alteration costs for its new hospital at San Diego. Detailed analyses of available partition systems reported in the Spring 1969 News Letter of the Building Systems Information Clearing House show that partition remodeling costs were reduced by 47%. To estimate potential savings, we have considered alteration to a moderately complex portion of the hospital such as patient rooms or outpatient examining rooms. For such areas the costs of alterations appear in changing partitions, finishes, plumbing, heating and air conditioning, and electrical lines. The changes, which are itemized in Table 3.6.2, are attributable to the following factors:

- As trunk utilities are built in interstitial spaces, the outlet components can be more easily relocated within the interstitial spaces.
  
- Partitions are not completely demolished as in conventional construction, but can be relocated or stored (30-50% recovery).
  
- The hospital maintenance crew is able to carry out more of the alterations work, and contractors are not always needed.

TABLE 3.6.2  
 CHANGES IN ALTERATION COSTS  
 BETWEEN CONVENTIONAL AND ADAPTABLE BUILDINGS

<u>Subsystem</u>	<u>Weight</u> <sup>a</sup>	<u>Estimated Change</u>
Partitions	0.46 <sup>b</sup>	-28%
Finishes	0.09 <sup>c</sup>	-60
Plumbing	0.05 <sup>d</sup>	0
HVAC	0.27 <sup>e</sup>	-33
Electrical	<u>0.13</u>	<u>-36</u>
	1.00	Avg. -32%

- a. Represent the portion of the job of alteration attributable to each subsystem
- b. 25% of this is for removal of partitions, 75% for installation
- c. Finishes of walls only
- d. Assuming no changes in major waste lines
- e. Relocating secondary ducts

Some other benefits are not accounted for, such as elimination of the cost of not making changes and extension of the useful life-span of the building. The cost of not making changes is, of course, almost impossible to quantify, although most people will acknowledge that not making changes as needs change can impair efficient operation.

#### 3.6.4. SUMMARY OF IDENTIFIABLE COST CHANGES IN ANNUAL MILITARY CONSTRUCTION BUDGET

The FY 1970 construction budget for the Department of Defense amounted to \$60 million, of which \$55 million was intended for new construction (including additions) and \$5 million for alterations of existing structures. Had the recommendations discussed in this volume been in effect, the total impact on the budget would have been as estimated in Table 3.6.3. The net saving amounts to \$1,600,000.

We have omitted from these computations all of the benefits which we were unable to quantify, including the following:

- Costs for inefficiency introduced by budget cuts or delays which raise operating costs, raise CHAMPUS costs, or increase loads on other facilities;
- Improved quality of construction;
- Reduced maintenance costs during lifetime of buildings; and
- Longer useful lifetime of buildings.

**TABLE 3.6.3**  
**ANNUAL COSTS AND SAVINGS**  
**ATTRIBUTABLE TO INNOVATIONS IN THE**  
**PLANNING PROCESS AND CONSTRUCTION**  
**(thousands of dollars)**

	<u>Costs</u>	<u>Savings</u>
Planning Units and Form Diagrams	\$ 400	\$ 400
Modular Design	-	1% x \$55M = \$ 550
Multitrack Scheduling	-	4% x \$55M = \$2,200
Adaptable Building Systems 5% x \$55M	= <u>2,750</u>	32% x \$ 5M = <u>\$1,600</u>
	\$3,150	\$4,750

Net savings on total new construction and alteration budget of \$60M for FY 1970: \$1,600,000.

### 3.6.5. APPLICATION TO ALTERATIONS AND ADDITIONS

While the innovations developed in this study have been aimed at a "new generation" of military hospitals, commencing with the prototype hospital to be constructed in the next few years, it seems clear that many existing military hospitals will not be replaced but only altered or added to. Therefore, the extent to which the innovations are applicable to alterations or additions is an important measure of their value.

In the case of alterations, it is possible to overlay the modular concept on existing facilities and to make use of the planning unit, but it is not easy to conceive applications for the other new methods. In the case of additions, all of the new methods are applicable. Since new additions can themselves be made more adaptable, it makes sense to consider adding departments where change in the future is likely to be needed (such as laboratory and radiology, where the technology is changing rapidly), even if current needs point to expanding other departments; in this way, other departments may be expandable into vacated space, and accommodation to future change is facilitated.

### 3.7. AREAS FOR FURTHER RESEARCH AND DEVELOPMENT

The purpose of this section is to indicate some of the areas which require further research and development. Many problems have been uncovered in this study, and many answers have been developed. However, many problems remain unsolved.

#### 3.7.1. ANALYSIS OF PROGRAM REQUIREMENTS

It is important to develop a program which is highly responsive to a statement of needs, but the accuracy of that statement is equally important. Inaccuracies lead to premature obsolescence and unnecessarily high operating costs. There is a need for research into improved analytical methods such as the following:

- Structured survey methods to determine meaningful morbidity data;
- Automation of data collection, analysis, and reporting;
- Conversion of information into accurate and usable detailed requirements; and
- Analysis of trends and potentials for change and of ways to accommodate them at the outset.

#### 3.7.2. AFFINITY MATRIX METHODOLOGY

A more rational and systematic method is needed for determining relationships among the functional elements of a health care program to yield affinity matrices which are accurate, meaningful, and useful.

The analysis of a program (and of medical facilities in general) to gain an understanding of functional interrelationships is an ongoing effort. This information is expressed in the form of an affinity matrix, the value of which depends upon its ability to communicate the proper understanding. Further research is needed into the methodologies of affinity matrix generation to include the following:

- Recognition of the component factors (materials, people, utilities, and information);
- Necessity for qualitative and intuitive input;
- Formats for data collection, collation, and communication;
- Recognition of areas where data are subject to change; and
- Possibilities with respect to standardization of matrices.

### 3.7.3. COMPUTER TECHNOLOGY FOR PLANNING

Some operations in the proposed acquisition cycle require the use of computers. There are many areas where the computer can become an important accelerating and labor-saving device in the planning of military health care facilities.

One area, which has been described in Section 6.4, is computer-aided design. The computer is used to help convert basic program data into layout proposals known as form diagrams. By bridging the gap between the Surgeon General's Office and the architect/engineers, the computer improves communication and makes the final result more responsive to the stated needs and requirements. However, more development is required. Though computer programs are available today which are operative in this area, none has all of the capabilities that would make the working situation ideal. Further research and

development is necessary to produce a computer system for design. Such a system must have several capabilities, some of which are already available. The system must:

- be highly interactive, allowing for human judgment and creativity;
- produce a result which is easily interpreted by people of all disciplines involved;
- be capable of generating high-quality (if not optimal) layout proposals;
- evaluate layout proposals, relieving humans of this task in all areas where quantitative judgment is possible; and
- incorporate into layout generation and evaluation all important inputs, such as: interrelationships among programs elements; constraints imposed by the construction site; structural and design constraints and criteria; fire, medical, legal and safety requirements; operating costs; adaptability; workability; and efficiency.

Computerized manipulation of data is possible because of the highly structured nature of planning units. An important area will be the development of a computerized system for the generation of the Project Summary Chart (PSC) described in Section 3.3. It is possible to input the needs and requirements of a new program into the computer, which then utilizes the data bank to compile the information on the PSC. This output is then reviewed, the necessary corrections are made in the assumptions and data, and the program

is run again until a satisfactory result is achieved. This process is diagrammed below.

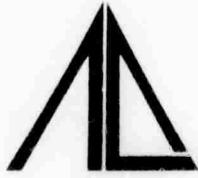


Such a system would reduce the time required for analyzing and compiling the data and would allow for many passes, to increase the accuracy of the result. In addition, this technique would become a platform for testing the data and insuring the quality of the information upon which new programs are based.

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