PROJECT REPORT

VOLUME 3

Volume Three, the Project Report, is the consultants account to the Veterans Administration of the systems integration program. It provides a summary, conclusions, recommendations, and various appendices such as the design rationale, example designs, special procedures and the cost and time analysis.

600 NARRATIVE

610 SUMMARY

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610 Summary

611 THE PROBLEM

611.1 COST VS. PERFORMANCE

Over the years there has been a steady increase in the construction cost of hospitals, and recently there has been a rapid escalation of these costs. Because of the long period from inception to occupancy of a field station, typically seven to eight years, the Veterans Administration is not only denied the use of the building as rapidly as desired, but the capital cost is increased by this escalation. At the same time, rapidly advancing medical technology calls for facilities that can respond efficiently to changing needs. A larger proportion of the VA's capital budget is allocated to alteration and renovation of existing hospitals than to the construction of new hospitals. Traditional modes of construction are not providing adequate adaptability, nor, in fact, are they fully meeting current user needs in terms of general performance.

611.2 CONVENTIONAL DESIGN AND CONSTRUCTION

Traditional procedure has tended to underemphasize many of the interrelationships between components and subsystems which significantly affect the overall cost, performance and adaptability of buildings. This tendency has produced inefficiencies at several levels:

1. Manufacturers develop specialized products without reference to specific ways in which they will be combined with the products of other manufacturers. The A/E must therefore in effect design a different building "system" each time he deals with a new building under new circumstances. Normal design schedules and budgets do not permit serious systems analysis, so the result is usually a composite of performance compromises, unintentional experiments, and vast numbers of special condition details.

2. Building and plan configurations tend to be overdesigned, as if they were to remain unaltered in any way for fifty years. The organization of building services (mechanical, electrical, etc.) on the other hand, is usually underdesigned, on the apparent assumption that as concealed elements, their configuration is of no consequence.

Each subcontractor is more or less free to use his own judgment in finding the shortest route between two points, and much of the detailed coordination between subcontractors is worked out in the field on an ad hoc basis. The result is a building which is awkward and costly in routine maintenance and repair, let alone in growth and change.

3. The lack of pre-coordination between manufactured products, and the lack of discipline in the layout of service subsystems, are serious deterrents to the development of prefabricated assemblies. Manufactures are unwilling to commit themselves to mass production of large complex units as long as interface conditions within buildings are essentially unpredictable from their point of view.

4. The conventional design approach has emphasized highly optimized opening configurations and the measure of planning efficiency in terms of gross-to-net-area ratios and the like. Thus, it has encouraged a design process in which many detailed architectural decisions are made prior to serious consideration of structural and service distribution requirements. The result has been very complex structures and service networks tailor-made for the opening configuration but severely restrictive to alteration.

5. Buildings are often evaluated during construction and occupation, but evaluation procedures are usually not specifically structured for maximum return of useful information, either to the original designer or to A/E's working on current similar building projects. Thus many design deficiencies are repeated, even though they may have been identified. Without specific feedback procedures for introducing improvements in design and construction, innovation is painfully slow, depending largely on the limited personal experience of individual designers.

6. Conventional design procedures are highly linear, requiring a complete program before design can begin, and a complete preliminary design before working drawings can begin. Furthermore, architectural design is developed to a considerable level of detail before engineering design is started. The people responsible for each phase do most of their work independently, rather than as a team. This type of process is time-consuming and makes coordination difficult.

Interrelated decisions which should be made on the basis of trade-offs are often made in different phases, so that the later decisions are unduly constrained by the earlier ones.

612 THE SYSTEMS APPROACH

The clear need for a more rational approach to the design, construction and alteration of buildings has led to widespread interest in the concept of systems.

612.1 TERMINOLOGY

612.1.1 THE SYSTEMS APPROACH is a strategy of problem definition and solution which emphasizes the interaction between problem elements and between the immediate problem and its larger context, and which specifically avoids traditional methods of independent or ad hoc treatment of the various elements.

612.1.2 BUILDING SYSTEMS INTEGRATION is the simultaneous development of a group of coordinated components, traditionally treated independently, to improve their combined performance through controlled interaction. Direct physical integration is not necessarily implied.

612.1.3 A BUILDING SYSTEM is a particular method of design and construction involving a specific group of coordinated components.

612.1.4 A PROTOTYPE DESIGN is a basic system design establishing the performance and dimensional limits within which alternative detailed designs may be produced to accommodate specific conditions at various times and places. It is not a standardized scheme for identical repetition; it is a generalized decision process, of which various specific designs are the products.

612.2 THE BUILDING AS A SYSTEM

There is nothing new about the notion that a building is a collection of systems: a structural system, a mechanical system, an electrical system, and so on. What has evolved more recently, however, is the conceptualization of the whole building as a system, and further, the total process of building production and utilization as a system demanding a much higher degree of internal coordination than has been achieved so far. This internal coordination, or integration, begins with an analysis of the building into its components and a study of how well each meets its intended function under real conditions. Of particular interest is how the characteristics of each component directly or indirectly affect the performance of the others and of the total building.

The object of the analysis is to identify those design features which are responsible for the most serious negative effects.

612.3 PERFORMANCE DESIGN

Before recommendations for corrective measure can be formulated, the various design determinants of the building type and components in question must be identified and interpreted. They include user needs, applicable standards and regulations, available technology, geographical and environmental factors, labor union practices and target costs. Building components are grouped under various categories, or subsystems, and formal statements of how each subsystem is expected to respond to these determinants are drafted to serve as the basis for system design; these are the “performance requirements”. In a prototype design, they are retained as an integral part of the system description as criteria for detailed design.

612.4 THE BUILDING SYSTEM AS A SET OF RULES

The first step toward increased efficiency is the establishment of rational standards for design and construction which can serve as a common basis for coordinated decisions among administrators, A/E’s, contractors and users. A prototype design is, first and foremost, a set of such rules. Not until all parties understand and agree to comply with the rules can the development of specific designs proceed effectively.

612.5 UNCOUPLING PRECEDES INTEGRATION

The principles of systems integration do not dictate immediate achievement of a high degree of physical integration of building products and components. Prefabricated assemblies as an efficient construction technique must evolve from the interpretation, application and refinement of a particular set of system rules by many people over a series of similar building projects. In fact, in the analytical phase in which the prototype design itself is under development, the major subsystems must be “uncoupled”, that is, clearly separated out within the building to establish radically simplified interface conditions. This technique allows designers, manufacturers and contractors to deal with manageable increments of the total problem on their own terms. It is also very useful in the detailed design of highly adaptable building subsystems.

612.6 COST/PERFORMANCE TRADE-OFF

A cost-effective design is one which either provides the highest level of performance for a given target cost or provides a given level of performance at the lowest cost. (There is rarely a "cheapest-best" alternative available.) But the usual cost-benefit analysis concerns itself simply with a comparison of several subsystem or component alternatives, whereas actual conditions within a building are the combined effect of various sets of components which cut across subsystem classification.

The acoustic environment, for example, depends on a high degree of design coordination between partitions, ceilings, mechanical equipment, surface materials and service distribution terminals. The theoretical sound transmission class of a partition is meaningless if the ceiling provides a flanking path, or if electrical outlets puncture the surface, or if sound passes readily along ductwork.

Systems analysis and integration include the identification of these performance-related component sets and the characteristics which must be balanced to achieve any given criterion. Cost-benefit analysis can then be more realistically applied to trade-off problems directly in terms of negotiable levels of performance.

612.7 CONVERGENCE AND FEEDBACK

612.7.1 The process of systems integration must be viewed as continuous, rather than as terminating at a certain point with a perfected set of components. New building products are constantly being developed and marketed by industry. New building techniques are periodically introduced by engineers or contractors. New performance requirements evolve as the activities within buildings change. And the evaluation of components in use invariably reveals unanticipated bugs which should be eliminated from future protection. This process involves five broad classes of activity:

1. Determination of performance requirements,

2. evaluation of available building products and techniques,

3. design of systems and components,

4. analysis of cost and scheduling implications, and

5. evaluation of buildings utilizing the integrated systems and components.

612.7.2 Several characteristics of the relationships between these activities must be pointed out as clarification of the manner in which the various tasks in this program were executed:

1. There is no clear boundary between these activities in actual practice. Their overlap is considerable, so the placement of certain tasks under one activity or another is fairly arbitrary. All of them may be considered as part of a general design process.

2. Although at first glance these activities appear to follow logically one from the other in the order listed, they are in fact not independent. Each cannot be carried beyond a certain point without information that must be obtained by starting one or more of the others. “Chicken-or-egg” questions arise constantly, and tasks often must proceed on the basis of assumptions about what will be learned from other work not yet completed.

3. Each of the first four activities must be repeated several times, at different levels of specificity, before a demonstration building can be designed and the fifth activity commenced. Field evaluation then becomes a primary source of feedback information for continuous development of the system. In other words, the process is cyclical, each cycle producing more design detail, more accurate cost projections, more effective performance, etc.

4. No amount of recycling of the first four activities can conclusively prove that the proposed prototype design will in fact achieve the stated objectives. Only the construction of one or more buildings will allow the fifth activity to be implemented and the feedback loop to be closed.

5. At least three parties must engage in these activities at various times and degrees: the consultant in executing this study, the VA in establishing a data base for continuous development and programming specific projects, and the A/E in designing the building. The scope of assigned tasks must be carefully adjusted so that each party can provide maximum benefit and minimum constraint to the others.

6. A fourth party could become involved in the process, specifically in the design activity, depending on the strategy chosen for implementation. This fourth party is the building product manufacturer. If a sufficient market can be aggregated and guaranteed, manufacturers can be induced to bid on the basis of performance specifications, contributing innovative product design particularly suited to the owner's special requirements.

   However, not only are such guarantees impractical within the constraints of current federal funding policies and procurement regulations, but new product development adds a significant amount of time and effort to the design activity which must be well under way before construction can begin. An alternate strategy, exemplified by this project, is to develop a building system prototype design directly, through more or less conventional A/E consultant procedures, utilizing products already available. Manufacturers can then be expected to respond later through their normal R & D programs when it becomes evident that the VA will continue to construct hospitals within the established context of the systems integration program.

613 SCOPE

The scope of this project has been limited to the first four activities described above (Section 612.7). The design and construction of a demonstration hospital is presently under consideration by the Veterans Administration to allow commencement of the fifth activity and thus provide a field test of the principles of systems integration.

The project was also limited in the following ways:

1. Only six building subsystems were under direct study: structure, ceiling, partitions, heating-ventilating-cooling, plumbing distribution and electrical power distribution,

2. only building products already in production are utilized in the design,

3. it has been assumed that the building system will be used exclusively for new construction,

4. the design had to conform to all federal procurement regulations, laws, and budget policies, and all VA construction standards and planning criteria, except as specifically authorized by the VA, and

5. the system had to be capable of effective application anywhere in the United States.

614 OBJECTIVES

The primary objectives of the VA systems integration program have been cost control, improved performance, adaptability, time reduction and the provision of a basis for long-range development of a hospital building system. The vehicle for working toward these objectives has been the Building System Prototype Design, referred to more briefly as the Prototype Design.

614.1 COST CONTROL

614.1.1 First Cost

Besides the manufacturer's delivered price for a building subsystem or component, the selection of that item has three other predictable interacting effects on the first cost of a building: the cost of its installation, the cost of products which must be used in conjunction with it, and its influence on the critical path of the construction schedule. Normally, the first of these is taken into account by conventional estimating procedures. But the other two are frequently overlooked, the second because there is usually not enough time allotted for design to allow effective cost-benefit analysis of significant alternatives; the third because selection often must be made before a construction schedule can be developed in sufficient detail to measure sensitivity. A special case of the latter difficulty is the cost effect of a product on change orders in which the product may become involved.

The development of the Prototype Design has been directed at the establishment of controlled interface conditions, permitting the widest possible latitude in the selection of components without adverse effect on adjacent components, and allowing postponement of certain critical selections until their impact on scheduling can be assessed. The purpose of this approach is not necessarily first cost reduction per se, but rather to improve control over cost and thus allow more realistic budgeting.

614.1.2 Life Cost

The total cost of housekeeping, maintenance and alterations of a hospital building over a forty-year period can be expected to be at least five times the contract cost of the original construction.

Also, these activities interfere to various degrees with medical and administrative activities; that is, they affect the total efficiency of the hospital. Furthermore, the more difficult it is to alter an existing configuration, the less likely that useful alteration will be undertaken, thus forcing staff to work under increasingly inefficient conditions. These considerations are primary design determinants, placing high priority on simplicity, adaptability and access.

614.2 IMPROVED PERFORMANCE

As noted above (Section 612.6), many aspects of a building's performance are not determined by the characteristics of any one component, but rather by the combined effect of certain sets of components. The development of the Prototype Design has proceeded from an analysis of these relationships, not so much to raise existing performance standards as to establish basic standards of coordination and thus assure that, whatever standards are applied by the VA, desired performance levels can be realistically achieved and maintained under field conditions. The A/E must preserve and exploit this precoordination in his detailed design if user needs are to be effectively satisfied.

614.3 ADAPTABILITY

614.3.1 Prevention of Obsolescence

By far the most critical aspect of building performance to be improved through systems integration is adaptability. Adaptability is critical not only because of the cost considerations mentioned above, but also because of the very rapid rate at which technical and administrative obsolescence can overtake any design configuration, no matter how carefully planned. Mission and program requirements are changing so rapidly, in fact, that hospitals are frequently referred to as obsolete the day they open their doors.

614.3.2 Options for Opening Configuration

One purpose of system adaptability is to allow the widest possible range of design configurations so that the particular demands of each site and program can be met on their own terms, without unnecessary additional constraints due to system limitations. The Prototype Design, in particular the planning discipline, has been developed to provide this versatility.

614.3.3 Efficient Alteration

The other purpose of system adaptability is to allow for rapid and economic execution of desired changes, both during and after original construction, with minimum down time for the elements being changed, and minimum interference with activities outside the area of change. It requires, however, that the detailed designs for each building be carefully considered to ensure full utilization of the Prototype Design concepts.

614.4 TIME REDUCTION

The problems of cost escalation, obsolescence and inefficiency of space utilization are all aggravated by the lengthy periods now taken for programming, planning, design, construction and alteration. A primary function of the Prototype Design is to simplify the decision-making process and thereby allow significant time reductions in at least some of these areas.

614.5 LONG-RANGE DEVELOPMENT

As mentioned in the problem statement (Section 611.2), conventional design and construction procedures are not well suited to the accumulation and application of experience. Efficient implementation of a long-range systems integration program will require the establishment of a data base and an evaluation and feedback mechanism so that each successive construction project can contribute a maximum of useful information. The intent of the Prototype Design is to propose a rational discipline which can serve as a vehicle for this type of systematic development.

615 TASKS

Since 1967 a joint venture of Building Systems Development and Stone, Marraccini and Patterson has been working with the Research Staff of the Veterans Administration's Office of Construction to apply the principles of systems integration to the problems and objectives described above.

615.1 The project has proceeded as a phased program with each phase under separate contract. Phase 1 was a feasibility study and was published by the Veterans Administration in October 1968 under the title "Integration of Mechanical, Electrical, Structural and Architectural Systems in VA Hospital Facilities".

615.2 Phase 2 involved the initial development of a prototype design for a building system, specifically for that portion of the hospital containing bedrooms and bed-related functions. Four building subsystems were selected as the primary subjects of this effort: structure, heating-ventilating-cooling, partitions and ceiling. The final report was published in February, 1971 and is titled "Application of the Principles of Systems Integration to the Design of the 'Nursing Tower' Portion of a VA Hospital".

615.3 This report is the product of Phase 3, during which the building system Prototype Design has been extended in applicability (to the total hospital) and scope (the plumbing distribution and electrical power distribution subsystems). A projected fourth phase would involve the design and construction of a hospital to demonstrate and evaluate the proposed system.

The procedure for Phase 3 was similar to that of Phase 2. Although not strictly linear, the following basic tasks were involved:

1. Identify configuration and activity requirements for the various functional areas and spaces within the total hospital, with particular emphasis on those requirements which may conflict with the "nursing tower" system proposed in Phase 2. (Sections 510 and 520.)

2. Modify Phase 2 building subsystem performance requirements as may be required by extension of functional space analysis into the total hospital. Develop performance requirements for plumbing distribution and electrical power distribution.

(In the early stages of the system development process, performance requirements for the building subsystems were derived from the user needs, functional requirements, VA regulations, etc. They have subsequently been revised to reflect the design decisions generated by that process and are now to be considered design criteria for specific construction projects. As such, they are literally components of the building subsystems, and have therefore been editorially integrated into the subsystem descriptions in Section 300.)

3. Expand the cost base developed in Phase 2 to include the total hospital and the two additional building subsystems. (Section 530.)

4. Review the space modules and other planning concepts developed in Phase 2 for the “nursing tower” and investigate their applicability to the rest of the hospital. Develop new planning modules as may be required to provide a coordinated group for a total hospital building system. (Section 200.)

5. Develop a set of hospital design configurations utilizing the proposed planning modules, which could be further developed into detailed building designs. (Section 250.)

6. Revise and expand the Prototype Design proposed in Phase 2 as required to include the six designated subsystems in a coordinated set of building components for the total hospital. Continue evaluation of building products presently on the market in terms of the subsystem performance requirements. (Section 300.)

7. Establish target costs for each subsystem, and compare long-term costs of conventional design and construction with anticipated long-term costs of buildings utilizing the Prototype Design. Similarly, compare conventional and system scheduling. (Section 750.)

8. Develop a schematic hospital design illustrating application of the Building System Prototype Design, and discuss its cost, scheduling and performance characteristics. (Section 730.)

9. Update investigation of labor union restrictions presented in Phase 2. (Section 540.)

10. Review applicable documents, report apparent conflicts with the Prototype Design and recommend changes as appropriate. (Section 550.)

616 THE BUILDING SYSTEM PROTOTYPE DESIGN

The results of executing the tasks outlined above are presented in Volume One, Design Manual; Volume Two, Data Base; and the appendices in Volume Three, Project Report. The basic characteristics of the Prototype Design are discussed in Section 110, and are only summarized here.

616.1 During preliminary planning, schematic building designs are generated as assemblies or relatively large-scale planning modules, rather that as arrangements of individual rooms. The modules establish overall dimensions of the building as well as primary structural and service distribution patterns. Detailed architectural plans are developed within this fixed framework, concurrently with, rather than prior to, detailed structural, mechanical and electrical designs.

616.2 The basic “building block” for generating schematic designs is the service module. Service modules are one-story units of building volume which can vary in area but are considered optimum at about 10,000 square feet. Each module has its own mechanical and electrical rooms on the functional floor, each is served by a single independent service distribution network, and each is completely contained, alone or with another module, within a single fire section.

616.3 Main horizontal service distribution within the service modules occurs in the “interstitial” space – a horizontally accessible service zone above the ceiling. The ceiling is suspended below a shallow girder-and-beam structure rather than from a truss, and is designed as a continuous platform to allow workmen to move freely over its entire surface. Recommended minimum clearance under the beams is five feet, thus providing full headroom between beams.

616.4 The service zone is highly organized into reserved subzones for various services. The purposes of this “precoordination” are to provide clear access and passage for all trades, to minimize crossovers and other conflicts, to assure reasonable space for future extensions and additions, and to permit positive location of all components. All services except gravity drains downfeed into the functional zone below.

616.5 All partitions except two-hour fire partitions stop at the ceiling-platform and thus do not interrupt the service zone.

To the greatest practical extent, service drops are surface-mounted and enclosed in furred-out partition components or proprietary containers.

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620 Conclusions

621 BENEFITS

621.1 COST CONTROL

621.1.1 First Cost

The Prototype Design developed in this study does not consist of a list of building products. Rather it provides a framework of coordinated basic subsystem designs within which the VA and the A/E can derive the optimum specific design for each program, time and place. process of trade-offs. The predetermination of interface conditions in advance of any specific building project and its detailed design problems saves the A/E time usually spent doing this for each job. This allows him more time for product selection and cost-benefit analysis.

An example of simplification through a controlled interface is the particular relation between the ceiling-platform and the structure selected for the Prototype Design. By limiting the structure to medium spans, a beam and suspended-ceiling scheme became practical for the establishment of a horizontally accessible service zone. In typical long-span, deep-truss, interstitial-space schemes, the ceiling is placed at or near the bottom chords, forcing a compromise between efficient truss depth and sufficient service space. But beams and girders can be proportioned to produce a relatively shallow structure, allowing most of the services to pass below them. Thus the depths of the structure and the service zone can be independently optimized.

The organization of component design by general building subsystems which cut across various trades provides a basis for structuring cost estimates so that they can be directly related to the performance level of a functionally related set of components, thus allowing rational cost-performance trade-offs. The organization of hospital design on the basis of service modules provides the capability of establishing a construction budget in terms of per module estimates, as well as the usual per-square-foot and per-bed figures, thus allowing budgeting adjustments in fairly large units.

The intent is to avoid the more traditional devices for cost-cutting which involve reduction in quantity or quality of more or less randomly selected products, or across-the-board tightening of space standards, without particular regard for the impact these decisions may have on the hospital as a system. Experience has shown that these devices are in fact often very wasteful in terms of the final cost-effectiveness of the project. The allocation of budgetary surpluses, and response to program changes, are likewise frequently inefficient in the context of traditional design and cost control procedures.

The principle impact of the Prototype Design on cost is intended to be in the areas of maintenance and alterations, rather than first cost. Nevertheless, the very characteristics which have been developed to reduce life costs – simplicity, adaptability and accessibility – are bound to have a beneficial effect on construction cost also, for example, by improving the feasibility of field changes. The simplicity and standardization of subsystem design also makes estimating itself a much simpler and more efficient process, less subject to accidental omissions and similar errors.

In a project constrained to use only currently available non-proprietary products, but directed to improve performance, some increase in first cost over present methods is implicit. There are prospects of compensating for this effect quite directly through significant reductions in design and construction time made possible by the deliberate detailing of the system for that purpose. But how much of a savings is realized depends on how far the VA is willing to go in the way of altering customary decision-making procedures, how well A/E's and building contractors understand the scheduling benefits of the system, and on what theoretical basis time savings are translated into cost savings.

621.1.2 Life Cost

A major part of the design effort has been on the organization of service distribution, the provision of convenient access for maintenance, repair and replacement, and the control of interface conditions for ease of alteration. The theory is that this discipline will pay off in the long run. However, an attempt to reliably predict actual cost savings in these areas is not feasible. There are too many variables involved, and not enough field experience with the particular kind of solution proposed. Nor is there any reasonable way to estimate what it is currently costing the VA to not have properly accessible and adaptable spaces in terms of physical plant utilization.

However, a discussion of the probable order of magnitude of the anticipated savings, and their implications for total owning cost, is presented in Section 752.

Actual long-term costs will depend to a considerable extent on geographical and other project-specific factors. For example, HVC operating costs will vary with climate, exterior wall design, building orientation, local utility rates, etc. Nevertheless, certain characteristics will have a beneficial effect regardless of local differences. The mechanical simplicity of a single-type HVC system, for instance, will require less elaborate training and supervision of maintenance personnel.

621.2 IMPROVED PERFORMANCE

621.2.1 The Shell

By utilizing only one-half to two-thirds the number of columns typical in conventional design and construction, the Prototype Design presents less structural obstruction in functional spaces. Also, the provision of a service zone accessible directly through service bays, rather than through functional spaces, will eliminate much of the usual cross-traffic of engineering personnel with patients and medical staff. This in turn makes scheduling of engineering personnel time less critical.

The use of a ceiling-platform as a barrier between service and functional zones provides required fire protection and acoustic separation without the necessity of constructing partitions from slab to slab. Surface mounting of services also enhances these characteristics by eliminating the many holes in partitions produced by the conventional practice of routing services internally.

621.2.2 Services

The decentralization of the HVC system into mechanically independent service modules with an approximate correspondence to departmental areas simplifies the problem of local variation in environmental requirements, and allows the service to each module to be modified, or even shut down, without affecting other areas of the hospital. For example, some areas of the hospital may be provided with 100% exhaust while others use varying amounts of return air, and each area can be individually adjusted one way or the other.

Organizing plumbing and electrical networks on the same basis further establishes the independence of the service modules.

621.3 ADAPTABILITY

621.3.1 Options for Opening Configuration

Rather than develop the Prototype Design around a single space or service module, a range of modules has been generated from a basic dimensional discipline, thus allowing the A/E a wide latitude in selecting spatial and assembly characteristics appropriate to a particular program and site. The possible combinations of these characteristics are so extensive as to provide a virtually infinite number of unique design configurations, including most conventional hospital forms.

Furthermore, the range of possible modules is open. That is, as VA policy in regard to, say, ward size or room size changes over time, new modules can be readily developed from the basic dimensional discipline. In fact, the discipline itself can be adjusted if necessary, without disturbing the overall organization of the system.

621.3.2 Efficient Alteration

Perhaps the single most significant advantage of the Prototype Design over conventional design and construction is in its capability for efficient alteration. This capability applies for all types of alteration from the simple addition of an electrical outlet to the complete renovation of a section of the hospital for the installation of a new specialty unit. It therefore has beneficial effects on both operating and capital budgets.

Adaptability has been achieved primarily through the “uncoupling” of the building components. Partitions and door frames do not penetrate the ceiling and so may be removed or relocated with minimum effect on the ceiling and the services above it. Services are distributed through highly accessible reserved zones and surface-mounted on partitions and so may be extended or relocated without breaking out sections of the ceiling or partitions.

Service distribution networks are separated into independent modules and thus minimize disruption caused by major shutdowns.

Adaptability has also been enhanced by the use of planning components of simple geometry with predetermined capabilities for a variety of internal functional arrangements. For example, the establishment of fire section boundaries prior to development of detailed departmental layouts may introduce some inconvenience in planning the opening configuration, but it provides a much simpler context for future alterations. This means a reduced probability that fire partitions would ever have to be relocated.

Alterations during design and construction, due to changes in program, budget or scheduling, are also simplified, and may be accomplished on a more rational basis than has been possible within conventional procedures.

621.4 TIME REDUCTION

621.4.1 Design Time

The planning components, particularly the space and service modules, have been specifically developed to expedite the schematic design process. These modules may be selected prior to availability of highly detailed program information. In fact, preliminary programs can be developed directly in terms of the modules themselves. Alternative design configurations can be quickly generated and evaluated by rearranging the comparatively large scale modules into various assemblies, rather than recombining vast numbers of individual rooms, as is normally the case in conventional design. Since these modules include specific structural and service distribution patterns, an early start on engineering design is also possible.

It must be emphasized in this regard that although the Prototype Design provides a high degree of precoordination, it in no sense is preengineered. The basic concepts are all sound in terms of good engineering practice, but their successful implementation will still require the full range of A/E services. In particular, the early involvement of structural, mechanical, electrical and acoustical engineers is recommended to obtain full benefit from the system.

621.4.2 Construction Time

The classification of building components as either permanent or adaptable has a critical effect on construction scheduling because the permanent parts are built first. A typical sequence is suggested in Section 463. The keys to construction time saving with the Prototype Design are the separation of rough and finish trades by means of the ceiling-platform and the provision of reserved zones for each service. A continuous platform has been judged to be much more useful for these purposes than a catwalk system. The termination of partitions at the platform is expected to allow more rapid installation.

621.4.3 Accelerated Scheduling

The time savings described above are provided by the Prototype Design within the context of federal funding constraints. However, much more significant savings are possible by the utilization of accelerated scheduling techniques such as “fast-track”. The basic strategy in these techniques is to overlap some of the major activities which in conventional practice are performed linearly. The various tasks within each activity are so arranged that the decisions necessary for commencement of the next activity can be made at the earliest possible time.

This requires a willingness on the part of all concerned parties to commit themselves early in the process to certain key decisions. However, if the schedule is properly designed, many detailed decisions can be made considerably later than normally required. That is, time available for each major activity except construction can actually be increased while significantly reducing the total production time.

The Prototype Design, for reasons mentioned in Sections 621.4.1 and 621.4.2 above, is particularly well suited for accelerated scheduling. This technique is discussed more fully in Section 761.

621.5 LONG-RANGE DEVELOPMENT

Optimum solutions to the basic cost/performance problems of VA hospitals, or any other building type for that matter, cannot be found in the context of the current fragmented and trade-oriented production process. Unfortunately, the necessary changes leading to fully industrialized building will require major commitments and considerable time, and are well outside the modest scope of the Prototype Design.

What has been established, however, is the basic framework for a rational development process which can immediately test some promising innovative concepts, and which can eventually lead to highly cost-effective building systems. The intent of this framework is to provide the VA with improved capability for effective utilization of whatever building products and design and construction methods are available at the time, while progressing incrementally toward a more complete hospital building system. It is also intended to serve as a common frame of reference for all departments and services within the VA which are concerned in any way with the programming, design, construction, operation and evaluation of hospitals.

622 COSTS

For purposes of comparison with projected costs of hospitals utilizing the Building System Prototype Design, a number of existing VA hospitals of conventional design and construction were analyzed to establish a cost base. (Section 530.) To assist in estimating probable costs of systems hospitals, an example building schematic design was developed from an actual VA master plan. (Section 730.) The cost estimate for the example design is presented and analyzed in Section 751.1, and target costs for the integrated subsystems are suggested and discussed in Section 751.2. The following table summarizes the subsystem cost estimates in dollars per outside gross square foot.

Subsystem	Cost Base Range	Cost Base Average	Target Range	Example Design
Structure	5.86 - 8.10	6.97	8.60 - 11.30	9.63
Ceiling	1.11 - 1.71	1.42	2.10 - 3.85	2.38
Partitions	5.26 - 6.35	5.88	3.30 - 5.90	3.63
HVC	4.92 - 8.62	7.02	4.00 - 6.50	4.75
Plumbing	2.09 - 2.20	2.15	2.00 - 3.00	2.14
Electrical	2.08 - 2.13	2.11	2.00 - 2.50	2.31
Totals		25.55		24.84

The “shell” subsystems have also been assigned target costs in units more meaningful to each.

Subsystem	Target Range	Subsystem Unit
Structure	$8.00 - 10.45	per square foot of framing
Ceiling	$2.50 - 4.55	per square foot of ceiling
Partitions	$31.75 - 56.00	per lineal foot of partition

The scope covered by these costs is outlined at the end of the description of each subsystem in Section 300 in the Design Manual.

623 LIMITATIONS AND CONSTRAINTS

623.1 CONSTRUCTION TYPES

There are certain types of construction for which the Prototype Design is not well suited. These include buildings of non-rectangular geometry, high-rise buildings over 160 feet, low-rise buildings less than two or three stories, and additions to existing buildings with floor-to-floor heights less than seventeen feet.

There are also certain functional space types which are considered “drop-outs” due to special structural or servicing requirements. They include kitchens, laundries, cobalt rooms, boiler rooms, and the like. Many of these areas can be incorporated within a systems building, but they may require significant modifications of one or more of the building subsystems by the A/E, at their location within the structure.

623.2 PLANNING AND DESIGN

Even though the planning components have been carefully studied to assure their internal capabilities, and even though a reasonable range of size and proportion is available for selection, nevertheless once the design configuration has been established the A/E is obliged to work within the boundaries of the service modules and fire sections, and this is a type of discipline not normally encountered in new construction. It is anticipated, however, that after the A/E has become familiar with the properties of the entire system, he will in fact find new design freedoms to compensate for this restriction. For example, these same planning components provide him with design tools which can greatly facilitate the generation and evaluation of significant configuration alternatives, for which he normally would simply not have the time.

The system rule concerning a uniform ceiling-platform height throughout each floor does not readily permit the variation in room height sometimes felt to be architecturally desirable. Three types of modification are available, however. Since it is actually the platform height which is critical as far as system performance is concerned, a suspended ceiling below it may be used to vary room height, if the partitions are attached to the platform rather than the ceiling. Or in special area such as auditoriums, an intermediate floor may be omitted to allow a full two-story space. On the ground floor, floor levels may vary in areas not used by non-ambulatory patients.

To provide the required lateral bracing, shear walls must extend continuously downward through the building to the foundations. Allowable openings are seriously restricted. Exterior shear walls limit fenestration, and internal shear walls inhibit planning. The system rules and suggested design configurations are intended to minimize this effect, but it cannot be altogether eliminated. The cluster of shear walls around stacked service bays can be particularly troublesome since they tend to form an enclosing row of towers at the building perimeter. In large horizontal design configurations, they can also introduce significant internal obstructions to the planning of efficient circulation patterns and departmental layouts. However, since the location, size and proportion of the service bays are only partially predetermined by the Prototype Design, these parameters can be adjusted within certain limits by the A/E to optimize any particular configuration.

623.3 REDUNDANCY

In the interests of design and construction simplicity and long-range adaptability, over-design of certain building components and spaces is recommended. These include floor load-bearing capacity, size of trunk ducts and other service mains, size of mechanical and electrical rooms and service chases, and depth of the service zone above the ceiling. Other system characteristics imply larger than normal amounts of materials or space. For example, the rigorous organization of service runs prohibits typical point-to-point routing, and increased floor-to-floor height produces taller columns and elevator shafts, more exterior wall, etc. Also, the use of a limited range of space and service modules adjustable only in rather sizeable increments of area implies deviations from maximum room sizes and gross-to-net-area ratios set by current practice or regulations.

This redundancy is considered entirely justified by anticipated benefits, but nevertheless must be taken into account when the Prototype Design is compared with conventional design and construction, particularly in terms of first cost. An analysis of these cost effects is presented in Section 751.3.

623.4 MAINTENANCE AND HOUSEKEEPING

Although the basic design of the building components has been specifically directed at the alleviation of various maintenance and housekeeping problems, a perfect solution has not yet been achieved. Three conditions in particular should be noted. First, the decentralization of air-handling equipment will require engineering personnel to travel throughout the hospital to execute some of their routine maintenance tasks. Second, the location of certain components in the service zone accessible only horizontally via space with restricted headroom may in some instances be less convenient to these personnel than direct access from below or access to the equipment if it were located in the functional zone. Third, surface mounting of services may not be as simple for housekeeping purposes as is the case with services concealed within partitions.

623.5 NEED FOR CARRY-THROUGH

The application of the principles of systems integration to the particular problems of VA hospital construction has so far produced a hypothesis and some suggestions on how it might be tested. However, no amount of theoretical argument or cost-benefit analysis can prove in advance that innovative design ideas, when implemented under field conditions, will in fact meet the stated objectives in a completely satisfactory manner. The principles must be continually applied through detailed design and construction, the entire process carefully monitored, and the results fully evaluated before the proposed system can claim specific improvements over conventional methods. Furthermore, efficient implementation of a long-range systems integration program will require the establishment of a data base and an evaluation and feedback mechanism so that each successive construction project can contribute a maximum of useful information. (See Section 111.2.2 for a diagram of this process.)

Some components of the data base have already been developed to a certain point for purposes of the systems integration study. (Volume Two.) It is recommended that the VA develop these components further and generate additional components. (See Section 632.) Particularly lacking in the present data base is operating and alteration cost information on existing hospitals suitable for cost-benefit evaluation of proposed designs. (Section 631.2.2.)

623.6 HAZARDS OF INNOVATION

One of the principle difficulties with the implementation of any new process is its integration into the existing framework of conventional practice. For example, in specifying that most partitions stop at the ceiling, the Prototype Design is in conflict with building codes and regulations which specifically require corridor and smoke-stop partitions to run from slab to slab. Many other requirements are presumably based on the assumption that this latter condition will be met. Thus in proposing what seems to be one simple deviation from conventional construction, an entire fire safety strategy becomes ambiguous in its application, forcing fire safety authorities to evaluate not only the specific change, but what amounts to a whole new strategy. (See Section 551.)

A similar difficulty arises from the fact that participants in the implementation of a new design and construction process must to some extent modify their customary work and thought patterns. This adjustment confronts not only administrators, as suggested above, but also A/E and construction contractors. The ultimate success or failure of an innovation depends largely on the understanding and attitudes applied to the experiment by these key people. For example, if construction contractors do not examine the ceiling-platform concept with sufficient care to convince themselves that it permits real time savings through more efficient trade phasing, their bids are not likely to reflect this theoretical advantage, at least not on the first “demonstration” hospital.

The A/E in particular has the responsibility not only of developing detailed designs for the integrated subsystems which reflect the intent of the Prototype Design, but also of developing the non-integrated subsystems in a complementary manner. The resident engineer in turn must exercise particular care in the supervision of construction to ensure compliance with the system rules, such as the rights-of-way in the service zone above the ceiling.

630 Recommendations

631 FURTHER DEVELOPMENT OF THE PROTOTYPE DESIGN

The Prototype Design is intended to provide the basic framework for the eventual development of a complete hospital building system. As such, it should be continually expanded and refined.

631.1 CONSTRUCT A DEMONSTRATION HOSPITAL

A Veterans Administration hospital project currently in progress should be selected as the vehicle for demonstration construction and evaluation (implementation of Step 5 in Section 612.7.1). The demonstration building should be new construction of a complete hospital to avoid constraints imposed by an existing building. This should occur in conjunction with the evaluation program described in Section 631.2 below. The A/E contractor selected for such a project must be one who is sympathetic with the systems approach in general, and the Prototype Design in particular, and who can be expected to fully exploit the functional, economic and architectural potentials of the system.

631.2 DEVELOP AN EVALUATION PROGRAM

To receive full benefit from a demonstration construction project, it will be necessary to carefully monitor the entire production process from inception through occupancy, and systematically evaluate the Prototype Design in the spirit of testing a hypothesis (See Sections 111.2 and 765.)

631.2.1 Design and Construction

As soon as a specific project is selected as the demonstration for system design and construction, development of a formal monitoring and evaluation program should be initiated. If possible, an approximately concurrent project, to proceed by conventional design and construction, should be designated the “control” project. Both demonstration and control projects should be monitored by the same program.

631.2.2 Operations and Alterations

Besides periodic inspections during the building life span to evaluate long-term performance, continuous monitoring through special cost accounting procedures should be initiated to provide a cost base specifically related to each subsystem.

For example, utilities supplied to each mechanical subsystem should be separately metered. Not only should the scope, cost and attendant problems of each alteration be carefully noted, but requests for alterations that are denied or postponed must also be recorded.

631.2.3 Operating Manuals

The staff operating the demonstration hospital, and each succeeding systems hospital, should be provided with all necessary information, perhaps in the form of “operating manuals”, to insure full utilization of the system characteristics. They should be instructed in system capabilities, particularly for various kinds of alteration. However, care must be taken to avoid alterations which would degrade original performance or impair future adaptability.

Operating manuals should be prepared for each project by the O/C and the A/E during design and construction of the building.

631.3 CONSTRUCT A MOCK-UP FOR PHYSICAL TESTING

An essential feature of a building system is the continuing development, testing and refinement of system components. The system described in this report provides the framework for an initial demonstration hospital, but more significantly, it is also a framework for a continuing program of system development and refinement. Access to physical testing facilities would provide valuable assistance for this program, as well as for testing and refinement of detailed design solutions.

Optimum testing facilities would consist of a full-scale mock-up of a systems building segment constructed with actual components. It is recommended that the Veterans Administration explore the feasibility of building a mock-up and implementing a systems test program.

Testing programs might include the investigation of:

1. Installation methods for specific components.

2. Performance of components including finishes, joints, sound transmission, etc.

3. Accessibility for maintenance and alterations.

4. Adaptability implications including cost, time, noise, dust, etc.

The opportunity to study new component designs prior to an actual field installation would allow verification of performance and refinement of details. It would also identify potential installation problems.

In addition to physical testing, a mock-up would be of informational value. Building users, potential bidders, VACO staff architects and others could familiarize themselves with the building system by touring a mock-up facility.

631.4 EXPAND SCOPE TO MORE SUBSYSTEMS

Research studies should be undertaken to incorporate more building subsystems into the Prototype Design.

Suggested priority is:

1. Materials handling and transportation.

2. Communication systems.

3. Exterior wall.

4. Casework, furniture and lighting.

5. Roofing, flooring, and other finishes.

631.5 MODIFY SYSTEM FOR SPECIAL BUILDING TYPES

The Veterans Administration currently builds relatively independent facilities for research, nursing-home care and psychiatric care. It may be beneficial to investigate the feasibility of adapting the building system to these specialized uses.

631.6 EXTEND CAPABILITY TO NEEDS OF OTHER USES

The Feasibility Study (Phase 1) indicated that a relatively large guaranteed market was necessary for an industrial response to performance requirements. Without a guarantee, it may be possible to achieve the desired response, provided a large potential market is available.

It is suggested that the Veterans Administration explore means of increasing the potential market for systems components. This might be accomplished through adaptation of the system to the medical needs of other governmental agencies or other health system organizations.

632 FURTHER DEVELOPMENT OF THE DATA BASE

As a further development of the material presented in Volume Two, the Office of Construction should establish and maintain a design and construction data base for use by the VA, A/E's, manufacturers, construction contractors, and agencies other than the VA, applicable to conventional as well as systems projects. The basic components of the data base could be:

632.1 USER NEEDS

The user need study should be extended to all hospital functional units. Once obtained and verified, this information should be made available to those responsible for building design decisions.

In addition, a continuing program of evaluation and updating of the user need statements should be implemented.

632.2 CODES AND STANDARDS

All pertinent VA documents, including existing codes and standards adopted by the VA, should be incorporated into the data base. Each should be modified in form and content as necessary to relate them very directly to all other data base components with minimum overlap and conflict.

632.3 PERFORMANCE REQUIREMENTS

632.3.1 The development of a comprehensive data base of criteria derived from a study of the dimensional and environmental requirements of activities would provide the Veterans Administration with the following benefits:

1. Optimum and minimum performance standards which may be varied as activity patterns change.

2. A means of obtaining approval of space performance by governmental agencies and "users" prior to individual facility design.

3. A body of information for use by architects in making design trade-offs.

4. A clear relationship between activity requirements and building performance would be established. Space criteria could be used to review subsystem performance requirements.

A similar program has been initiated by the Ministry of Health in England with apparent benefit.

632.3.2 Subsystem Performance Requirements

The design criteria for the integrated subsystem (Section 300) provide the format and initial content for a current statement of VA building subsystem performance requirements. These should be periodically expanded and refined to eventually describe a complete hospital building system in performance terms. VA Construction Standards should be converted to this format, translated into performance requirements and incorporated into the data base. (See Section 632.2 above.) Construction Standard CD-31 for curtain walls is already in the appropriate language.

632.4 SPACE MODULE CATALOG

The planning module and configuration concepts contained in this report form the framework for a continuing program of plan development and evaluation. It is proposed that the VA undertake the development of a catalog of space module capabilities to provide a data base for the initial selection of space modules and for service module organization.

This Report identifies a limited range of plan capabilities for eleven space modules plus a number of configuration options for each. It is suggested that these space modules be tested with additional arrangements for various functional units. Further study will allow dimensional “tuning” of the modules and may lead to the development of additional modules and/or the discarding of some of the eleven. New modules, for example, would be required if the VA were to adopt a 30-bed G.M. & S. unit as a standard.

Evaluation is an essential element of the program outlined. The space module catalog must represent current VA thinking. A continuous process of field evaluation of functional layouts, feedback and modification must be maintained.

Every space module constructed should be monitored as to its ability to meet current needs and to provide the desired adaptability.

The assembly of a space module catalog and its continual evaluation would provide the VA with a measure of reliability. That is, the selection and construction of permanent building elements prior to detailed programming and design can be based on the experience represented by the catalog.

632.5 BUILDING TECHNOLOGY AND SYSTEMS INFORMATION

The data base should include a reference file of building products and construction methods. Manufacturers should be asked to provide reliable product information in a form allowing direct cost-performance comparisons. A/E's should be required to submit product evaluation information on standard forms developed by the VA. Products installed in hospitals should be evaluated periodically to verify performance.

632.5.1 Systems Information

In addition to data developed within the VA, it is suggested that other building system projects be closely monitored. Systems information on these might include: products, performance bidding, building organization, construction management, accelerated scheduling, etc. An active program of investigation could entail:

1. Establishing a comprehensive systems library including information from medical and non-medical projects throughout the world.

2. Seminars with persons who are directly involved with systems development programs.

3. Field investigation and evaluation of project performance. In some cases, detailed monitoring of adaptability, cost or other factors over a period of years may be warranted.

4. Initiating joint study programs involving VA research personnel and staff members from systems-oriented private firms. VA staff might work in consultants' offices or individuals from consultant firms could join the VACO staff for specific research programs.

633 FURTHER RESEARCH

633.1 DEVELOP COMPUTER PROGRAMS

As the data base develops into a functioning clearinghouse for all VA construction information and procedures, the feasibility of handling some of the material by computer should be studied. Rapid and reliable processing and retrieval of up-to-date information is indispensable to an efficient design and construction process.

Computer programs could also be developed to assist the O/C and the A/E in some of the more complex design procedures, particularly in cost-performance trade-offs.

633.2 ENCOURAGE MANUFACTURERS TO DEVELOP NEW PRODUCTS

A variety of product development programs are described in Section 764. They should be periodically explored for feasibility as experience is gained with the Prototype Design. Meanwhile, the subsystem design criteria should be used to encourage manufacturers to develop new products with improved cost and/or performance characteristics. As long as the VA cannot guarantee specific markets to these manufacturers, it must at least assure them that the Prototype Design has been officially adopted as the basis of an ongoing system development program within the context of the overall construction program (See Sections 111. 2.2 and 614.5).

633.3 STUDY FEASIBILITY OF PHASED BIDDING AND CONSTRUCTION MANAGEMENT

Various means of accelerating the design and construction process are discussed in Section 761. Phased bidding is seen as the most promising of these approaches. Construction management, as described in Section 762, offers a technique for handling the special problems of phased bidding. These methods have a potential for reducing project time and improving cost control far exceeding what can be achieved simply by application of integrated subsystems within current scheduling and management procedures. They should therefore be made the subject of detailed feasibility studies to determine how they may be adopted by the VA for all construction, systems and conventional.

633.4 STUDY RELATIVE MERITS OF HORIZONTAL VS. VERTICAL HOSPITAL CONFIGURATIONS

Currently adequate cost/benefit information related to configuration is not available. It is suggested that there is sufficient benefit potential for the Veterans Administration to warrant such a study.

Operational costs are closely interrelated with hospital configuration. Factors such as the selection of transportation systems, building height and the relationship of functional units are coupled with decisions regarding type of distribution systems, administrative policy, employee wage rates and socio-medical factors such as acceptable patient waiting times. A system of trade-offs involving these factors is suggested.

633.5 DEVELOP NEW WORKING DRAWING TECHNIQUES

Section 440 in the Design Manual stresses the importance of contract documents in the successful application of the Prototype Design. Some ways in which working drawings could be organized to take advantage of system characteristics are also mentioned.

There has been a recent proliferation of new techniques for working drawing production including photography, multi-color printing, and the use of computers. The unique characteristics of the Prototype Design may make it particularly well suited for the exploitation of some or all these techniques.

With the rapidly increasing complexity of modern hospitals, working drawings have become correspondingly complex and voluminous. The cost of producing, checking, reviewing, changing, printing and transmitting these documents has become a major expense in the design process. Increasingly large contingency factors are being included in construction contractors' bids because of the extreme difficulty in arriving at accurate estimates on the basis of such complicated, and often confusing, documents.

The VA should study the general problem of effective and efficient communication through contract documents in the light of these developments, in terms of both organization of symbolism and notation and the use of advanced production techniques, particularly as appropriate to the Prototype Design.

634 REVIEW OF PLANNING CRITERIA

634.1 The Joint Venture has been asked to identify areas where changes in VA criteria such as Manual M-7 would provide the Veterans Administration with better design and construction methods or space utilization. A comprehensive study of space utilization was not within the scope of this study; however, considerable effort was expended in an attempt to identify constraints to desired building performance or other project objectives.

It is not intended to recommend specific changes, but rather to suggest a basis for possible further investigation. The objectives of cost control and equitable distribution of funds to each project which are implied in Manual M-7 must be maintained. Within the context of this study, the additional objectives of reduced design and construction time, minimum obsolescence at the time of first occupancy, and efficient use of space throughout a building's life span should also be considered.

634.2 There is a close relationship between room size, operational policies and building organization. Currently, maximum square foot requirements for individual spaces are precisely defined. Maximum areas are in many cases effectively minimum; that is, spaces cannot be reduced much below the maximum indicated and still function.

It may be desirable to allow the building designer more freedom to vary room sizes to accommodate different patterns of operation, or to achieve a plan which is consistent with overall building organization and future adaptability. For example, it is conceivable that an increase in a specified room size may allow multi-use of space, thus eliminating other required spaces; or, increased space for single-bed rooms may allow the building perimeter to run straight through rather than notching in, thus providing for future adaptability at minimal cost. (See Section 751.3.3 for a discussion of the cost effect.)

It may be possible to allocate space with, say, a 15% increase allowance above a reasonable minimum. All spaces would not require this increase, thus the overall average increase could be restricted to, say, five percent. Further investigation would, of course, be needed to determine a workable range for the desired result.

634.3 It is generally true that if adaptability is to be provided, certain concessions to future use must be made. Decentralized mechanical systems may require more area. Circulation systems may be organized to accommodate future uses and thus will not be tailored to a specific solution. Factors such as these will tend to decrease the net-to-gross ratio; however, they may not increase first cost and should reduce life cost substantially.

634.4 The system discipline will also result in increased total area. Space module and structural disciplines must be respected. Area requirements may indicate that 4-1/2 space modules are required or that 15-1/2 structural bays are necessary on a particular floor. A method of allowing increases in area to even module or span increments must be provided within the space allocation system.

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700 APPENDICES

710 DESIGN RATIONALE, PLANNING MODULES

720 DESIGN RATIONALE, BUILDING SUBSYSTEMS

730 EXAMPLE BUILDING SCHEMATIC DESIGN

740 EXAMPLE SERVICE MODULE

750 COST AND TIME ANALYSIS

760 SPECIAL PROCEDURES

710 Design Rationale, Planning Module

711 CHOICE OF MODULE SCALE

711.1 THREE OPTIONS IDENTIFIED

711.1.1 Planning modules are increments of a total system of organization, in this case, the hospital. A module may be derived from:

1. the space required to perform a certain activity;

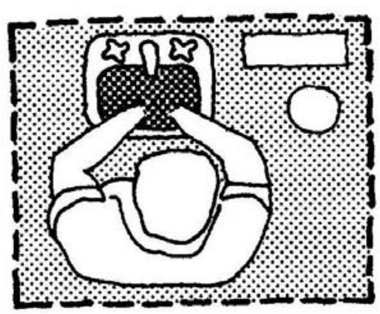
2. the range of activities which may be coupled together in one space (a room), or,

3. a grouping of rooms which are interrelated by functional need (functional unit).

These are illustrated in Figure 710-1.

711.2 CHARACTERISTICS OF THREE POSSIBLE MODULE SCALES

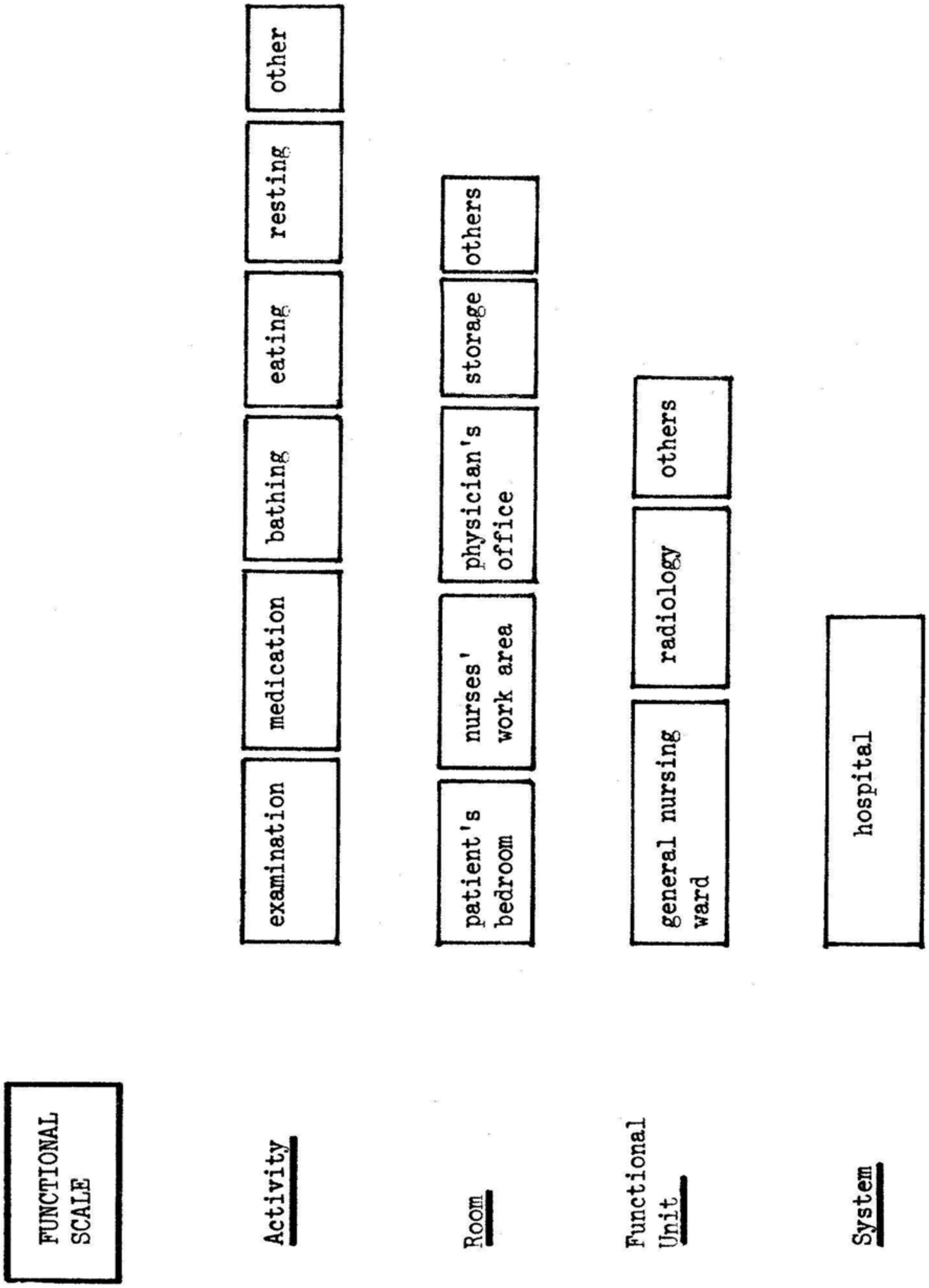
711.2.1 Activity Module



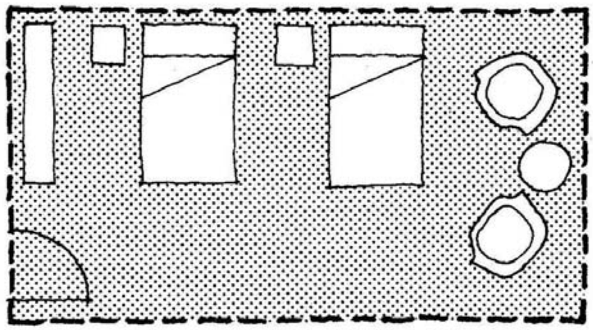
1. The activity module is a fundamental element in planning, an irreducible minimum, although not independent of other functions.

2. An activity, for example hand washing, will influence the system by generating a need for space, plumbing, partition finishes, partition attachments, lighting, temperature control, etc.

Figure 710-1. FUNCTIONAL NETWORK EXAMPLE



711.2.2 Room Module



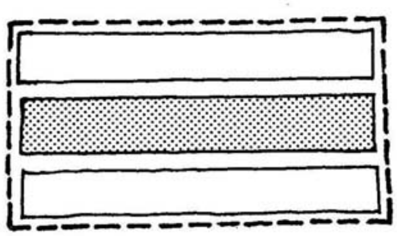
1. A room is the most commonly used “building block” in the current planning process.

2. A room must integrate and generalize the needs of all activities contained within it. In addition it generates needs relating to sound transmission, perimeter exposure, fire safety, organization, etc.

3. The range of adaptability necessary for hospitals cannot be approached at a room scale. However, adaptability within rooms is necessary to permit increase or change in functional capacity.

4. It is difficult to relate structural or mechanical organization to an individual room in a systematic way. A room is not sufficient to generate service sub-systems.

711.2.3 Functional Unit Module



1. This module allows the generalization of environmental and planning characteristics at a scale compatible with mechanical and structural considerations.

2. This module can be manipulated to achieve various configurations while functional and environmental capability remain constant.

711.2.4 Each module scale option: activity, room or functional unit, generates a level of need which must be satisfied by the building system. The functional unit scale has been selected as the major “building block” for the system. Only at this scale can one deal with problems of service distribution, structure, fire safety, and configuration.

712 THE SPACE MODULE

712.1 DERIVATION

712.1.1 When viewed in the context of the total hospital, the bed care portion is somewhat unique:

1. The bed care portion consists of generally repetitive elements (nursing units).

2. It has particular requirements for aspect (outlook) and perimeter to area ratios.

3. Nursing units are often consistent in size and arrangement from one hospital to the next.

The above features led to the development of space modules with pretested functional content which can be configured and, if desired, constructed prior to the actual plan layout of each module.

712.1.2 Within the capabilities of the building system, it is obviously preferable to maximize the range of plan options available to the VA, provided that the objectives of functional content, cost and adaptability can be achieved. While it may be possible to develop one optimum plan solution for a specific medical program, the uncertainty of medical programs and change in facility requirements makes the ability to achieve a large number of plan solutions necessary.

712.1.3 From an analysis of current nursing unit plan types, it was apparent that almost every imaginable variation of geometrical form has been used at one time or another. It is interesting to note, however, that the vast majority of solutions fall into a limited number of geometrical patterns and have reasonably consistent dimensional characteristics. Almost all solutions examined are variations of the core (“race track”), double-loaded corridor or cluster organizations which have been used as independent towers or attached to a larger element. A representative sample of plan solutions is shown on the following pages.

712.1.4 **Organization**

In examining the inherent characteristics of nursing unit plans, it was apparent that certain functional requirements tend to establish sets of constraints and variables.

1. The patient room must be on the perimeter of the unit, adjacent either to the exterior of the building or an interior court.

2. Patient rooms must be adjacent to a corridor or circulation space.

3. The location and amount of support facilities directly associated with patient beds is variable.

4. The greatest need for large, unobstructed area is in various types of intensive care units.

5. The general nursing unit (acute unit) comprises the majority of hospital areas devoted to patient bed-related care. Thus, it usually becomes the determinant of "nursing tower" configuration.

6. Rectilinear plans may be categorized as two-, three-, or four-aspects; that is, having two, three, or four sides used for rooms requiring perimeter location for natural light or ventilation.

While it is desirable to allow the VA a maximum of plan options within the building system capability it was found that certain examples, if included, would penalize the efficiency of the entire system; e.g., the circular cluster type plans.

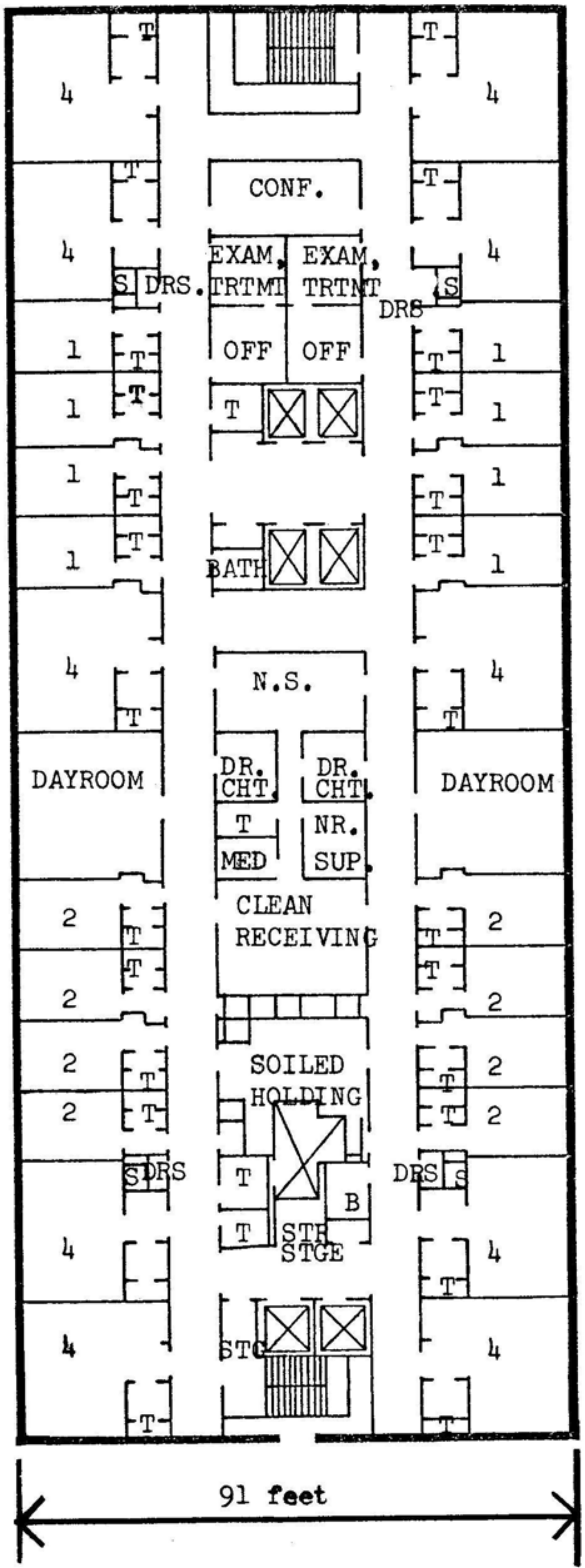
The circular cluster appears to have a number of disadvantages for the Veterans Administration in addition to imposing severe constraints on the building system.

1. The number of beds is directly proportional to the amount of support (core) area. Space for supporting facilities cannot be varied for a given number of beds.

2. A circular cluster cannot be joined to other modules or support areas except with a narrow link or at the expense of valuable perimeter.

3. The geometry requires a large number of angles by which structural members and partitions must be joined.

The advantages of a circular cluster plan can also be achieved by means of a rectilinear cluster solution.



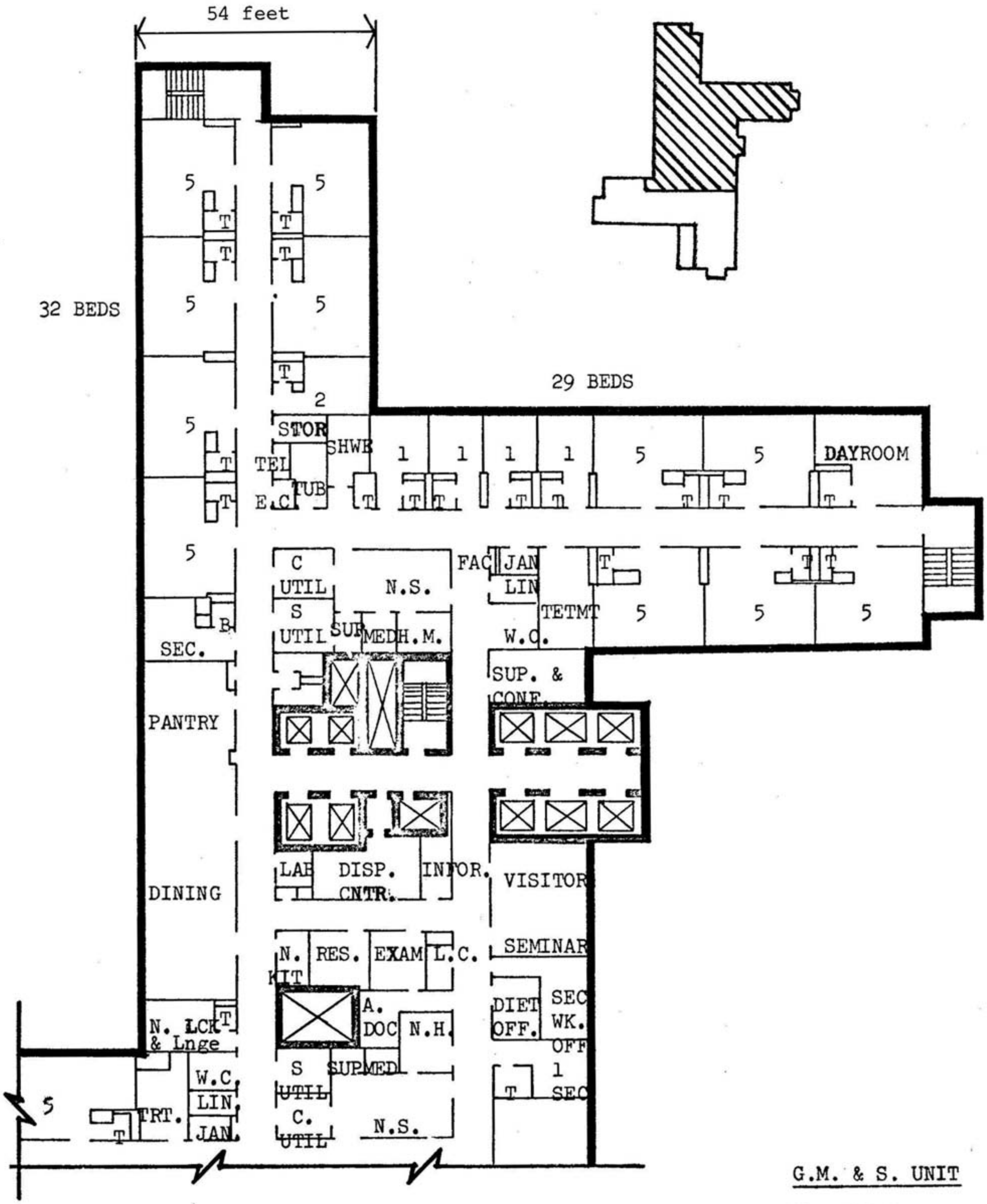
32 BEDS

32 BEDS

G.M. & S UNIT

5TH FLOOR
V.A. HOSPITAL
ATLANTA, GEORGIA

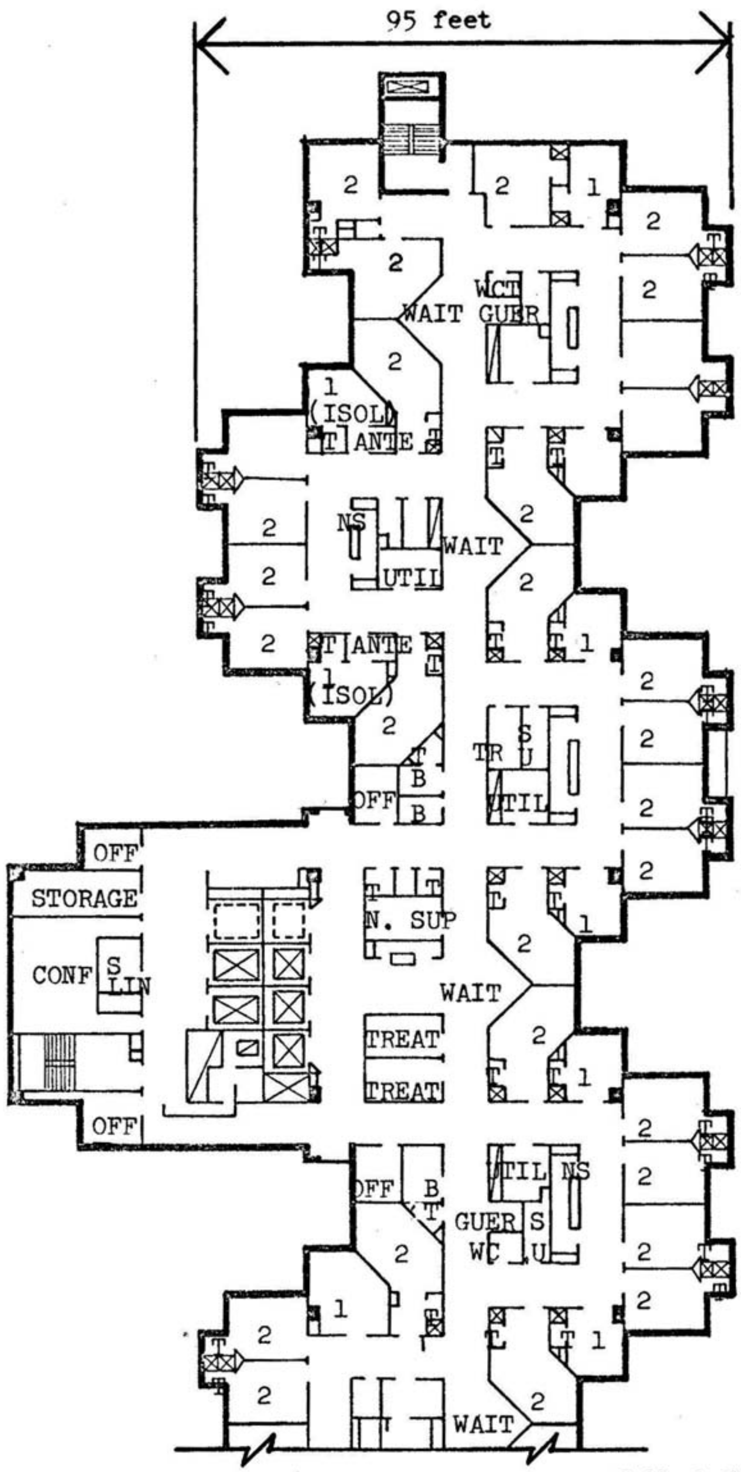
CORE PLAN EXAMPLE



DOUBLE LOADED CORRIDOR AND CORE
PLAN EXAMPLE

G.M. & S. UNIT

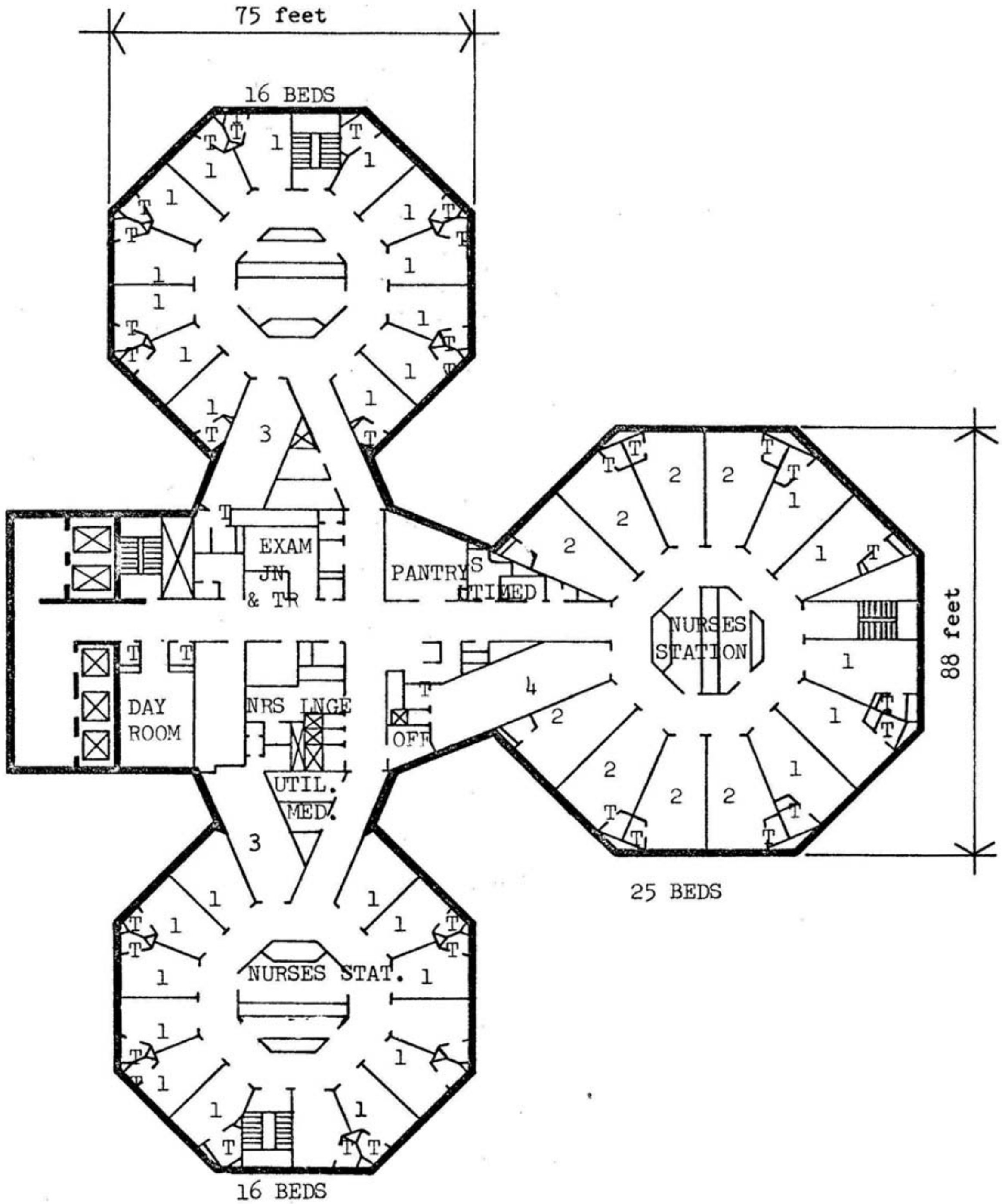
11TH FLOOR
V.A. HOSPITAL
MIAMI, FLORIDA



G.M. & S. UNIT

6TH FLOOR
PACIFIC MEDICAL CENTER
SAN FRANCISCO, CALIF.

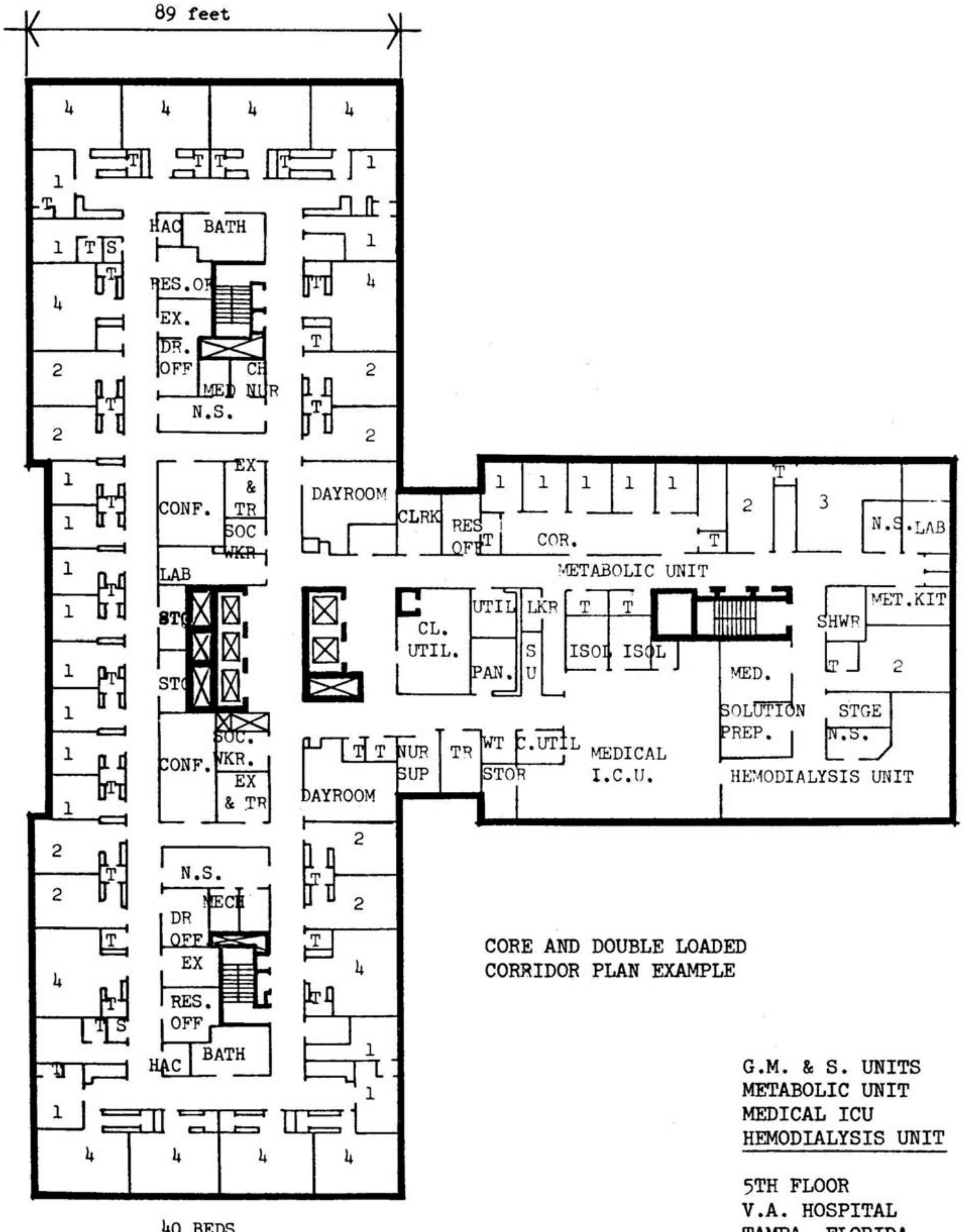
CLUSTER PLAN EXAMPLE



G.M. & S. UNITS

TYPICAL FLOOR
SCOTT-WHITE MEMORIAL HOSPITAL
TEMPLE, TEXAS

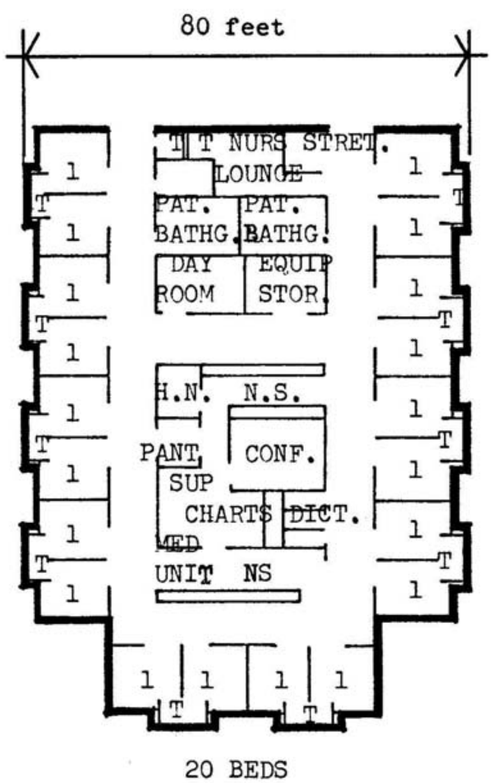
CLUSTER PLAN EXAMPLE



CORE AND DOUBLE LOADED
CORRIDOR PLAN EXAMPLE

G.M. & S. UNITS
METABOLIC UNIT
MEDICAL ICU
HEMODIALYSIS UNIT

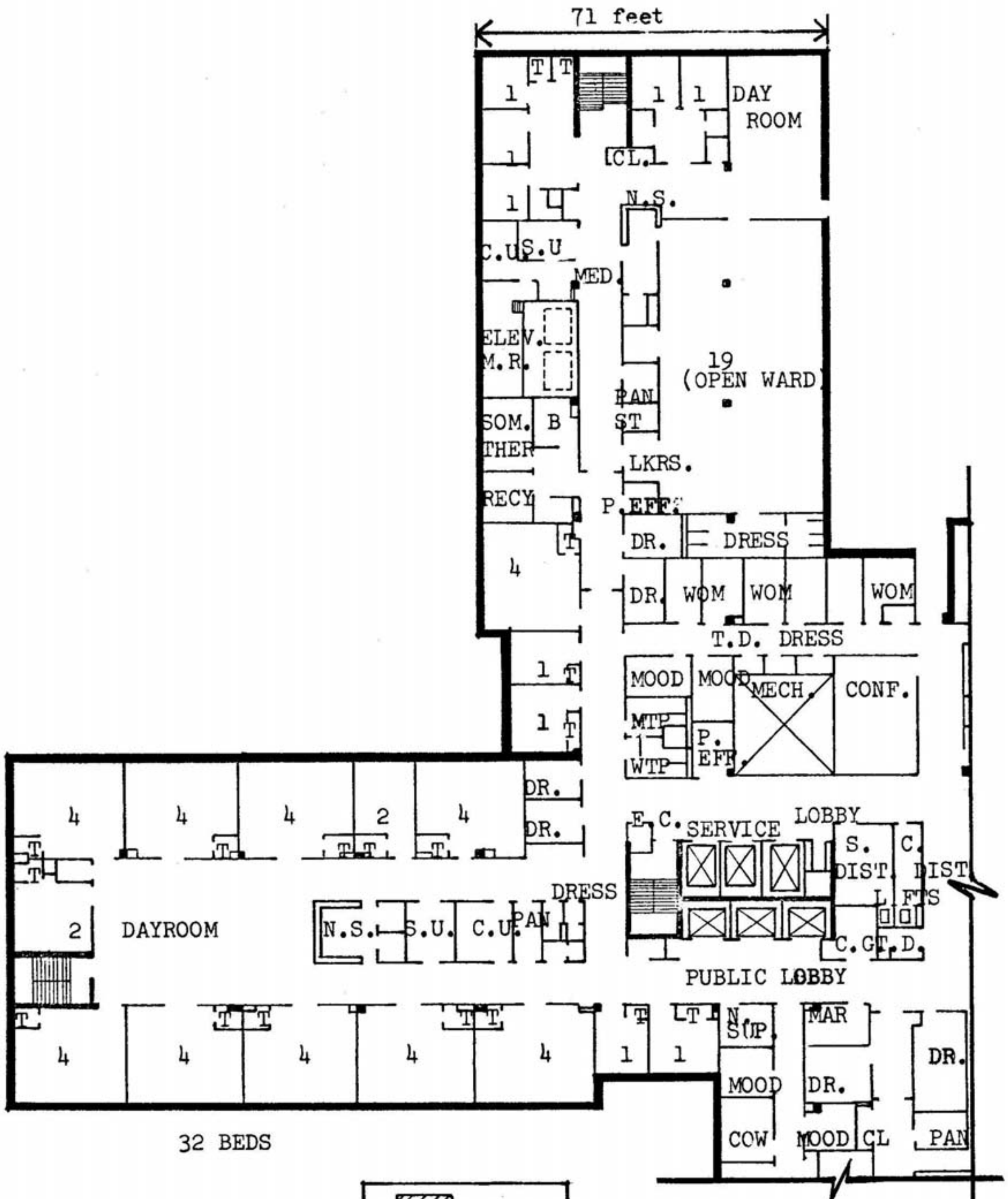
5TH FLOOR
V.A. HOSPITAL
TAMPA, FLORIDA

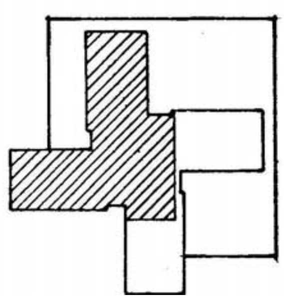


INTENSIVE CARE

MONTEFIORE HOSPITAL
NEW YORK

CORE PLAN EXAMPLE



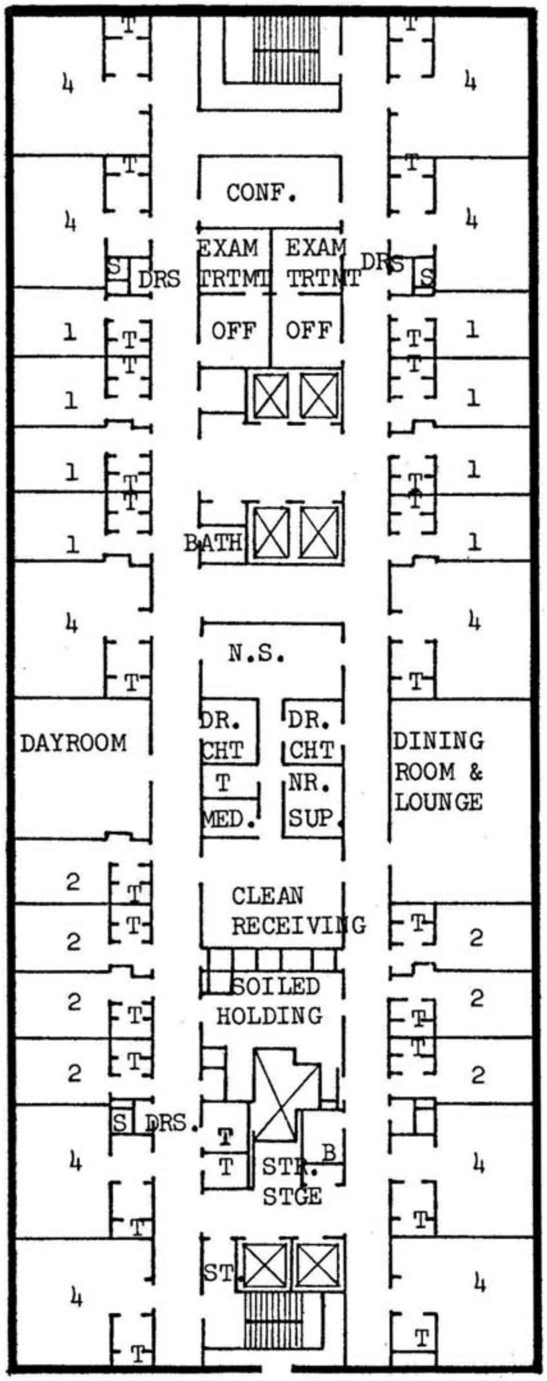


DOUBLE LOADED CORRIDOR AND CORE PLAN EXAMPLE

N.P. MEDIUM DISTURBED

PSYCHIATRIC UNITS

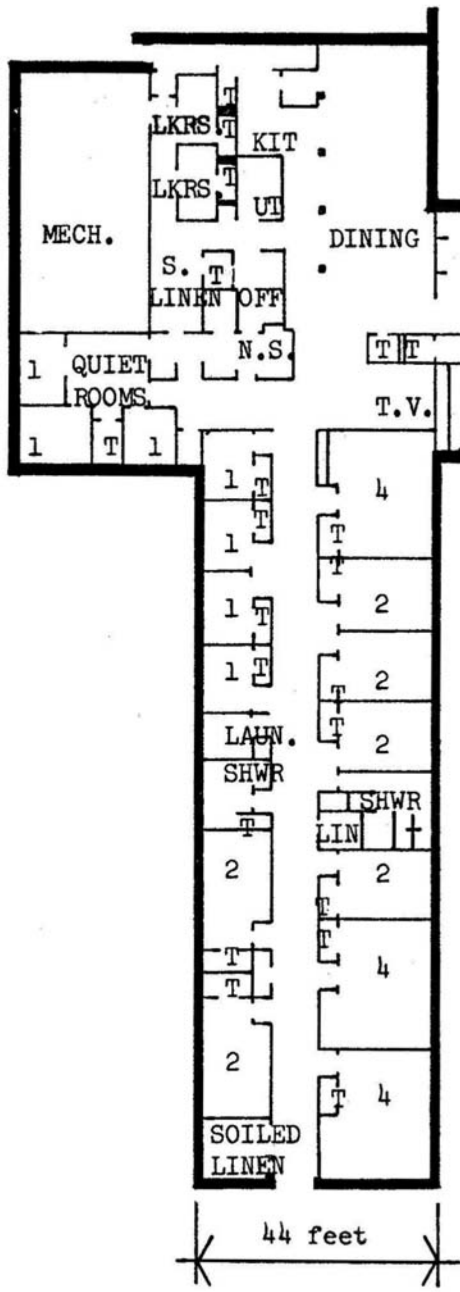
5th FLOOR
OAK KNOLL HOSPITAL
OAKLAND, CALIFORNIA



CORE
PLAN EXAMPLE

PSYCHIATRIC UNIT

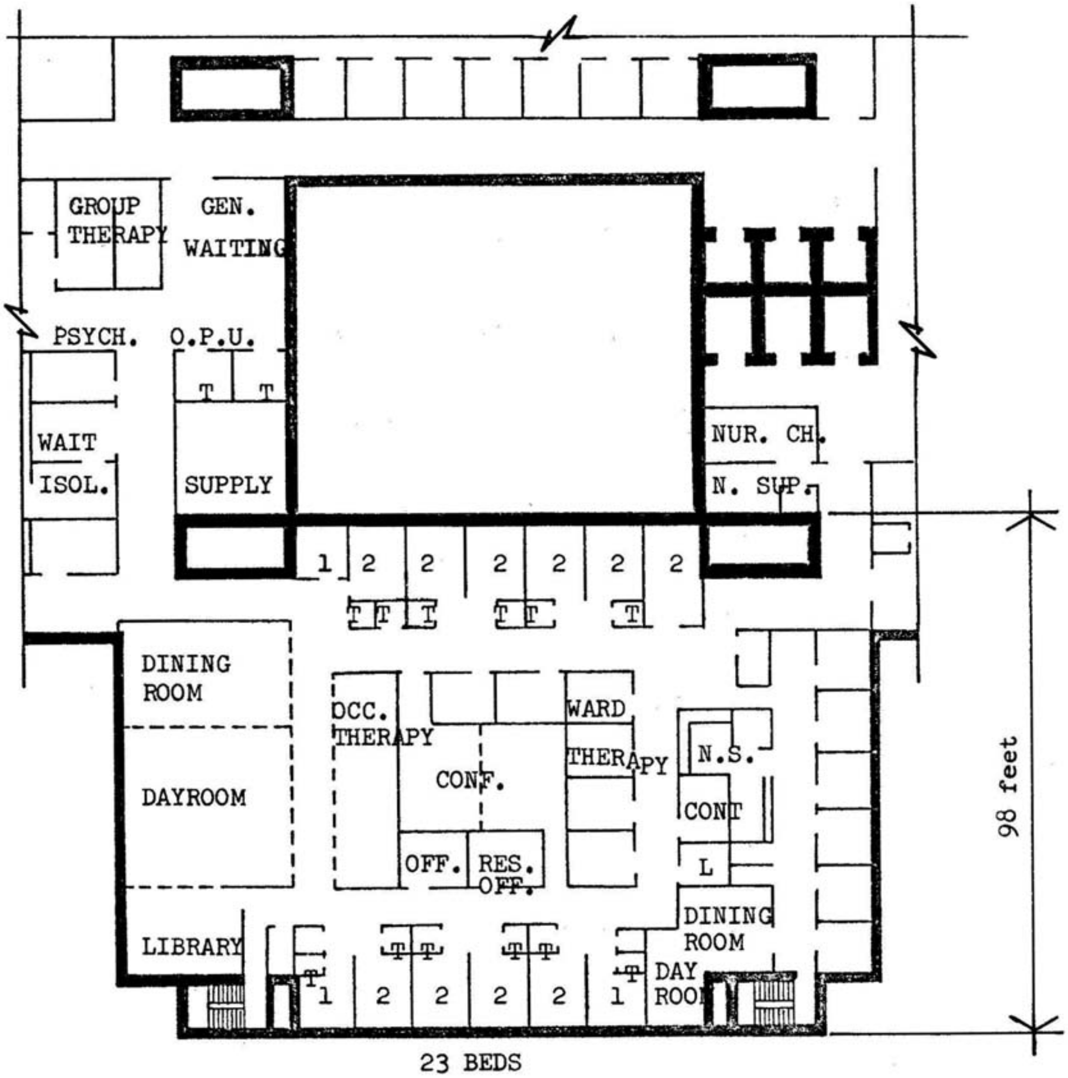
4TH FLOOR
V.A. HOSPITAL
ATLANTA, GEORGIA

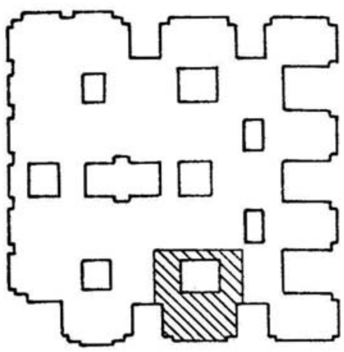


PSYCHIATRIC UNIT

ANDREW McFARLAND
ZONE CENTER
SPRINGFIELD, ILLINOIS

DOUBLE LOADED CORRIDOR
PLAN EXAMPLE

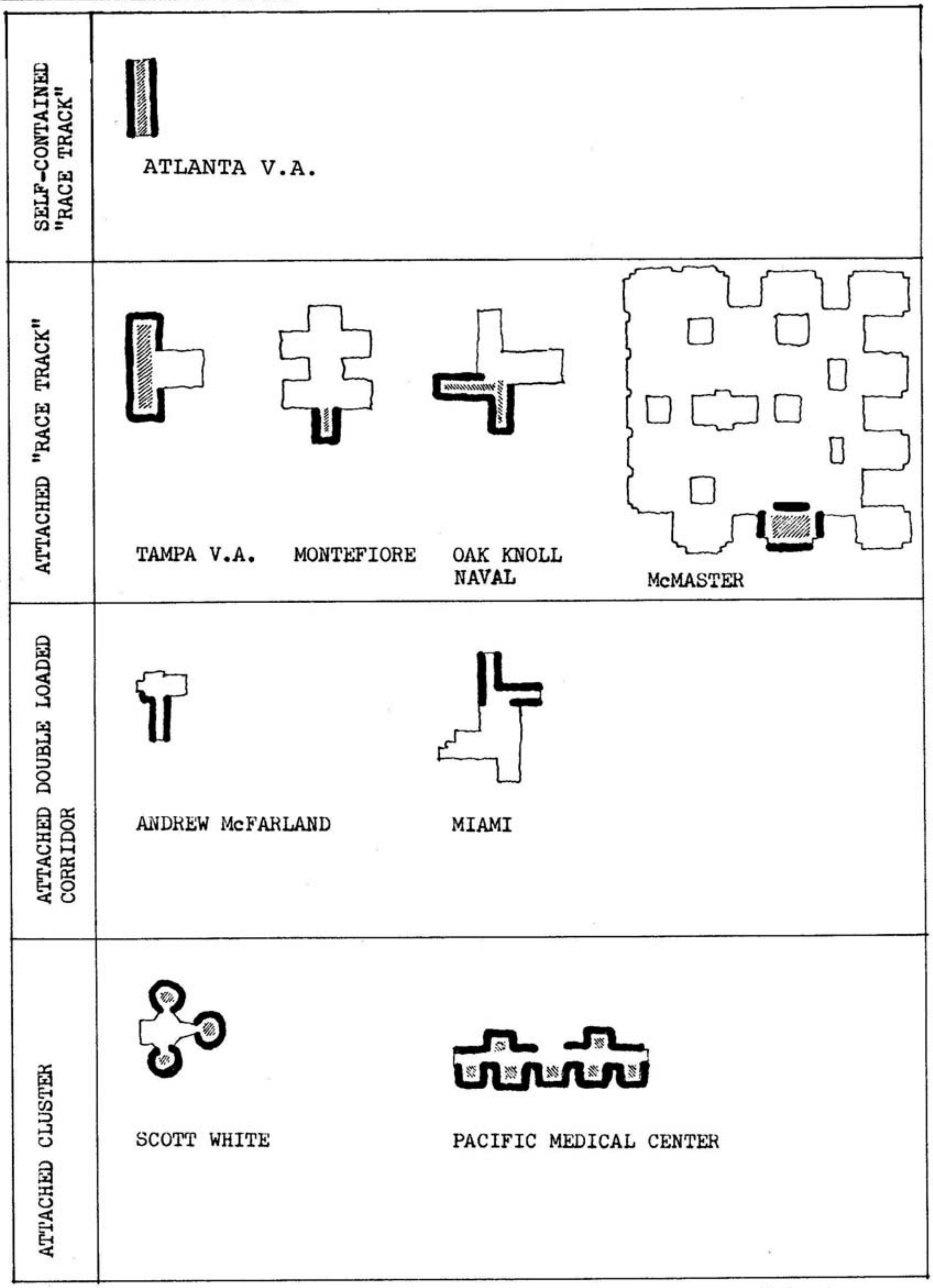




CORE PLAN EXAMPLE

PSYCHIATRIC ICU

3RD FLOOR
McMASTER UNIVERSITY
HEALTH SCIENCES CENTRE
HAMILTON, ONTARIO



CONFIGURATION TYPES 1"=400'

Architects for Example Nursing Units

Andrew McFarland	Phillips & Swager Hewitt & Bastian
McMaster University, Health Sciences Centre	Craig, Zeilder & Strong
Montefiore Hospital	Kelly & Gruzen Westermann & Miller
Oak Knoll Hospital	Stone, Marraccini & Patterson M. T. Pflueger
Pacific Medical Center	Stone, Marraccini & Patterson
Scott-White Memorial Hospital	Wyatt C. Hedrick Ellerbe Architects, Consultant
V.A. Hospital, Atlanta	Gregson & Associates Gordon A. Friesen Associates, Consultant
V.A. Hospital, Miami	Smith & Korach Beinswenger, Hoch & Arnold
V.A. Hospital, Tampa	Eliot C. Fletcher Frank S. Valenti Schmidt, Garden & Erikson, Associate Architects

712.1.5 Dimensional Characteristics

In the nursing tower plans studied, not only were certain patterns of organization relatively consistent, but also many dimensional characteristics remained constant or varied within narrow limits.

1. The dimension between the perimeter and the corridor (bedroom and sanitary zones) varies within a relatively narrow range and is dependent upon the specific building program. Variables include the number of beds per room and the type of sanitary facilities provided.

2. Corridor widths have generally been standardized at an eight-foot clear dimension. This is sufficient to allow a hospital bed to exit from a room perpendicular to the corridor wall.

3. The greatest variable in nursing unit width is the area for support facilities. In a teaching hospital, nursing units are generally attached to a larger central area containing functions related to patient care but which are not needed within the unit. Direct nursing support is found in the interior zone of core and most cluster plans. This interior zone or core area usually varies in width from a minimum of 12 feet to a maximum of about 30 feet and usually varies in approximate increments of standard room widths (12, 16, 24 feet).

4. Nursing unit length is usually a function of the perimeter necessary to satisfy a given program and often relates directly to the number of beds and bed rooms required.

712.2 DESIRED PERFORMANCE

712.2.1 Relation of Span to Space Use

1. The Desire for Structural Economy

   There is no doubt that totally column-free spaces provide the greatest degree of plan adaptability. However, it was desired, in the interest of economy, to identify precisely the minimum spans required for an acceptable degree of adaptability.

a. Clear sightlines in intensive care units.

Any space module may contain, or has the capacity to be modified to contain, specialty units such as intensive care. These units typically require the direct visual surveillance of all patients from a central nursing station. Planning studies indicated that this requirement could always be met if column-free areas measuring at least 40 feet in their short dimension were provided.

b. Free planning of narrow cores.

The support facilities in core-type space modules are contained in a central core which may vary in width from twelve to thirty or more feet. The core is typically divided into small rooms, and this division can be expected to change much more frequently than the partitioning of the bedrooms. When such cores are at the narrow end of the scale of widths, a column creates a significant impediment to plan adaptability, especially at the lower floors of a hi-rise tower. Columns are therefore to be excluded from narrow core type modules.

c. Possible changes in corridor location.

A common location for interior columns is along one side of the corridor. This location is undesirable as the corridor may move, either during the detailed planning stage (when the structure may already be under construction) or in future alterations. Examples in which the corridor may move include:

(1) An upgrading of bedroom sanitary facilities, say from lavatory only to lavatory, toilet and shower per bedroom.

(2) The conversion of a General Medical Nursing Unit to an Intensive Care Unit.

2. Identification of Permissible Column Locations.

a. Columns may occur at the perimeter of any building.

b. Columns may occur along the center line of any building 81 feet or greater in width. This satisfies the requirements stated above:

(1) Two column-free areas measuring at least 40 feet in their short dimensions are provided.

(2) The most narrow core possible (assuming the widest sanitary zone) is over 16 feet in width, i.e., a double row of small rooms. This core is wide enough to accept a central column.

(3) Corridor location is unaffected by the columns.

c. Columns may occur 18 feet (to column centerline) within the perimeter of any building 58’6” or greater in width. This also satisfies the requirements stated above:

(1) One column-free area measuring at least 40 feet in its short dimension is provided.

(2) The core is completely free of columns.

(3) Corridor location is unaffected by columns.

This column location, implying an asymmetric cantilever, is based on the fact that the most constant and predictable dimension on the nursing floor is the clear depth required for bedrooms. This has been set at 15’6”. (See ergonomic studies in Section 230.)

Eighteen feet is the sum of:

(1) the required clear space (inside face of exterior wall to outside face of column)

(2) one-half the maximum depth of the column (36”/2 = 18”)

(3) one foot maximum allowable thickness of exterior wall.

In this location the column will fall either on the boundary between the bedroom and the corridor (sanitary zone 1) or it will be absorbed within the sanitary zone (sanitary zones 2 and 3).

3. Sequence of Structural Types

   The placement of columns in these permissible locations produces a sequence of structural types - single span, cantilever and double span - which satisfies the planning requirements with great economy. (See Structural Rationale Section 720.)

4. Other Permanent Vertical Elements

   The requirements for uninterrupted space are also satisfied by the exclusion of other permanent vertical elements (air shafts, piping and electrical risers, equipment rooms, stairs, elevators and other transport systems) from the space modules.

712.2.2 Relation of Bay Width to Space Use

The coordination of bay widths with the critical dimensions of one-, two- and four-bed rooms (as described in Section 230):

1. Produces, in the case of a building programmed for one- and four-bed rooms, and possessing the capability to convert to two-bed rooms, an overall length which is significantly less than that required for a bay spacing designed to accommodate either a four-bed room, a pair of two-bed rooms or a pair of one-bed rooms.

2. Produces one-, two- and four-bed rooms which are very close to the recommended critical dimensions. The usual compromise solution produces one- and four-bed rooms which are wider than necessary, and a two-bed room which is not really wide enough to allow the passage of one bed past the second.

712.2.3 A Set of 11 Space Modules

Once the validity of the space module as a planning module is accepted, it still may be asked why there are eleven modules in the catalog, rather than twenty or more.

1. Full Range of Planning Options

   The eleven modules provide the desired range of options in:

   a. Internal organization.

      Both core and double-loaded corridor types have suitable applications and should therefore be included.

   b. Assembly characteristics.

      A full range of assembly possibilities is provided by including two- and four-aspect modules, each of which has different assembly characteristics. The four-aspect modules may be modified to produce three-aspect modules: either, a twenty-bed three-aspect unit by using one-half of certain modules or, a 40-bed three-aspect unit by increasing the length of the modules by one structural bay. (See Section 230)

   c. Program variation.

      The provision of a range of widths (spans) in each of the aspect- and organization-types provides for fluctuations in program for:

      (1) Sanitary facilities.

      (2) Support space on the nursing unit

2. Minimum Workable Number of Modules

   a. The clarity and simplicity of the system is increased as the number of modules is reduced to the minimum required to achieve the desired range of planning options.

   b. At any point in time, the current state of the continuing evolution of programs and standards within the VA may eliminate some of the eleven, reducing the number further.

c. As the system is applied and feedback received, dimensions may be revised and/or new space modules developed. For example, the building width of 63 feet (45' + 18' cantilever) has been dropped from the current set of space modules, as it does not appear to offer plan possibilities which differ significantly from the sizes above and below it. After further testing, the VA may decide to include this width in the set.

712.2.4 Additional Space

The concept of additional space has been developed to allow a finer tuning of space allocation in relation to VA space programs.

Currently, VA nursing unit programs are generally consistent from one facility to another. They are therefore more or less predictable.

However, the space associated with nursing units, but not necessarily an integral part of direct patient care, is highly variable from one facility to the next. A strict application of space modules to these areas would result in a relatively inflexible discipline. Therefore, the ability to obtain additional space, between modules or adjacent to them, which is incremental in structural bay units (22'6" by the module width) provides a valuable, small scale, space option.

713 VERIFICATION OF STRUCTURAL SYSTEM

713.1 STRUCTURAL COMPATABILITY

Once the minimum spans required for an acceptable degree of adaptability and an acceptable range of plan options had been identified for the bed care functions of the hospital, it was necessary to test these spans in terms of the requirements of the non-bed care portions of the hospital.

713.2 DIVERSITY OF REQUIREMENTS

713.2.1 Size

In contrast to the nursing unit, non-bed care functional units are less predictable. They vary widely in size not only from one unit to another but from one hospital to another, depending upon the relative number of beds served, outpatient load, degree of medical specialization, etc.

713.2.2 Internal Organization

Non-bed care units were examined to identify consistent patterns of organization which might be sufficiently extensive to justify a new structural discipline. No consistency of plan organization exists between functional units. Each is optimized in response to the medical and operational needs of a particular set of activities. It is unlikely, therefore, that any non-bed care unit or combination of units will become a generator of a new structural discipline.

713.2.3 Large Column-free Areas

Structural spans in the nursing tower system range from 40’6” to 58’6”. Bay spacing is 22’6”. Functional units were examined to determine individual spaces which exceeded 22’-6” in one or both dimensions and in which of these a clear, column-free area was required. Certain large areas such as auditorium, swimming pool, etc., must be column-free. Although relatively few in number, they must be accommodated within the building system.

The structural system provides bands of free space equal to the length of span. The minimum of 40’-6” can readily accommodate any auditorium with a seating capacity of up to 200 seats and a band of 58’6” can accommodate an auditorium with a seating capacity of up to 400 seats.

For height considerations of these special areas see Section 210: The Structural Bay.

713.2.4 Suites of Large Rooms

In addition to considering large spaces, non-bed care areas were reviewed to determine inherent relationships between spaces which might not be compatible with structural column locations. In the case of functional units such as Surgery and Radiology where there is a precise organizational pattern, it may become necessary to intersect a line of columns. In these areas, the 22’-6” bay spacing becomes critical. In the typical operating room there is no occasion where both dimensions exceed 20’-0”.

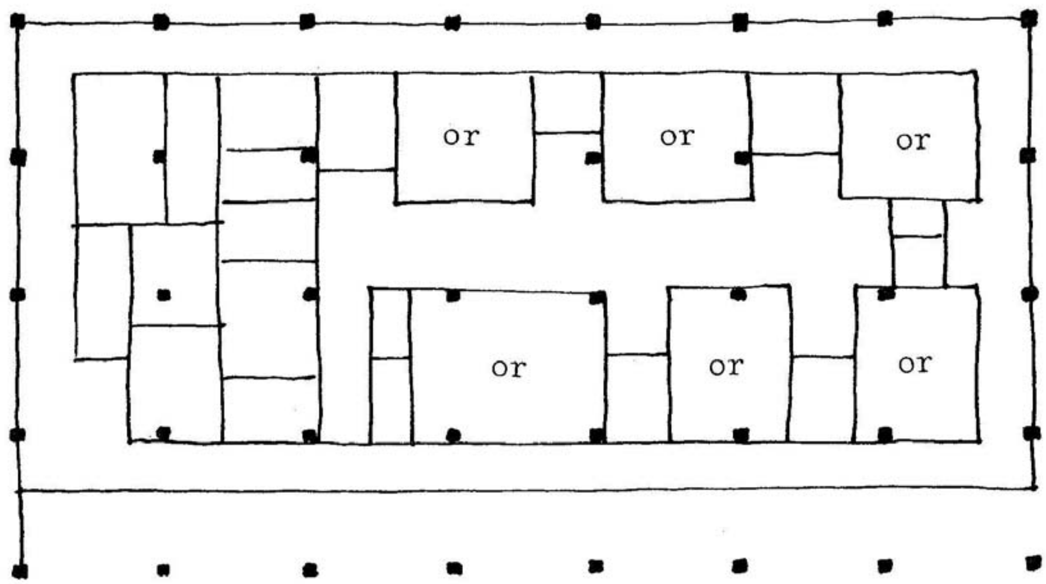
A review of existing VA hospitals indicates that the most typical surgical layout is that of operating rooms grouped around a central work corridor for staff and clean supply, with a perimeter corridor for patient access and egress.

A simulation study of three existing surgical suite layouts and three radiology suite layouts and superimposing these on the minimum size of structural bay, namely 22’-6” x 40’-6”, demonstrates how the organization of these critical areas can be readily achieved within the constraints of the structural system. (See Figures 710-2, 3, 4, 5, 6, and 7)

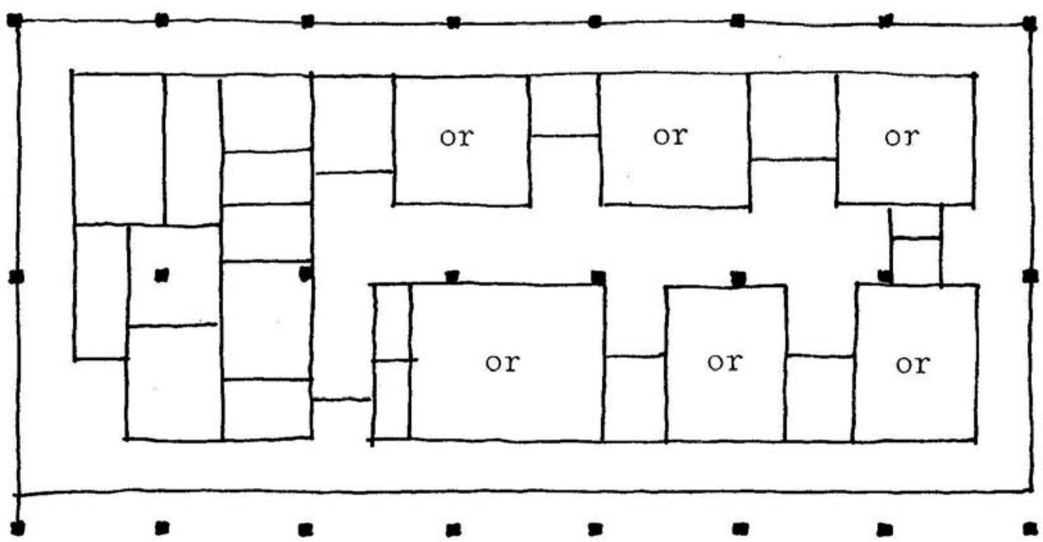
713.2.5 Other Areas

For other areas, it is obvious that any reduction in the number of permanent elements such as columns reduces constraints in planning. Current spans in VA and most non-VA hospitals are considerably shorter than those in the proposed structural system.

Figure 710-2. **SURGERY SIMULATION**
V.A. HOSPITAL, TAMPA, FLORIDA

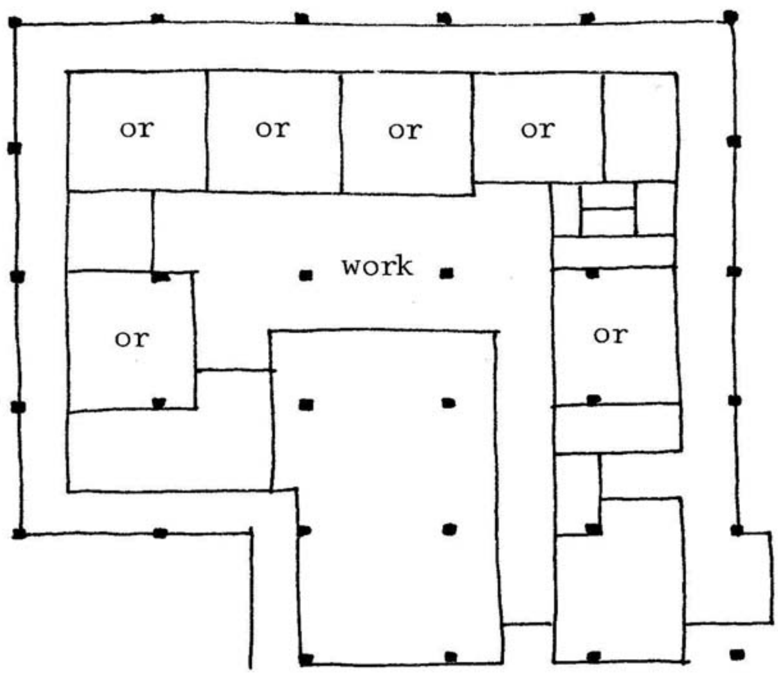


actual plan

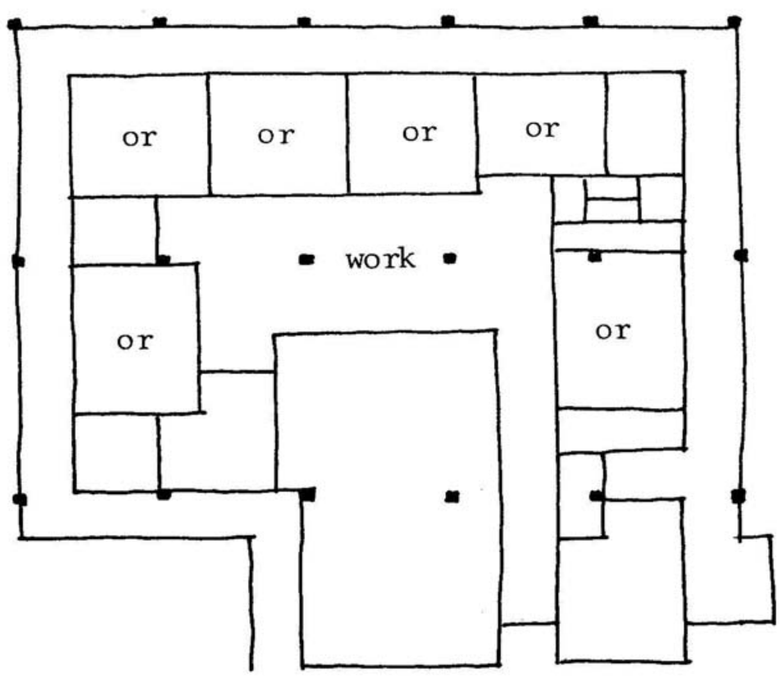


simulation

**Figure 710-3. SURGERY SIMULATION
V.A. HOSPITAL, MEMPHIS, TENNESSEE**

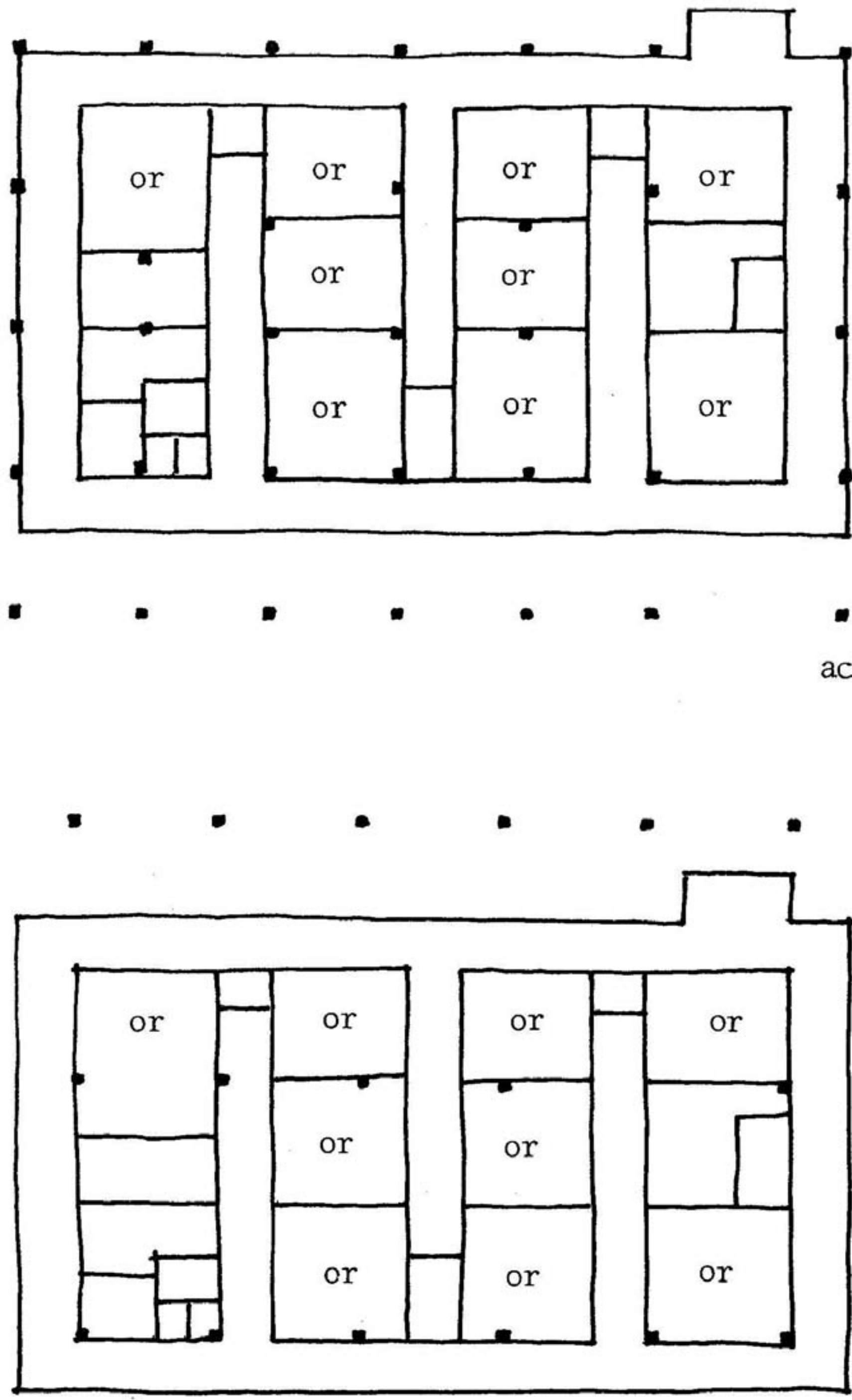


actual plan



simulation

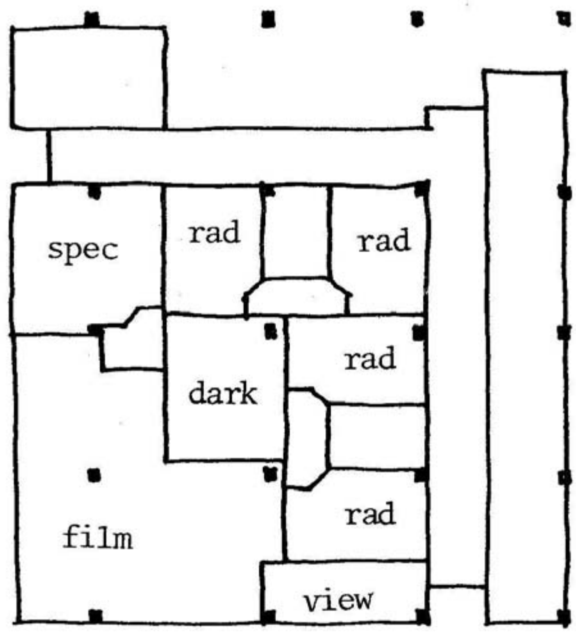
Figure 710-4. SURGERY SIMULATION
V.A. HOSPITAL, CLEVELAND, OHIO



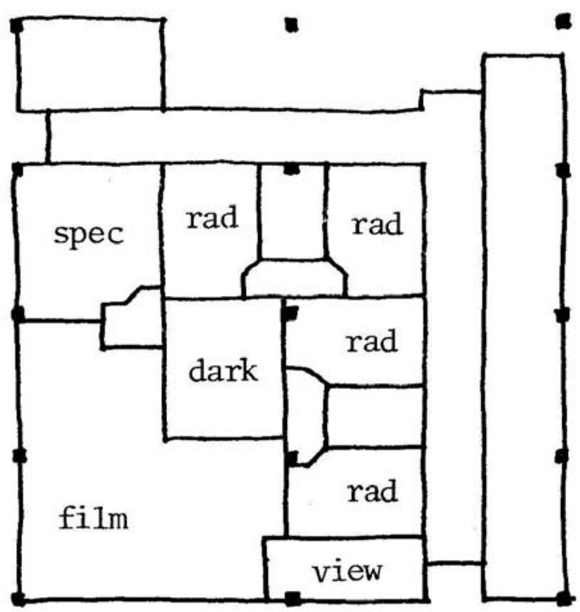
actual plan

simulation

Figure 710-5. RADIOLOGY SIMULATION
V.A. HOSPITAL, TAMPA, FLORIDA

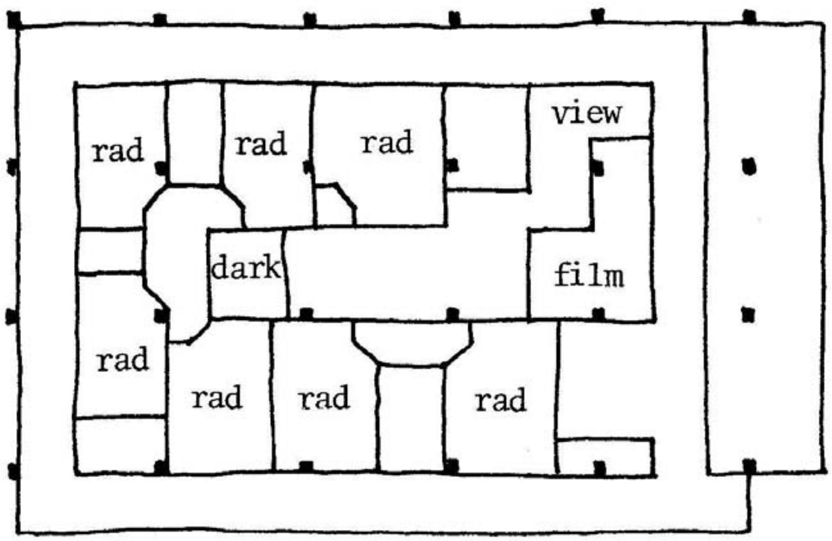


actual plan

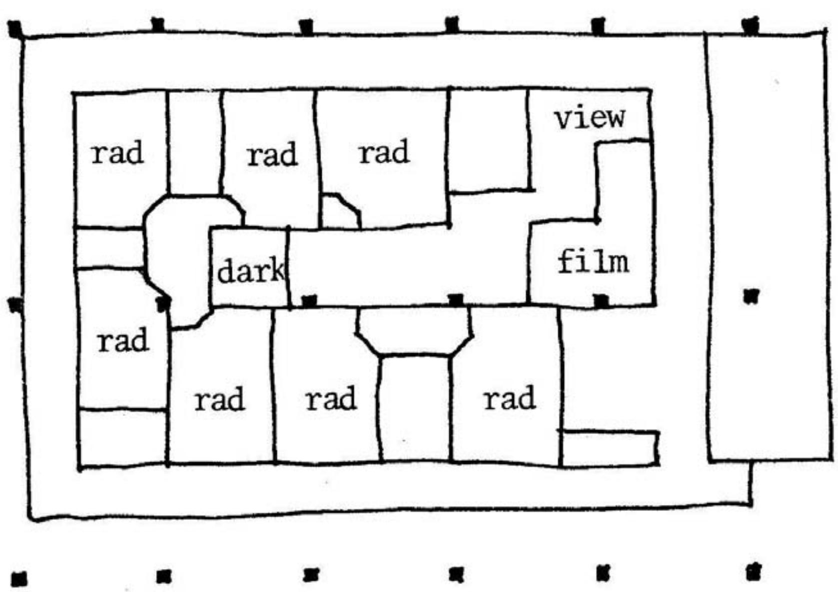


simulation

Figure 710-6 RADIOLOGY SIMULATION
V.A. HOSPITAL, MEMPHIS, TENNESSEE

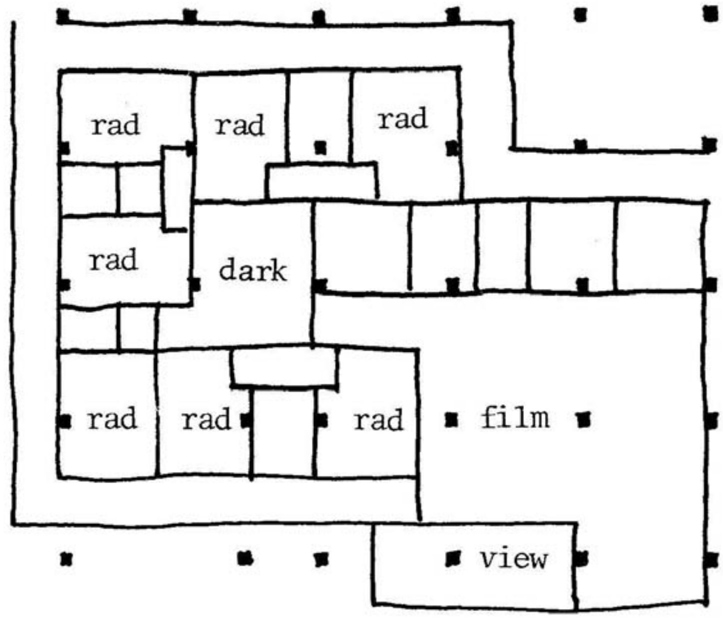


actual plan

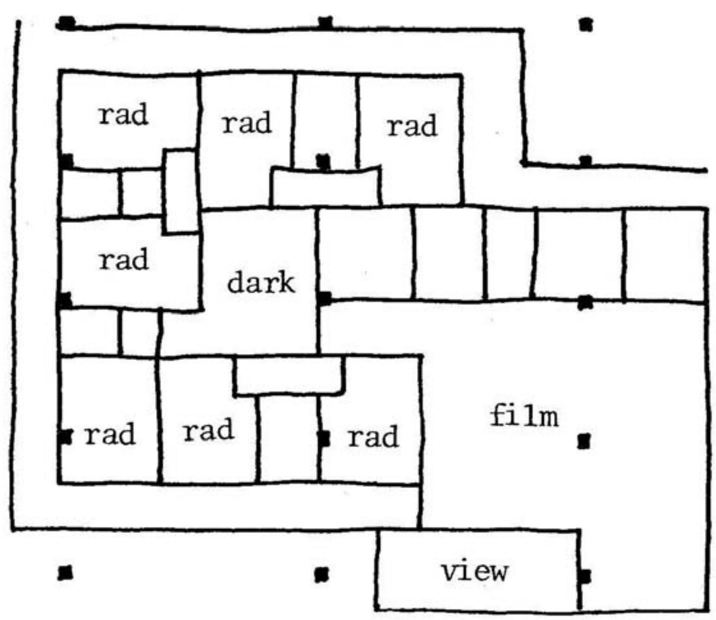


simulation

Figure 710-7. RADIOLOGY SIMULATION
V.A. HOSPITAL, CLEVELAND, OHIO



actual plan



simulation

714 CONFIGURATION STUDIES

Three existing VA hospitals were examined to demonstrate the applicability of the Prototype Design to the total hospital. They represent a cross section of nursing unit space module types and suggest different structural span and organizational variations.

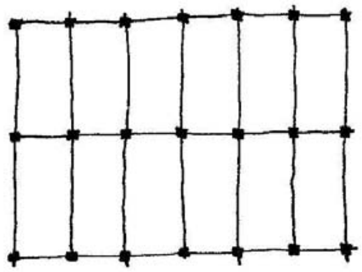
Although these examples are specific applications of the system, each can generally be compared to one of the configurations illustrated in Figure 250-2. The following hospitals were examined.

1. Columbia, Missouri (Figure 710-8) utilizes a single 45-foot span, a simple structural and mechanical component pattern, and is a simple assembly. This hospital plan is similar to configuration E-2 in Figure 250-2.

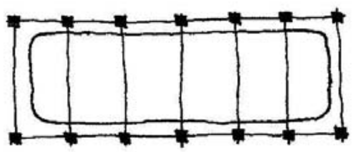
2. Wood, Wisconsin (Figure 710-9) utilizes a 54-foot span with an 18-foot cantilever, and a simple structural and mechanical assembly pattern. It can be directly related to configuration D-2 in Figure 250-2.

3. Lexington, Kentucky (Figure 710-10) utilizes a double 45-foot span and maintains a simple mechanical pattern. The structural pattern is compound as a result of the “t” shape of the nursing tower. The configuration can be related to configuration B-4 in Figure 250-2.

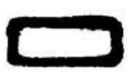
LEGEND (Figures 710-8, 9 & 10)



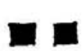
Structural Bays



Service Module

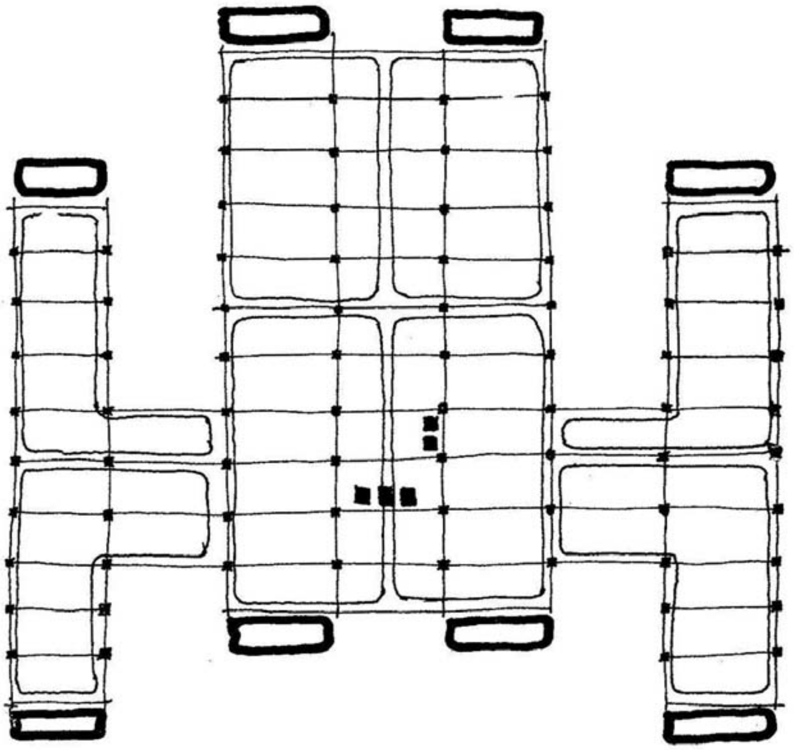


Service Bays

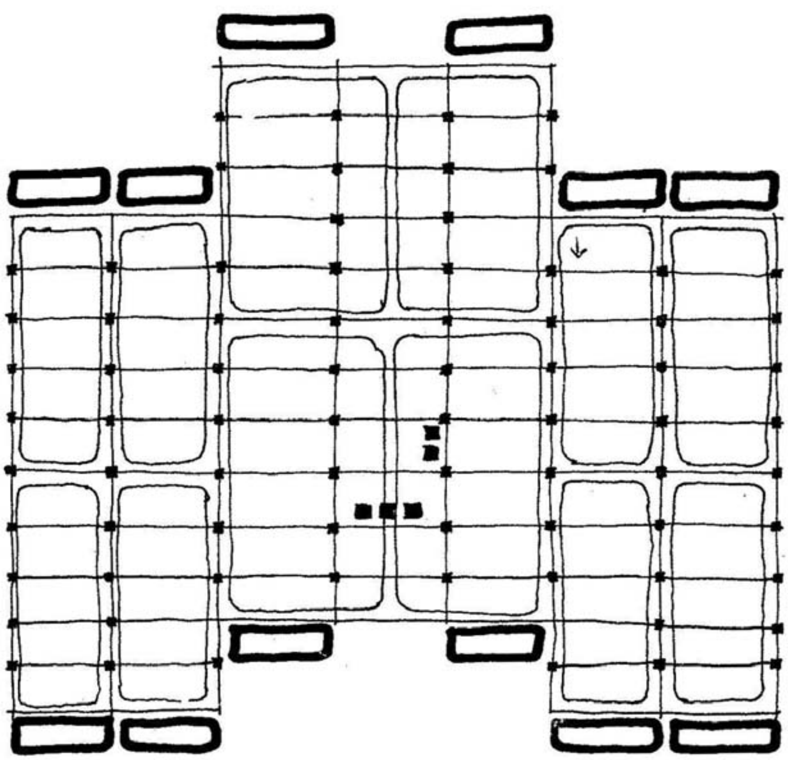


Elevators

Figure 710-8 V.A. HOSPITAL, COLUMBIA, MISSOURI



tower



base

Figure 710-9 V.A. HOSPITAL, WOOD, WISCONSIN

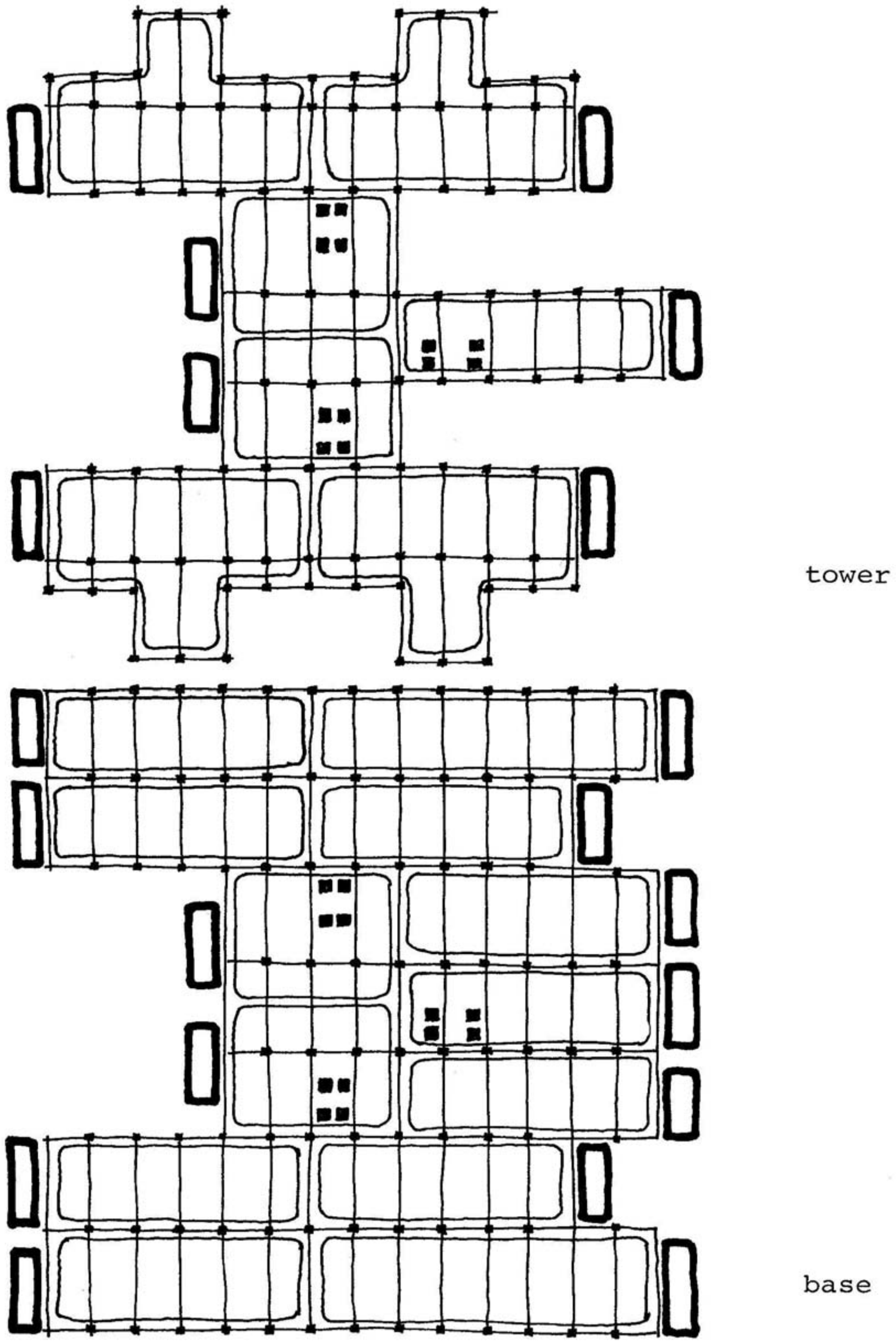
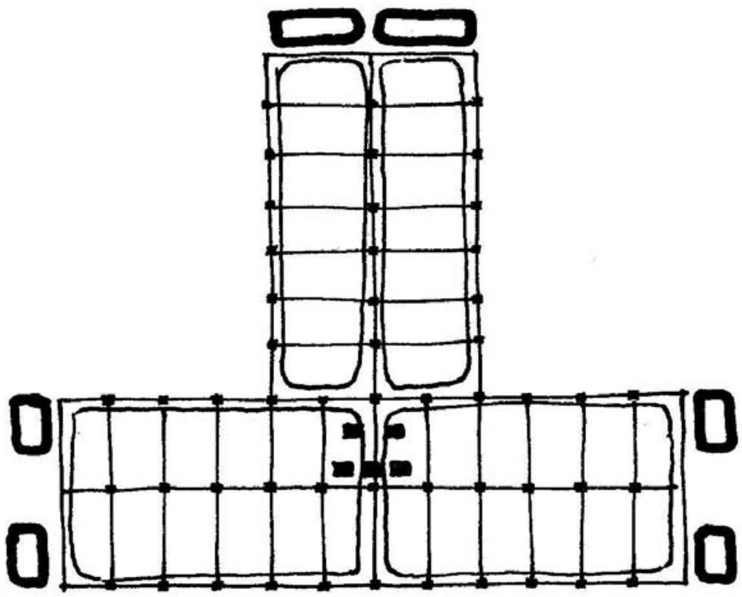
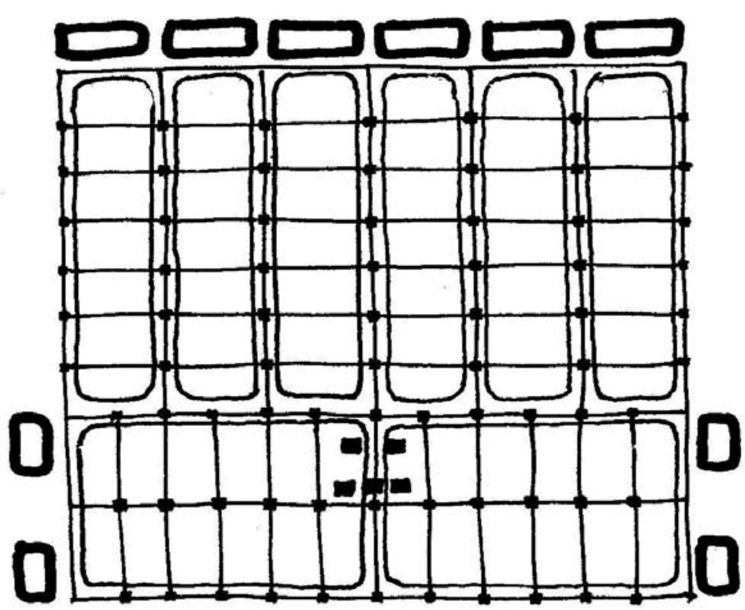


Figure 710-10 V.A. HOSPITAL, LEXINGTON, KENTUCKY



tower



base

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720 Design Rationale, Building Subsystems

721 STRUCTURE

Many of the reasons leading to particular details in the structural subsystem of the Prototype Design are discussed in Section 310 of the Design Manual. This section consists mainly of those discussions considered too detailed to be included in the Design Manual.

721.1 CLEAR SPANS

721.1.1 Span Range

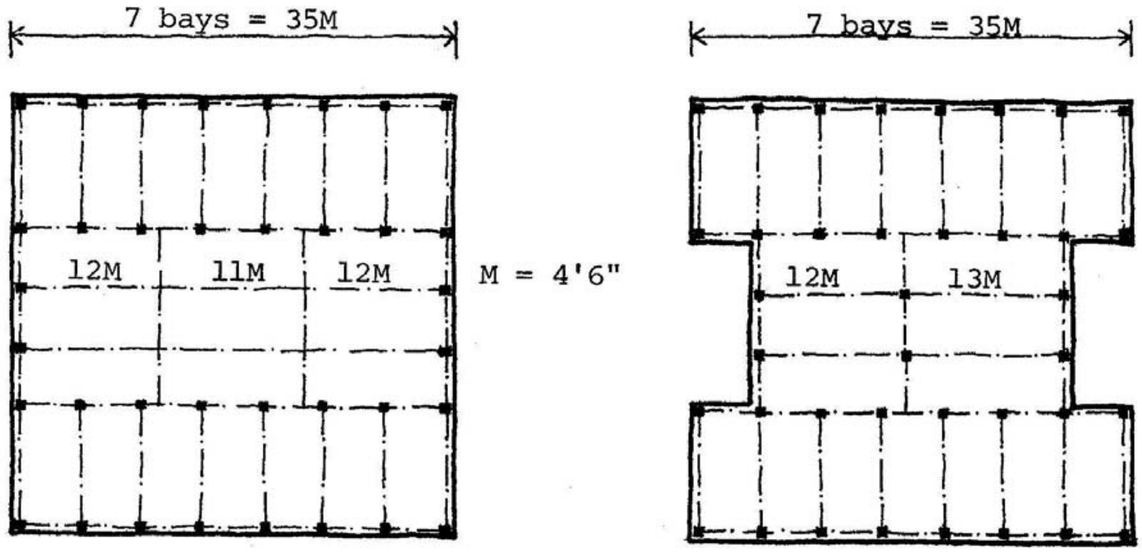
Before a basic framing system could be selected, it was determined that the clear spans required in the Prototype Design would fall within the forty- to sixty-foot range. This range was determined by identifying the maximum and minimum spans necessary for an acceptable degree of adaptability. (See Section 710.) The upper end of the range was also influenced by issues of cost since spans over sixty feet would have eliminated the more economical of the structural alternatives.

The clear spans in the Prototype Design are somewhat greater than those commonly found in current VA hospitals, but less than the spans seen in some recent projects, e.g., VA San Diego (80’0”); McMaster University Health Sciences Center, Hamilton, Ontario (73’6”).

721.1.2 Spans in Modular Lengths

The actual spans selected vary in 4’6” increments from 40’6” to 58’6”. These dimensions are based on the same module as the 22’6” bay width, namely 4’6”. In other words, the bay width is always equal to five modules and the beam lengths range from nine modules to thirteen modules. An 18’0” cantilever extends the bay length by four modules.

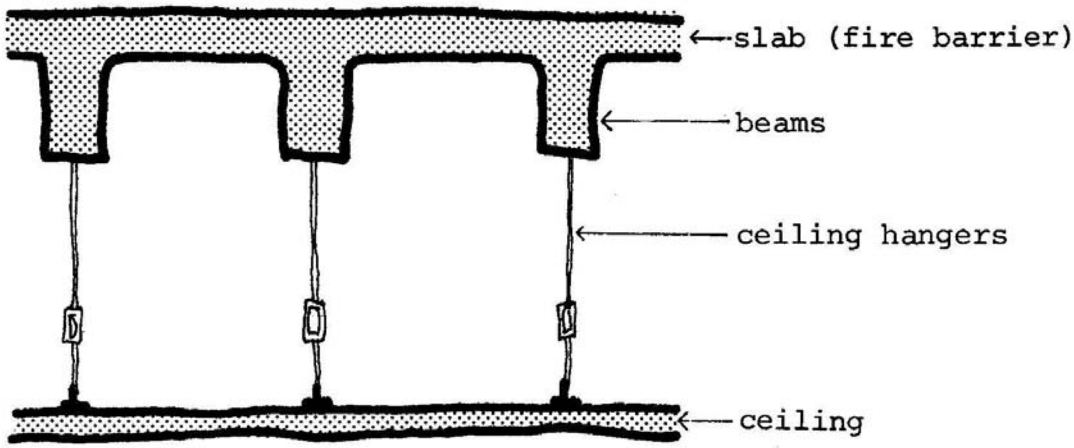
The small increments in the beam length allow adjustment of building width. Also, any number of bay widths above three can be matched in length by some combination of modular spans. Thus even a change of direction in framing can result in buildings with a simple configuration, as illustrated by the following examples.



721.2 FRAMING SYSTEM FOR VERTICAL LOADS

The basic design of the framing system was selected from various structural alternatives mainly in relation to service distribution routing and access. The pros and cons of four major design alternatives are:

721.2.1 Shallow Beams Combined with Suspended Ceiling-Platform



Pro:

1. Beams are simple to construct and economic in the span range in either concrete or steel.

2. Independence of depth of structure and depth of service zone allows each to be optimized in its own terms.

3. Ceiling hangers provide minimum obstruction to service distribution.

4. If one-way structure, space between beams may be reclaimed for service distribution.

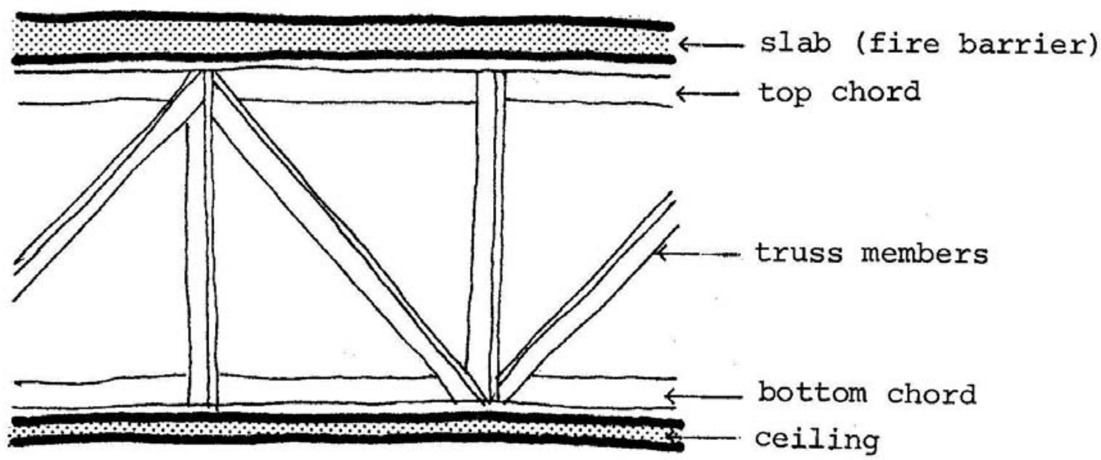
5. Service zone can be made deep enough for horizontal access.

Con:

1. Closely spaced beams impose restrictions on drops for drainage.

2. Substantial additional structure needed for walking surface on ceiling.

721.2.2 Deep Truss



Pro:

1. Allows longest clear spans (fewer columns).

2. Service zone can be deep enough for horizontal access.

Con:

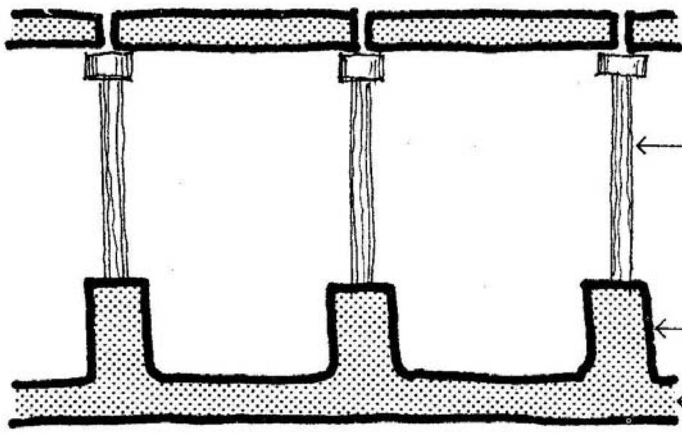
1. Uneconomic at shorter spans. More costly than beams at medium-range spans as well. Long spans, where truss is most applicable, are not considered necessary.

2. Truss depth controlled by depth required for service distribution (or vice versa).

3. Truss diagonals impose severe restrictions on service distribution and access, especially with fireproofing. Less inhibiting Vierendeel truss is inefficient

4. Truss solution weights system toward steel, ignoring regional differences which may favor concrete.

721.2.3 Access Floor



Pro:

1. All service distribution to one floor can be in the same service zone if air is served up from below.

2. Service zone can be deep enough for horizontal access.

3. Depth of service zone is independent of depth of beams.

Con:

1. Floor jointing may be problem in hospital.

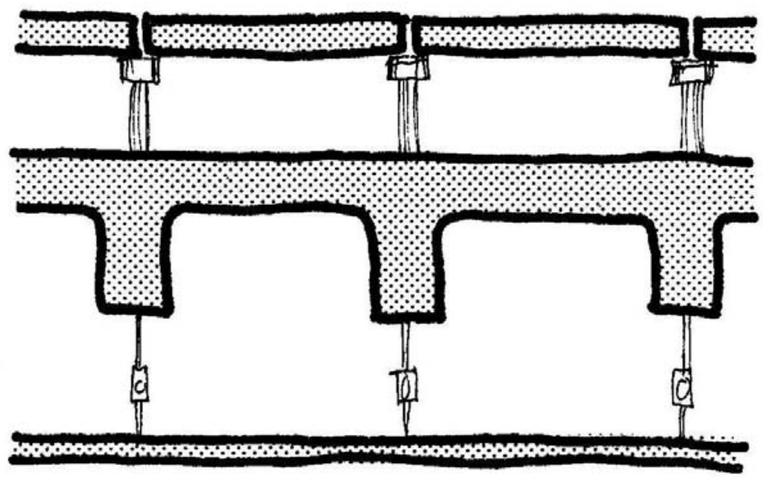
2. Air served from below implies extra duct cost, many large floor penetrations.

3. Air served down to the floor below creates fire isolation problem.

4. Floor struts impede service distribution more than ceiling hangers, although much less than truss members.

5. Structure must be level to serve as ceiling.

721.2.4 Combination Access Floor and Suspended Ceiling



Pro:

1. Access to all distribution systems for a floor is available from that floor. (Air feeds down through ceiling with no need for fire dampers. Drainage is through floor. Supply piping can be in either location.)

2. Ceiling leveling is inherent in the system.

Con:

1. Floor jointing may be a problem in hospital.

2. Performance requirement of access to service distribution systems without disturbing hospital functions cannot be met, i.e., horizontal access is not practical.

3. If a non-acoustically-rated ceiling is used, partitions must penetrate to slab to close flanking path.

721.3 USE OF SHEAR WALL AND/OR BRACED FRAME SYSTEM OF RESISTING LATERAL FORCES

There are two basic schemes for resisting lateral forces in building structures. The first is the shear wall or “box” system, consisting of solid walls (concrete) and/or braced frames subjected primarily to axial loadings (usually steel).

The second is the rigid frame system, in which the members and joints are capable of resisting lateral forces by bending.

The shear wall system is considered the more applicable for the structures of this study for the following reasons:

1. In general, for buildings up to approximately ten stories in height, shear wall lateral systems are more economical than rigid frame systems.

2. The size of vertical shafts normally required in hospital buildings suggests a concentration of lateral stiffness at these shafts, leading to a shear wall system. Often these shafts have concrete walls for fire protection, acoustical or maintenance reasons. In this case, the stiffness of rigid frames is incompatible with the stiffness of the shafts.

3. The spans generally contemplated for planning flexibility are not conducive to development of an economical rigid frame.

4. Prestressed concrete members cannot be used in rigid frames designed to resist earthquake forces because of the unknown ductility of the material. This would indicate shear wall systems wherever prestressed members are used to carry vertical loads.

721.4 BUILDING HEIGHT LIMITATION

Since the structural lateral force resisting system has been defined as a “box system”, a 160-foot height limit was set to coincide with the height at which the building code design requirements change.

In seismic zones 2 and 3, the Uniform Building Code requires buildings over 160 feet in height to have a ductile moment-resisting space frame capable of resisting not less than 25% of the required seismic force. This moment-resisting frame requirement would change the structural priorities and therefore affect the final system.

However, if for some reason it is extremely desirable to go over 160 feet with the system, it could be done, and the following directions should be considered.

721.4.1 **Seismic Zone 1** (least susceptible to earthquake)

Buildings in Seismic Zone 1 fall into a code exception to the moment-resisting frame requirement and the system could be used intact to any height, limited only by the available shear walls' capacity to withstand local wind pressures.

721.4.2 **Seismic Zone 2** (moderately susceptible to earthquake)

A ductile moment-resisting space frame is required to resist 25% of seismic forces in buildings over 160 feet. The moment-resisting frame could probably be incorporated into the concentrated shear element locations due to the small seismic force factor required. Thus each shear element would be designed for 100% of the required seismic or wind force working as a wall or braced frame, and 25% of the required seismic force working as a ductile moment-resisting space frame.

721.4.3 **Seismic Zone 3** (most susceptible to earthquake)

A ductile moment-resisting space frame is required to resist 25% of seismic forces in buildings over 160 feet. Due to the large seismic forces generated, the entire building frame (i.e. all columns) would probably be required to satisfy the 25% moment-resisting frame requirement. This would cause no difficulty in the direction parallel to the girders, as the already required vertical load-carrying girder-column space frame would merely have to be designed for the additional lateral loads. However, in the direction parallel to the beams, difficulty would be encountered due to the long span, shallow beams, and lack of a rigid beam coincident with the columns. This could probably be overcome by shifting the beams to align with the columns and making the aligned beam heavier than the typical beam.

These deviations from the basic design will affect typical interface conditions with other subsystems, and will necessitate reconsideration of certain precoordinated details.

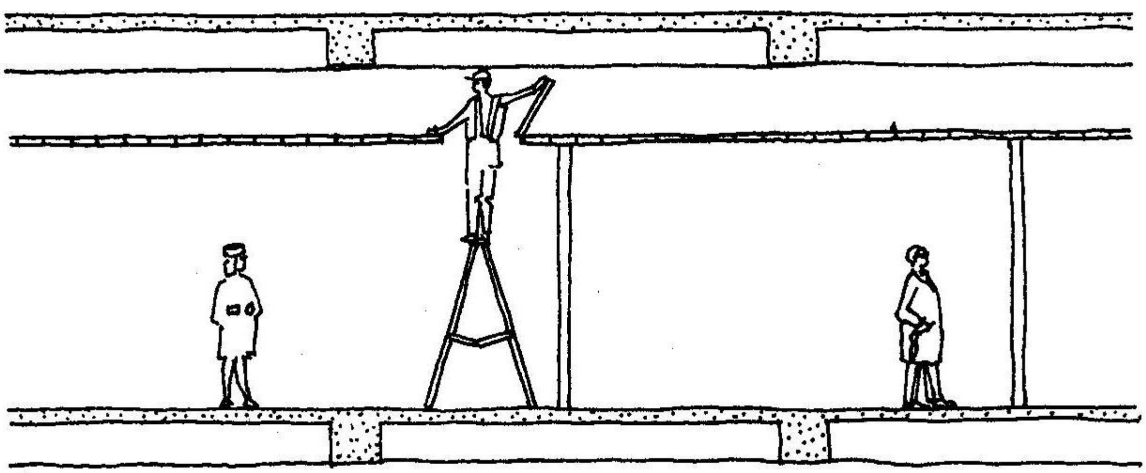
It should be pointed out that all members being used as part of the moment-resisting space frame must be ductile, either steel or ductile concrete, as defined by UBC.

722 CEILING

722.1 WALK-ON PLATFORM

A key characteristic of the Prototype Design is the walk-on platform, which was selected from three basic methods of gaining access to services above the ceiling: Vertical access from below, horizontal access in combination with catwalks, and horizontal access in combination with a walk-on platform.

722.1.1 Vertical Access

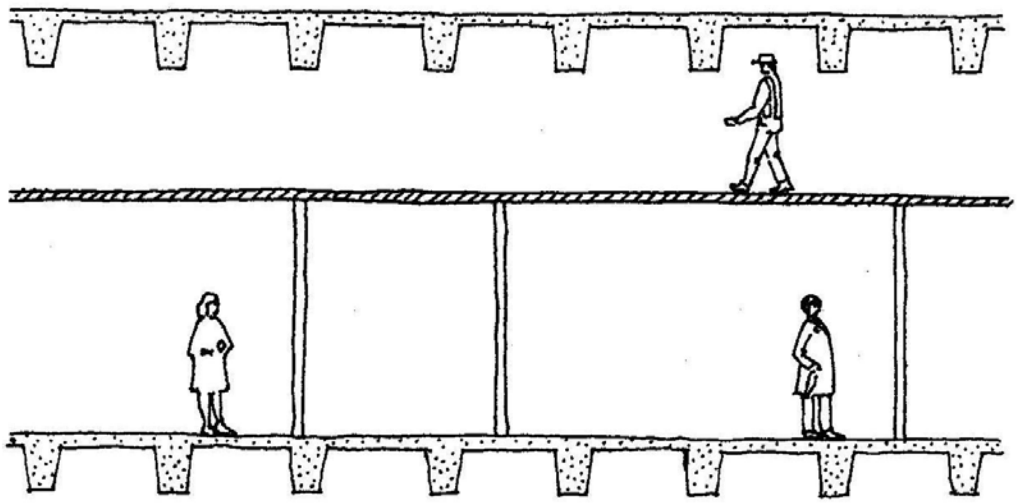


The advantages of this method are that services can be tightly packed under the structure so that floor-to-floor heights may be minimized. This is offset by the following disadvantages:

1. Any access to the space interferes with functional activities.
2. Dust and debris from work increases housekeeping and can mean that patients and personnel have to be moved while work is in progress.
3. Because services are cramped together, some become inaccessible.
4. Adding new services is difficult.
5. It is difficult to seal access panels if space is used as a plenum.
6. When alterations take place on one floor, interference with other floors is inevitable. For instance, if the alteration necessitates new drainage, the ceiling to the room below has to be opened up and two functional areas are affected by the alteration.

722.1.2 Horizontal Access

By increasing the space for services sufficiently to enable maintenance and repairs to be done above the ceiling, all the disadvantages of access from below are resolved. The additional space means better organization of services. The primary disadvantage is the added cost of the increase in floor-to-floor height.

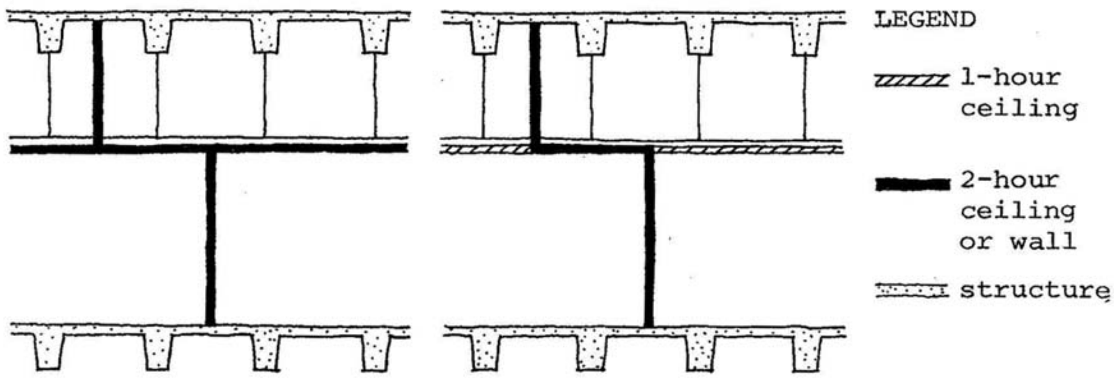


Horizontal access can be achieved by means of catwalks, or by making the whole ceiling capable of supporting the live load of people and materials. The latter option was selected because catwalks require services to be organized so that all controls, etc., are grouped within reach of the catwalk. This is often difficult and also increases the cost of services. The density of services precludes the use of movable catwalks.

722.2 THE PLATFORM MUST BE ONE-HOUR RATED

In order to facilitate change, partitions may not penetrate the platform. Except for two-hour fire barriers, all partitions stop at the ceiling-platform, including one-hour smokestop partitions. The ceiling-platform, therefore, must also be one-hour rated and smoketight. (See discussion in Section 326.)

Other strategies for fire safety were considered. For instance, in the ideal situation, the ceiling would have a fire resistivity of two hours, thereby permitting two-hour fire barriers in functional zones also to be freely relocated. It may also be possible to achieve this freedom in planning by upgrading the fire resistivity of the ceiling from one to two hours in limited areas only. These two possibilities are illustrated below.

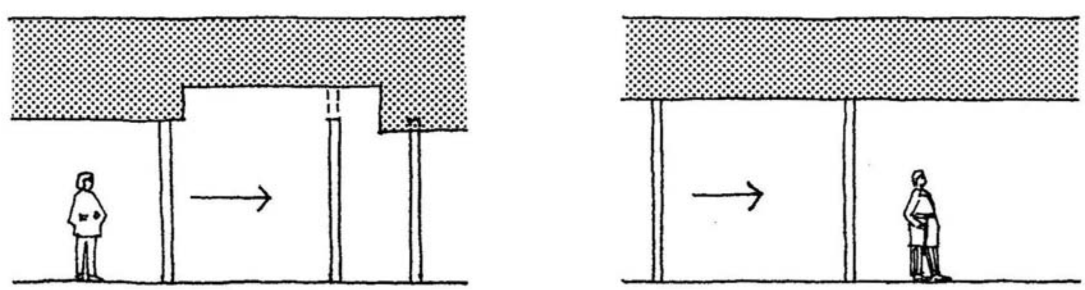


Alternative (a) **Alternative (b)**

Both alternatives were rejected on the basis that they would cause unacceptable complications in the mechanical distribution system. The second is also impractical since the relationship of partitions in the functional and service zones would be appropriate only for the opening configuration.

722.3 THE PLATFORM IS A CONSTANT HEIGHT ABOVE THE FLOOR

Change is facilitated by the ability to relocate partitions easily, and to be able to change the functions of spaces from those typically having low ceilings, say, to those with higher ceilings. This change is made possible if a constant ceiling height is maintained and all partitions are the same height.



The recommended heights were determined on the basis of an analysis of the functional space requirements.

Limited areas which may have requirements for heights greater than those recommended should be located on the ground floor or in the basement where the extra height can be obtained by depressing the floor level. The alternatives are either to raise the height of a total floor or to raise the platform over a limited area. The former alternative is the most costly, and the latter would interfere with service distribution organization. (See Section 224.)

722.4 CEILING LIGHTING FIXTURES ARE SURFACE MOUNTED

The Prototype Design does not incorporate integrated lighting-ceiling systems. To be effective, these systems require:

1. A rigid planning module that imposes a strict discipline on partitions, as well as lighting and ceiling components.

2. Overall lighting intensities that can be averaged out. For example, the patient bedroom would be averaged out at about 30 foot-candles.

3. Standardization of fixture sizes to allow for interchangeability.

The variability of the lighting performance required throughout the hospital precludes this type of system as a standard design though it is possible to use it in limited areas. (See Section 322.2.3.)

723 PARTITIONS

723.1 SERVICES ARE PREFERABLY NOT HOUSED WITHIN PARTITIONS

In conventional construction, partitions typically perform at least two major and often conflicting functions; they serve as barriers - visual, acoustic or fire - and they serve as containers of services. The rate of change varies with respect to these two functions. By separating these functions, change is facilitated and the barrier function of the partition is improved. This separation is one of the key characteristics of the basic design in which the partitions act mainly as barriers, and the services are typically housed in a variety of surface mounted containers or “consoles”. (See Section 780.) Figure 720-1 illustrates the interface between partitions and services in both conventional design and the Prototype Design.

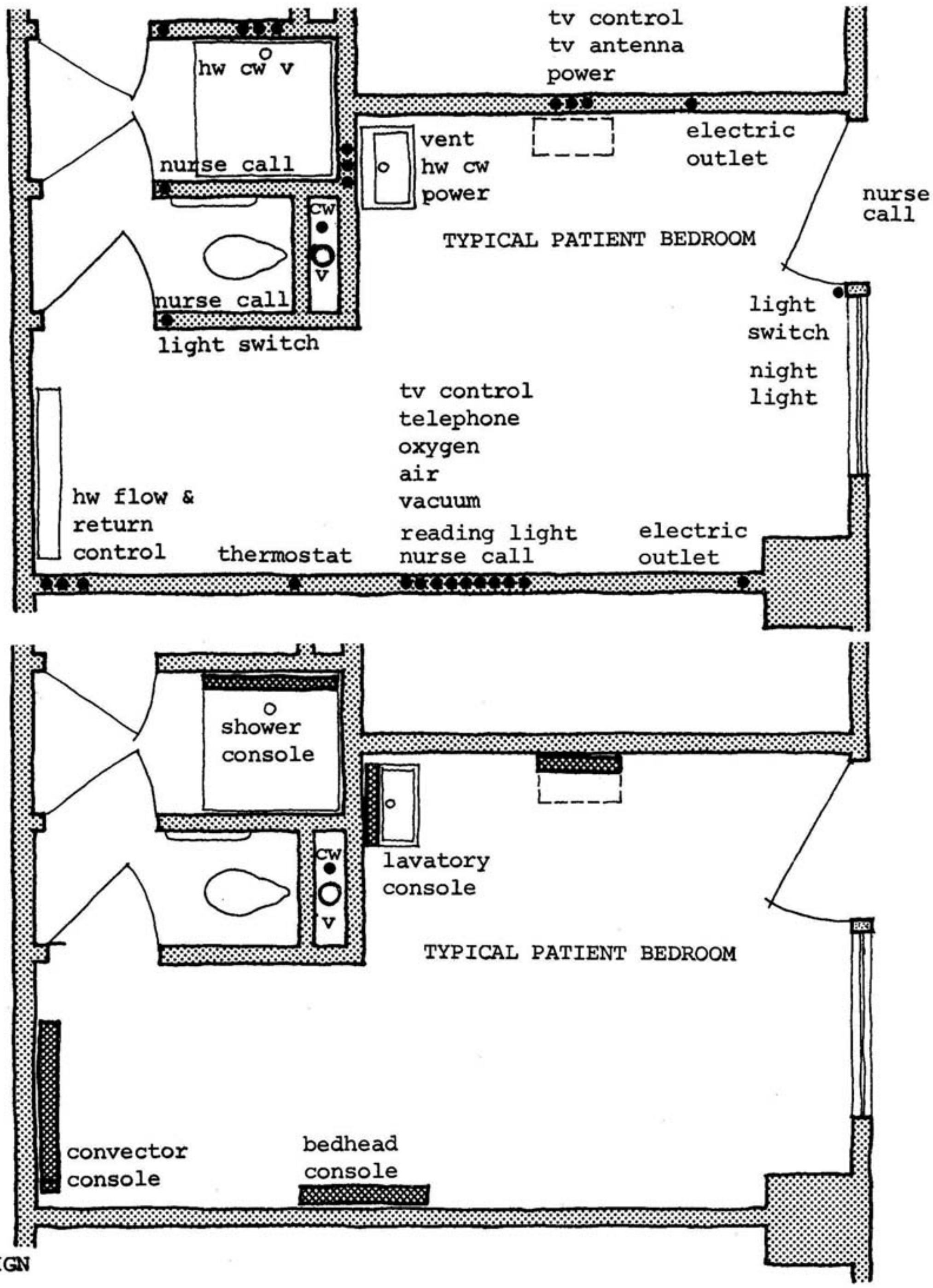
723.2 PARTITIONS TYPICALLY STOP AT THE CEILING

Another key characteristic of the Prototype Design is the fact that, with the exception of two-hour fire barriers, all components of the partition subsystem stop at the ceiling and are the same height on any one floor. In this way, partitions may be regarded almost as furniture or equipment, easily relocated in response to demand. The actual construction of the partitions will affect the degree of ease with which they can be relocated or removed, and this may vary in the different functional areas; but stopping the partitions at the ceiling makes any type reasonably removable and future alterations relatively simple.

723.3 GENERIC DESIGN OPTIONS

On the basis of the wide range of performance required in hospitals, and of the particular performance requirements generated by the basic design, an evaluation was made of a variety of partition types including metal lath and plaster, block, metal faced panels, laminated gypsum board and gypsum board on metal studs. The latter two were selected mainly for reasons stated in Section 332.1. The other types are both more costly and have a less flexible performance range. For instance, metal-faced panels provide the highest level of accessibility, even where this level of performance is not required. At the same time, the acoustic performance of metal-faced panels cannot be upgraded beyond a certain point and the range of finishes obtainable is limited.

Figure 720-1. INTERFACE BETWEEN PARTITIONS AND SERVICES



PLAN A:
CONVENTIONAL

PLAN B:
PROTOTYPE DESIGN

The wet systems - i.e. metal lath and plaster, and block - are more difficult and costly to relocate; they are messy and little material is salvageable. One of the few disadvantages of the generic design options selected is relatively poor accessibility; but this is unimportant since, in the Prototype Design, services are not housed within the partitions. This also removes the comparatively messy and time-consuming task of cutting holes in the partition surfaces, increasing the salvageability of materials during alterations and speeding up the assembly process.

724 SERVICES

The three service subsystems are organized into discrete networks each serving a single service module. The point of entry into the service module is the service bay, where each service is controlled, zoned or valved, and equipment rooms are placed.

724.1 HEATING-VENTILATING-COOLING

A uniform system of air distribution throughout the entire service module, by its simplicity and generality, allows the greatest degree of adaptability.

724.1.1 Single All-Air Supply with Supplementary Perimeter Heating

When the many commonly used air-conditioning systems are each tested against the performance requirements, it is found that only all-air systems are capable of meeting all of them. All-air systems may be classified as:

1. single-duct terminal reheat
2. dual-duct
3. variable volume
4. multi-zone

The first three are similar in design and the fourth is eliminated from consideration only because the size, complexity and frequency of change of the areas served would require too great an extent of expensive ductwork and more temperature control zones than packaged multi-zone units could handle.

Variable volume systems are not considered as suitable as dual-duct and terminal reheat are for this application, as they cannot easily achieve the control of pressure differentials required in many areas. Variable volume systems are also less easily adapted to changes in plan and function than dual-duct or terminal reheat systems.

724.1.2 Supplementary Perimeter Heating

The most common mixed system uses dual-duct or terminal reheat distribution for interior zones, and fan-coil or induction systems for perimeter rooms.

1. Individual Fan-Coil Units.

   This type of unit has had wide application, particularly in patient rooms. Since fan-coil units recirculate part of the supply air within the space itself, they minimize the possibility of the spread of infection from room to room. Their drawbacks, however, include:

   a. low efficiency filters;

   b. impracticality of providing humidification;

   c. requirement for outside air to each unit, or a supplemental ventilation system;

   d. limited ability to meet changing needs, as units are built in standard sizes which fix their capabilities;

   e. difficulty in adjusting and maintaining system balance under changing conditions (greater than with all-air systems).

2. Induction systems, although superior to fan-coil systems, possess serious drawbacks as well:

   a. they are designed primarily for the exterior zone;

   b. they are provided in a few standard sizes, and thus suffer the same limited adaptability as the fan-coil units;

   c. they are also inferior to all-air systems in their ability to maintain system balance easily.

3. There are other systems which might be considered. However, they would require supplementation to meet the criteria. For example, radiant heating or cooling could be designed to maintain dry bulb temperatures, but a supplemental ventilation system must be provided. In this regard, the possibility is not excluded of a supplemental system even to an all-air system in areas having extremely cold winter conditions.

724.1.3 Air Velocity

Low- or medium-velocity systems are considered most appropriate in the Prototype Design. The S3 subzone at a depth of 36” in a 10,000 square foot service module will handle low-velocity ductwork. Low-velocity distribution requires less energy to move the air, and greatly reduces the noise generation problems found in high-velocity systems. High-velocity systems are considered inappropriate except with dual-duct systems where the mixing box can reduce velocity and noise in the system. The need for extra care in construction to avoid leakage and the limited contractor experience in some areas of the country would also limit their application.

724.1.4 Fan Units: Satellite versus Central Fan Room

1. Adaptability

   Satellite air-handling units may be changed to respond to changes in the areas which they serve without disrupting the operation of other functional areas. Breakdowns affect only local areas.

2. Quality Control

   Large central fan systems must be site-fabricated. Units of the size contemplated are assembled in the factory and trucked to the site for installation. Since VA hospitals are constructed in every part of the country, it is not always possible to find mechanical contractors experienced enough to guarantee top-quality on-site assembly of large central fan systems. The packaged units offer predictable quality.

3. First Cost

   In addition to predictable quality, factory-fabricated units offer predictable first cost. Several factors also tend to reduce the first cost of systems composed of small satellite units, compared to large central fan systems.

   a. Vertical supply air shafts are eliminated, as well as the pressure-reducing devices to the take-offs at each floor.

b. The use of factory labor for all but final installation cuts costs both directly and by adding to the certainty of scheduling.

c. Actual fan ratings (horsepower) can be reduced, as the additional friction to be overcome in the vertical shaft is eliminated.

It is impossible to predict the actual cost difference between a system of satellite units and a central fan system as it will vary considerably with building height and configuration. Higher buildings favor the system of satellite units.

4. Operating and Maintenance Costs

a. Energy expended in heating or cooling air should be the same in central fan systems and satellite systems, assuming similar distribution patterns at the local level.

b. As noted above, energy expended for air circulation will be reduced. In the case of a tall building, this differential is maximized. In that case, fan horsepower requirements are reduced ten percent by eliminating the vertical supply air shaft.

c. The satellite units still take advantage of the economics implicit in centralized energy conversion devices (boilers and chillers).

d. Maintenance costs can be expected to rise, as servicing is decentralized. The efficiency of maintenance, given a decentralized system, is maximized by providing highly accessible mechanical rooms with adequate clearances around equipment, which are stacked next to a stairway.

e. In the case of major mechanical malfunction, repair of the smaller units would be easier, and would not affect hospital areas beyond the service module in which the malfunction occurred.

5. Availability of Packaged Air-Handling Units

The following list of products is not exhaustive, but it demonstrates the ready availability of the type of component which is being considered.

a. Single-Duct Air-Handling Units (with heating and cooling coils).

Manufacturer & Model	Space Served (sq. ft.) Based on 2 CFM/sq. ft.
McQuay LA or LM Single Zone Season Master	500-19000
Dunham-Bush AH	500-19000
Trane Draw-Thru Climate Changer	500-23000
Carrier Weathermaker Model 39D	500-20000
Bohn HCS	500-19000
Chrysler Air Temp	500-17000
York Type A	500-18000

b. Dual-Duct Air-Handling Units (with heating and cooling coils).

Manufacturer & Model	Space Served (sq. ft.) Based on 2 CFM/sq. ft.
McQuay MS or MM Multizone Season Master	900-19000
Dunham-Bush MZ	900-19000
Trane Blow-Thru Climate Changer	1000-23000
Carrier Weathermaker Model 39C	1200-20000
Bohn HMZ	1400-19000
Chrysler Air Temp BD	1000-17000
York Type M	600-18000

6. Floor Area Required for Equipment

   More floor area will be required for equipment, but this increase is mitigated by two factors:

   a. Area required for supply air shafts is eliminated.

   b. Added area is distributed over all floors, reducing building height while increasing site coverage.

7. Air Intake per Floor

   a. Assuming one air-handling unit per service module, air intake per floor reduces ducting. When local conditions disallow intake per floor, the mechanical room will be replaced by a supply duct from a roof-mounted fan unit.

   b. The opening required for removal and replacement of the air-handling unit is always large enough for the required fresh air intake.

724.1.5 Return/Exhaust Systems

For the general return/exhaust system a plenum can be used.

Pro:

1. Elimination of exhaust/return trunk and branch ducts reduces HVC system cost by approximately 70 cents per square foot.

2. The ceiling required for a walk-on platform and acoustical barrier is easily sealed to provide air tightness.

3. The elimination of the exhaust/return ductwork eases access to other service distribution components.

4. Toilet, isolation room, fume hood, and other special exhaust air is separately ducted to an exhaust shaft to the roof.

5. The usual drawback of return plenums – an accumulation of dust which spills down through accessible-ceiling panels – is virtually eliminated because vertical access through the platform-ceiling can be limited to hatches in non-critical rooms.

In addition to this, the accumulation of dust can be cleaned up periodically since a man can comfortably reach every corner of the service zone.

Con:

1. Special precautions must be taken for the control of smoke in case of a fire.

2. Special devices must be used to control noise transference through the return air boots.

724.1.6 Exhaust Shaft to the Roof

Expelling exhaust air at the roof eliminates cross-contamination of the fresh air supply. If, for reasons of economy on a particular project, the expulsion of general exhaust air is desired on a per floor basis, it must be shown to be safe by wind studies based upon local conditions.

Special exhaust air (from toilets, isolation rooms, fume hoods and other heat and odor-producing functions) is always expelled at the roof through a separate shaft or shafts.

724.1.7 Adaptability

1. Supply and Return/Exhaust: Main Distribution

   The return/exhaust main is the largest duct. As other components pass over it, under it and beside it, and as it tends to be located toward the center of the service zone, it would be extremely difficult to remove and replace if its size had to be changed. It is therefore considered to be a permanent component. As such, this main duct must be sized for the maximum loading anticipated in the life of the building. This increases first cost somewhat, but actually reduces the fan horsepower required, as friction losses are diminished in an oversized duct.

2. Special Exhaust and Toilet Exhaust: Main Distribution

   The special exhaust ducts (isolation room, kitchen exhausts, etc.) are considered adaptable components, although they would probably rarely be altered unless a floor is converted to research use. In that case, an acid-resistant duct network is added to exhaust fume hoods. In order to make the main special exhaust ducts permanent, one of two conditions would have to be met:

   a. Install acid-resistant exhaust trunks of sufficient size throughout, in anticipation of the conversion of any floor to research use.

   b. Restrict research to a specified set of floors. Install the less expensive non-acid-resistant trunks on all other floors as permanent components.

3. Branch Ducts

   Branch ducts are considered adaptable so they may be sized and positioned precisely to suit the demands of the opening configuration.

   In alterations, many zone ducts and terminals will in fact be reusable. Any removal or installation of new ductwork can be handled quite easily, as ample work-space is provided within the service zone.

4. Fans and Air-Handling Units

   a. Fans sized for ultimate capacity in the opening configuration would increase first cost considerably. Also, a fan unit sized for a research laboratory would run quite inefficiently if it only had to serve a nursing unit (at perhaps one-half the air volume). For this reason, provision must be made to replace supply air-handling units and/or exhaust fans when air volume requirements change radically.

   b. Supply air-handling units and exhaust fans must be positioned to allow replacement in any case, as their predicted lifespan is far less than that of the structure itself.

724.2 PLUMBING

724.2.1 Independent Layouts for Each Service Module

Each service module contains its own layout of mains and branch distribution fed from the common risers in the service bays. This allows each service zone to have easily identifiable maintenance valving and controls. It also provides independent capacity to change pressure systems and branch layouts without interfering with adjacent modules.

724.2.2 Adaptability

The pressure systems and drainage main distribution runs should be oversized and have blanked-off tees at every hanger space. These mains can be considered permanent installations. But as the pipes are not difficult to add to or supplement like the HVC mains, the secondary subzone will contain enough room to allow modification of these mains in the future. All branch distribution can be considered adaptable as the runs are easily modified when change occurs in the functional zone.

724.3 ELECTRICAL

724.3.1 Distribution from Substations to Service Bays

The distribution of power from the main distribution boards must be via easily accessible busducts to the stacks of service bays. This will provide the necessary degree of freedom for adjustment of load for each service module as future functional requirements demand.

724.3.2 Independent Electrical Rooms and Distribution to each Service Module

The entry of the power distribution systems to each service module must be through an electrical room in the service bay where all circuits are controlled so that all changes for the module can originate there with no interference to other modules.

724.3.3 Adaptability

The main distribution wireways in the service zone can be considered permanent with the freedom to change branch circuits within the wireway. The wireways and conduit in the branch distribution and lateral runs are considered adaptable to change as required by functional zone demands.

730 Example Building Schematic Design

731 INTENT

The building schematic design is intended to demonstrate the application of the Prototype Design to the design of a complete hospital based on current VA needs and space requirements expressed in an updated master hospital plan (program) for Wood, Wisconsin.

For convenience, the existing Wood site and associated characteristics in terms of access, topography, relation to existing facilities have also been assumed for the purposes of the example. There is one exception, the location of the site has been hypothetically changed from Wood, Wisconsin to the San Francisco Bay area in order to facilitate the cost studies discussed in Section 760.

It must be emphasized that the selection of the Wood, Wisconsin, site does not imply any criticism of the existing VA facilities there which, in many ways, are eminently satisfactory.

732 PROGRAM ANALYSIS

732.1 EVALUATION

732.1.1 Ratio of Beds to Support

The updated program from Wood, Wisconsin is rather unusual in that the ratio of bed area to support is 1:1 whereas, typically, the ratio is more in the order of 1:2. There are 640 General Medical beds, 320 General Surgical beds, 102 Psychiatric beds, 56 Spinal Cord Injury beds, 26 Neurological beds, 8 Hemodialysis beds and 7 Medical and 6 Surgical Intensive Care beds giving a total of 1,165 beds to be accommodated. Given the general trend towards fewer inpatient beds, there is the possibility that some of the programmed nursing units may in the future be converted to other, possibly support, functions.

732.1.2 Ratio of Gross to Net

Net area requirements are converted to gross area requirements by a conversion factor which makes certain provision for mechanical services, circulation and other factors such as partition thicknesses, etc. In the Prototype Design, the planning modules represent gross space. However, in interpreting the net program in terms of the planning modules a larger than typical conversion factor should be applied, for two reasons:

1. In the interests of adaptability, the planning modules are generalized units of space which can only be approximately tailored to particular program requirements. This implies that net area requirements are generally rounded upwards.

2. The decentralized air-handling concept requires that a larger percentage of the overall gross is taken up by mechanical requirements.

In plan, the service module consists of the service bay and the functional zone (structural bays). From experience, a net to gross conversion factor can be applied to net area requirements in order to establish gross area requirements exclusive of any provision for mechanical services. This establishes a relationship between gross area requirements and the service module functional zone. The total gross area requirement is that figure against which the aggregate of service module functional zones must be tested.

In the bed care portion of the hospital a more precise interpretation of nursing unit net requirements can be made in terms of space modules. In addition to the gross area contained within the space modules, the gross area of each department can be calculated using appropriate factors which include consideration of the rounding up of net areas to accommodate the modular system of planning. The following program summary lists departmental net areas, the relevant net to gross conversion factor and the resultant departmental gross area.

732.2 PROGRAM SUMMARY

DEPARTMENT	TOTAL NET	EST. %*	TOTAL GROSS
Audiology & Speech Pathology Unit	1,230	1.45	1,784
Building Management Division	17,653	1.25	22,068
Canteen Service	10,658	1.25	13,325
Chaplain Service	3,453	1.25	4,428
Clinical Cardiac Laboratory	3,901	1.40	5,462
Clinical Pulmonary Laboratory	2,747	1.40	3,846
Clinical Services Administration	3,010	1.40	3,214
Contact Location	360	1.45	522
Credit Union	230	1.15	266
Data Processing	96	1.10	107
Dental Service	8,475	1.45	12,289
Dietetic Service	15,682	1.25	19,603
Directors Suite	1,860	1.45	2,697
Domiciliary Facility	530	1.30	690
EEG Unit	565	1.30	735
Engineering Division	7,690	1.25	9,613

* Estimated net to gross ratio exclusive of mechanical and general circulation.

DEPARTMENT	TOTAL NET	EST. %*	TOTAL GROSS
Eye & ENT. Exam Unit	1,860	1.45	2,697
Fiscal Division	2,205	1.45	3,197
Genito-Urinary Clinic	1,319	1.45	1,913
Hemodialysis Unit	3,611	1.50	5,418
Laboratory Service	16,840	1.30	21,892
Library Service	3,670	1.25	4,588
Lobby	950	1.10	1,045
Lockers, Lounges Toilets & Showers	13,162	1.35	17,770
Medical Administrative Division	15,130	1.45	21,939
Medical Illustration Service	1,785	1.25	2,231
Nuclear Medicine Service	5,275	1.45	7,647
Nursing Service Administration	1,770	1.45	2,567
Nursing Service Education & Training	600	1.45	870
Nursing Units Psychiatric	189,577	1.50	284,365
Nursing Units, Psychiatric	(20,976)	1.50	(31,464)
Organ Transplant Unit			
Orthopedic Clinic	1,385	1.45	2,008
Outpatient Psychiatric Service	(3,390)	1.45	(4,916)
Outpatient Service	11,194	1.45	16,232

ACTIVITY	TOTAL NET	EST. %*	TOTAL GROSS
Personnel Division	1,580	1.45	2,291
Pharmacy Service	3,540	1.25	4,425
Physical Medicine & Rehabilitation Service	19,324	1.30	25,121
Process & Distribution	7,200	1.40	10,080
Prosthetics Service	1,576	1.45	2,380
Psychology Service	2,510	1.45	3,640
Quarters, Residents	2,019	1.50	3,029
Radiology Service	9,689	1.40	13,577
Service Organizations	240	1.10	264
Social Work Service	3,470	1.45	5,032
Supply Division	26,599	1.25	33,249
Surgical Service	7,045	1.50	10,568
Voluntary Services	942	1.30	1,225
TOTAL	455,355	1.47	669,302

Departmental gross areas exclude any provision for mechanical services or general circulation.

NOTE: Areas indicated in brackets ( ) not included in totals.

733 SPACE MODULE SELECTION

733.1 THE GENERAL NURSING UNIT

The typical general medical and surgical nursing unit is the basis from which the eligible space modules are derived.

733.1.1 Program Breakdown

The net area requirements for the typical unit are reduced to the following categories:

1. Number and type of bed rooms

2. Sanitary facilities associated with patient bed rooms (Sanitary Zone).

3. Direct Care Support.

   Staff work spaces and other support facilities considered necessary to be immediately adjacent to patient beds.

4. Ancillary Support.

   Support spaces that are considered less critical in terms of their immediate adjacency to patient beds.

733.1.2 Figure 730-1 indicates how this breakdown may be presented.

733.2 ELIGIBLE SPACE MODULES

733.2.1 Sanitary Zone and Direct Care Support

Eligible modules are determined by the sanitary zone and the area required for direct care support. The Space Module Summary Sheet (Figure 730-2) identifies the sanitary zone and the core area available in each module for direct care support space. As the core areas are not directly comparable to the required net areas – they include partition thickness and columns – the space modules should possess a core area slightly greater than the required direct care support. Some additional core area may be useful to allow for future increases in direct support requirements. This area can be used for some ancillary support initially.

Figure 730-1

Typical Nursing Unit (40-bed general surgical and medical)

	Number	Sanitary Zone	Direct Care Support	Ancillary Support
4 bed rooms	6	2		
2 bed rooms	5	2		
1 bed rooms	6	2		
Bath	1		110	
Nurses Station	1		360	
Clean Utility	1		120	
Soil Utility	1		120	
Linen	1		60	
Supplies	1		40	
Nourishment Kitchen	1		60	
Wheelchair & Litter	1		120	
HAC	1		40	
Examination	1		140	
Physicians Office	1			120
Day Room	1			320
Residents Office	2		140	
Study Space	6			216
Classroom	1			300
Procedure Room	1			300
			1,310	1,256

733.2.2 Eligible Space Modules

The space module types whose available core area most directly relates to the required area of 1,310 square feet for direct care support are 6 and 11. The essential characteristics are:

1. Module type 6

   2 aspect, core

   Span: 58’6 plus 18’0 cantilever

   Core: 1,680 square feet (2 x 840)

2. Module type 11

   4 aspect, core

   Span: 58’6 x 2

   Core: 1,400 square feet.

733.2.3 Module Capability

The eligible space modules are then tested against the programs for other functional units. The catalog of space module capabilities (Section 233) provides an indication of the comparative ranges of plan performance for the selected module types.

734 CONFIGURATION OPTIONS

734.1 NUMBER OF SPACE MODULES

General nursing units can be directly translated into numbers of space modules. Special nursing units are not directly translatable and must be approximated.

Nursing Unit	Number	Number of Space Modules	
		SM6	SM11
40 bed G.M.	16	32	16
40 bed G.S.	8	16	8
26 bed neurology	1	1-2	1
28 bed spinal cord injury	2	2-3	2
34 bed psychiatric	3	6	3
8 bed hemodialysis	1	1	1/2
7 bed I.C.U. (Medical)	1	1	1/2
6 bed I.C.U. (Surgical)	1	1	1/2
		60-62	31-1/2 (32)

734.2 HEIGHT RELATIVE TO BEDS PER FLOOR

The structural system imposes a nominal maximum of nine floors on the height of the hospital. At this height, assuming a minimum of one floor for central support functions, the number floors available for nursing units is eight. Therefore, there must be a minimum of four nursing units per floor i.e. a nominal 160 beds per floor.

The total number of space modules can now be organized into optional nursing floor configurations based on the assembly characteristics of the eligible module types 6 and 11 (Catalog of Space Module Capabilities, Section 233) and numbers of beds per floor.

Figures 730-2 and 730-3 show some of the possible configuration options.

Figure 730-2. MODULE TYPE 6

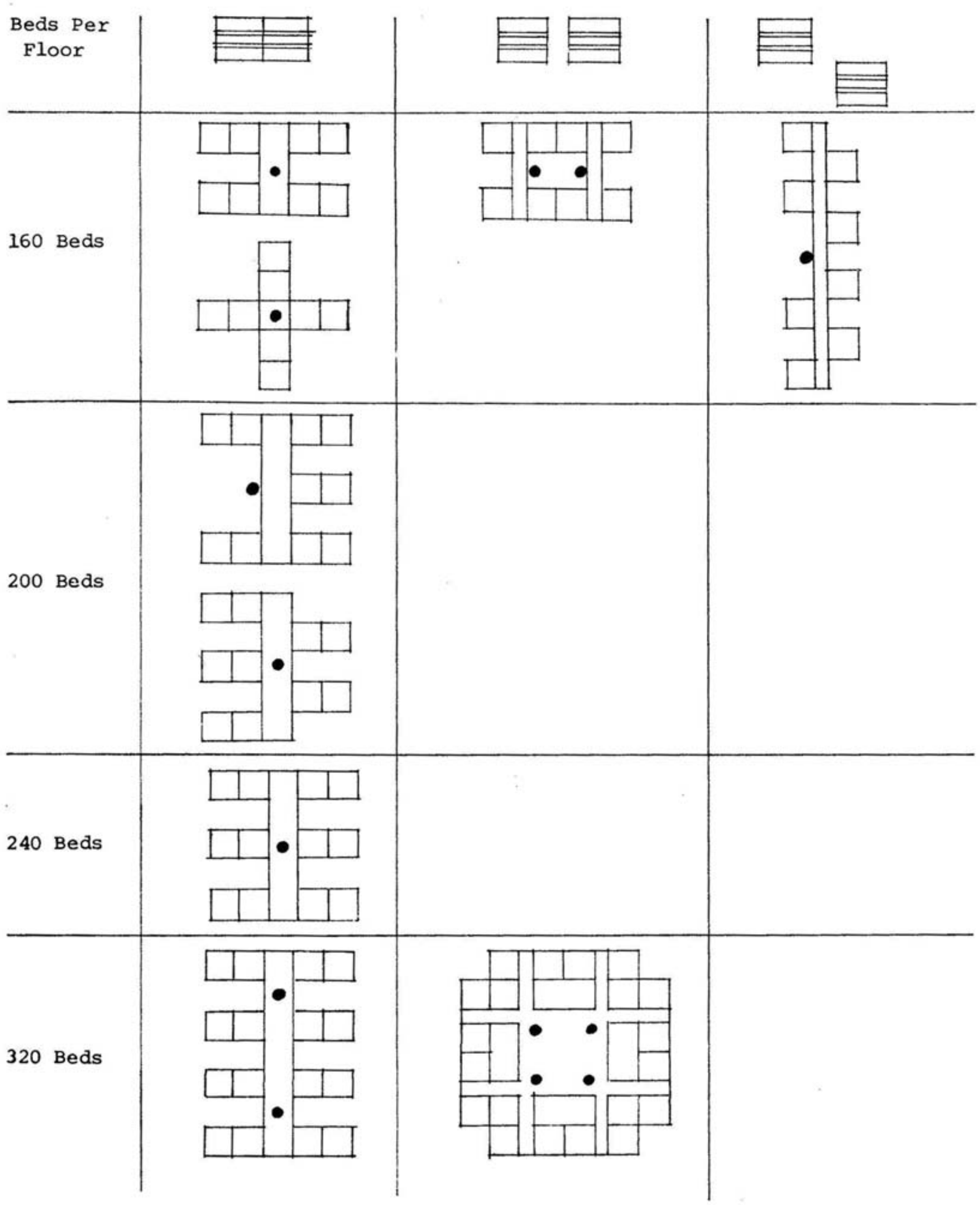
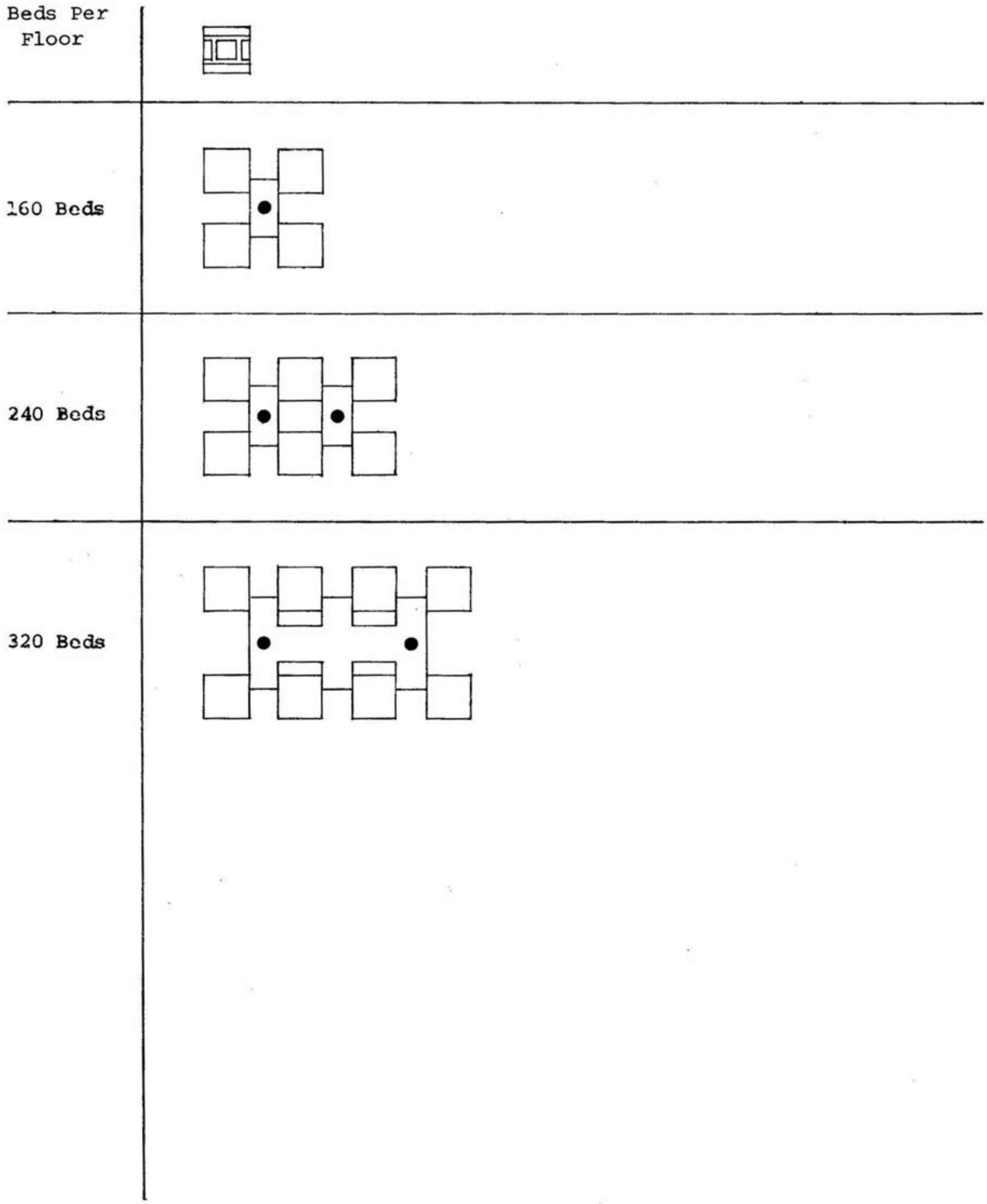


Figure 730-3. MODULE TYPE 11



734.3 CHOICE OF CONFIGURATION

734.3.1 At this stage, the constraints of the site, access, topography, soil, existing facilities, together with the current medical philosophy expressed through the program in terms of functional relationships must be evaluated. All will have a fundamental influence on the choice of configuration.

Overall gross area, service module, functional areas, and gross departmental areas are all manipulated to arrive at appropriate configuration options. It is also possible, at this time, to undertake a comparative cost analysis of the favored options to confirm the choice of configuration.

734.3.2 The particular configuration chosen for the Building Schematic Design can be justified in those terms particularly with regard to the height of the hospital and the horizontal relationships between bed care and support. In addition, the Building Schematic Design presents an opportunity to illustrate, in greater detail, many system concepts which are discussed in general form in the report. The particular configuration serves to demonstrate:

1. A compound assembly.

2. External service bays and internal service bays.

3. Internal courtyards.

734.3.3 Thus, the building schematic design is based on module type 6 and demonstrates a low block configuration of 320 beds per floor with some of the beds overlooking internal courtyards (Figure 730-2, bottom line, center column).

734.3.4 This is essentially a closed configuration as it is unlikely that the number of beds will increase. Rather, as noted previously, they may in fact be reduced. However, central support functions may increase: either, by extending beyond the building perimeter on the lower floor or by extending into the courtyards on the lower floor or by expanding into nursing units that may become redundant.

735 DESIGN DESCRIPTION

735.1 DETAILED CONFIGURATION DEVELOPMENT

735.1.1 Additional Space

Given Module 6, zone 2, a 320-bed nursing floor and a height limit of four floors, the space program is now studied and gross space allocations made in conjunction with total nursing floor plan studies, in order to determine the extent of additional area necessary to achieve a balanced set of functions for each floor. Balanced, that is, in terms of achieving an equal area on every floor, optimum relationships with given constraints and a suitable organization of the major circulation and transportation elements. Obviously, some variation exists between this space allocation and the original program summary. One structural bay of additional space per 40 bed nursing unit is required to achieve the appropriate functional balance. The bays used are identical to those which comprise Module 6: 76’6” x 22’6”.

Gross configuration and gross space allocation are now established to the degree shown on the following diagram. Overall building dimensions are known with the exception of the vertical transport towers and the service bays (Figure 730-4).

735.1.2 Service Modules

Each floor is divided into the appropriate number of service modules to correspond as closely as possible with the other divisions of the floor:

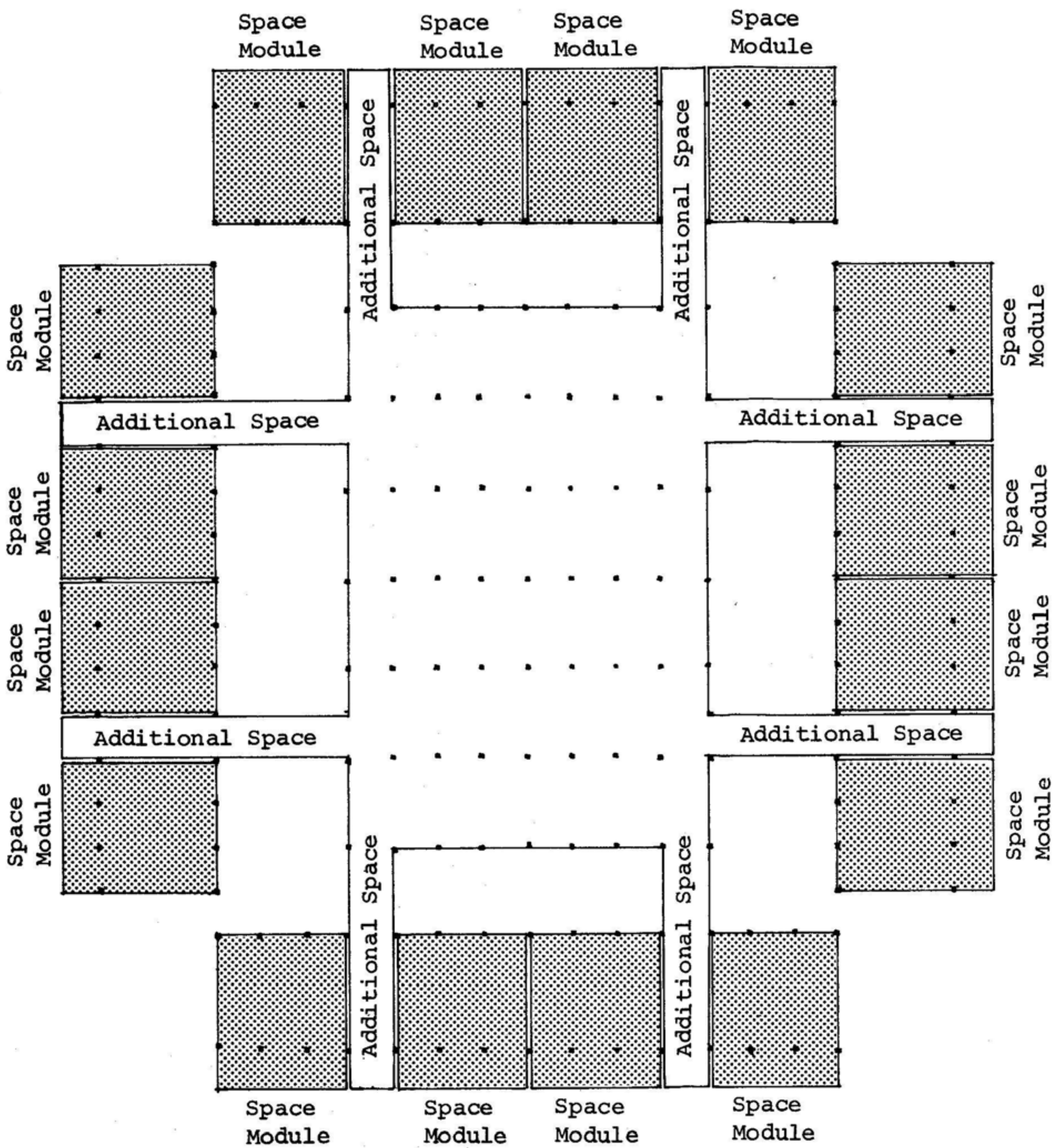
1. Functional Units

   In the nursing unit area, one service module embraces two space modules plus one or two structural bays of additional space. The service bays are external and contain the air-handling units on the same floor as the service module.

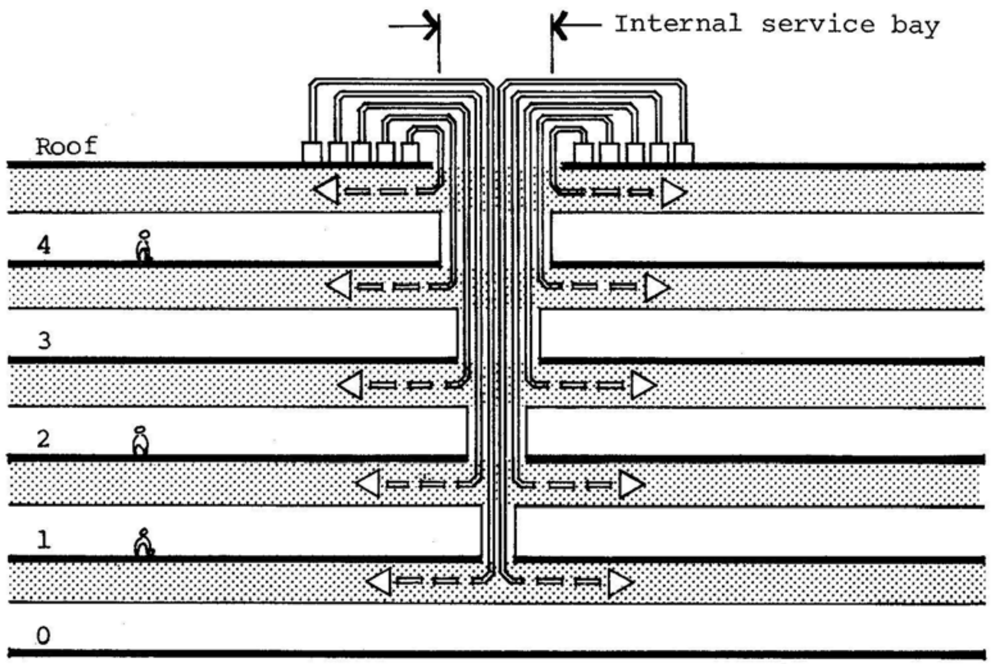
   In the central support area, the service bays are internal and create a service strip.

   The service modules are organized on such a way as to minimize the obstruction of the internal service bays on functional planning. Air handling units are located on the roof of the central area for easy access and vertical ducts distribute the air to their respective service modules.

Figure 730-4. GROSS SPACE ALLOCATION



The cross section of the vertical shaft is reduced on the lower floors as the ducts peel off into the service zone of the service strip to serve their respective modules.



2. Fire Sections

   The service modules are organized into fire sections in such a way that the permanent two-hour fire partitions cause as little obstruction as possible to the organization of the functional units.

3. Structural Units

   As the building dimensions exceed 300 feet, expansion joints are required. As structural continuity is interrupted by the internal courtyards, separation joints are required. In the structural layout, these joints are coincident. Where these joints are associated with shear walls, they occur at the boundaries of the service modules.

735.1.3 Transport Systems

From the number of floors and the respective floor occupancy ratings it is determined that six public elevators, 12 service elevators, and a trash-linen pneumatic system will provide an efficient transport and service distribution system. The separation of the public and service elevators provides a useful degree of traffic organization. The disposition of the service elevators to serve each floor quadrant provides a desirable symmetry in conjunction with the service bays in terms of structural shear considerations. These occur on the boundaries of the service modules.

Figure 730-5 shows a typical floor with service modules, expansion and separation joints, shear walls and the elevator towers.

735.1.4 Detailed Design

The next set of tasks are those which are required before the design of work below grade can begin. These include the identification and location of functional areas with special requirements such as extra heavy loads, floor slabs depressions, etc., and the detailed design of the service bays. As the design of the service bays varies with the size of service module, with the building configuration and with the space required for service equipment, it is designed uniquely for each specific building project. Section 740 presents an example of the detailed design of a service module and service bay.

735.2 RELATIONSHIPS

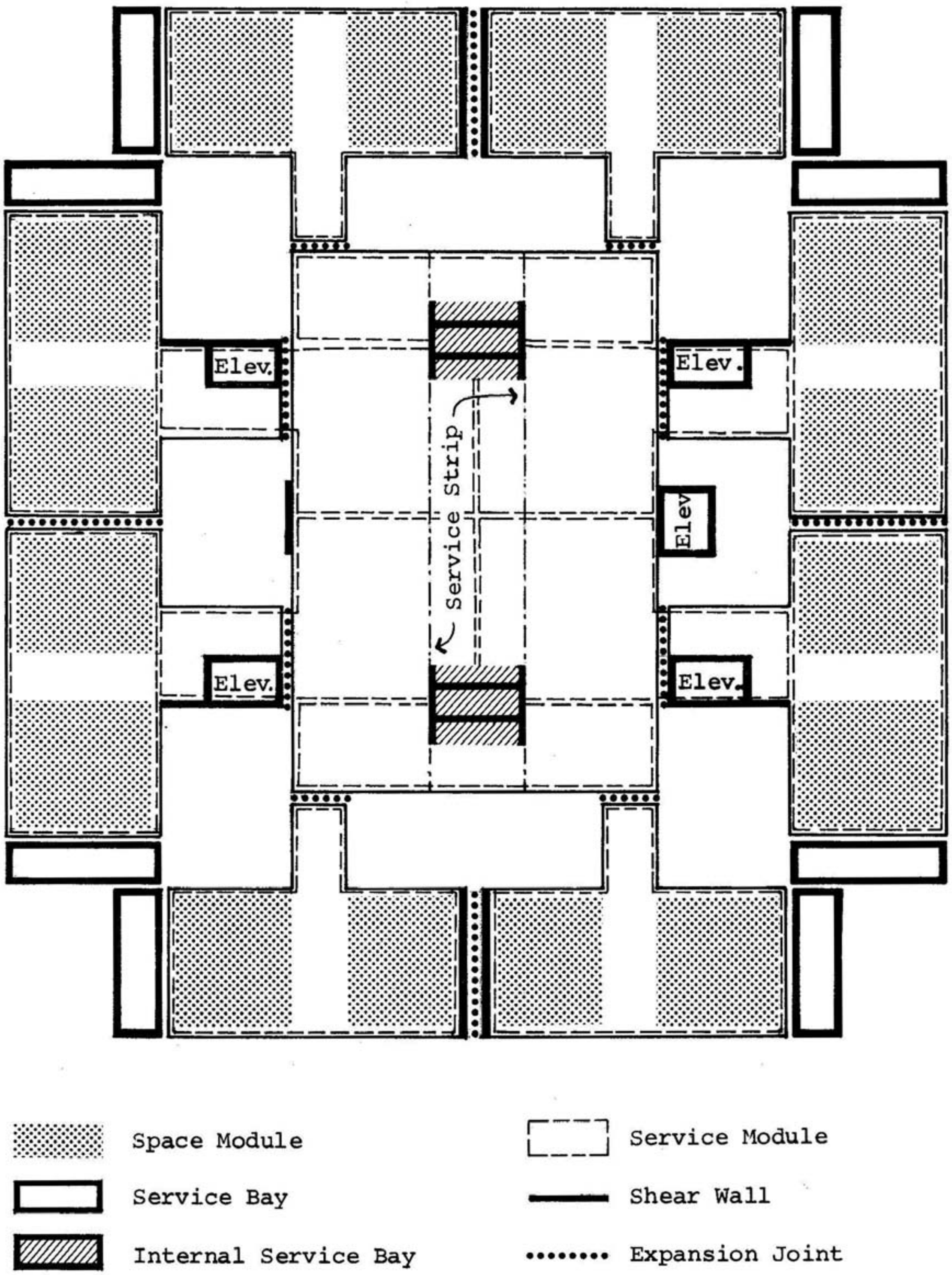
735.2.1 Level 01

This area forms the industrial zone of the hospital. Delivery of supplies and food, storage and processing, mechanical plant and maintenance shops are contained on this level. These functions are connected by a loop “street” which provides access to vertical circulation elements. Lockers and lounges for certain employees are also located on this level.

735.2.2 Level 1

This is the basic access level for patients, visitors and staff. In addition to outpatient clinics and administration, it contains certain long term care nursing units which are provided with direct access to the out of doors.

Figure 730-5. BUILDING CONFIGURATION



Horizontal connections to the adjacent psychiatric facility are provided on both this and the service level. Earlier program analysis determined that a separate, connected facility house psychiatric inpatient and outpatient services. That facility is established as a one-story building, and is hence a non-systems building, since the building system is applicable only to multi-story facilities.

735.2.3 Level 2

Level 2 is the intensive nursing level. It includes surgery, radiology and other diagnostic and treatment functions as well as nursing units for severely ill patients.

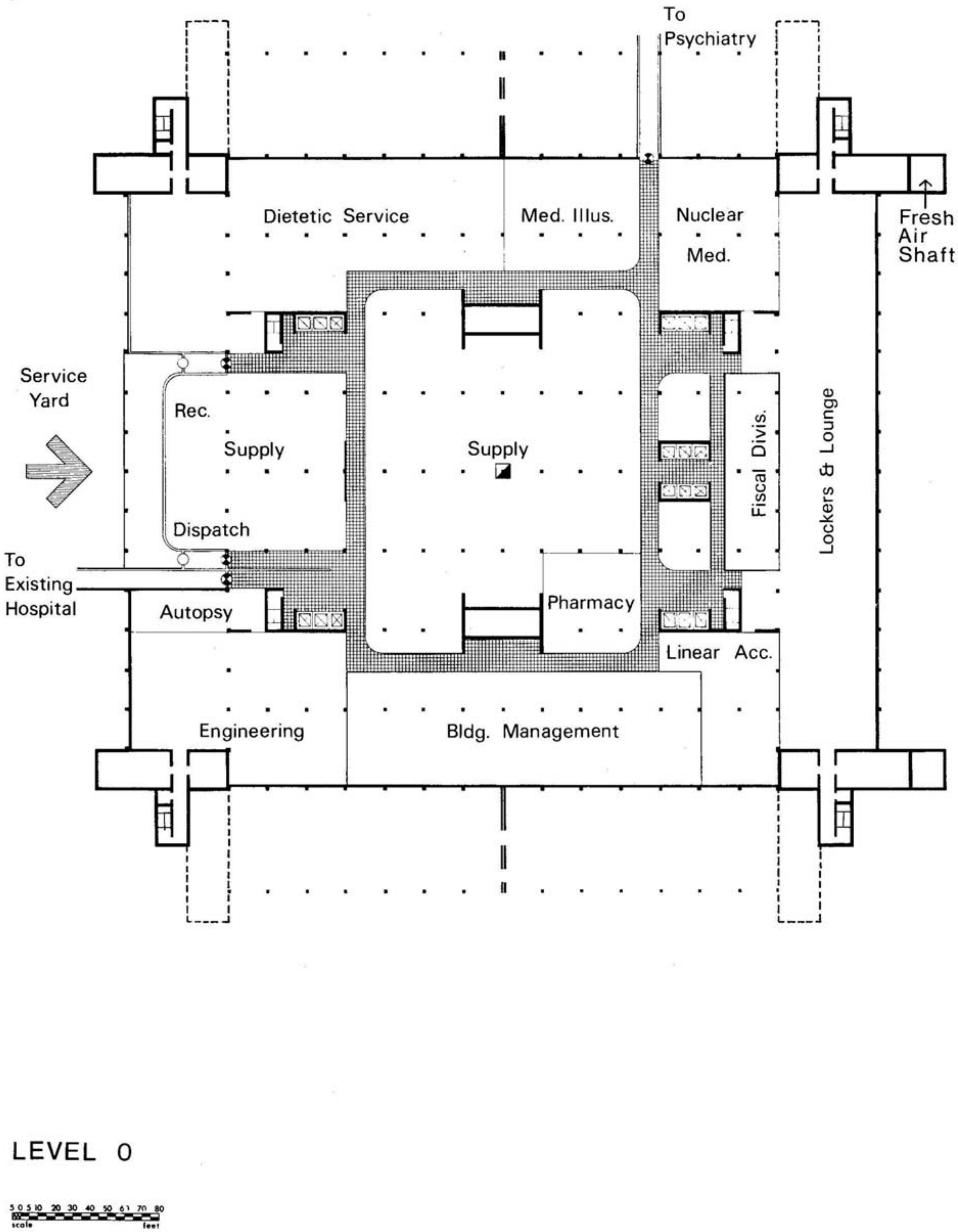
735.2.4 Level 3 and 4

These levels are reserved for less intensively ill patients as well as general supportive functions for the hospital.

735.2.5 Courtyards

Courtyards have been provided adjacent to the ring “street” on all but the service level. These will assist in defining the principal circulation routes of the hospital as well as providing a desirable and economical amenity for the hospital.

Figure 730-6



To
Psychiatry
Dietetic Service
Med. Illus.
Nuclear
Med.
Fresh
Air
Shaft
Service
Yard
Rec.
Supply
Dispatch
Supply
Fiscal Divis.
Lockers & Lounge
To
Existing
Hospital
Autopsy
Pharmacy
Linear Acc.
Engineering
Bldg. Management
LEVEL 0

Figure 730-7

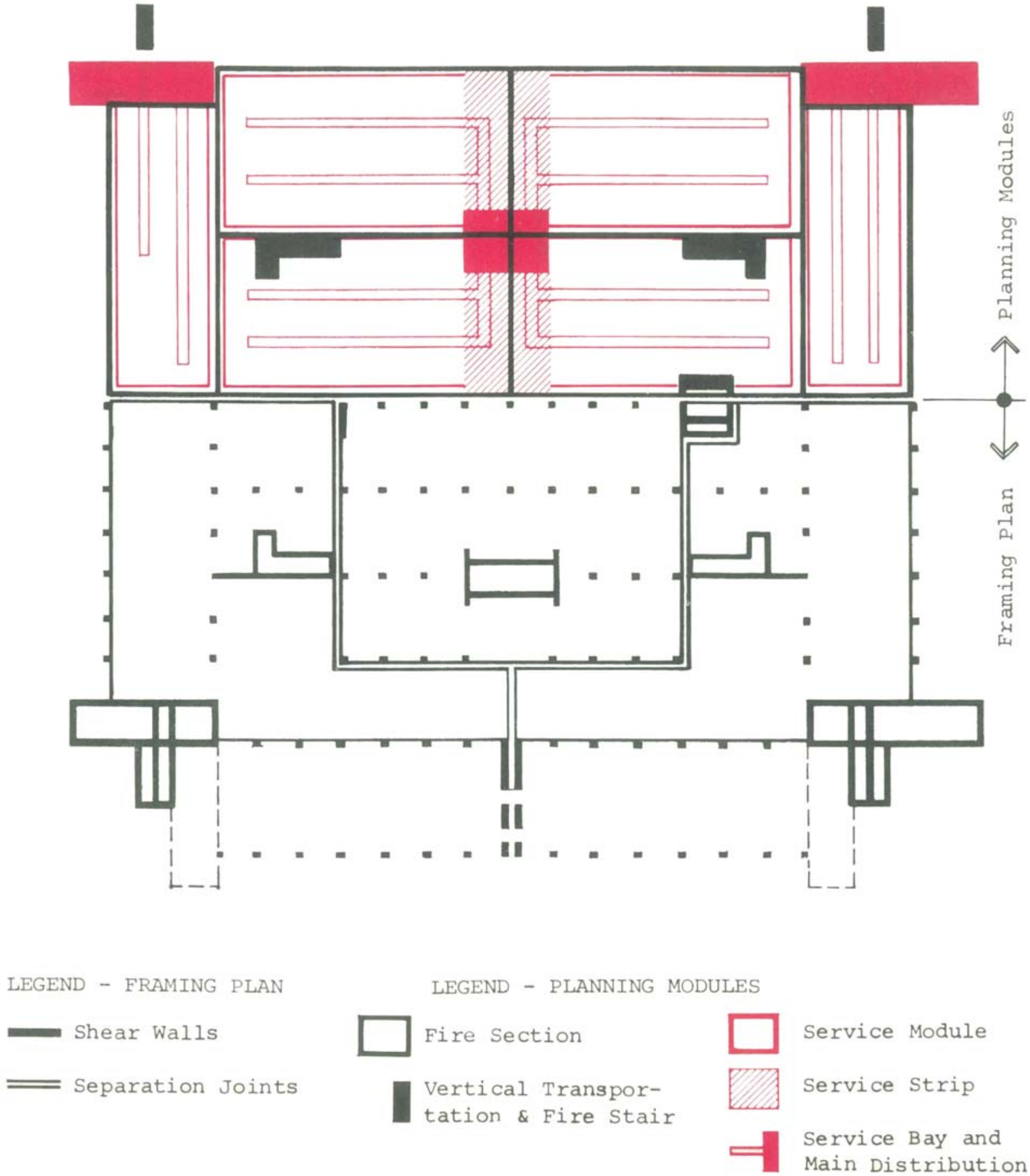

Planning Modules
Framing Plan
LEGEND - FRAMING PLAN
Shear Walls
Separation Joints
LEGEND - PLANNING MODULES
Fire Section
Vertical Transportation & Fire Stair
Service Module
Service Strip
Service Bay and Main Distribution

Figure 730-8

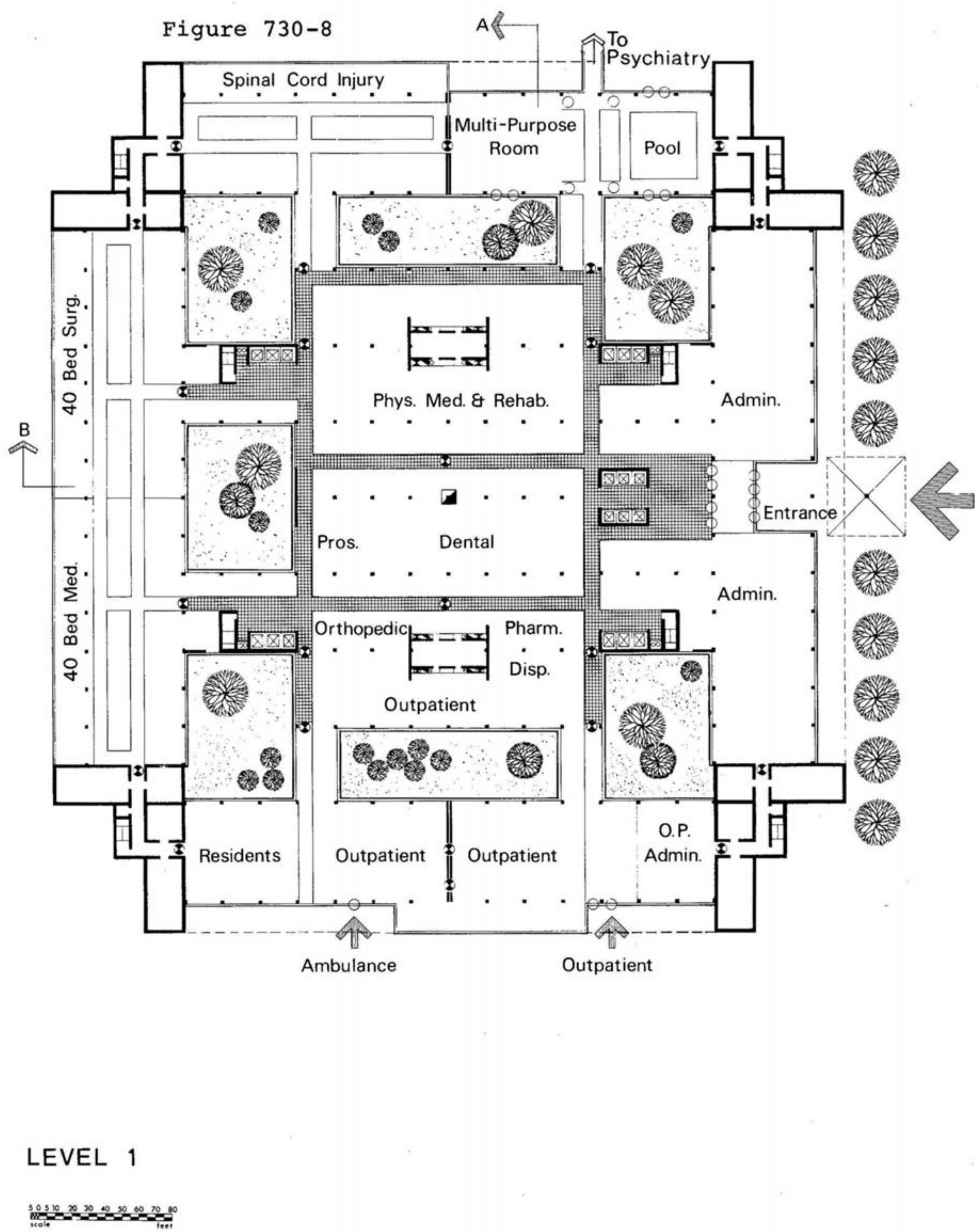


Figure 730-8
A
To Psychiatry
Spinal Cord Injury
Multi-Purpose Room
Pool
40 Bed Surg.
Phys. Med. & Rehab.
Admin.
B
Entrance
Pros.
Dental
40 Bed Med.
Admin.
Orthopedic
Pharm.
Disp.
Outpatient
Residents
Outpatient
Outpatient
O.P. Admin.
Ambulance
Outpatient
LEVEL 1
scale
feet

Figure 730-9

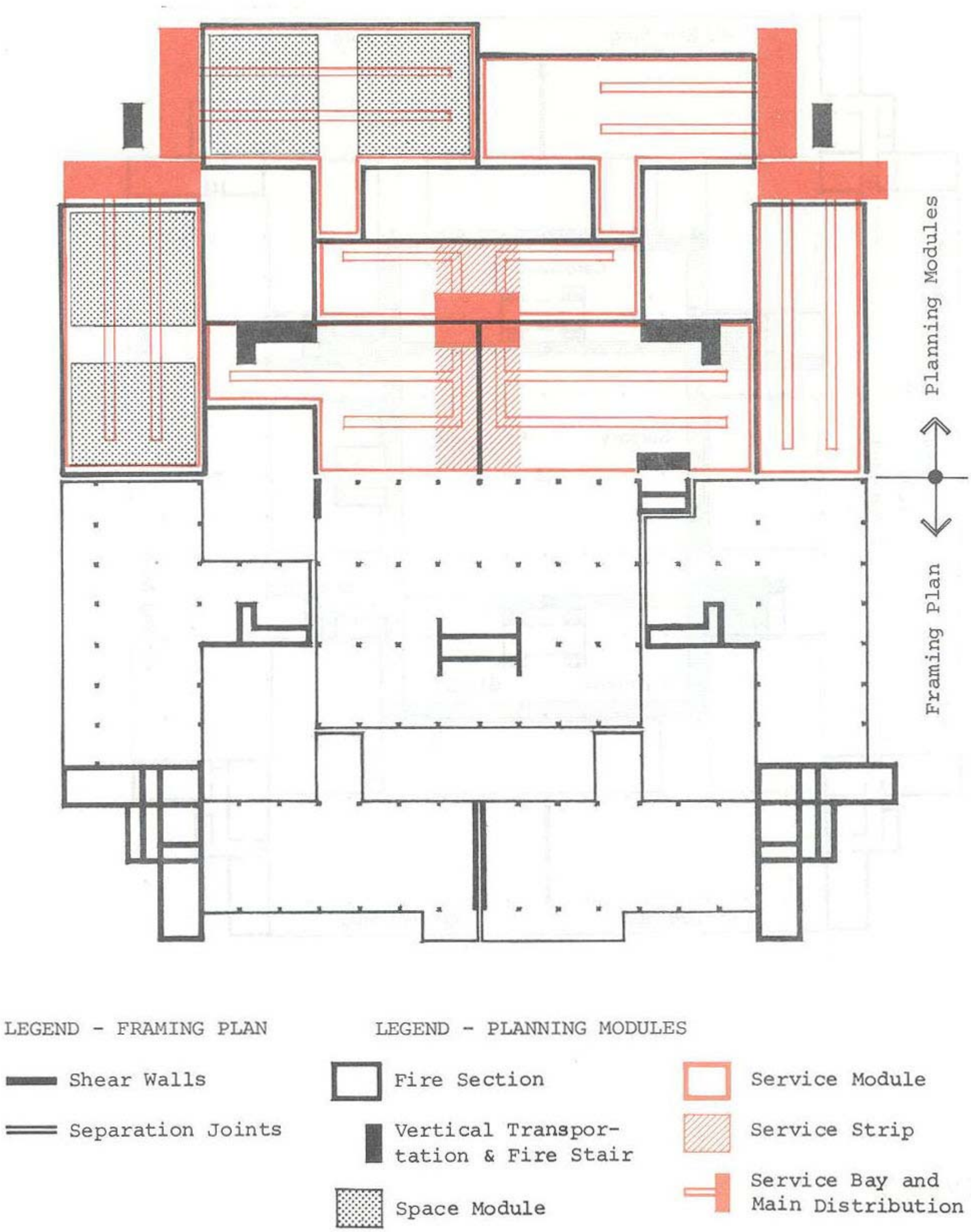
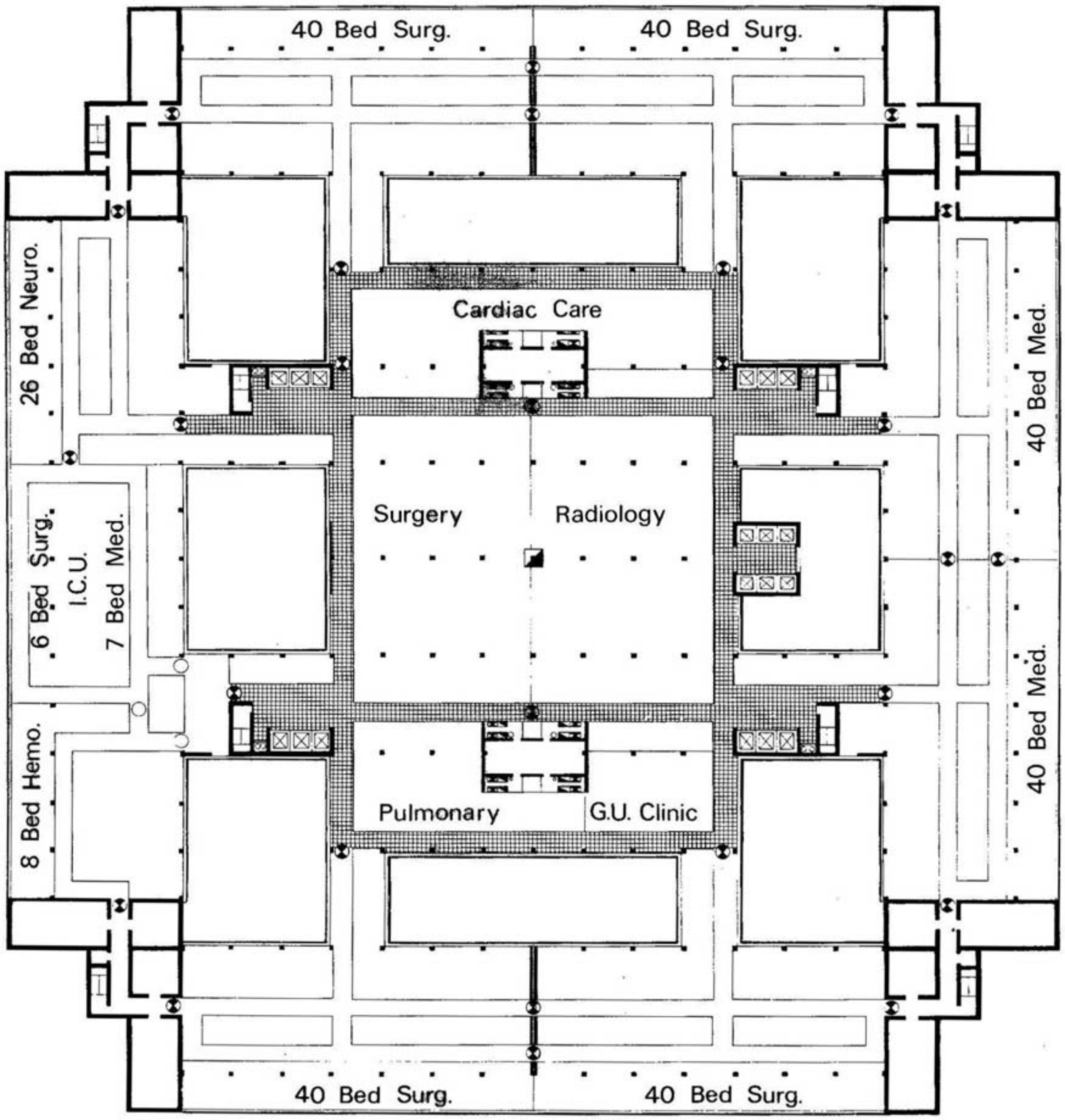

Planning Modules
Framing Plan
LEGEND - FRAMING PLAN
Shear Walls
Separation Joints
LEGEND - PLANNING MODULES
Fire Section
Vertical Transpor-
tation & Fire Stair
Space Module
Service Module
Service Strip
Service Bay and
Main Distribution

Figure 730-10



LEVEL 2

Figure 730-11

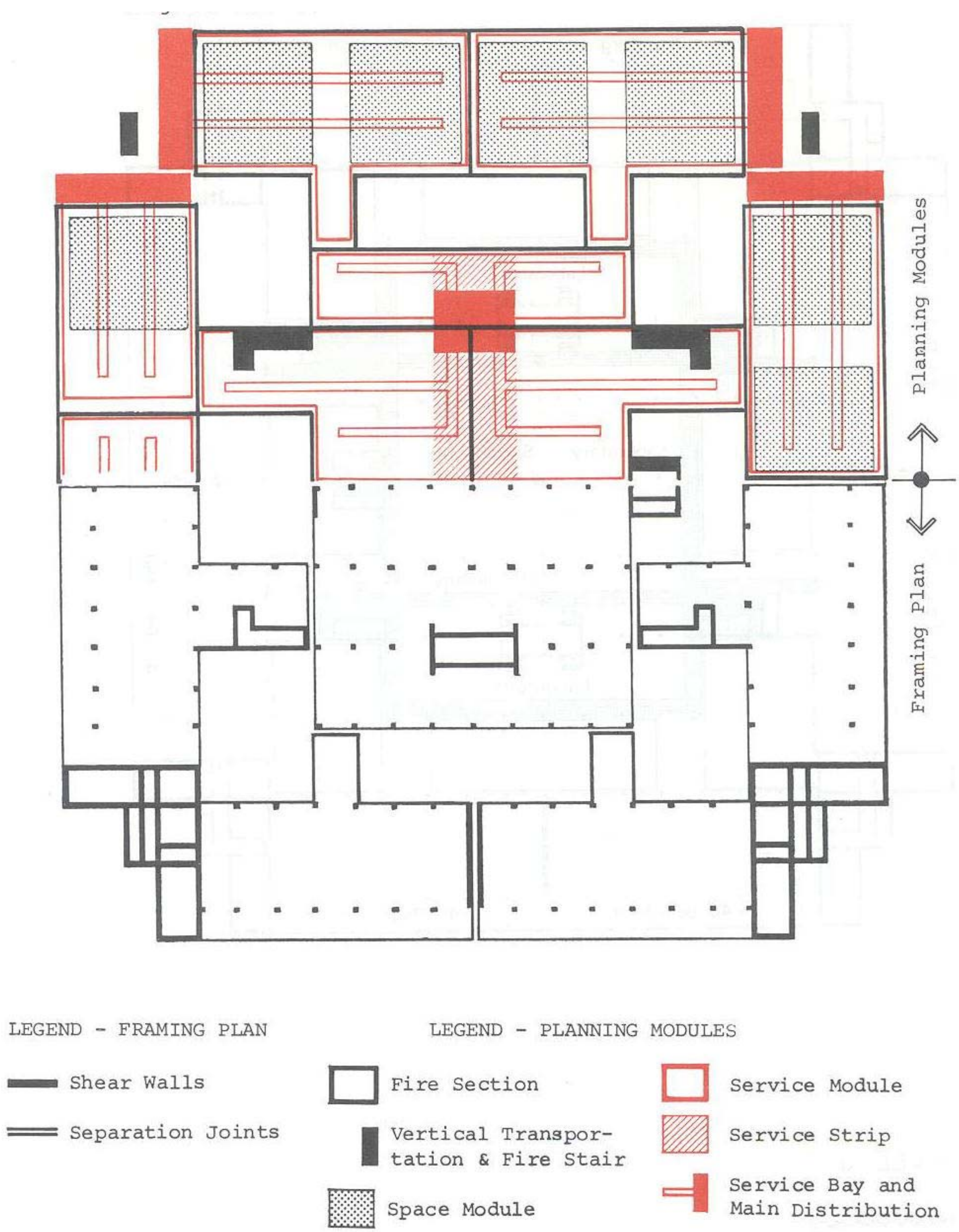


Figure 730-12

Figure 730-12

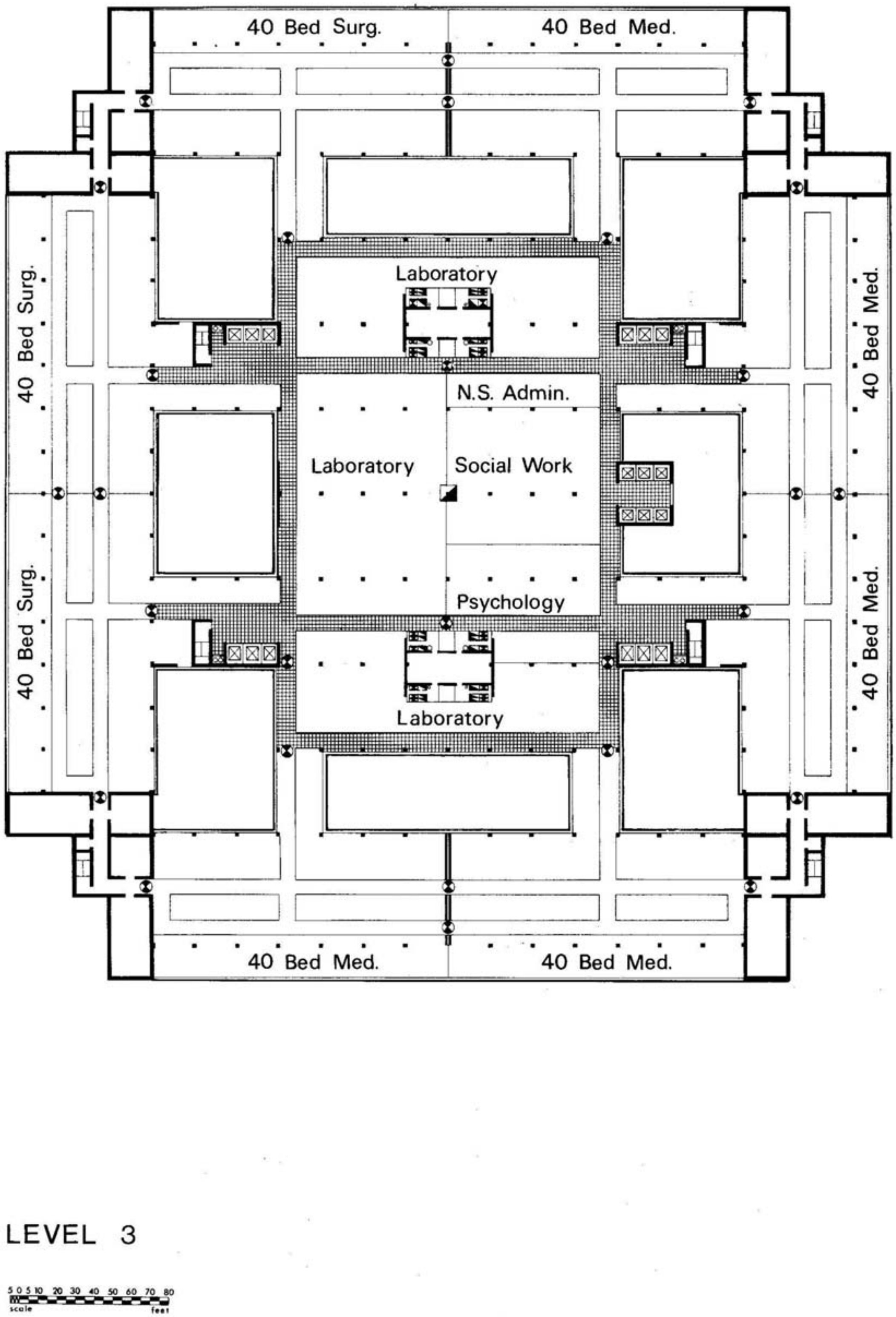


Figure 730-13

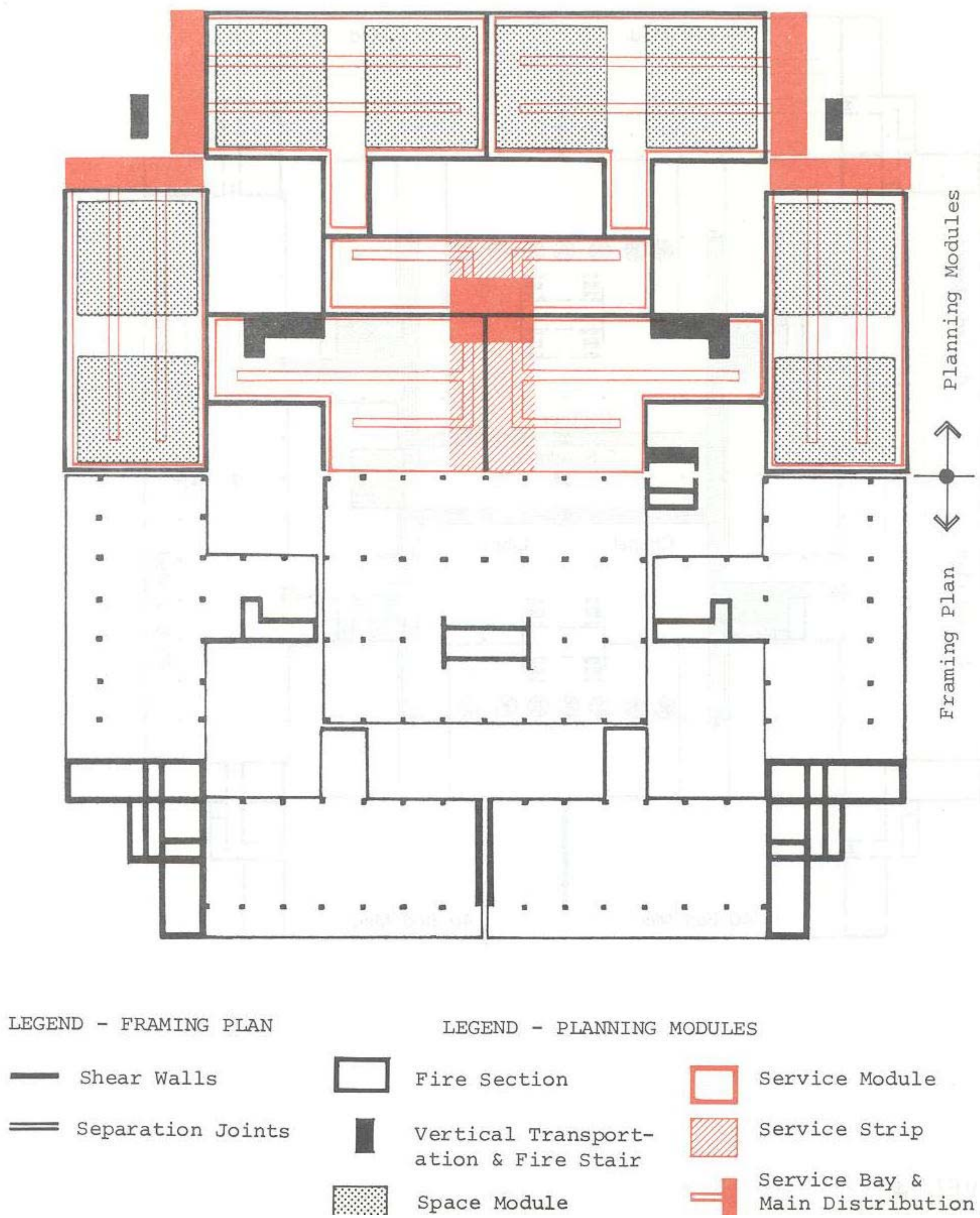
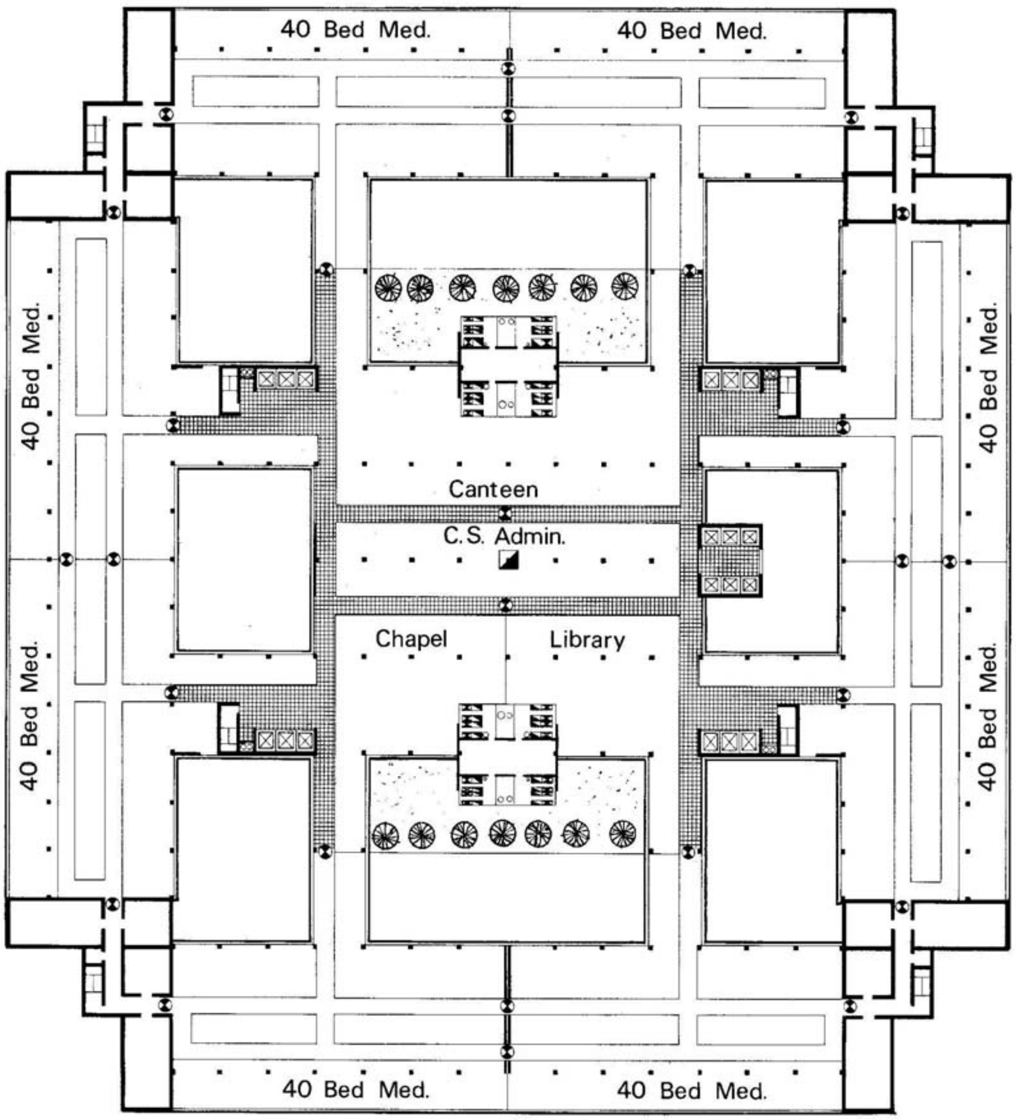


Figure 730-14



LEVEL 4

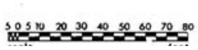


Figure 730-15

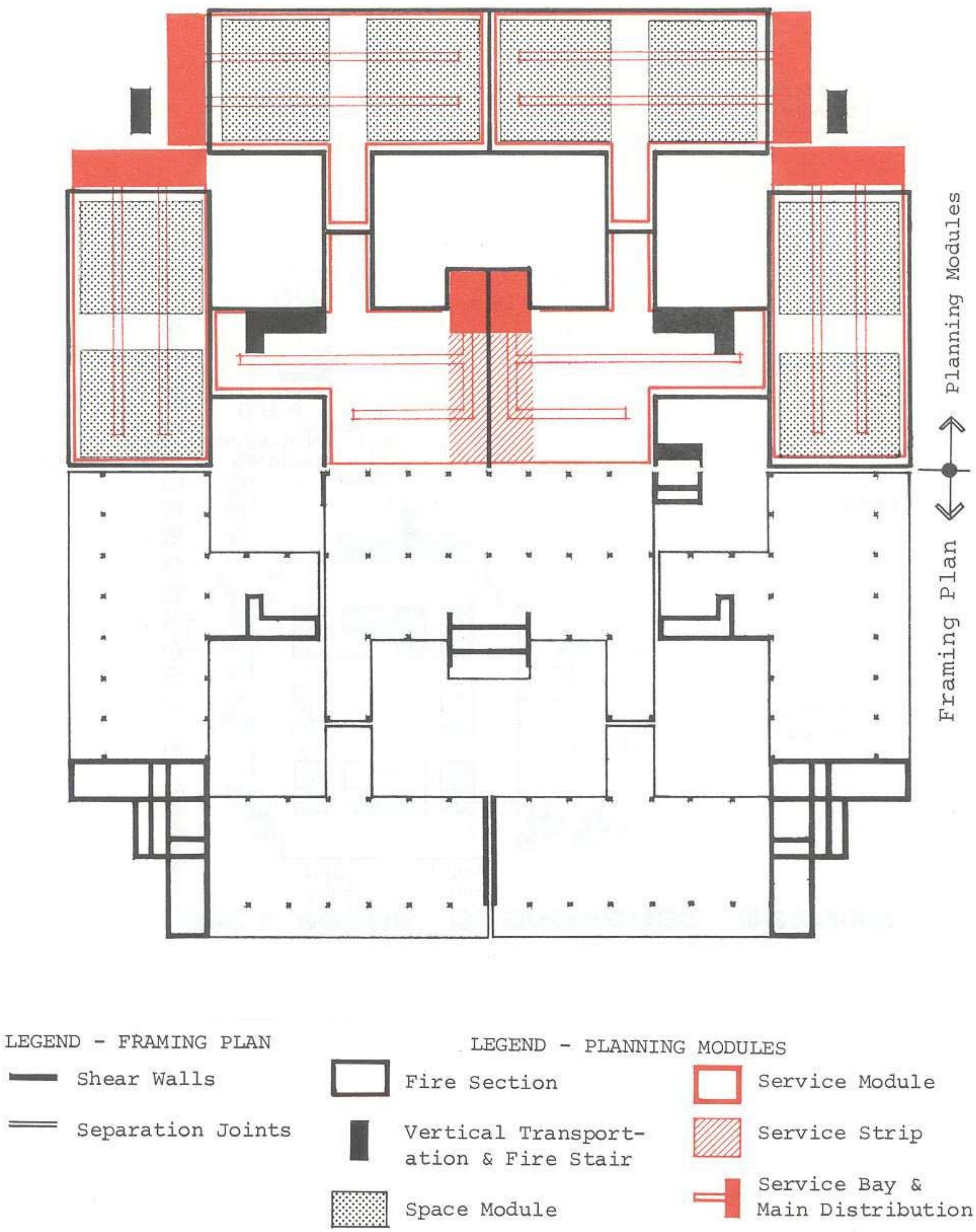
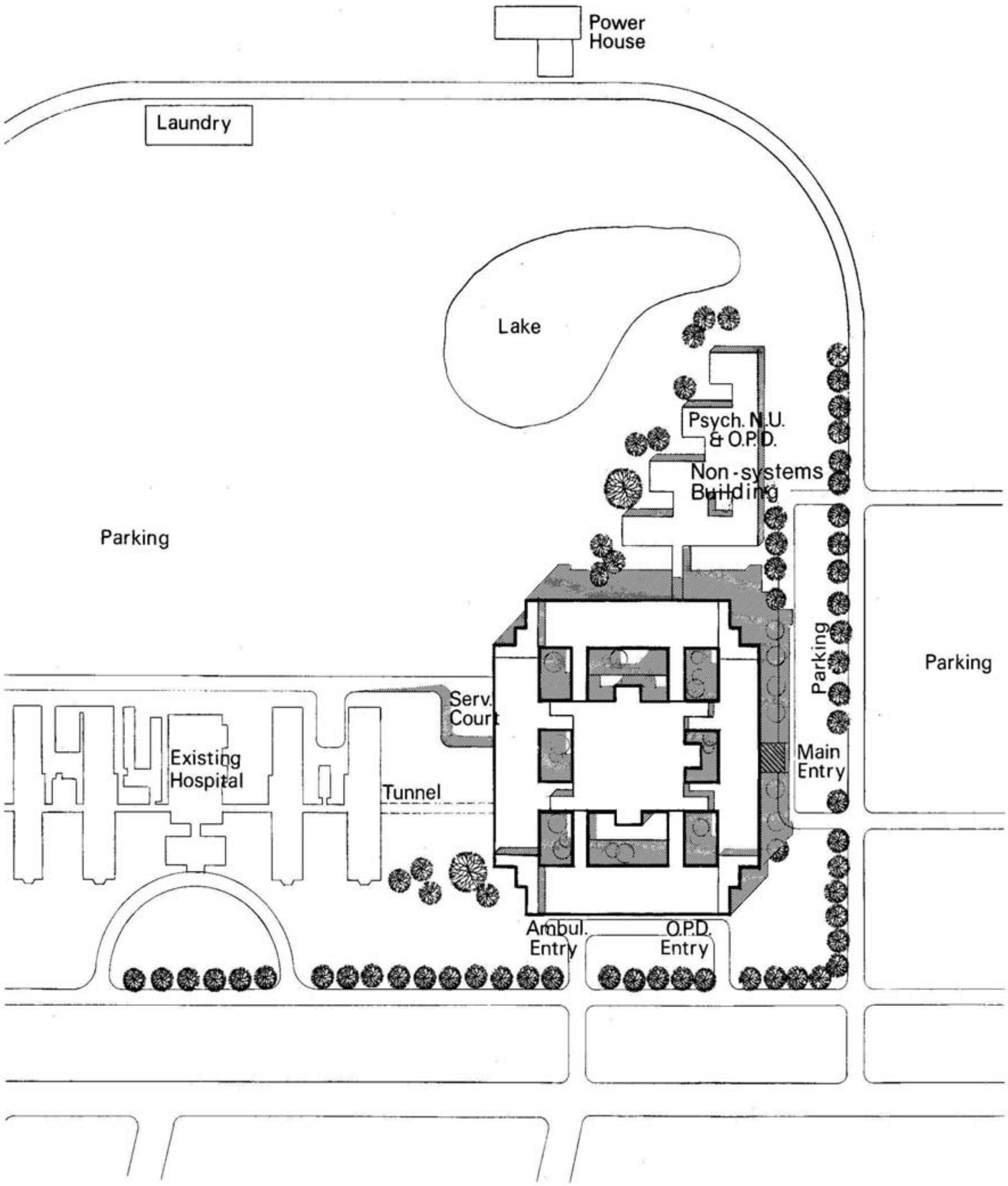
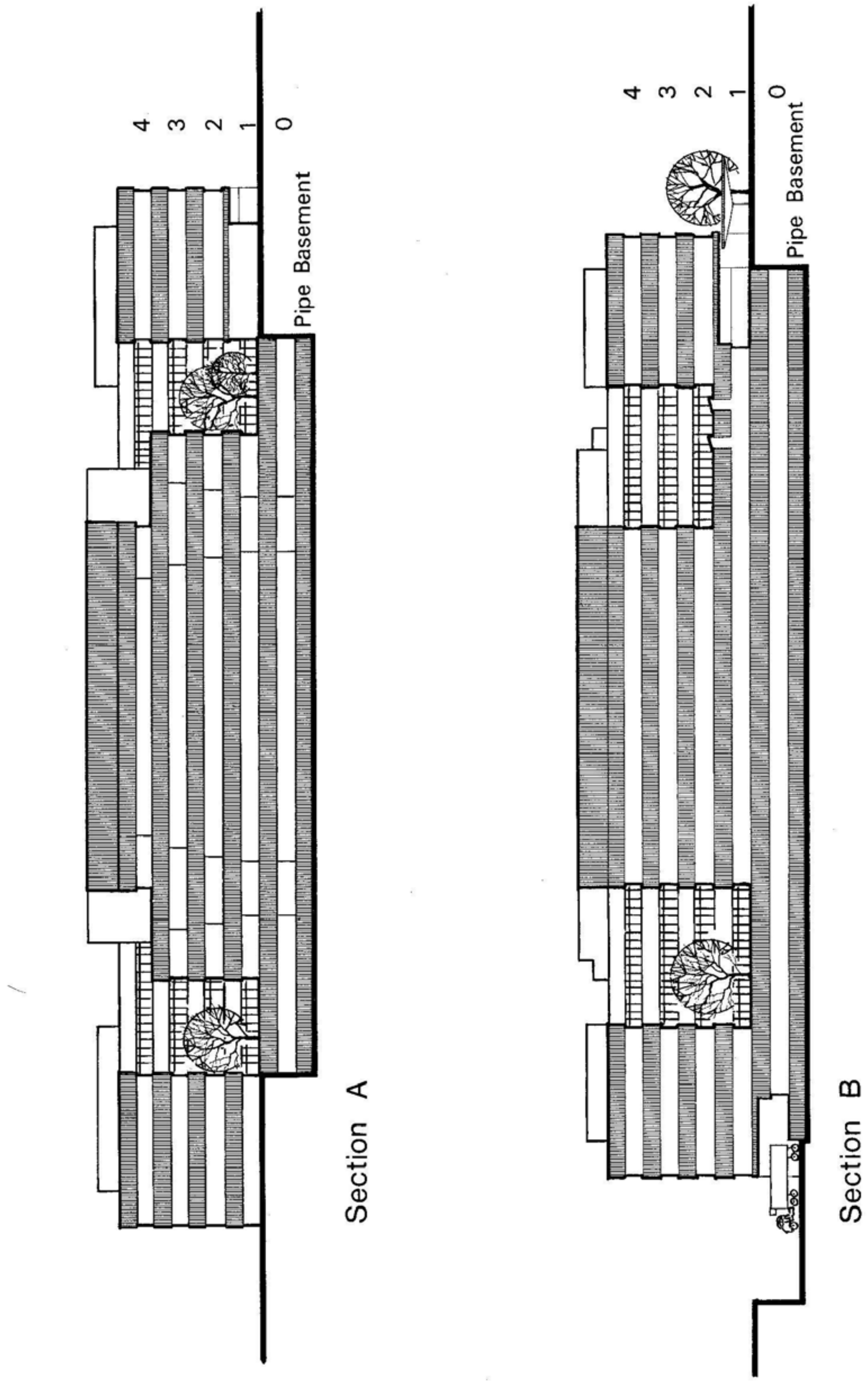


Figure 730-16



SITE PLAN

Figure 730-17



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740 Example Service Module

741 GENERAL CHARACTERISTICS

The following example of service module design is presented to illustrate an application of the principles recommended in the Prototype Design. It demonstrates a hypothetical layout of a functional zone, a subsequent plan change and the related organization of the services subsystems. The factors that need to be considered to arrive at the service distribution patterns are examined in the text and diagrams.

741.1 CONFIGURATION

A hypothetical service module five 22'6" bays in length by two 40'6" spans in width plus a service bay has been taken as the basis for the example. The gross floor area of the functional zone is 9,200 square feet, and it is assumed to have no exterior walls. The service bay has one wall at the edge of the building. The module is at a support function level on a lower floor of a nine-story building. It combines with a similar module, adjacent to its long dimension, to form a fire section of 18,400 square feet bounded by two-hour fire partitions. Between these two modules is a smokestop partition from floor slab to floor slab through the functional and service zones.

In practice, this service module would have been the result of studies of space modules for the nursing units, studies of typical functional layouts within the rest of the hospital program and the total hospital configuration that was selected for a particular project.

741.2 THE SHELL

Figure 740-1 illustrates the physical framework of the service module. It includes the structural members, the ceiling components and the mechanical rooms of the service bay, all of which are permanent components of the module. The configuration of these permanent components is a major constraint on the service distribution design.

The following selections were made for these components from the generic design options:

1. The structure is based on reinforced concrete construction, eighteen feet floor to floor with a ten-foot functional zone.

The beams are prestressed, cast-in-place at 5'7-1/2" centers and are continuous over the girders. The service bay is constructed of solid concrete shear walls as part of the building's seismic bracing.

2. The ceiling subsystem is a poured gypsum deck supported on truss tees and I-beam strongbacks, the latter at 8'0" centers supported from the beams by hanger rods.

3. The partitions are gypsum board on metal studs and extend from the floor to the underside of ceiling. The radiology room partitions have lead backing and stronger metal studs to take the loading of the lead and wall-hung equipment.

4. The HVC mechanical room has set at least one wall which is exterior to allow a louvred opening for the fan unit as a direct air inlet, and also to permit external access when a fan unit needs replacement.

741.3 SERVICES

Figure 740-2 illustrates the layout of the equipment in the service bay and the main distribution of services in the service zone.

741.3.1 Service Bay

The service bay is laid out with the following assumptions:

1. The mechanical room could accommodate a 24,000 cfm supply fan unit and a 20,000 cfm exhaust/return fan, based on an assumed maximum service module requirement of 2.4 cfm/square foot. The items of equipment shown are an 11,000 to 18,000 cfm supply fan unit and an exhaust fan rated at 8,000 to 13,000 cfm, based on the functions in this module requiring approximately 1.5 cfm/square foot. The excess exhaust will be extracted by the toilet or special exhaust systems with their fans located at the roof level.

2. The general exhaust shaft has an area of 130 square feet and can handle about 100,000 cfm for the nine stacked service modules. The toilet exhaust shaft at twelve square feet will handle about 10,000 cfm. The special exhaust shaft could accommodate the equivalent of two ducted exhausts of 36" diameter for laboratory fume hoods, etc.

This would give a reasonable latitude to the planning of functions requiring special exhaust in service modules attached to this common stack of service bays.

3. The plumbing risers are grouped at one end of the mechanical room, with those services not required for this module valved and capped off for future availability. Drainage pipes drop vertically through the stack of service bays at their point of entry to the bay on either side of the module.

4. The electrical room houses all the equipment for normal, emergency and critical circuits. It is assumed in this module that critical distribution is only required for the HVC equipment. The transformers to provide the 277/120 volt service would be of the order of 75 KVA, and having the capacity to serve more than one service module, would not appear in every electrical room as shown here.

741.3.2 Main Distribution

The main distribution in the service zone at the S3 subzone level has been laid out to allow the most direct connections to equipment and risers in the service bay. The layout was also influenced by the constraints on penetrations through the shear wall between the service bay and service zone. The maintenance access is at either side of the module where branch distribution runs would be least dense.

The HVC subsystem is assumed to be a single-duct terminal-reheat system with a supply duct on each side of the central girder. The branch connections to each supply duct would be as far as possible from the same side of the duct to simplify the run of HVC plumbing to the terminal-reheat units. The exhaust system is shown as ducted to illustrate how it can be handled even though a plenum return could have been used. The only special exhaust required for this module is the toilet exhaust.

741.3.3 Branch Distribution

Figure 740-3 shows the proposed locations of the branch distribution of the services in each hanger space at the S2 and S4 subzone levels. In practice, this organization would need detailed consideration to optimize the locations and space assigned to each service to accommodate all routing conditions.

For instance, the HVC branches are placed only one branch per hanger space in this example. It could happen that the density of supply and exhaust branches in some hospital areas would require more. This can be done, and schemes with other beam and hanger spacings would need their own assessment. But to prevent local overcrowding of services and preserve reasonable future access through the ceiling, this kind of general constraint, such as limiting the number of duct branches, will be necessary. The S5 subzone is shown as approximately twelve inches deep to accommodate the lateral branches including the flexible duct connections to the HVC system. The latter are limited to a maximum of twelve feet in length and a maximum of ten inches in diameter.

Figure 740-1. THE SHELL: PLAN

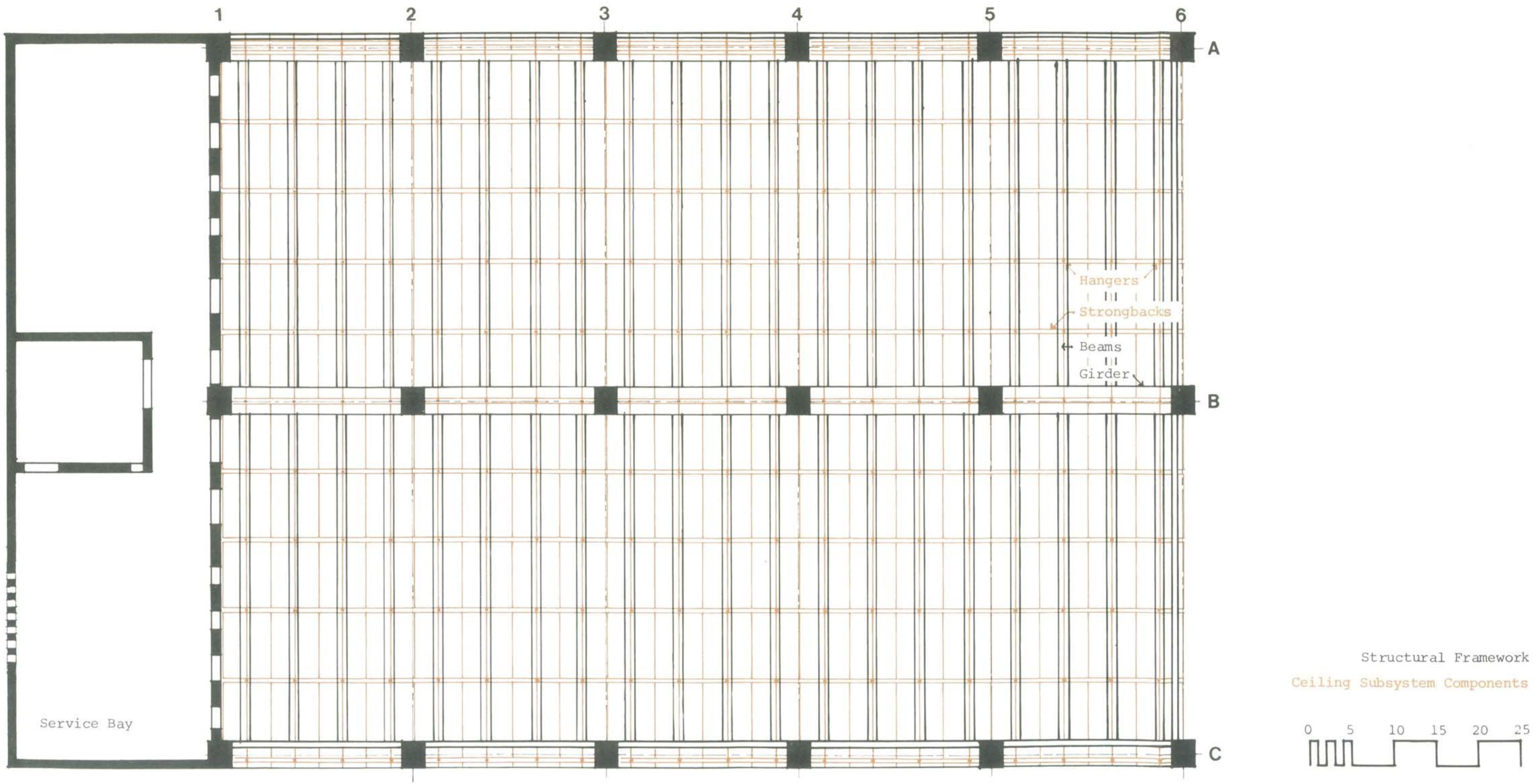
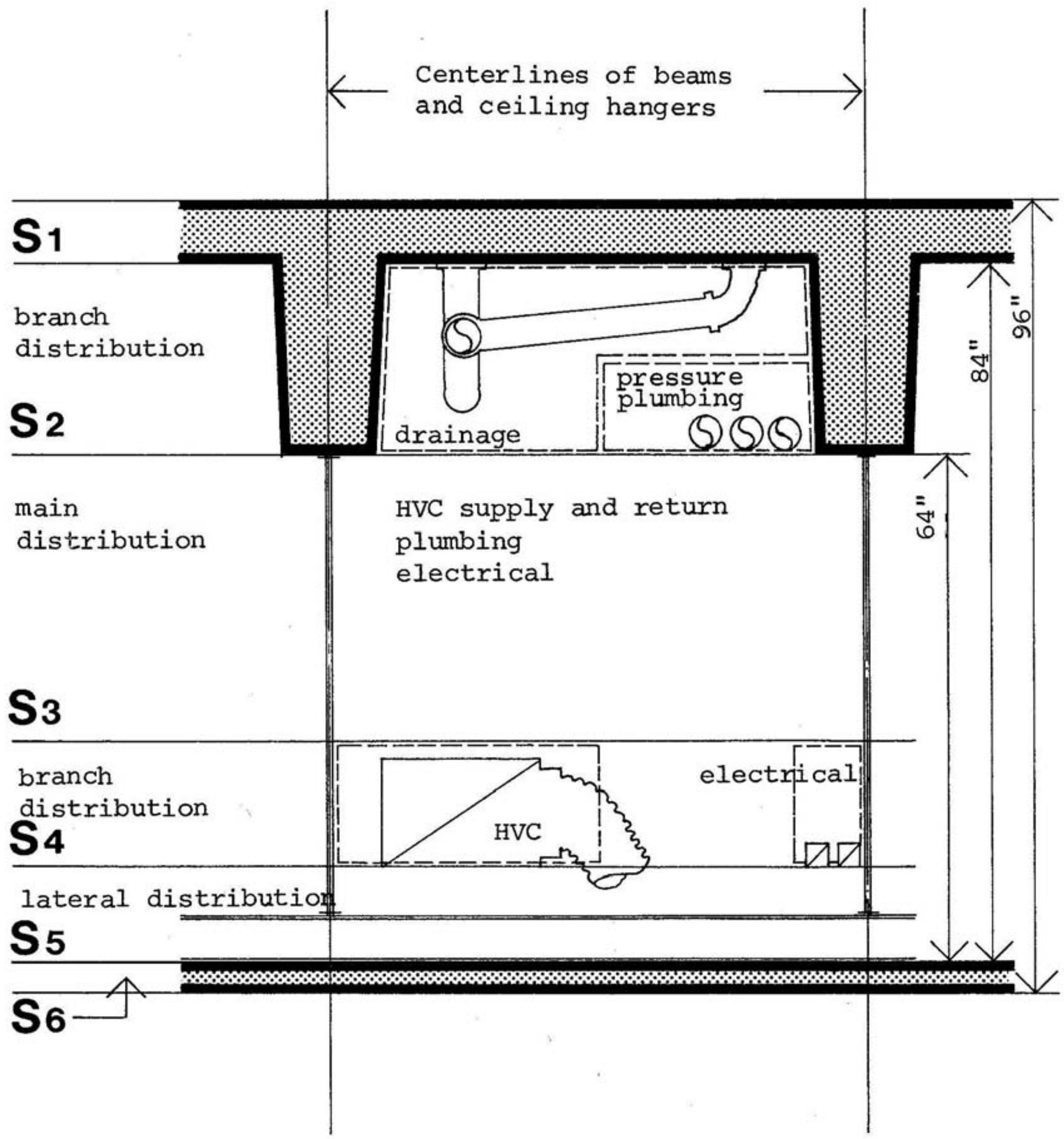


Figure 740-2. THE SERVICES: PLAN

Figure 740-3. SUBZONES: SECTION



742 OPENING CONFIGURATION

742.1 FUNCTIONAL ZONE

Figure 740-4 shows an assumed functional zone layout in the service module. It includes departmental offices, a small radiology suite, and the overflow from an outpatient department in the adjacent service module.

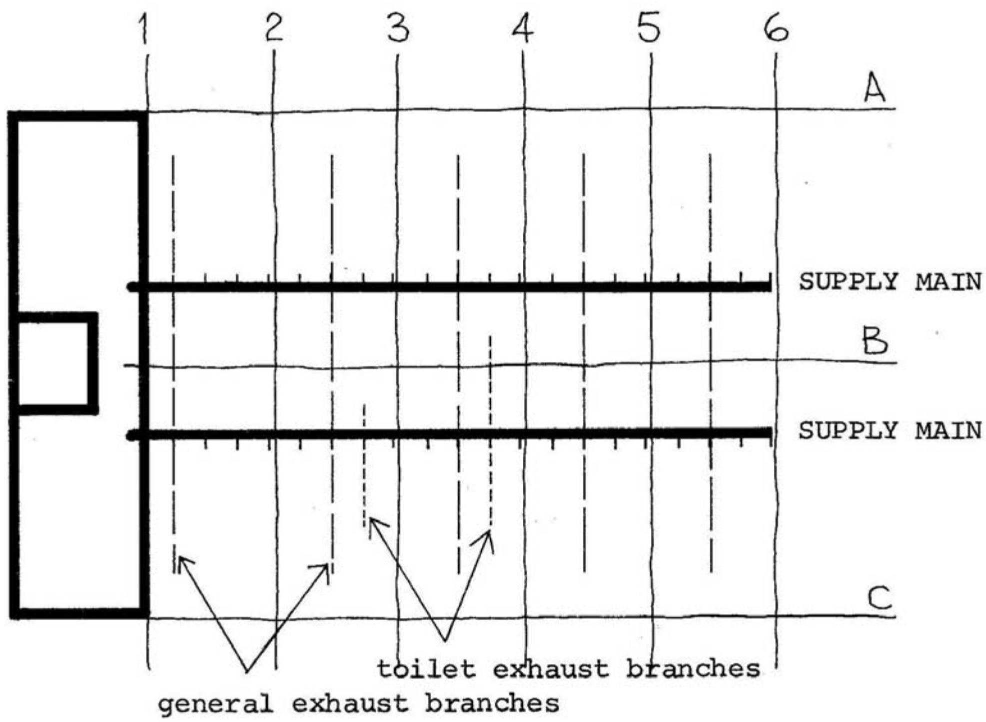
Service drops have been assumed in the rooms to give reference points for the layout of branch service distribution above the ceiling, and a representative ceiling-lighting pattern is shown in two of the bays to demonstrate conduit runs. No partition planning grid is necessary or assumed in this example, but the partition layout should be always planned with careful reference to the floor beam pattern where drainage is required, and to the ceiling construction where the service drops are expected. For example, service drops along the line of a trussed tee could be provided if required, but the predictability of these supports makes them easily avoided if they are considered during the layout planning.

742.2 HVC DISTRIBUTION

Figure 740-5 shows the layout of the main and branch distribution and flexible duct laterals of the HVC subsystem. The illustration is diagrammatic, but gives a complete picture of the required layout with the exception of the duct, diffuser and outlet sizes which would be added to a production drawing. This concise diagrammatic view would be possible for all service module layouts in a system hospital because of the predetermination of service layout shown on the preceding drawings. The branch distribution layout was produced in the following steps:

1. First, the number of required supply zones was established for the functional zone layout. In this case, 24 were identified, including corridors, some grouping of offices and generally separate zoning of radiology suite rooms.

2. Next, the general exhaust duct branches were placed at one per 22'6" bay. Two special exhaust branches were required for the toilet areas. The following sketch resulted:



HVC Zone Analysis

3. The number of possible branch supply duct locations in this service bay is forty, based on two main supply ducts, five bays long, each with four hanger spacings per bay (assuming one HVC branch per spacing); that is, 2 x 5 x 4 = 40.

4. Each general exhaust branch would occupy two of these possible locations per bay, and the two special exhaust branches one each, as shown on the sketch; that is, (5 x 2) + 2 = 12.

5. The resulting 28 remaining locations were then organized to provide the 24 supply zones, with the use of flexible duct connections in the S5 subzone as required.

It is recognized that there may be areas of a hospital where several small adjacent rooms requiring separate zoning would require a modification of this pattern. In such cases, supply branch ducts could be taken from both sides of the mains, or more than one branch per hanger space could be allowed.

Nevertheless, acceptance of the simple rule demonstrated here will greatly ease location and installation in the majority of cases. Special cases can be pointed out in the contract documents and provision made accordingly.

742.3 PLUMBING DISTRIBUTION

Figure 740-6 shows the layout of the main and branch distribution of the plumbing subsystem. The plumbing for this functional zone is relatively simple but shows the general principles. The drainage is collected at separate mains on each side of the central girder. (The drainage mains actually serve the floor above, which for this example is assumed to have drains in the identical location as the radiology suite.)

All the branches are in the S2 subzone between the beams. As discussed in the following section, electrical work is heavy in the radiology suite areas and some large branches are required for this service. In this example, it was found quite possible to use hanger spaces other than those occupied by the large electrical runs, thus avoiding a conflict between plumbing drops and the large wireways below. This is a consideration which is likely to occur between the two services in most areas of the hospital.

As discussed under HVC distribution, the layout is shown diagrammatically. Plumbing layouts are not shown to this degree of specificity traditionally, but to achieve the coordination required by the Prototype Design, such layouts are essential. The simplicity of general predetermined routing makes the diagrams feasible and effective working documents.

742.4 ELECTRICAL DISTRIBUTION

Figure 740-7 shows the layout of the electrical mains and branch distribution. Communications, which has not been considered in this project as an integrated subsystem, has been shown to illustrate its layout in relationship to the electrical power and lighting runs.

Two electrical systems are carried in the main wireways in this service zone, normal and emergency. In general, each bay has one pair of 2-1/2" square wireways carrying normal distribution of 208/120 volts and 480/277 volts. Wireways carrying emergency distribution are provided in separate hanger spacings as required; in this example for corridor lighting, one radiology room and the radiology viewing room.

Each radiology room has a special wireway carrying power at 120/207 volts to a position over the circuit breaker and control room. The circuitry to transformers and equipment is assumed to be within the functional zone. The large group of control wiring is shown distributed from the control room over the ceiling-platform in S5 to the drop positions in the radiology room. The wiring could be housed in either conduit or wireways along this route. The voltage transformers are assumed within or adjacent to the radiology room.

The branch communication wireways have been shown in separate hanger spaces from the electrical. This arrangement is not mandatory but is desirable for clarity of layout where it can be achieved. In this example, the wireways would primarily carry telephone lines.

The conduit runs from the branch wireways for lighting and power drops to the functional zone have been included in the first two left-hand bays to indicate the kind of pattern that would develop in the S5 subzone.

In several instances, the subzone available in a hanger space for electrical branches is not used. This moderate use would be generally true in some areas of the hospital. But immediately adjacent to the radiology rooms the heavy demand on wireways for power and control circuits would require more room, in this case the equivalent of two 4” x 4” or 6” x 6” wireways. Such local conditions are easily handled. Here the plumbing branches are excluded from those hanger spaces where this condition occurs to allow more dimensional freedom.

Again, a much higher specificity of detail is shown in the diagrammatic representation than is normally found in traditional work, and is very necessary for the success of the highly integrated service layout in the building system.

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Figure 740-4. FUNCTIONAL ZONE: OUTPATIENT AND RADIOLOGY

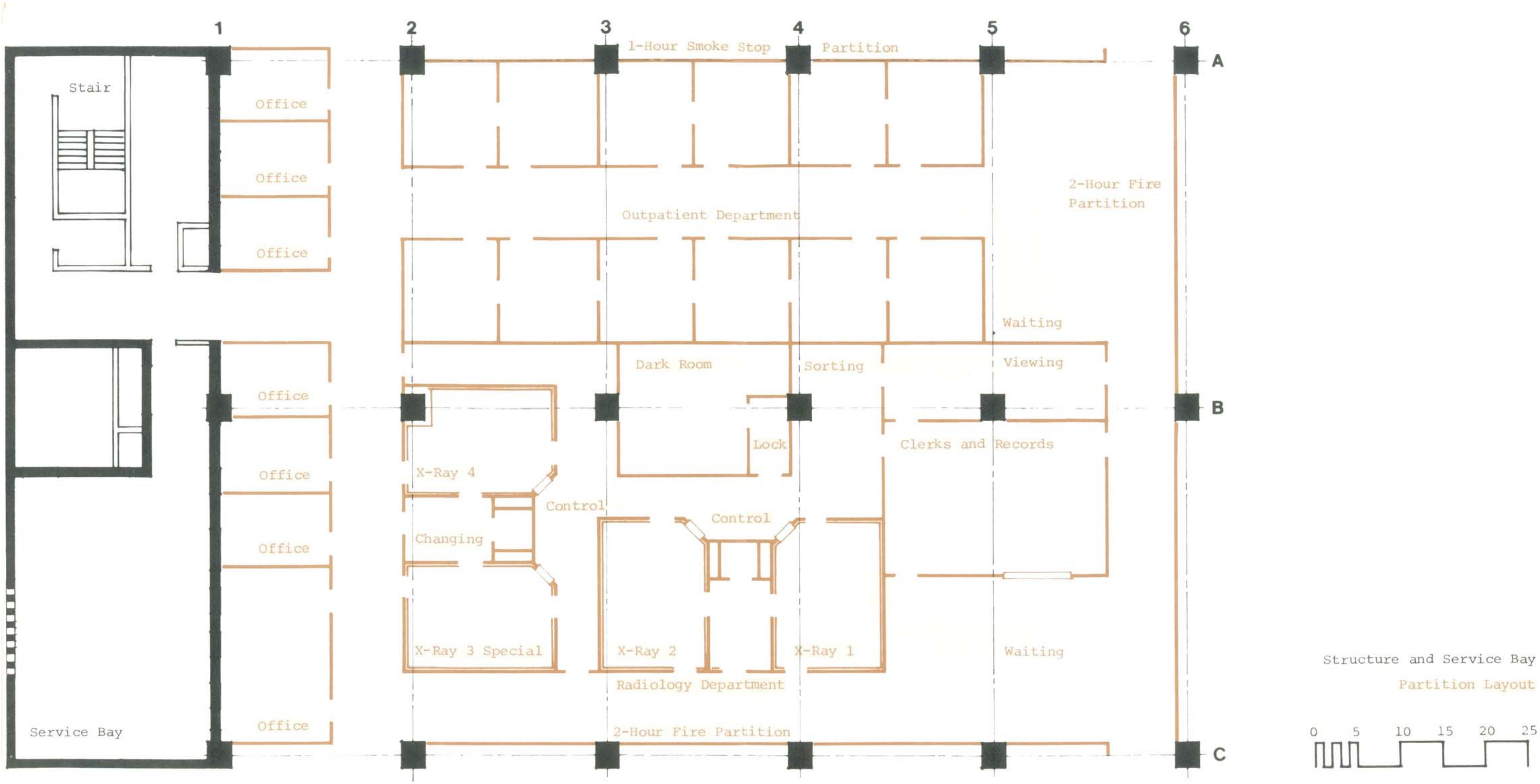


Figure 740-5. SERVICE ZONE: HVC SUBSYSTEM

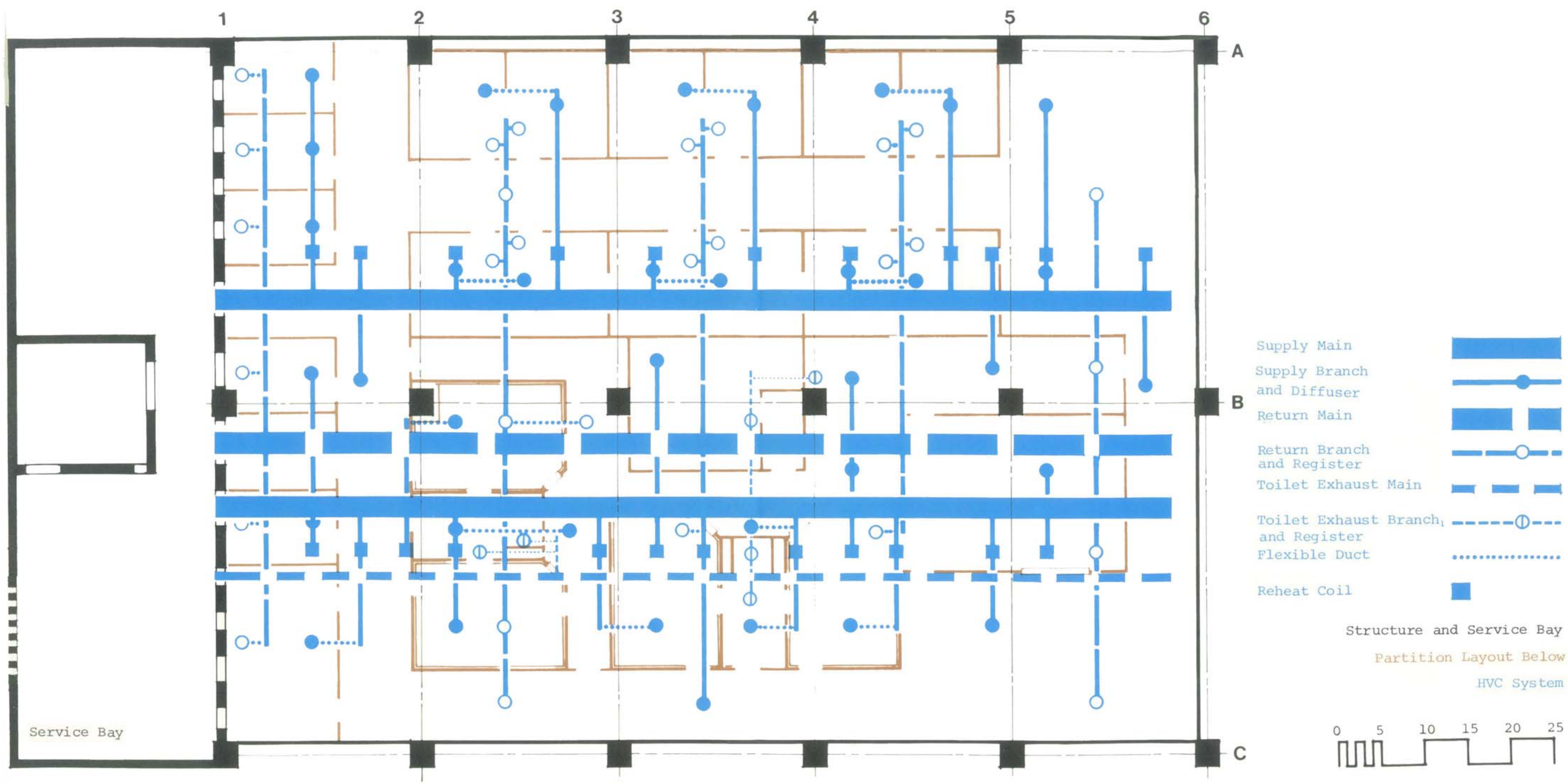


Figure 740-6. SERVICE ZONE: PLUMBING SUBSYSTEM

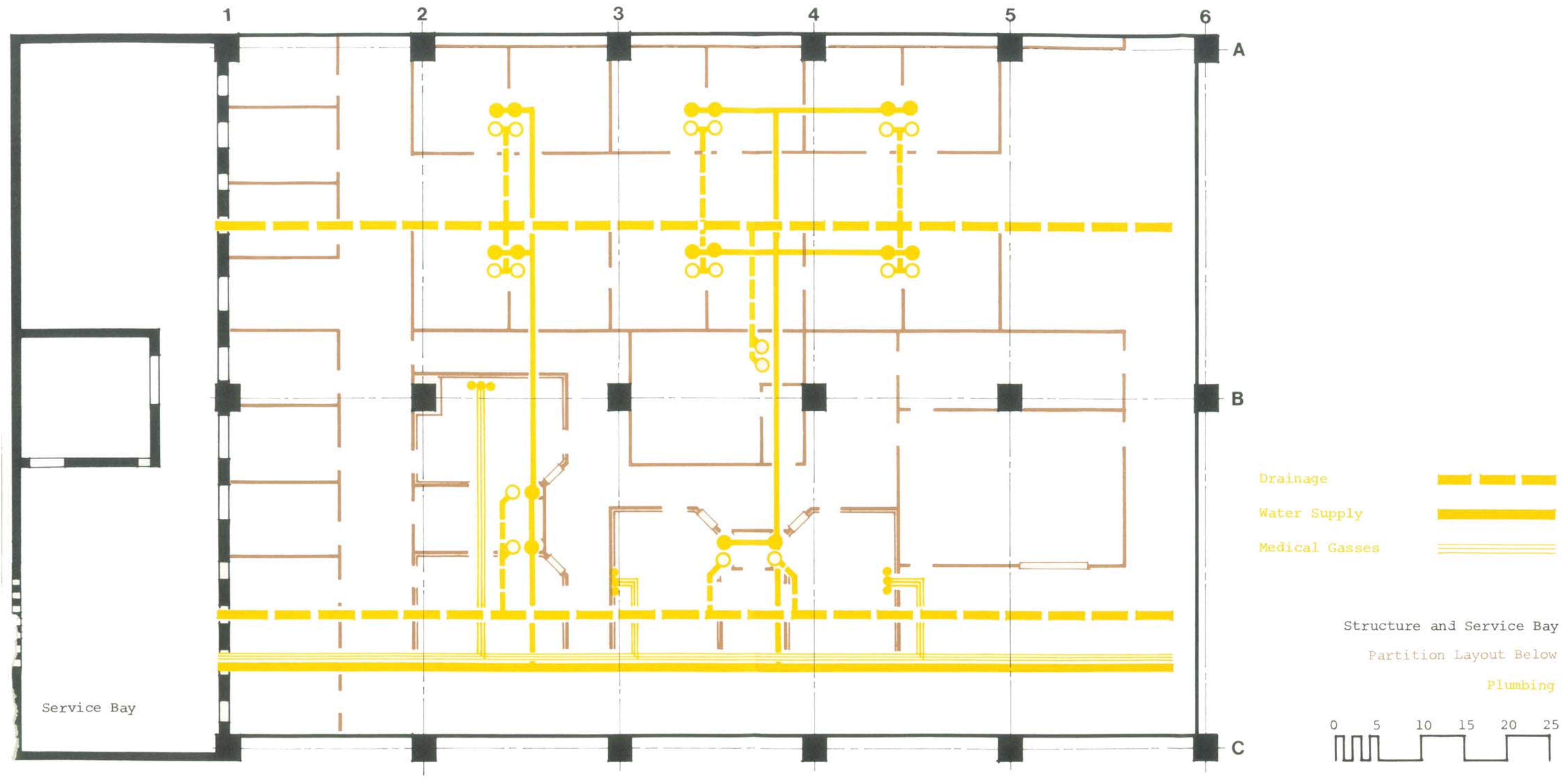
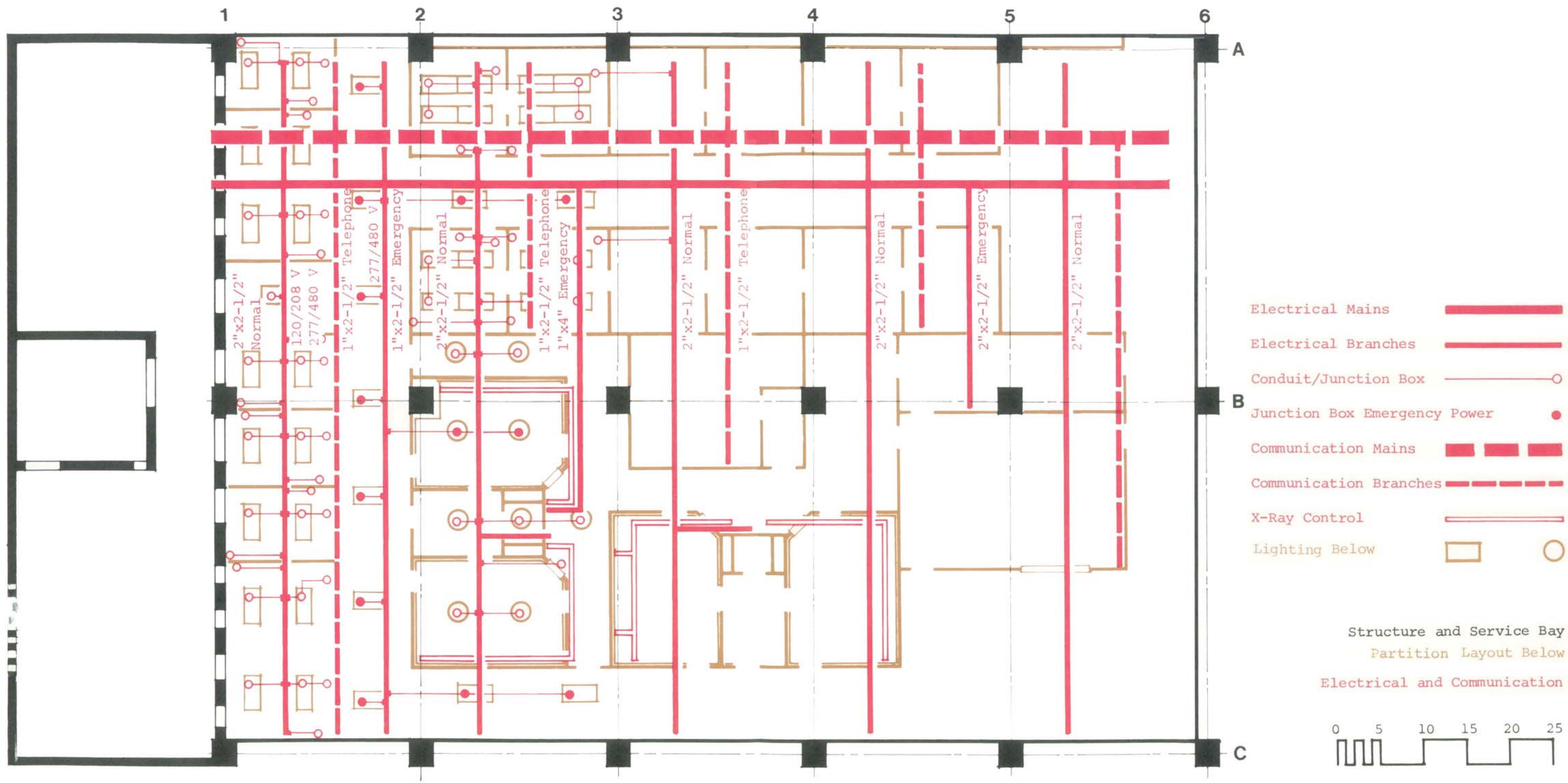


Figure 740-7. SERVICE ZONE: ELECTRICAL SUBSYSTEM



743 ALTERATION

743.1 FUNCTIONAL ZONE

To demonstrate the effect of functional zone replanning, it is assumed that the radiology suite in the opening configuration requires expansion to nearly twice its original size, from four to seven radiology rooms, including a special procedures room. To achieve this, the outpatient department is relocated elsewhere and some offices taken over to supplement the departmental offices.

The change of use of the offices causes little alteration to service layouts, but the new radiology rooms require complete alteration of the branch services in that area.

Figure 740-8 shows the revised layout with proposed service drops in the area affected by the change.

743.2 SERVICE ZONE

Figures 740-9, 10, and 11 show the revised layouts for the three services. In each case, the main distribution remains unchanged.

743.2.1 Main Distribution

The HVC supply and general exhaust/return main ducts are all permanent installations sized to handle up to the maximum air flow of 24,000 cfm and the alteration of functions in this example does not significantly change the cfm requirement from before. The slight increase in toilet exhaust requirement can be handled by the original duct.

The electrical and plumbing main distribution remain constant with some circuit variation in the wireways, and the generally oversized plumbing mains are capable of handling the increase in load.

743.2.2 Branch Distribution

The branch distribution in the changed area requires either extension or replacement.

For the HVC branches, the procedure described above for the opening configuration was repeated, except that the remaining branches of the existing layout were taken into account to minimize the new branches required. Twenty-two supply zones were found to be necessary to serve this new functional zone layout.

The plumbing branch change are a simple cutting back of domestic water runs and extension of the medical gas lines to the new radiology room locations.

The electrical branches are virtually unchanged except for cable variations within each wireway. But the short conduit runs and junction boxes to the final lighting and power drops would vary heavily from the original layout.

Figure 740-8. FUNCTIONAL ZONE: RADIOLOGY DEPARTMENT

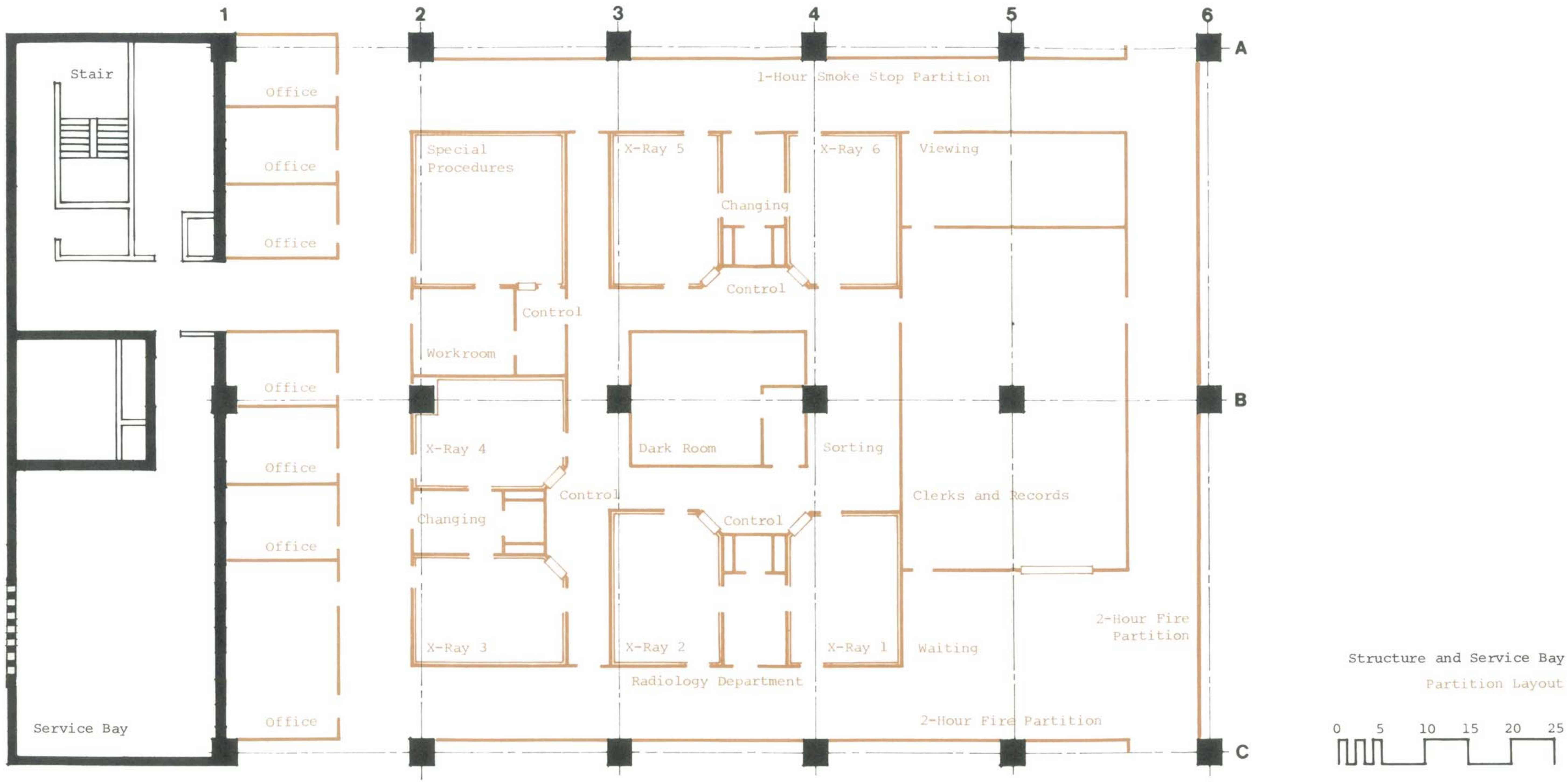


Figure 740-9. SERVICE ZONE: HVC SUBSYSTEM

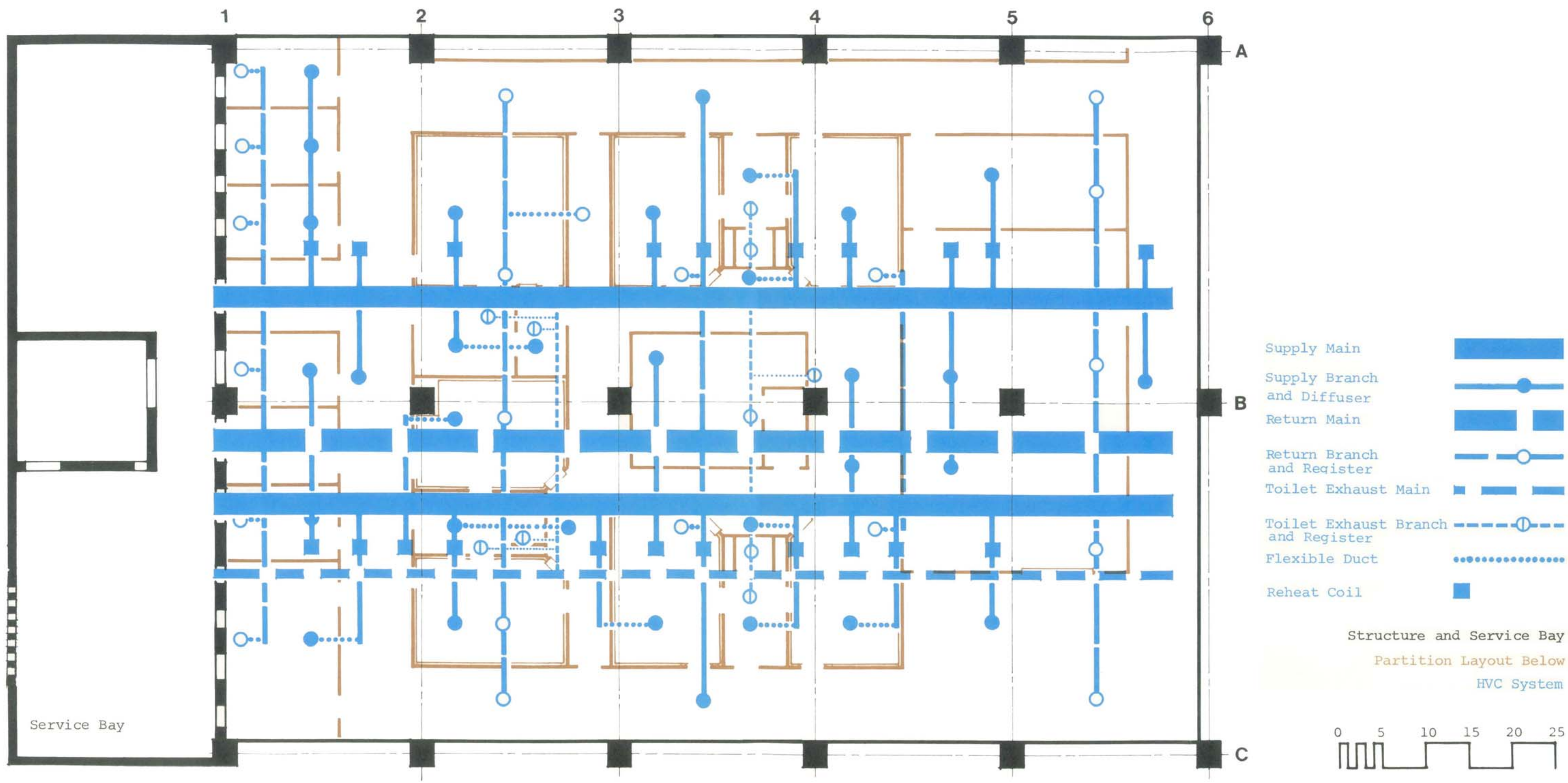


Figure 740-10. SERVICE ZONE: PLUMBING SUBSYSTEM

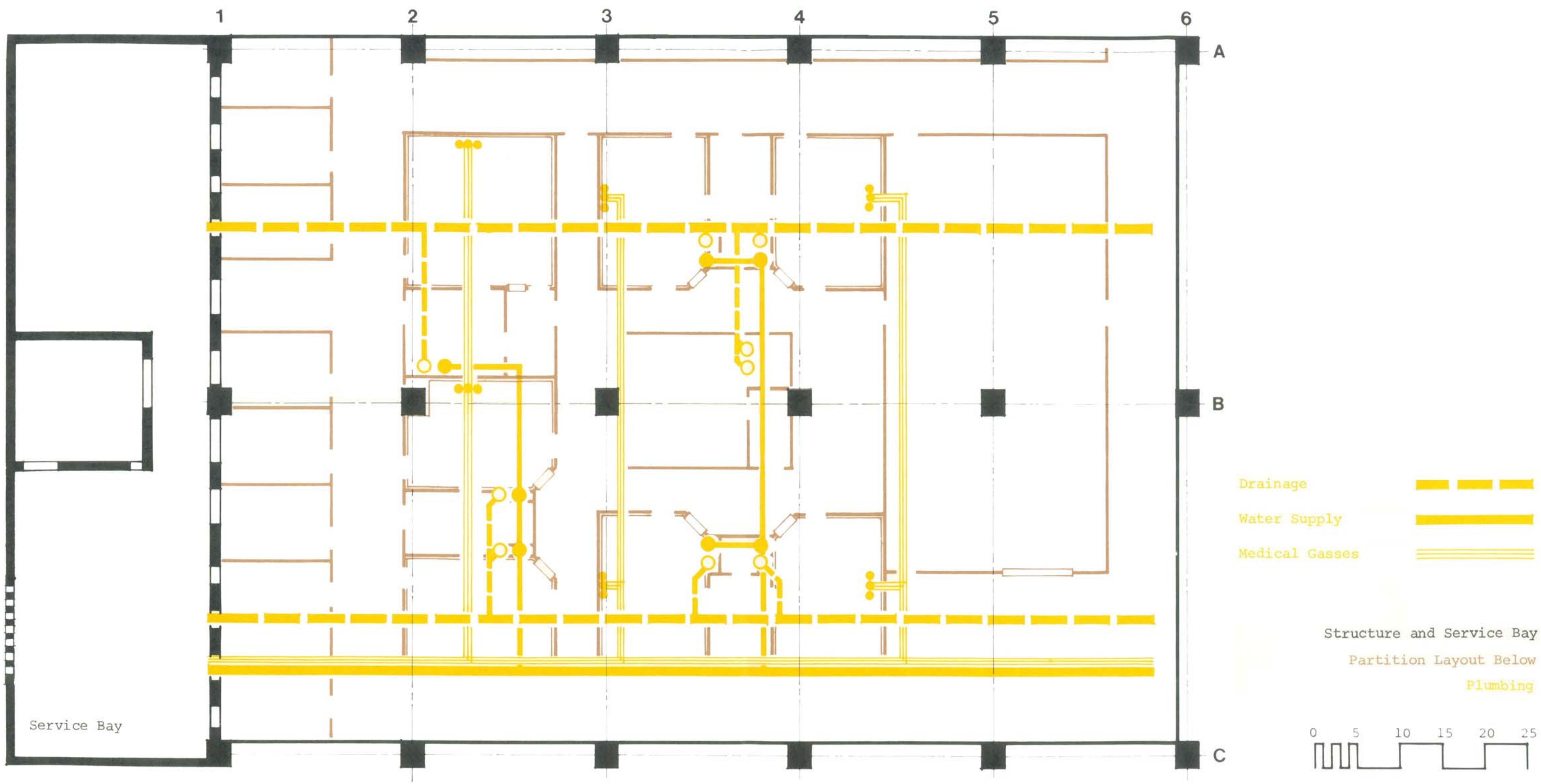
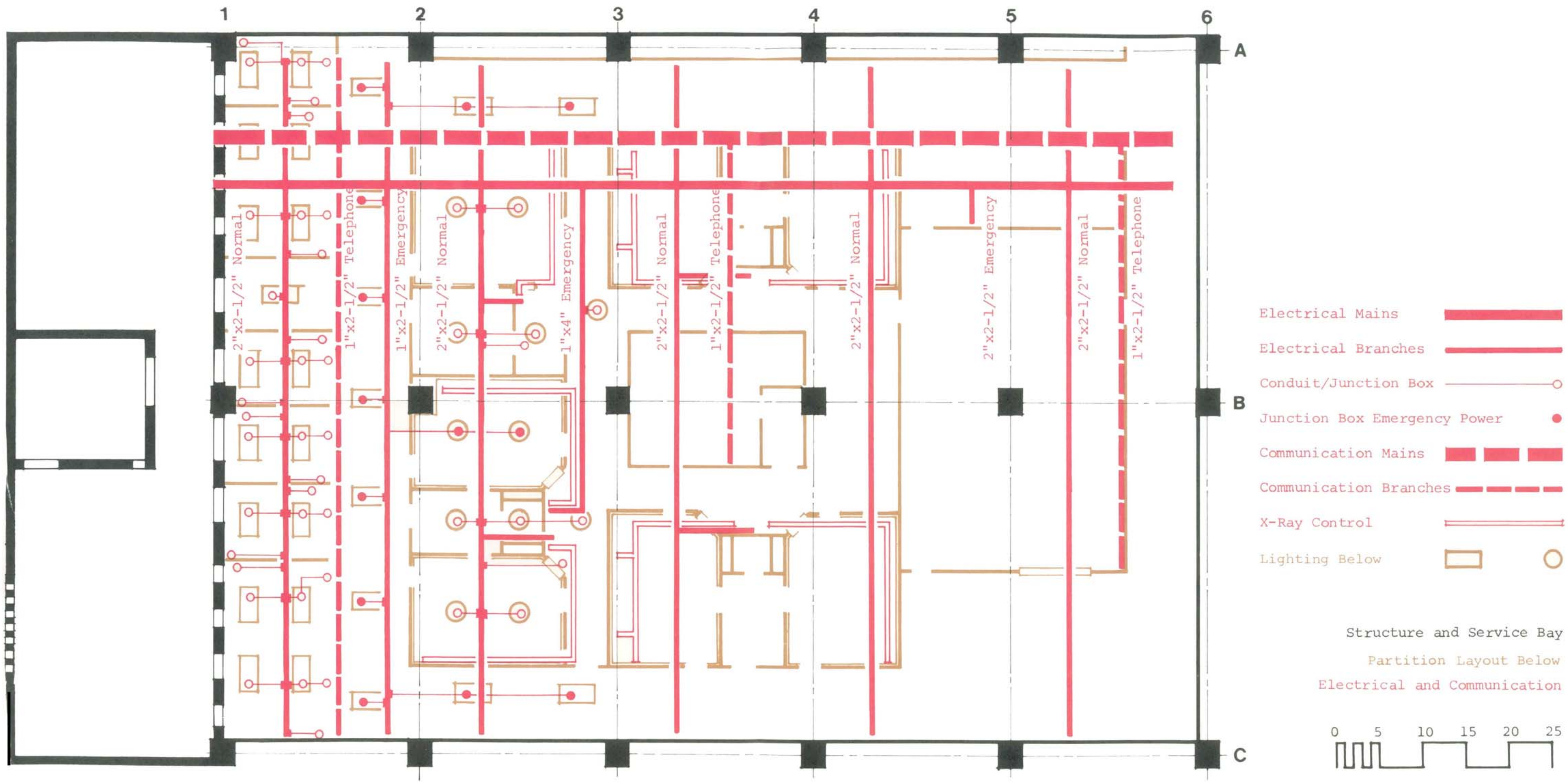


Figure 740-11. SERVICE ZONE: ELECTRICAL SUBSYSTEM



744 CONCLUSION

This example does not pretend to give a comprehensive picture of the total service module distribution problem. It has attempted to show a general approach to a solution. The successful integration of the subsystem layouts in a rational network depends on early study of the immediate and potential requirements for service. The general character of the service layouts needs to be developed simultaneously with structural and functional decisions. If this design procedure is followed, it will result in:

1. simplified layout drawings with a high content of diagrammatic detail for contract documents;
2. precise location of restrictions on service drops during functional zone planning;
3. simpler coordination and installation during construction stages;
4. simpler service change procedures during the life of the building.

745 MODEL AND MOCK-UP DEMONSTRATION

During the development of the example service module, a model of part of the service module was built to study the general organization of space and the layout of services. Also a full size mock-up was constructed representing a small area in the service zone of just over two hanger spaces in each direction. A congested service area was chosen deliberately to test general access and installation of services.

The group of photographs which follow show various aspects of both the model and the mock-up.

Figure 740-12. MODEL: THE SERVICE MODULE

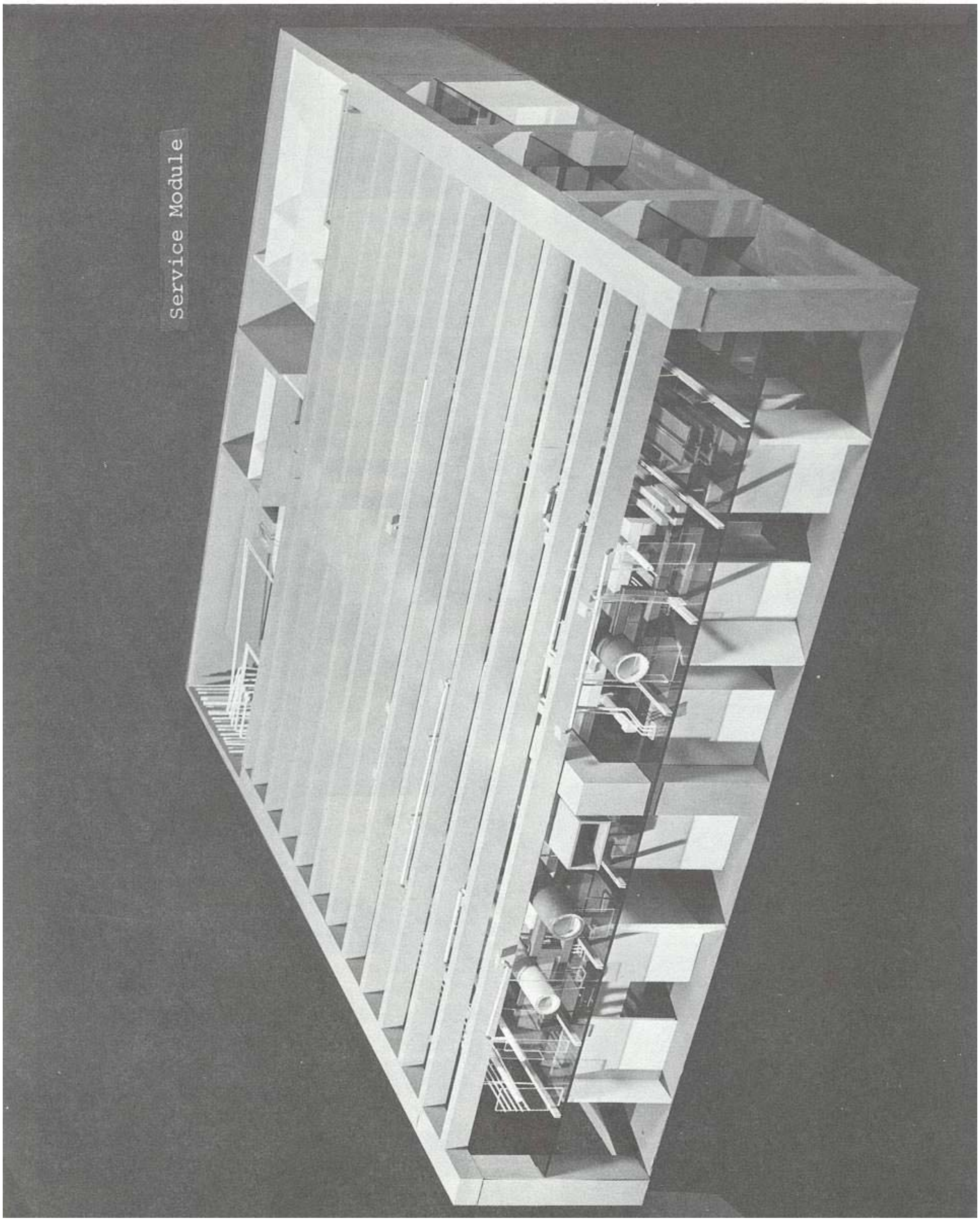


Figure 740-13. MODEL: CROSSECTION

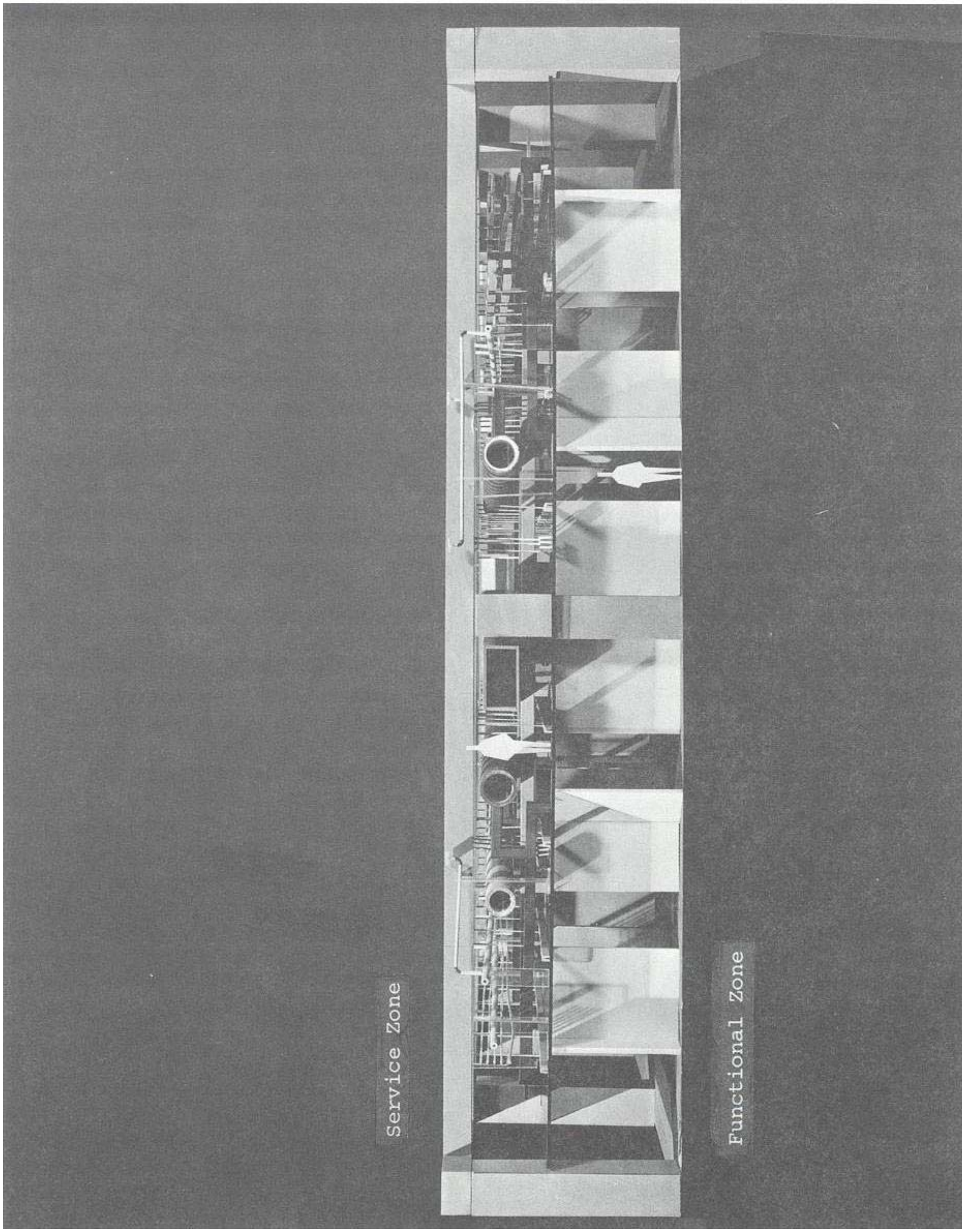


Figure 740-14. MODEL: HVC SUBSYSTEM

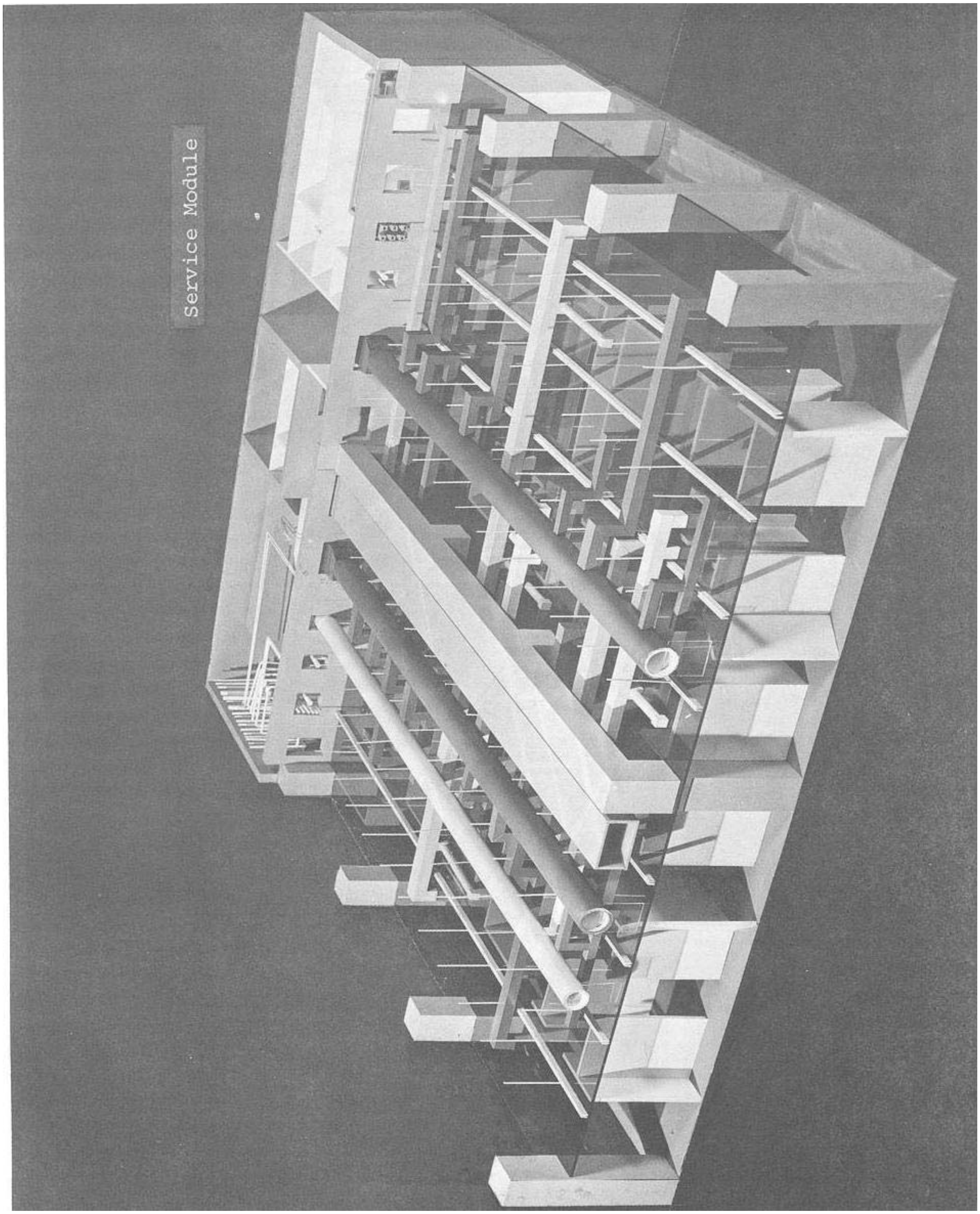


Figure 740-15. MODEL: PLUMBING SUBSYSTEM

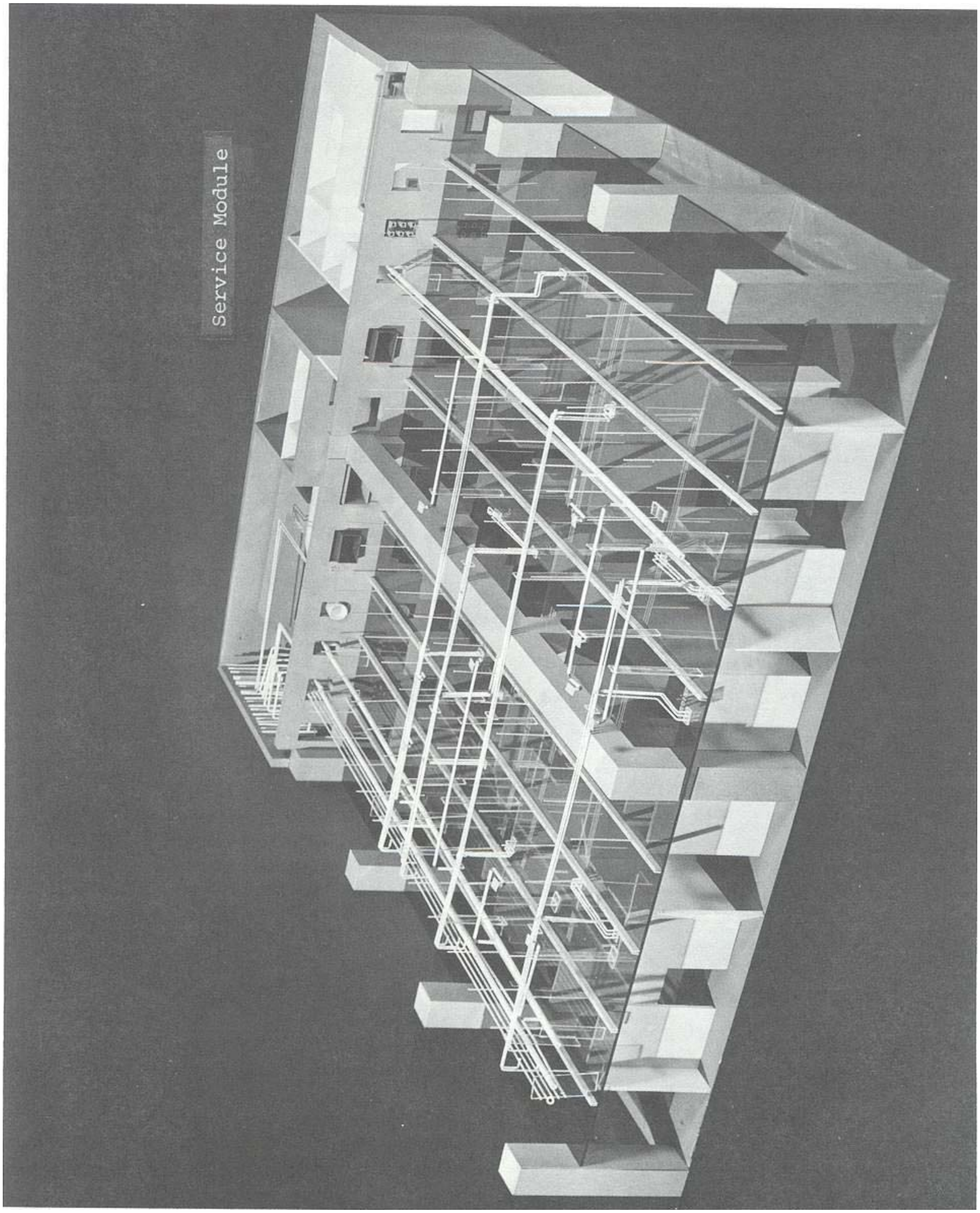


Figure 740-16. MODEL: ELECTRICAL SUBSYSTEM

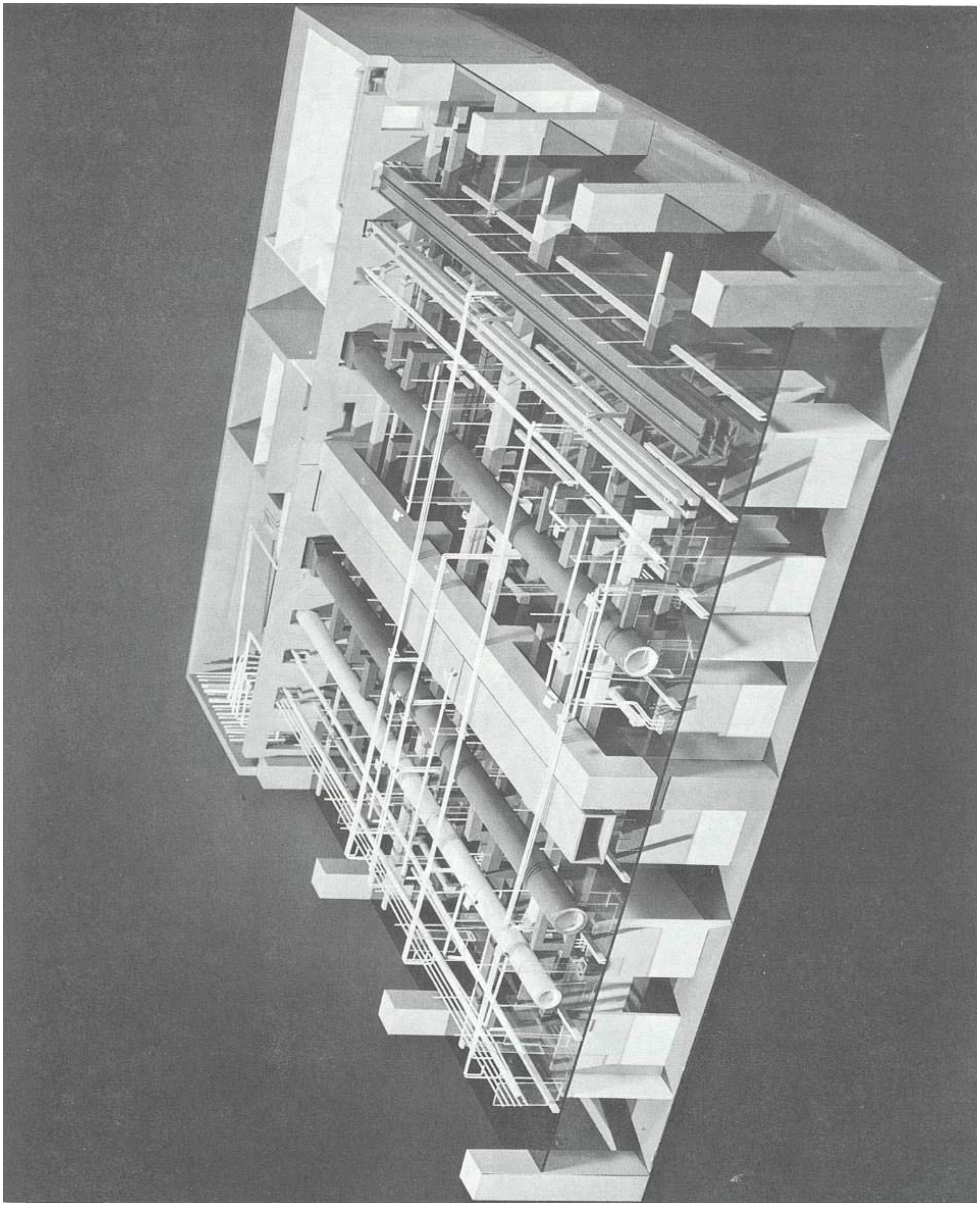


Figure 740-17. MODEL: COMBINED SUBSYSTEMS

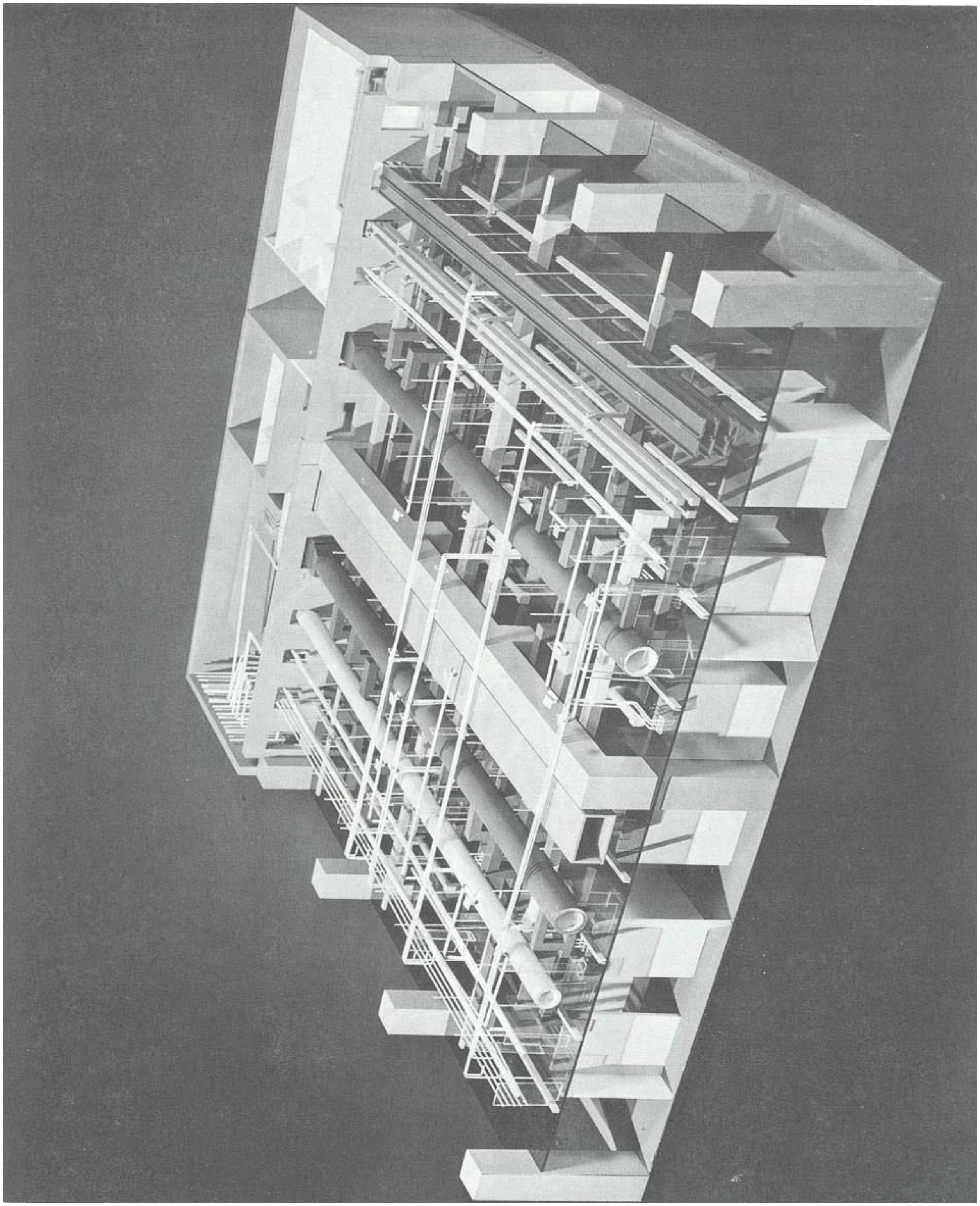


Figure 740-18. MODEL: SERVICE BAY

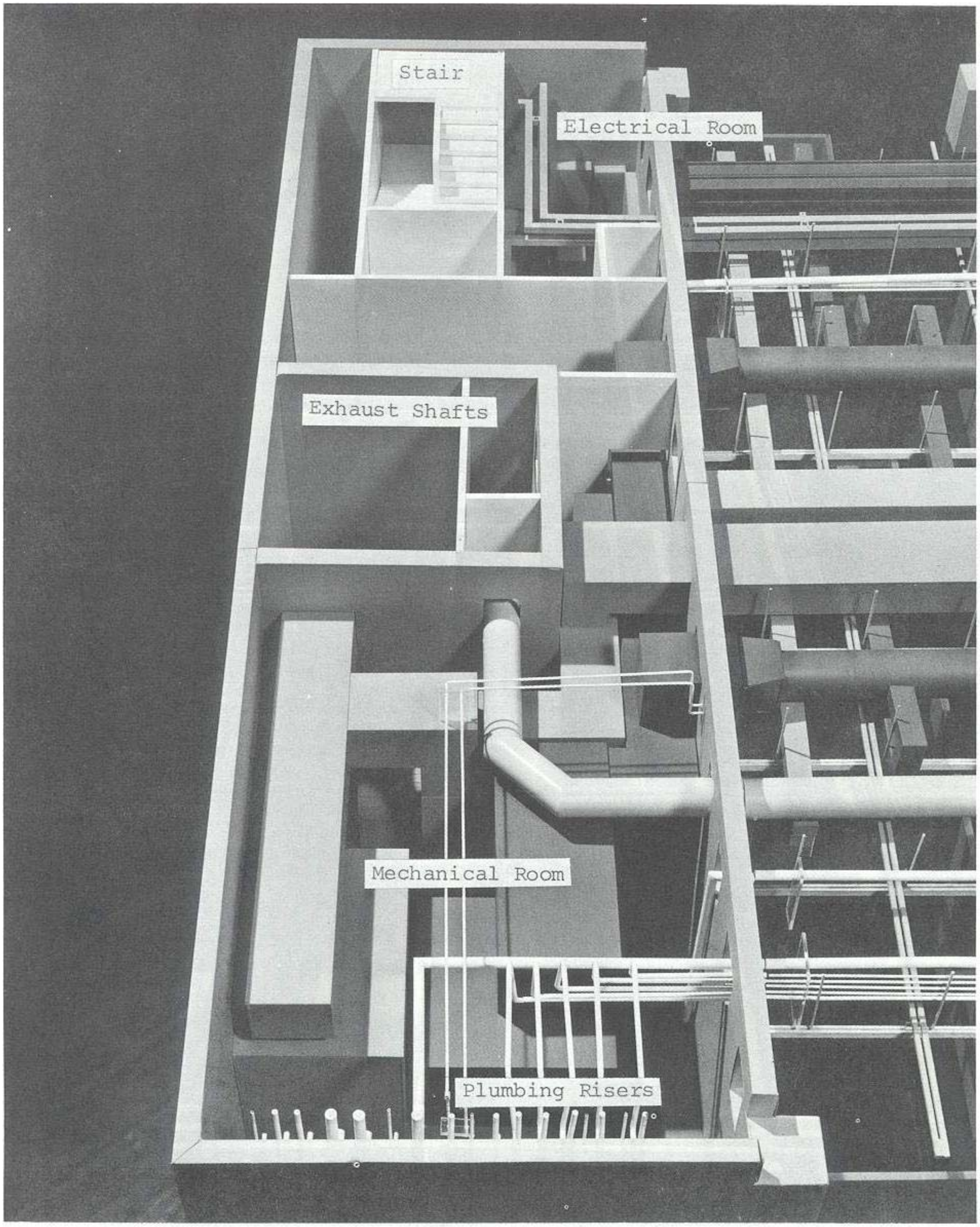


Figure 740-19. MODEL: CLOSE UP

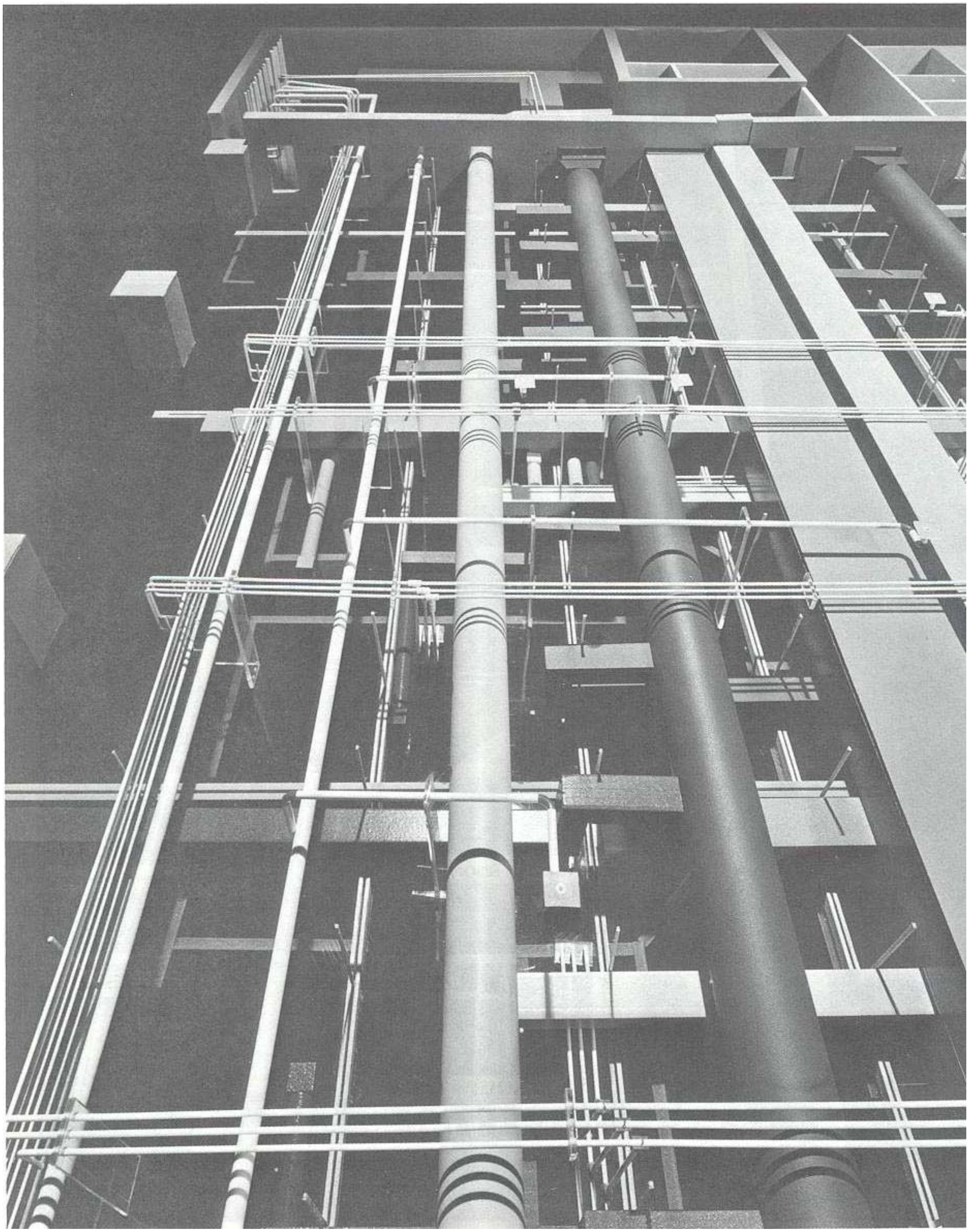


Figure 740-20. FULL SIZE MOCK UP OF SERVICE ZONE

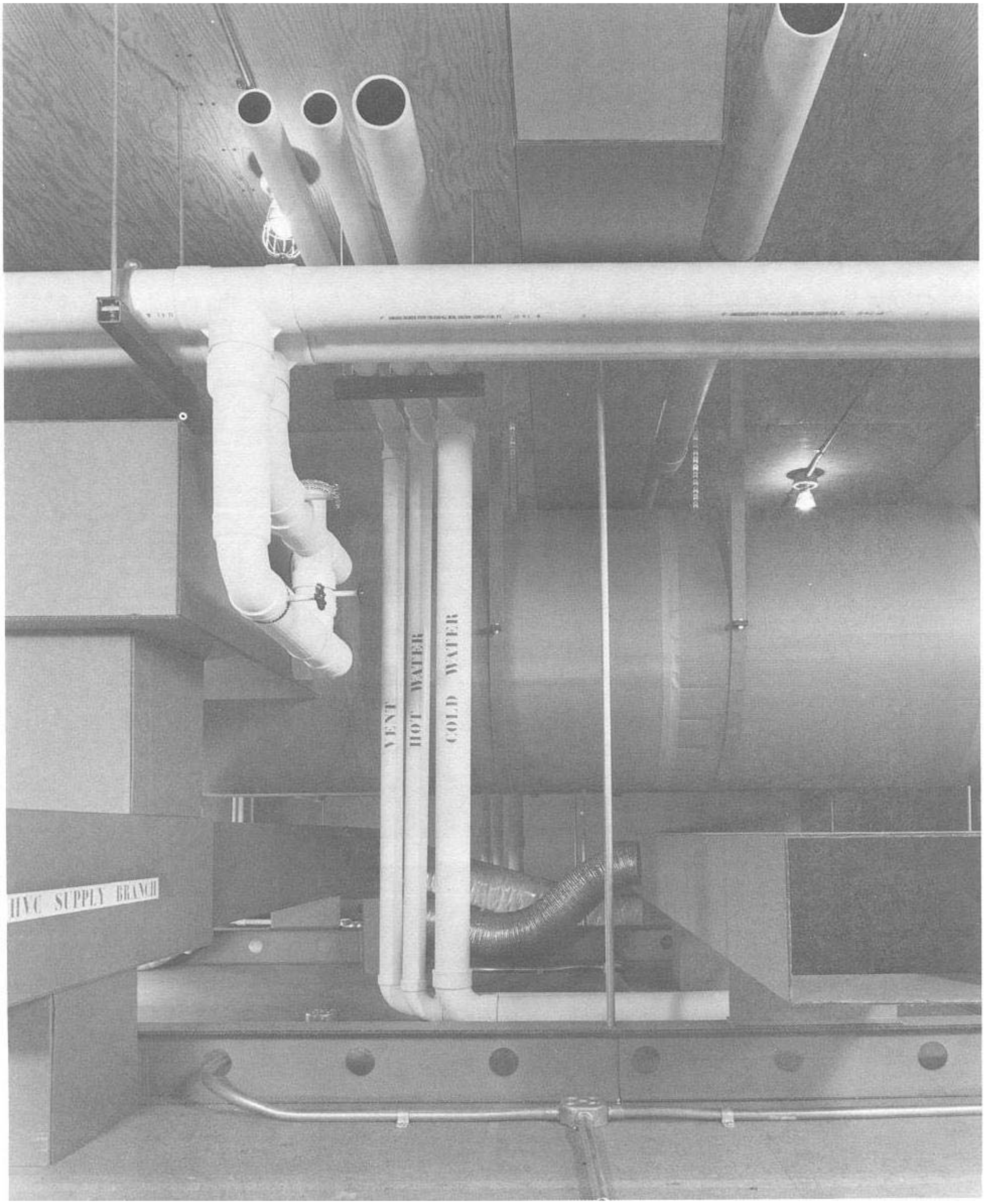


Figure 740-21. FULL SIZE MOCK UP OF SERVICE ZONE

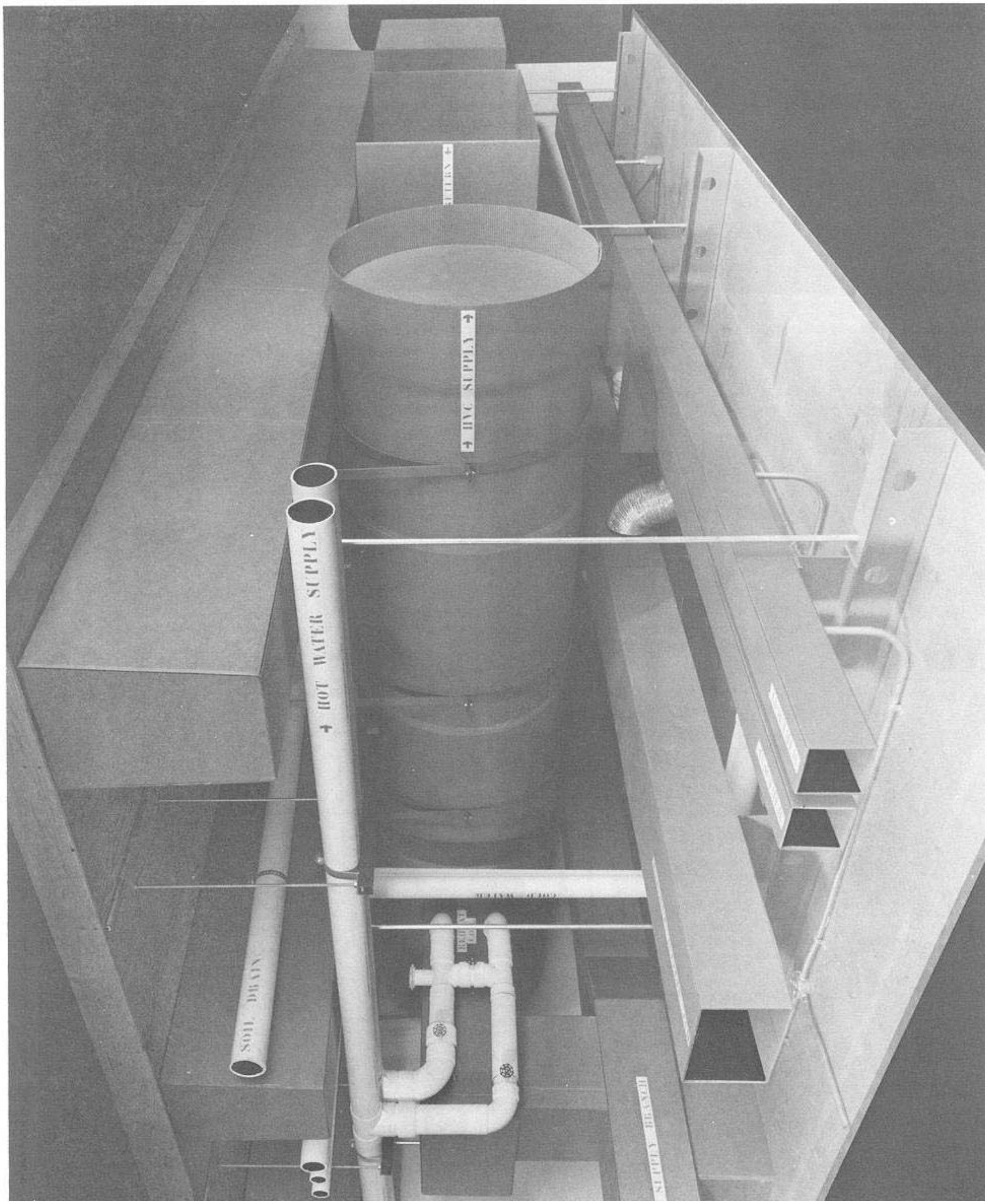


Figure 740-22. FULL SIZE MOCK UP OF SERVICE ZONE

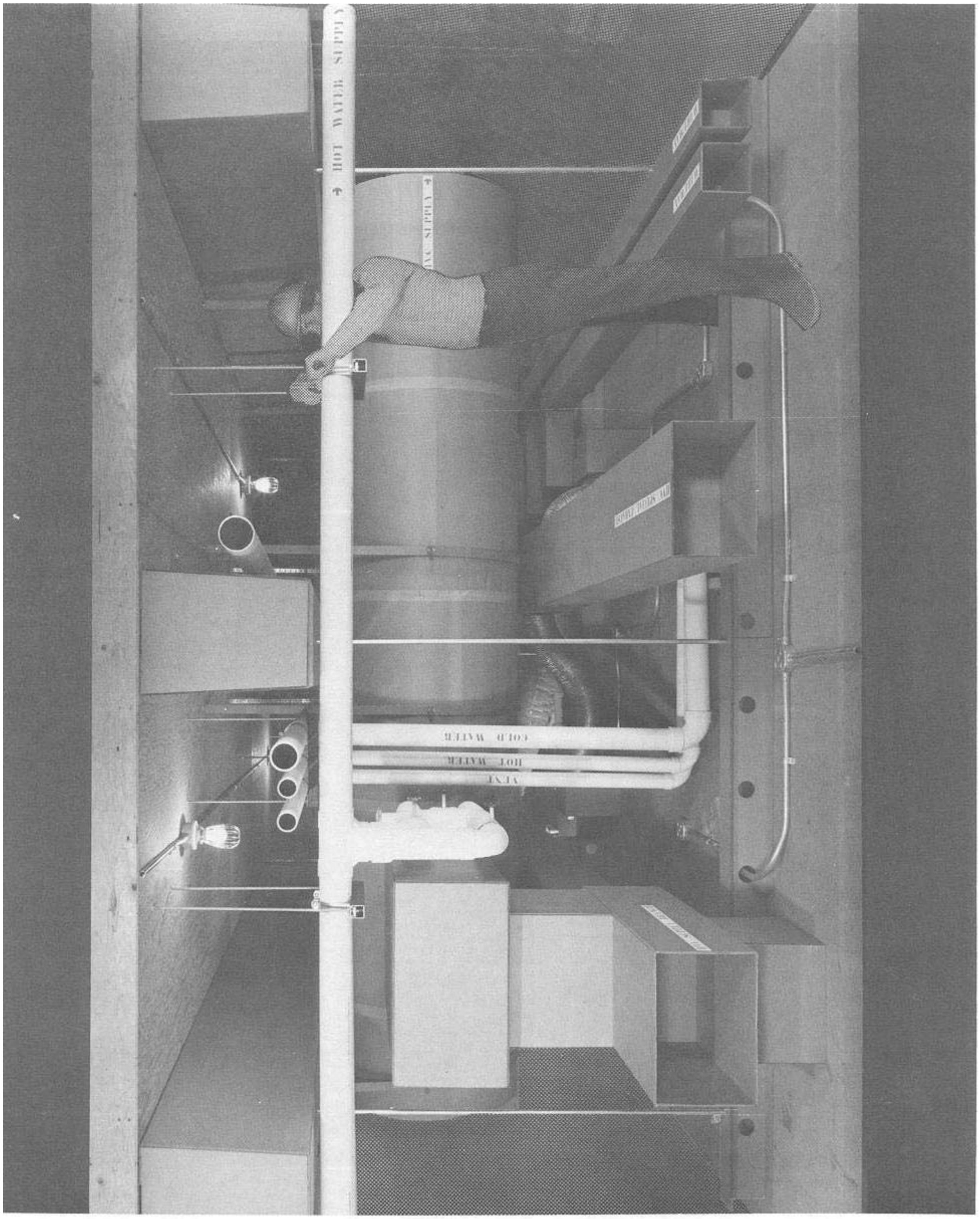


Figure 740-23. FULL SIZE MOCK UP OF SERVICE ZONE

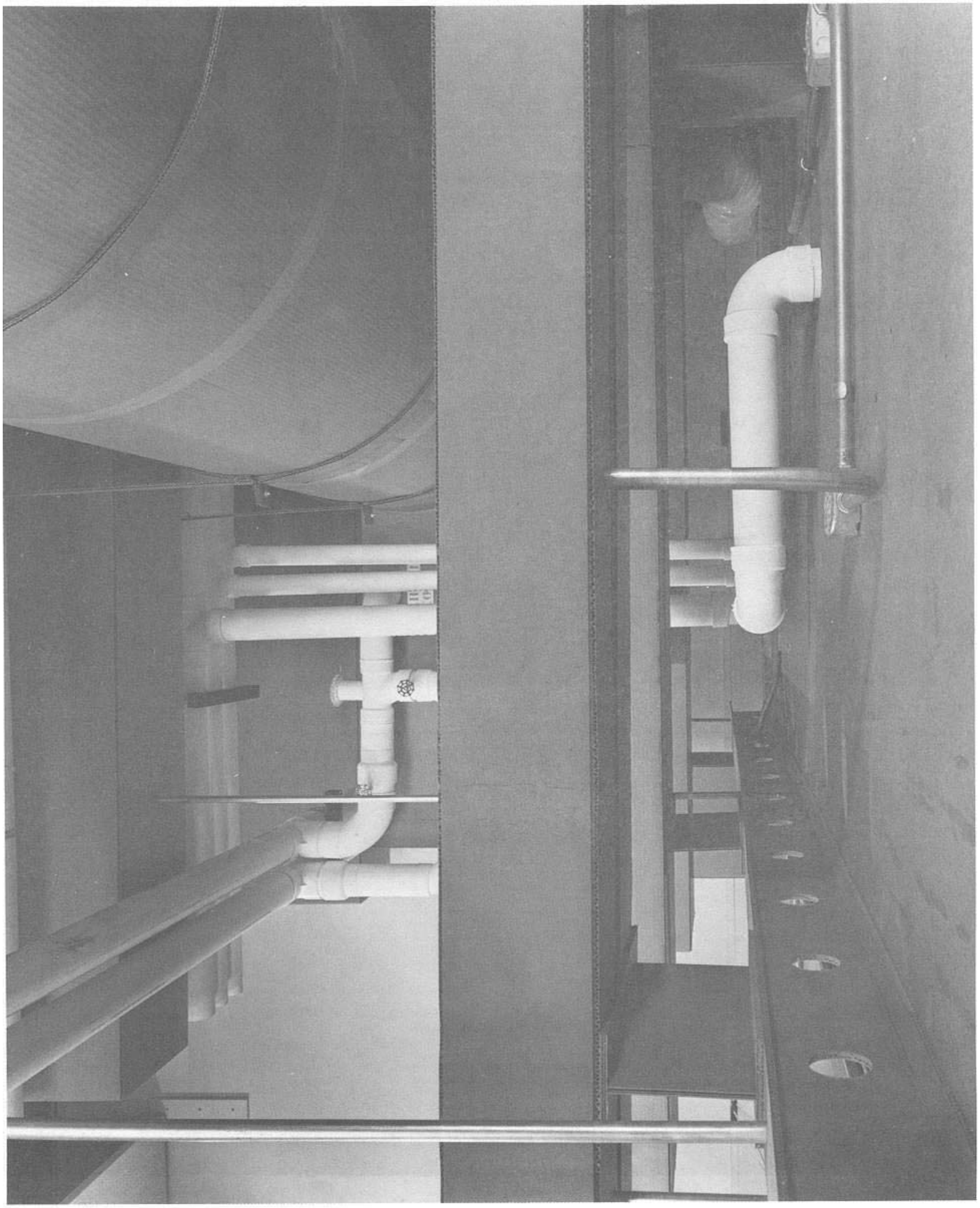
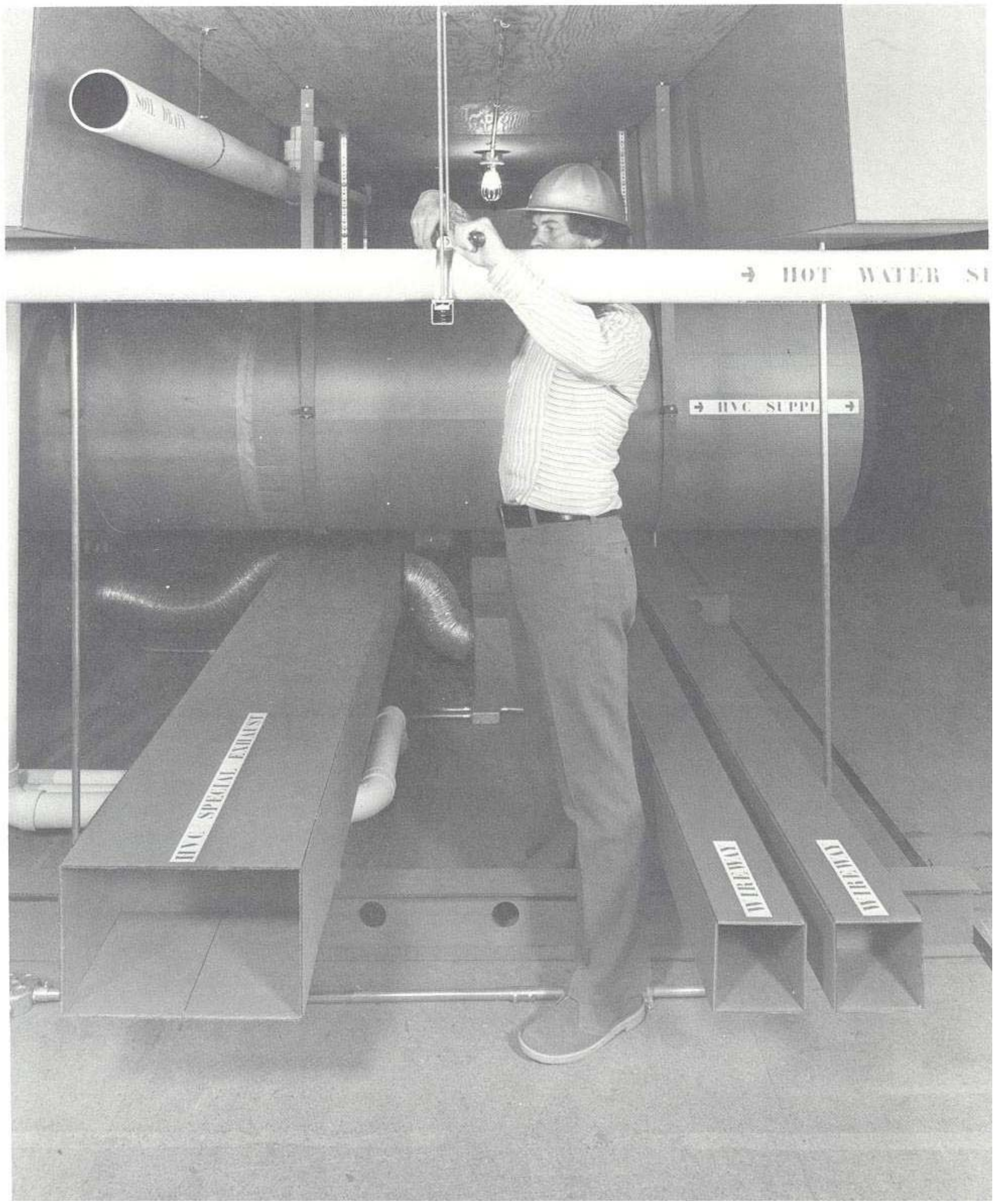


Figure 740-24. FULL SIZE MOCK UP OF SERVICE ZONE



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750 Cost and Time Analysis

751 FIRST COST

751.1 EXAMPLE BUILDING SCHEMATIC DESIGN

751.1.1 The cost estimate for the example building schematic design (Section 730) is based on material and labor costs prevailing in the San Francisco Bay Area with the national ENR Building Cost Index at 960. All figures include the general contractor's and subcontractor's overhead and profit. The estimate is for the entire building to a point five feet beyond the building line, except for the figures for central plant and laundry, which are not in the example schematic design, but have been added to make the total comparable in scope to the cost base (the six hospitals analyzed in Section 530). The outside gross area of the example schematic design is approximately 843,000 square feet. (See Table 750-1.)

751.1.2 Structure, exterior wall, ceiling, fire partition and corridor partition quantities were measured on the plans. Other partition quantities were based on the average functional area quantities of the Miami and Memphis field stations. (See Section 534 for explanation of functional area breakdown.) Mechanical, plumbing and electrical costs were based on functional area take-offs, with unit prices established for each type of functional area. Items such as casework, conveyors, hospital equipment, lighting, communications and building specialties were prorated from the Miami and Memphis analyses.

751.1.3 Direct comparison of the total unit cost of the example schematic design ($40.79) with the basic construction cost established in the cost base ($48.60) could be misleading because the example schematic design has a higher gross-to-net-area ratio than is typically the case in VA hospitals. The additional gross area is in the more generous service spaces and shafts, and in "incremental" assignable space introduced by the use of large-scale planning modules. (The latter type of space is not really gross, but is in addition to "programmed" net.)

The exact gross-to-net ratios for the six hospitals analyzed in the cost base were not calculated, but based on VA standards current at the time, these ratios probably average about 1.6. The equivalent ratio for the example schematic design is 1.9.

Table 750-1. CONSTRUCTION COST ESTIMATE, EXAMPLE BUILDING SCHEMATIC DESIGN

Integrated Subsystems	Total $	$/OGSF	Sub-total
Structure	8,118,000	9.63	
Ceiling	2,009,000	2.38	
Partitions	3,060,400	3.63	
Heating-ventilating-cooling	4,007,900	4.75	
Plumbing distribution	1,803,000	2.14	
Electrical power distribution	1,945,400	2.31	
			24.84
Non-System Components			
Excavation, backfill, shoring	618,000	.73	
Basement waterproofing	72,600	.09	
Foundations and basement	1,474,000	1.75	
Exterior wall	2,558,200	3.04	
Penthouse and soffits	254,300	.30	
Miscellaneous metals	440,000	.52	
Roofing, insulation and deck surface	344,500	.41	
Non-system partitions	139,500	.17	
Non-system ceiling	2,700	.01	
Finish flooring	457,600	.54	
Casework	83,600	.10	
Elevators and conveyors	927,300	1.10	
Misc. building specialties	880,000	1.04	
Hospital equipment	1,400,000	1.66	
Plumbing fixtures and fittings	751,000	.89	
Sterilizers, fume hoods, etc.	463,600	.55	
Finish electrical and control station	927,200	1.10	
Communications and fire alarm	154,000	.18	
			14.18
Items Outside Building			
Central plant and laundry	1,496,300		1.77
TOTALS	$34,388,100		$40.79

A more meaningful parameter for comparing the example with the cost base hospitals would be dollars per programmed net square foot ($/PNSF).

Cost base hospitals: $48.60/OGSF x 1.6 = $ 77.76/PNSF

Example design: $40.79/OGSF x 1.9 = $ 77.50/PNSF

Taking into consideration the small statistical base and the degree of accuracy possible with the type of cost estimate involved, the conclusion suggested by these figures is that, for practical purposes, the cost of the "systems" hospital would be about the same as a conventionally designed and constructed hospital with the same programmed area.

751.1.4 Another parameter which can provide an interesting comparison is dollars per departmental gross square foot ($/DGSF). For purposes of this analysis, departmental gross area is defined as the outside gross area of the hospital, minus the area of all space in the "zero" functional area category established for the cost base. The zero category includes mechanical rooms, stairways, elevators, etc. (See Section 534.) This parameter has been quantified for the Miami and Memphis hospitals as well as the example schematic design.

Miami: $49.30/DGSF

Memphis: $48.59/DGSF

Example: $48.70/DGSF

Since departmental gross area is "actual" rather than "programmed", it includes any extra assignable area that may be inherent in the particular building design. This comparison, like the previous one, indicates a "systems" cost essentially the same as conventional. When the two comparisons are considered together, therefore, they imply that an attempt to modify the system building design to force the actual net area closer to the programmed net would have very little impact on total first cost. This conclusion is reinforced by the analysis of "incremental space" in Section 751.3.2 below.

751.1.5 There is an aspect of the cost estimate of the example schematic design which raises a further question of comparability with the cost base.

The cost of the non-system components in the example design is only $15.95/OGSF (the sum of $14.18 and $1.77 from Table 750-1), whereas the average cost of the equivalent portion of the six hospitals in the cost base was $23.05. (See Table 530-1.) Thus the non-integrated subsystems account for only 39% of the total cost of the example schematic design as compared to 47% in the cost base. Even when adjusted to dollars per programmed net square foot, the non-system portion of the building would cost 17% less in the system example than in the cost base.

Cost base:	$23.05/OGSF x 1.6 = $36.88/PNSF
Example design:	$15.95/OGSF x 1.9 = $30.30/PNSF
Difference:	$6.58/PNSF

Unfortunately, the cost base figure was not obtained by direct estimate; it is simply the result of subtracting the estimates for the integrated subsystems from the contract cost in each case. The example design figure, on the other hand, is based on a direct estimate, as indicated by the breakdown in Table 750-1, which in turn is based on a scope assumed to be approximately the same as that included in the non-system portion of the contract costs of the six cost-base hospitals. The considerable discrepancy in the two figures seems to challenge this assumption of equivalent scope.

We can introduce an additional safety factor into our comparisons by examining the effect of arbitrarily adding the $6.58/PNSF difference to the total estimate for the example design, on the theory that this figure represents an actual discrepancy in the assumed scope. The “adjusted” figure would then be $77.50 + $6.58 = $84.08/PNSF, which puts the example design now 8% higher than the $77.76 computed for the cost base. (See Section 751.1.3 above.) It can be shown that even if this was in fact the marginal extra cost of a systems building, the difference can be easily recovered by anticipated savings in maintenance and alterations. (See Sections 752.2 and 752.6 below.)

If the difference in non-system estimates is taken directly in dollars per outside gross square foot and added to the total figure for the example schematic design from Table 750-1, the result is still about 1.5% less than the basic construction cost given by the cost base.

Cost base:	$48.60/OGSF
Example design:	$40.79 + (23.05-15.95) = $47.89/OGSF
Difference:	$ .71/OGSF

751.2 BUILDING SUBSYSTEM TARGET COSTS

751.2.1 Structure

The target cost range for structure is between $8.60 and $11.30/OGSF, or from $8.00 to $10.45 per square foot of structural framing. These figures are higher than the comparable cost base range of $5.86 (Martinez) to $8.10 (Atlanta) due to increased floor-to-floor height, longer spans, higher uniform live loads, and the addition of a three-inch topping slab.

The major variables affecting these costs are:

1. Building Height. Up to four stories, unit costs change very little. From four to nine levels, the unit cost increases from five to ten percent.

2. Beam Spans. When the longer of the modular spans (49'-6" to 58'-6") are used rather than the shorter spans (40'-6" and 45'-0"), unit cost will increase from three to six percent. The cost will also be affected by the efficiency of the structure in terms of the number of continuous spans and the use of cantilevers. A single span is the least efficient whereas beams continuous over three or more spans are the most efficient. The cantilever is most effective for economy of structure when used in conjunction with the longer beam spans which are also continuous over two or more supports.

3. Shear Elements. In high seismic load zones, the cost of shear resisting elements will be approximately $0.55 to $0.80 per square foot of structural framing for a four-story building, and $0.90 to $1.20 for a nine-story building. In low seismic load zones, these costs will be reduced by approximately 50%.

4. Generic Design Option. Generally speaking, the concrete options will cost up to fifteen percent less than steel. However, the shorter construction time required for steel framing may under some circumstances provide a lower cost.

5. Building Configuration. Simple assemblies of service modules will generally be more economical than compound assemblies due to the change in direction of structural framing and/or internal service bays in the latter case. (See Section 411.2 for a discussion of simple and compound assemblies.) Cost will also be minimized by utilizing a simple building perimeter with few setbacks or projections.

751.2.2 Ceiling

The target cost range for ceiling is between $2.10 and $3.85/OGSF, or from $2.50 to $4.55 per square foot of ceiling. These figures are higher than the comparable cost base range of $1.11 (Memphis) to $1.71 (Washington) due to the provision of better acoustic separation and strength (to give lateral support to partitions and a continuous walkable surface). Cost is also added for special fire protection of the supporting framework.

The cost per square foot of ceiling is broken down as follows:

Item	Low	High
Platform, supporting framework, hangers and attachments to structural beams	1.45	2.50
Finish ceiling	.65	.85
One-hour protection of hangers	.15	.80
Subtotal	2.25	4.15
Contractor's overhead and profit, 10%	.22	.41
Total (to nearest $.05)	$2.50	$4.55

The low total assumes the use of a reinforced poured-gypsum platform. Half of the finished ceiling is acoustic tile and the remainder is painted gypsum board except where no finished ceiling or special finishes are required. Finishes are continuous and glued on except where the acoustic tile is interrupted by strips of gypsum board to accommodate partition heads, which is assumed to be about one-half of all cases. (See options 1 and 2a in Section 322.2.) The hangers are fireproofed with a factory application of intumescent mastic, and the strongbacks are protected with field-applied “Monocoat” (vermiculite and gypsum sprayed-on coating) plus a hardcoat finish to provide physical protection.

The high total assumes a lightweight precast concrete platform and 70% accessible acoustic tile finished ceilings. All finishes are interrupted by the partitions and mechanically attached to the platform. A sprinkler system is used throughout the functional zone to provide indirect protection of the supporting framework.

The major variables affecting the cost of the ceiling subsystem are the materials selected for the platform, the method selected for fire protection of the ceiling hangers, and the type and quantity of various finished ceiling materials used. The latter varies not only in the material and finish itself, but also in the way in which it is attached to the ceiling and whether it is continuous or interrupted (See Section 322.2).

751.2.3 Partitions

The target cost range for partitions is between $3.33 and $5.88/OGSF, or from $31.75 to $56.00 per lineal foot of partition. These figures are lower than the comparable cost base range of $4.26 (Memphis) to $6.35 (Washington), and the average cost per lineal foot of $43.85 for the system compares with $47.50 for conventional design and construction. This reduction is due primarily to the use of less vinyl wall covering, the substitution of drywall for block and lath and plaster, and stopping the partitions at the ceiling. The full effect of these characteristics has been offset by additional items such as continuous back-up plates, furring around services, special details required to accommodate the greater deflections resulting from increased structural spans, and the need for two layers of gypsum on both sides of corridor partitions. (See Section 336.1 for an explanation of this last requirement.)

The costs do not reflect any savings which would result from the more rapid installation of the system partitions as compared with conventional partitions because these savings are not likely to be reflected in the subcontractor’s prices in the first few projects using the Prototype Design. Indirect savings will be evident through a contraction of construction time.

The cost per lineal foot of partition is broken down as follows:

Item	Low	High
Average 9'-6" partition	12.50	15.00
Finishes	7.60	18.00
Doors and miscellaneous	7.00	12.50
Prorated cost for furring around surface mounted services	.55	1.40
Prorated cost for non-structural two-hour fire barriers	1.24	3.10
Continuous backing plates	0	.90
Subtotal	28.89	50.90
Contractor's overhead and profit, 10%	2.88	5.09
Total (to nearest $.05)	$31.75	$56.00

These figures are based on the following assumptions:

1. The average hospital has .10 lineal feet of partition per OGSF (from measurements of Miami, Memphis, and the Phase 2 Example).

2. The areas of the hospital with 10'-0" high ceilings will constitute no more than 50% of the area, resulting in a 9'-6" high maximum average height of partition (excluding slab-to-slab two-hour fire barriers).

3. The cost range of the partition finishes in the Prototype Design is lower than that in typical VA hospital construction as reflected in the cost base. The low end of the target cost range is based on the partition finishes selected for the Building Schematic Design. The high end of the range is the average cost of partition finishes in the hospitals analyzed in the cost base. The reduction in the cost of finishes is mainly attributable to the reduced quantities of vinyl wall covering considered necessary. It includes heavy vinyl wall covering in corridors and ceramic tile in areas requiring aseptic conditions or resistance to moisture.

4. The cost range of the doors per lineal foot of partition in both the Prototype Design and conventional design and construction will be equal. The higher cost of the floor-to-ceiling door sets will be offset by the reduction in the cost of the partitions which will not need to be cut around the door head.

5. The number of clusters of services to be furred out will be approximately one per 40 lineal feet of partition in the nursing areas and one per 200 lineal feet in the support areas of the hospital. On the basis of the distribution of partitions assumed for the Example Building Schematic Design, there will be approximately one cluster of furred-out services for every 70 lineal foot of partition.

6. The number of lineal feet of two-hour non-structural partitions will vary between 40 and 100 per 10,000 OGSF.

The major variables affecting the cost of the partitions are:

1. The number of lineal feet of partition per OGSF of building, which varies in the different functional areas of the hospital between approximately .05 and .12. The size of these various functional areas will therefore affect the quantity of partitions in relation to the total area.

2. The variability in the finishes specified. In VA hospital projects this variability is reflected in the difference in the cost of finishes in the “nursing towers” at Memphis and Washington, i.e. $1.72 to $3.20 per OGSF, adjusted to an ENR Index of 960 from the Phase 2 Report. This is the equivalent of $14.40 to $21.59 per lineal foot of partition.

3. The number and type of doors specified, which can affect the cost of doors per OGSF by as much as 50%. For instance, Section 350 of the Phase 2 Report shows a range between $1.21 per OGSF and $1.86 per OGSF. This is equivalent to $7.00 and $12.55 per lineal foot of partition.

4. The number of clusters of services enclosed with furring. This type of cluster will typically occur in patient bedrooms, examination rooms and treatment rooms.

5. The number of two-hour fire barriers which must also act as shear elements and are therefore included in the structural subsystem.

751.2.4 Heating-Ventilating-Cooling

The target cost range for HVC is between $4.00 and $6.50/OGSF. These figures are below the cost base range of $4.92 (Miami) and $8.62 (Watsonville) because of the reduced amount of ductwork in a decentralized arrangement, and reduced labor costs during installation due to less conflict with other trades (organized arrangement of services in a deep service zone) which more than offsets increased costs for redundancy in service distribution and size of equipment and ductwork and decentralization of air-handling units.

The lower end of the target range is the estimated cost of a single-duct, terminal-reheat system with plenum exhaust/return, but without a supplementary perimeter convector system, in a building of simple configuration in a mild climate. The upper end of the range would be appropriate for a dual-duct, mixing-box system, plus ducted exhaust/return and a perimeter convector system, in a building of complex configuration, including interior service bays, located in an extreme climate and containing a relatively high proportion of functional areas with special HVC requirements.

The cost effect of a compound assembly (complex building configuration) as compared with a simple assembly is to add about $0.25/OGSF for ducting into the internal service modules (assumed to be one-half of all modules at most). The use of supplementary perimeter convectors adds about $0.40/OGSF.

751.2.5 Plumbing Distribution

The target cost range for plumbing distribution is between $2.00 and $3.00/OGSF. These figures imply a typical cost slightly higher than those estimated for Memphis and Miami, $2.09 and $2.20 respectively. This rise can be attributed to the increase in the number of horizontal mains and the oversizing of permanent runs to allow for demand increases.

Labor costs will rise because of the capped tees introduced for future modifications. Branch distribution costs will also be greater as the plumbing will not necessarily follow the shortest possible routes to its destination because of the sub-zoning organization. No attempt has been made to assess the savings that could result from reduced installation time made possible by the service zone organization, including some degree of prefabrication.

The low figure represents a plumbing system in a hospital of simple configuration with a small proportion of special plumbing requirements. The high figure indicates the possible cost in a complex building with a large proportion of functional areas with special plumbing requirements, plus the use of sprinklers for fire protection throughout the entire hospital. A typical breakdown would be:

General piping:	1.50
Medical gases:	.50
Fire protection:	.30
Equipment:	.04
Total:	$2.34/OGSF

The effect of total sprinklering is to add about $0.50/OGSF. It is considered that the use of standardized pre-plumbed items such as service consoles and service walls would not seriously change the cost target figures. The first cost of these units is higher than standard fixtures, but installation costs are substantially less.

751.2.6 Electrical Power Distribution

The target cost range for electrical power distribution is between $2.00 and $2.50/OGSF. Comparison with the Memphis and Miami estimates, $2.08 and $2.13 respectively, indicate a systems cost about equal to conventional design and construction.

Busducts, which are to be used extensively for the horizontal and vertical feeders, cost more than the comparable conduits and cables used in conventional construction, but installation costs should offset the increase. This will remain true even when installed busducts are sized for future predicted loads.

There will be a slight increase in cost through the use of wireways in the service zone horizontal distribution.

The use of service containers or service walls and surface mounted wireways in the functional zone will increase first costs, but again ease of installation should eliminate the extra cost overall.

The target figures do not reflect the cost of the console casings which could average about $150 per unit excluding wiring and plumbing. Dynamic grounding for techniques such as fibrilation would add about $3,000 per installation to the total electrical costs.

751.3 MISCELLANEOUS COST-BENEFIT ANAYLSES

751.3.1 Increased Floor-to-Floor Height

To account for the increased total cost of building construction due to the greater floor-to-floor height required by the Building System Prototype Design, an estimate of the additional cost of the extension of all vertical elements passing through the service zone has been made on the basis of an assumed increase of five feet over conventional design and construction. The figures are tabulated below in dollars per outside gross square foot.

Component	Additional Cost
Columns	.288
Shear walls	.184
Exterior wall	.899
Ductwork	.084
Stairs	.058
Elevators	.178
Electrical risers	.062
Lighting in service zone	.298
Piping	.064
General contractor	.318
Total five-foot increase:	$2.43

What this means is that increasing the floor-to-floor height of a hospital by five feet increases the overall cost of construction by $2.43 per square foot. This is best compared to the basic construction cost in terms of cubage. It the basic construction cost of $48.60 is distributed over a typical twelve-foot floor-to-floor height, the cost of space is $4.05 per cubic foot. But the cost of the additional service zone space is one-fifth of $2.43, or $.49 per cubic foot. Thus, the additional space and all its benefits can be purchased for about 12% of the basic construction cost.

751.3.2 Additional Space Resulting from the Use of a Structural Module

The criticism of “waste space” could be directed at the use of modular structural dimensions that allowed building width to vary only in rather large increments such as the 4’6” structural module of the Prototype Design. That is, if conventional design procedures working with standard area formulas produced a building width which could not be reduced further than, say, 74’6”, the next larger modular dimension, 76’6”, would have to be used. However, if it is assumed that the extra foot of space on each side of the building was not used for increasing the number of rooms but was simply added to some of the original rooms, only “raw space” costs are involved, e.g., structure, ceiling, finishes, partitions without doors or services, etc. The following items should be deducted from the basic construction costs of the total building:

Cost Item	$/OGSF
Heating-ventilating-cooling	4.50
Plumbing	3.50
Electrical	4.00
Casework, building equipment, etc.	4.00
Vertical transportation	1.00
Site work	1.25
Services (medical gasses, etc.)	1.75
Total non-applicable costs	$20.00

Subtracting from $48.60, the incremental space is priced at only $28.60, or about 60% of the overall cost of the minimized configuration. It must be emphasized that “raw space” costs apply only to increments of space small enough that lighting, HVC, plumbing, etc., are not affected.

The effect of this added space on the total cost of a hospital can be illustrated by application of these figures to the Example Building Schematic Design presented in Section 730. The total area of the building shown in about 843,000 square feet. It the nursing wards are composed of space modules which could have been four feet narrower in width if not constrained by modular dimensions, then about 18,000 square feet of incremental space has been added to allow conformance to the module. That is, the total area has been increased by 2.2%.

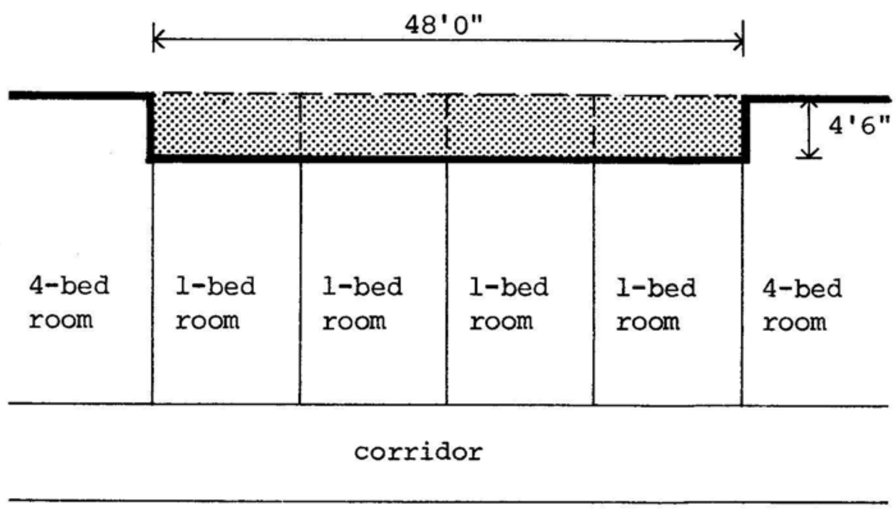
The original area would have been 843,000-18,000 = 825,000 square feet, which at $48.60 per OGSF would have given a total cost of $40,095,000. The incremental space added would cost 18,000 times $28.60 or $514,800, bringing the actual total cost to $40,609,800. This is an increase of 1.3% in the total cost of the hospital to add four feet of width to every nursing ward.

751.3.3 Simple vs. Complex Perimeter

Another criticism of the use of dimensionally predetermined planning modules might be that the absolute optimization of the efficiency of an opening configuration is not possible. That is, in conventional design it is common practice to adjust the perimeter of the building to allow tight packing of the various interior spaces, each of which has had its area set by a formula for minimum requirements and/or maximum allowable size, thus producing the most favorable gross-to-net-area ration. The answer to this criticism is that the time-saving and adaptability characteristics of the space modules are worth the price of some “redundant” space.

To get some idea of what this kind of incremental space might cost, the following model has been used as a basis for estimating:

Four adjacent one-bed rooms are located between two-or-four bed rooms along a corridor of constant width in a typical nursing unit. The one-bed rooms require 4’6” less depth than the others, so there is a recess of that dimension in the building perimeter. Since the one-bed rooms are each twelve feet wide to partition centerlines, the recess is about 48 feet wide overall. The horizontal area of the recess is 4’6” by 48’0” = 216 square feet.



If the dimensions of the multi-bed rooms, the corridors and the core cannot be reduced, the only way to simplify the perimeter is to eliminate the recess and arbitrarily assign the added space to the one-bed rooms. It can be assumed that since to new rooms are added and room function does not change, no additional services are required. It is further assumed that the reduced building perimeter compensates for the added space as far as HVC requirements are concerned. Dimensions are based on the Prototype Design, e.g., floor-to-floor height is seventeen feet. The same reasoning given in Section 751.3.2 above concerning deductions from basic construction cost applies to this case except that certain adjustments must be made for the effect on the exterior wall.

Add:

Interior partitions (without doors)	9 lf @ $25.00 = $225

Deduct:

Exterior wall	153 sf @ $ 6.00 = $920
Corners	68 lf @ $ 6.00 = 400
Interior furring	80 sf @ $ 1.00 = 80
	$1400

This amounts to an additional deduction of $1175 distributed over 216 square feet, or $5.45 per square foot. Subtracting from the figure given in 751.3.2, we have $28.60 - $5.45 = $23.15 per OGSF, or about 48% of base construction cost. The effect of this kind of incremental space on the total cost of the hospital obviously depends on how much of it is added in any particular case, but it would typically be of the same order of magnitude as that indicated in 751.3.2 above.

751.3.4 Beams vs. Trusses

The beam and suspended ceiling approach for providing a deep service zone was preferred to a truss and directly attached ceiling for the Prototype Design primarily for functional reasons. Also, it was assumed that since for planning purposes spans over sixty feet were not required, beams would always be more economical than trusses. In fact, it was this very consideration of a cost break that led to a careful planning study of how interior columns could be located to minimize the constraints to planning and adaptability.

To check the cost break assumption, three general structural types were carried through detailed design on the basis of a single bay of 22’6” with a span of 58’6” plus an 18’ cantilever. Appropriate items were added to each to make final figures comparable, e.g., cost of hangers added to beams and fireproofing added to steel. The conclusion was that concrete beams are much lower in cost than steel trusses at these spans, and steel beams are slightly less than trusses. The following figures include 10% contingency and 10% contractor’s overhead and profit, but cost savings attributable to speed of construction were not estimated.

Structure-Ceiling Solution	**$/OGSF**
Cast-in-place concrete beams and ceiling	8.00
Steel beams and suspended ceiling	10.25
Steel truss and directly attached ceiling	10.50

The functional advantages of the beam-and-hanger solution are:

1. Service zone more efficiently utilized by ductwork, etc.

2. Less obstruction to movement of workmen and equipment.

3. Independence of structural depth and service zone depth.

Trusses also have some advantages:

1. Less deflection.

2. Less weight.

752 LIFE COST

752.1 THE PROBLEM OF MEANINGFUL COMPARISONS

The costs of financing, operating, maintaining and altering buildings usually exceed their first cost. The total long term (forty years) cost of VA hospitals runs eight to ten times their construction cost. No one denies that an attempt to reduce first cost to an absolute minimum without regard to these other long term factors would be false economy. But there are several difficulties in applying this principle.

First, capital and operating budgets are maintained separately for administrative purposes, introducing motivations in conflict with trade-off efforts. Second, capital funds are committed to specific projects so far in advance that they become severely constrained by escalation of construction costs. And third, current methods of operations cost accounting do not readily yield data that can be exclusively assigned to specific subsystems and components. So, although the various elements of long term costs are the subjects of considerable individual management discipline, it has been impossible to optimize their total effect, and especially difficult to justify higher first cost in terms of potential long-range savings. The problem of meaningful comparisons is further complicated by the following difficulties:

1. The Prototype Design developed in this study does not consist of a specific list of building products. Rather it provides a framework of coordinated generic subsystem designs within which the VA and the A/E can derive the optimum detailed design for each specific program, time and place through a rational process of trade-offs. Cost projections can only be approximations based on the generic solutions.

2. Actual long term costs will depend to a considerable extent on geographical and other project-specific factors. For example, mechanical operating costs will vary with climate, exterior wall design, building orientation, local utility rates, etc.

3. A major part of the design effort has been on the organization of service distribution, the provision of convenient access for maintenance, repair and replacement, and the control of interface conditions for ease of alteration.

The theory is this discipline will pay off in the long run. But an attempt to reliably predict actual cost savings in these areas is not feasible. There are too many variables involved, and not enough field experience with the particular kind of solution proposed. Not is there any reasonable way to estimate what it is currently costing the VA to not have properly accessible and adaptable spaces in terms of physical plant utilization.

4. In a project constrained to use currently available non-proprietary products, but directed to improve performance, some increase in first cost over present methods is implicit. There are prospects of compensating for this effect quite directly through significant reductions in design and construction time made possible by the deliberate detailing of the system for that purpose. But how much of a savings is realized depends on how far the VA is willing to go in the way of altering customary decision-making procedures, how well A/E's and building contractors understand the scheduling benefits of the system, and on what theoretical basis time savings is translated into cost savings.

752.2 RELATION OF LIFE COST TO FIRST COST

752.2.1 To be justified solely on the basis of long-term cost, any additional first cost must be "paid for" by savings in housekeeping, maintenance, and minor and major alterations. The amount of savings required can be calculated from the additional first cost by discounting it at, say, 5% over forty years. The trade-off factor under these conditions is 17:1.

752.2.2 For example, if the marginal cost of a systems hospital over conventional design and construction in a particular case is 8%, then 1/17th of that amount, or about 0.5% of the first cost of the building must be saved each year from operating, maintenance and alteration costs to break even in forty years.

752.2.3 There are many items of operating cost that will not be materially affected by the Prototype Design, such as dietetic equipment, engineering supervision, utility costs and elevator maintenance. The three areas where savings are anticipated are housekeeping, maintenance (including minor alternations), and major alterations. In the Phase 1 (feasibility) study, these costs were reviewed for eleven VA hospitals over a three-year period.

When conservative escalation rates were applied to the data for a forty year period, it indicated that the total average annual cost of these three items alone would amount to about 12.5% of the original construction cost. If the 0.5% marginal first cost of the system building is to be paid for out of an item costing 12.5% of the same base figure, then 1/25th, or 4%, of that item must be saved each year.

752.2.4 To summarize, if a systems hospital cost 8% more than an equivalent conventional hospital, then it must allow a 4% reduction in the annual total cost of housekeeping, maintenance and alterations to break even after forty years.

752.3 ANALYSIS OF EXISTING VA HOSPITALS

752.3.1 The field change orders, Central Office change orders and the station-initiated completion items for each of the five hospitals studied for the cost base (Section 530) were reviewed with the intent of relating them to the integrated subsystems. The results of this attempt, however, were inconclusive to the point that tabulations would be worthless.

752.3.2 It is apparent that since most of the hospitals are relatively new, there is a conflict between the needs for changes resulting from “settling down” and those dictated by new technology or other new requirements. The time lapse of at least seven years from inception to occupancy increases this conflict. At any rate, none of the subsystems provided for any form of adaptability in spatial arrangements or performance characteristics. The oldest hospital studied, Martinez, was constructed under a policy of only partial air-conditioning. Expanding the cooled areas of this hospital has been very costly. It is interesting to note that, in spite of the restricted cooling in the initial design, the original cost of this installation is among the highest. (See Section 532.4.7).

752.3.3 There have been very few additions to the hospitals studied, in terms of adding space. There have been, however, numerous instances of conversion of ward areas to other uses. This has resulted in the fact that many of the hospitals do not contain the number of nursing beds required by their original design program. An outstanding example of this is a complete floor of the tower at Miami which now contains administrative offices created by merely adding doors and partitions in the five-bed ward areas. Such situations appear to be characteristic; their scope and costs practically impossible to identify.

752.3.4 As mentioned in Section 752.2.3 above, eleven VA hospitals have been analyzed in terms of those particular items of life cost on which the Prototype Design is expected to have some beneficial effect. The breakdown was as follows:

1. Maintenance and minor alterations cost an average of $1.46 per OGSF annually for the eleven hospitals in the years 1965, 1966, and 1967. Bringing this figure up to 1971 and projecting the average annual cost for the next forty years results in an average annual cost of $3.62 per square foot at an average compounded escalation of three percent per year.

2. Housekeeping costs for the same period were $ .54 per OGSF. Projected for the next forty years at an average compounded escalation of three percent per year, this would average $1.34 per year.

3. Major rehabilitation accounted for an average of $.31 per OGSF per year. (The only data giving a long enough rehabilitation record to be useful was obtained at Salt Lake City.) The average annual cost for forty years, with an average compounded construction cost escalation of four percent per year, would be $1.09 per year.

The total of these items of operations and maintenance amounts to $6.05 per square foot per year; for forty years this totals $242.00 per square foot for the assumed useful life of the building, or five times the first-cost average of $48.60 for the six-hospital cost base (Section 351).

752.4 OPERATIONS AND MAINTENANCE

The total average annual cost of maintenance and minor alterations and housekeeping has been estimated at $4.96 per OGSF. (Sum of the first two items listed in 752.3.4 above.) An overall savings of 5% may be reasonably expected for these items, mainly due to accessibility and relocatability of service elements, and reduction of down time during alterations and repairs. Also, the HVC subsystem does not utilize induction units, so filters are centralized at the air-handling units.

Applying the trade-off factor described in Section 752.2.1 above, the annual savings of $.25 per OGSF would pay for $4.25 per OGSF of additional first cost in forty years.

752.5 MAJOR ALTERATIONS

752.5.1 To obtain some measure of how the Prototype Design might affect the cost of major alterations, a cost estimate was made for a hypothetical alteration to the Example Service Module Design (Section 743). The cost assuming conventional design and construction (Table 750-2) was compared with the cost assuming a systems application (Table 750-3). In dollars per gross square foot, the systems cost was $14.54, whereas the conventional cost would be $17.86. The difference of $3.32 represents a savings of 18.6%.

A similar estimate was made for the Phase 2 study, analyzing an alteration to a GM & S nursing ward. (See Section 361.2 of the Phase 2 report.) In that case, the saving was 42%.

If actual alteration costs averaged 20% less than with conventional design and construction, the average annual cost of $1.09 per OGSF calculated for this item in the eleven-hospital study (Section 752.3.4) would be reduced by $ .22. This can be considered a conservative figure because the frequency of demand for changes and the complexity of the types of change required may be expected to increase steadily over the foreseeable future. Also, the actual construction cost escalation rate over the last few years has been much higher than the four percent used in the calculations.

Application of the 17:1 trade-off factor results in an equivalent first cost of $3.74 per OGSF which can be justified by this saving in forty years.

752.5.2 The cost estimate in Table 750-2 is based on the following assumed conventional conditions:

1. Structural metal studs with metal lath and plaster over lead-lined plywood for shielded walls.

2. Sheet metal studs with metal lath and plaster for other partitions. Corridor partitions extend from slab to slab.

Table 750-2. ALTERATION COST ESTIMATE, EXAMPLE SERVICE MODULE DESIGN, CONVENTIONAL DESIGN AND CONSTRUCTION

Work	Cost	Totals
Remove:		
Corridor partitions (to structure)	$1,050	
Room-to-room partitions	630	
Office doors and frames	200	
Acoustic ceiling	350	
Flooring	880	
Plumbing, lavatories	600	
Lighting fixtures	900	
HVC diffusers	70	
Ductwork, reheat coils and piping	360	
		5,040
Install:		
X-ray partitions, corridor	$3,800	
X-ray partitions, room-to-room	8,180	
Other corridor partitions	1,560	
Other room-to-room partitions	1,110	
Lead-lined doors	3,120	
Rehang doors and frames	350	
Lead glass windows	900	
Ceramic tile	610	
Ceiling	3,500	
Vinyl asbestos flooring	2,630	
New water closet	600	
Relocate lavatory	500	
Toilet exhaust	300	
Supply and return diffusers	1,000	
Ductwork and insulation	4,500	
Temperature controls	750	
Reheat coils and piping	3,000	
Light fixtures	2,380	
Switches and outlets	1,500	
X-ray wireways and power wire	2,000	
X-ray control conduit and boxes	6,000	
Suction, air and oxygen	2,480	
		50,770
Subtotal, remove plus install		55,810
General contractor, 12%		6,700
Total cost, conventional		$62,510

Distributed over 3,500 square feet = $17.86/sf.

Table 750-3. ALTERATION COST ESTIMATE, EXAMPLE SERVICE MODULE DESIGN, BUILDING SYSTEM PROTOTYPE DESIGN

Work		Cost	Totals
Remove:			
	Partitions	800	
	Doors and frames	200	
	Acoustic ceiling tile	180	
	Service container furring	30	
	Lavatories	600	
	Lighting fixtures	720	
	Outlets and switches	370	
	HVC diffusers	190	
	Ducts, reheat coils and piping	240	
			3,330
Install:			
	X-ray partitions, corridor	3,070	
	X-ray partitions, room-to-room	6,840	
	Other corridor partitions	1,630	
	Other room-to-room partitions	1,060	
	Lead-lined doors and frames	3,920	
	Lead glass windows	900	
	Relocate doors and frames	350	
	Ceramic tile	610	
	Replace ceiling tile	600	
	Protect and patch flooring	350	
	New water closet	350	
	Relocate lavatory	200	
	Light fixtures	1,700	
	Switches and outlets	1,500	
	Toilet exhaust	230	
	HVC diffusers	1,000	
	Patch gypsum platform	250	
	Ductwork and insulation	4,050	
	Temperature controls	750	
	Reheat coils and piping	3,000	
	X-ray control conduit and boxes	6,000	
	X-ray conduit and power wire	1,000	
	Suction, air and oxygen	2,480	
			41,840
	Subtotal, remove plus install		45,170
	General contractor, 12%		5,420
	Total cost, Prototype Design		$50,590

Distributed over 3,500 square feet = $14.54/sf.

3. Suspended mineral time ceiling, one-hour rated in corridors, completely removed because of penetrating partitions.

4. Flooring interrupted by partitions.

The cost estimate in Table 750-3 is based on the following assumed system conditions:

1. Lead-lined gypsum board on structural metal studs for shielded walls.

2. Gypsum board on sheet metal studs for other partitions. All partitions stop at the ceiling-platform.

3. Accessible acoustic tile on modular runners attached to poured-gypsum platform. Only areas disturbed by partitions and diffusers need to be replaced.

4. Flooring uninterrupted beneath partitions.

752.6 TOTAL EFFECT ON LIFE COST

Assuming that no other items of long-term cost other than those discussed above are affected by the Prototype Design, and the annual savings suggested are actually realized, the total savings of $ .47 per OGSF will pay for $7.99 of additional first cost. This total savings is 8% of the three items of life cost considered, which is enough to pay for 16% of additional first cost. (See Section 752.2.4 above.)

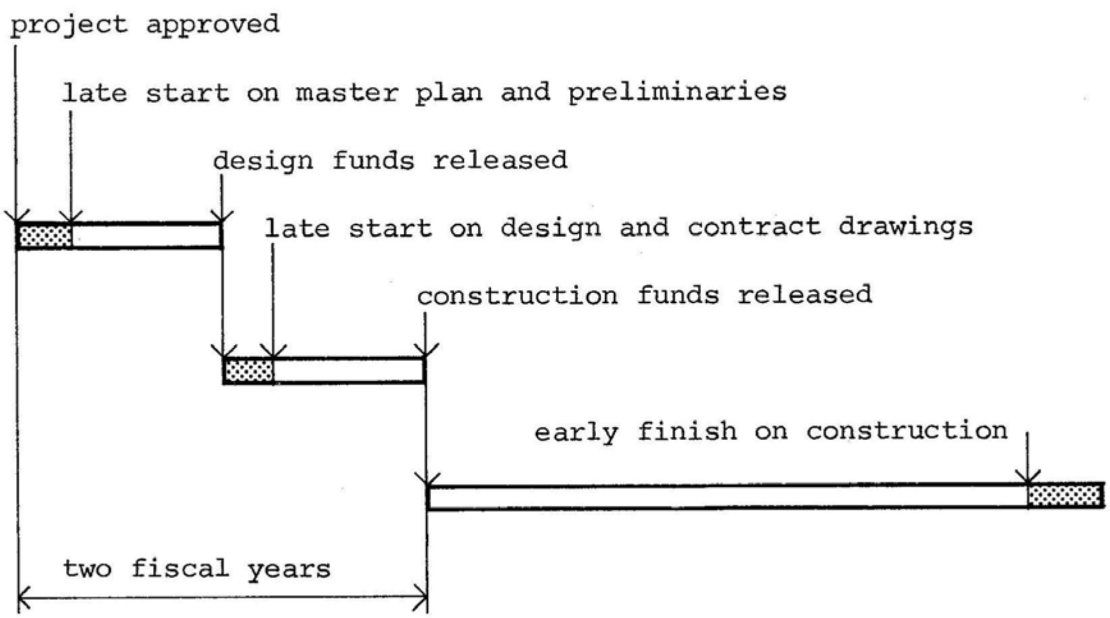
753 TIME REDUCTION

753.1 ADVANTAGE OF THE PROTOTYPE DESIGN

If all system characteristics are fully exploited for time reduction within the current schedule for obtaining funds, there are two main benefits:

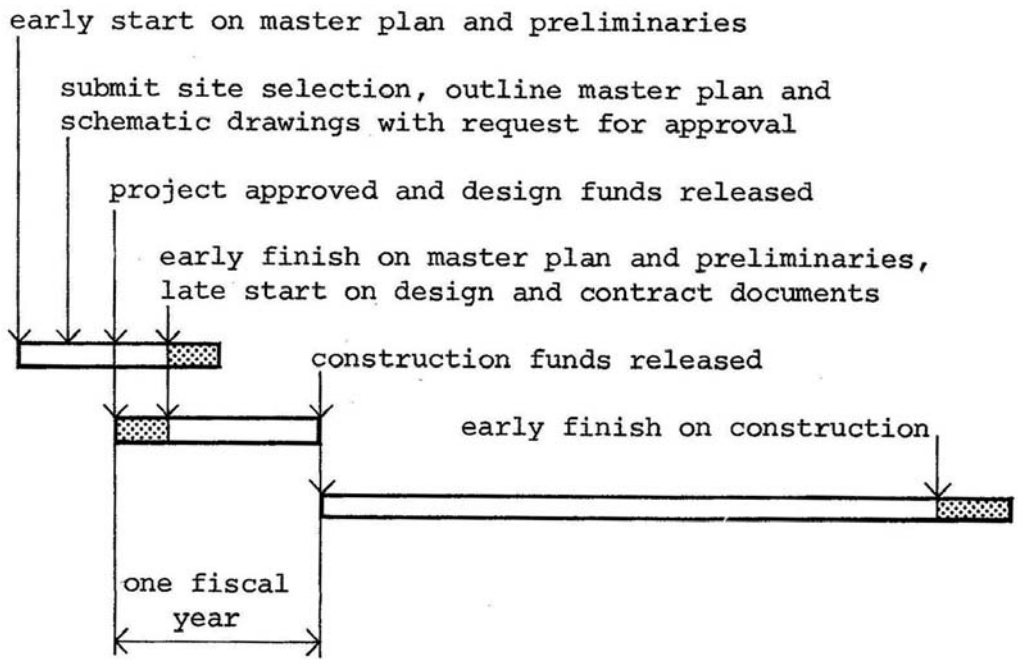
1. Master planning and preliminary design may be started later than normal for purposes of obtaining design funds in a given year, and detailed designs and contract documents can get a later start for purposes of releasing construction money.

2. As much as six months may be saved during construction.



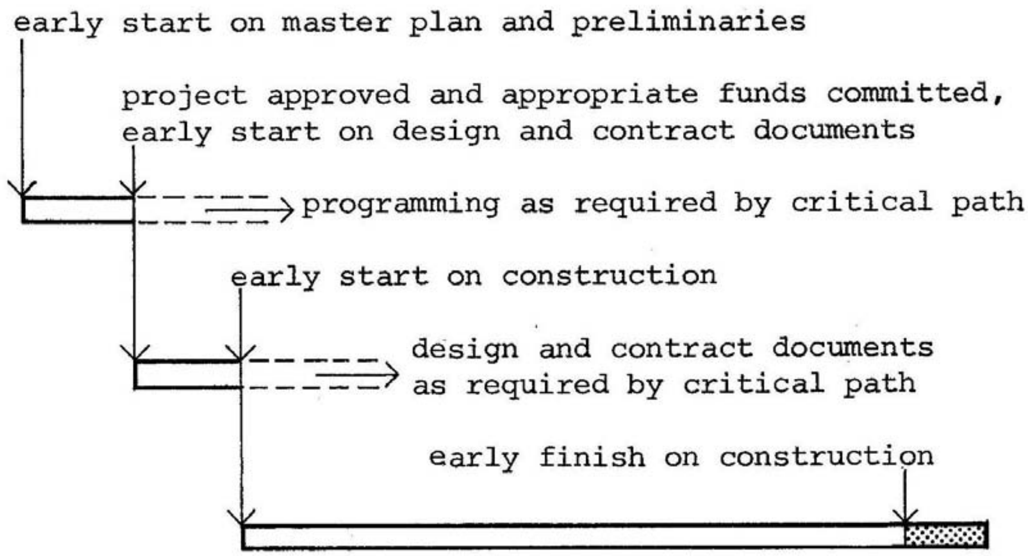
753.2 ADVANTAGES OF SPECIAL FUNDING

A much more significant time saving can be realized if design and construction funds are released earlier than the present schedule allows. Since such funds are normally available only at the beginning of a fiscal year, the schedule may be most readily altered, if at all, in one year increments. For example, if both design and construction money could be obtained one year early, and six months are saved during construction, the present six-year minimum schedule would be reduced by eighteen months.



753.3 ADVANTAGES OF PHASED BIDDING

If all available time-saving opportunities are fully utilized, and all necessary funding can be obtained in a timely manner, regardless of fiscal year considerations, still further reduction is possible. This arises from the fact that site work and erection of structure can begin without a complete set of working drawings for the finished building. Furthermore, working drawings for site work and structure do not require detailed design of the finished building. Finally, design of the site and structure does not require a detailed master plan for the finished building. That is, sufficient information can be developed to allow construction to begin prior to final completion of programming, design and contract documents. After sufficient experience with streamlined decision-making processes has been obtained over several projects, a skilled management team might reduce total production time by about two years. For a discussion of accelerated scheduling techniques, see Section 761.



753.4 IMPLICATIONS OF TIME REDUCTION

It must be emphasized that although the planning modules and the integrated subsystems allow certain time reductions and facilitate accelerated scheduling, they do not reduce the actual amount of work to be done. They simply allow the work to be carried out more efficiently. They in no way substitute for the knowledge, skills, or decision-making capabilities of administrators, architects, engineers, technical consultants and construction contractors and sub-contractors. The intent is to assist all parties concerned in making more effective use of their time.

It must also be pointed out that it is highly unlikely that all the potential advantages of these devices will be fully obtained on the first building project. Since many features of the proposed system are innovative or theoretical, there is no way to accurately predict their performance in the field. It must be expected that actual cost and time savings will be subject to the typical learning curve of any new production process.

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760 Special Procedures

761 ACCELERATED SCHEDULING

761.1 THE PRINICIPLE OF "FAST-TRACK"

To obtain the earliest possible construction start, not only must funding be provided sooner than current practice permits, but bidding must proceed before completion of all contract documents, in fact, before the building is completely designed. This technique is known as "fast-track", and is commonly used in private construction, but is usually precluded in public work by elaborate approval procedures and safeguard measures. (See Figure 760-1.)

Obviously, this approach requires early commitment to certain key decisions which cannot be reversed subsequently without serious loss of time and resources. Some of the opportunities for second thoughts which are inherent in conventional design and construction must be foregone.

This discipline has a secondary payoff, however: many detailed decisions which had to be made years before they could be put into effect can now be postponed until immediately prior to their implementation, thus providing a powerful hedge against obsolescence.

761.2 BIDDING PROCEDURES

761.2.1 Unit Prices

If construction is to start prior to completion of all contract documents, bidding must proceed in some manner different from current VA practice. In theory, general construction contractors could provide single lump sum bids for an entire project based on the following documents:

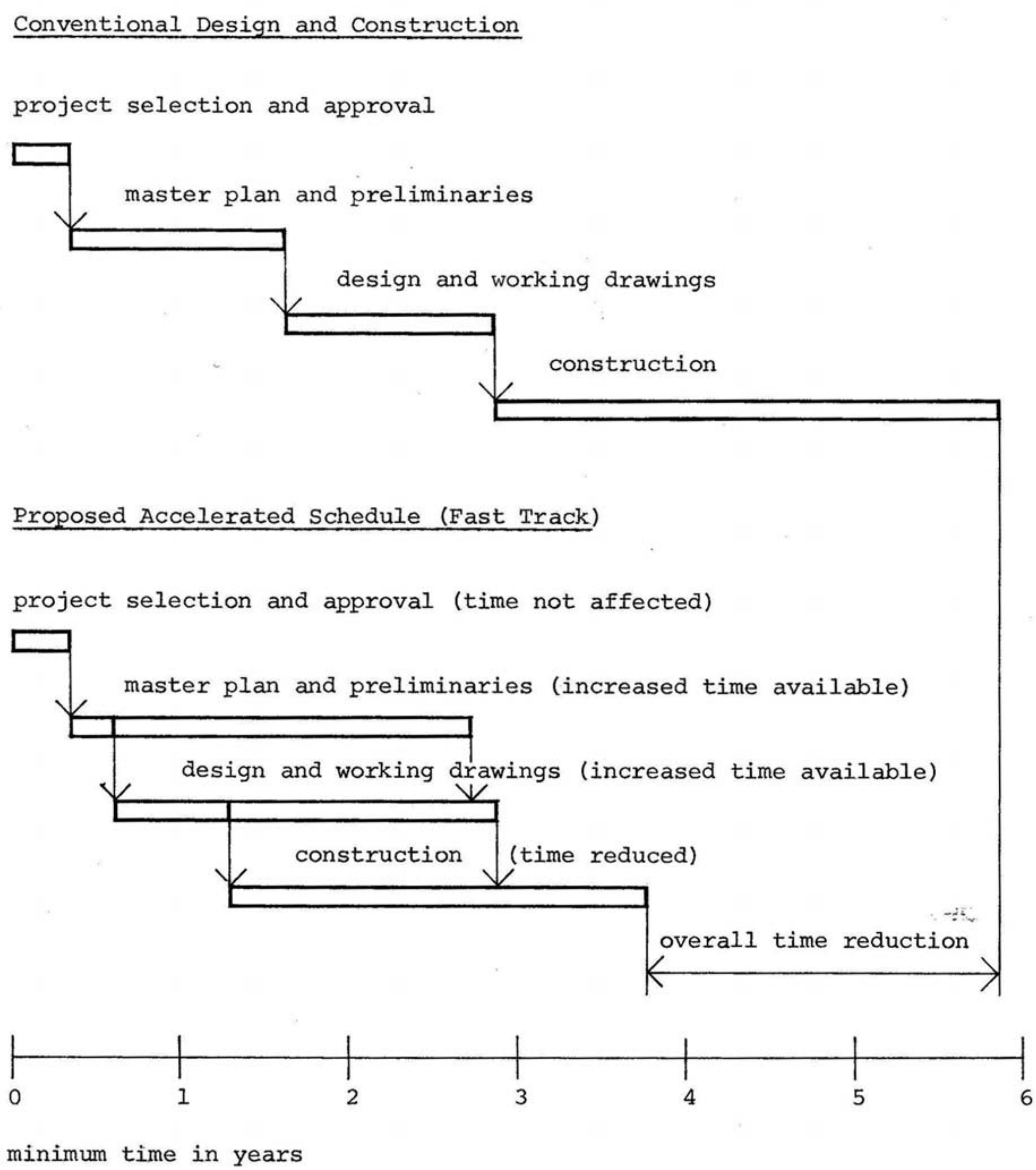
1. Schematic or preliminary drawings of the whole building. Complete specification for all work.

2. Working drawings for site work and foundations.

3. Estimated takeoffs (quantity surveys) and standard details for all other work.

Sub-contractors' bids would be translated into unit prices guaranteed within a specified range of the bid quantity and subject to a specified escalation rate.

Figure 760-1. COMPARATIVE SCHEDULES



If actual quantities required by final design fell outside the range, prices would be subject to negotiation.

There are a number of drawbacks to this approach:

1. The necessity for specifications and standard details at the time of bidding can seriously constrain subsequent design development, thus partially defeating the objective of reduced obsolescence.

2. The specifications and details may have to be more elaborate than usual to cover some range of future detailed design conditions, and the time required for their complete development might delay construction start.

3. Contractors may increase their normal contingency factors in bid calculations due to the uncertainty of future conditions. (One of the benefits of accelerated scheduling should be the reduction of the contingency and escalation factors that contractors and sub-contractors must take into account.)

761.2.2 Phased Bidding

The most rational approach to design and construction efficiency involves breaking up construction work into a series of relatively small bid packages which are released only as required to provide sufficient lead time to keep construction on schedule. This technique has some significant advantages:

1. The scope of the various bid packages can be tailored to the particular characteristics of the project, e.g., local contractor capabilities, labor conditions, critical path considerations, etc.

2. Latest possible development of each package reduces obsolescence.

3. Latest possible bidding by each specialty contractor allows relatively low contingency factors in bid calculations.

4. The quantity and quality content of each successive package can be controlled through tradeoff considerations by the VA and A/E to adjust for deviation of current actual costs from budget estimates.

5. Since each package is much smaller than the typical total construction contract, many small contractors who would normally not be bondable would now be eligible, thus improving the competitive situation to the VA's advantage.

The associated disadvantages are:

1. At the time of construction start, there is no guarantee of the final cost of the building equivalent to the traditional prime contractor's lump sum bid.

2. The VA must deal with a series of individual contracts rather than with a single prime contractor. However, this problem may be alleviated through use of a "construction manager." (See Section 762 below.)

3. Successful management of phased bidding requires a serious team effort among persons who are generally accustomed to more traditional procedures. The VA and its typical A/E contractors may not presently have the internal resources required in terms of skills and experience. Although these can certainly be developed over time, the problem is how to get started. Again, the use of a construction manager in lieu of a prime contractor can provide the necessary capability.

762 CONSTRUCTION MANAGEMENT

762.1 One of the present major sources of production delay, not to mention difficulty of cost and quality control, is the fragmentation of project management brought about by the traditional shifting of the major burden of responsibility, first from the VA to the A/E and then to the general construction contractor. If phased bidding, with consequent elimination of the single prime contractor, were to be introduced directly into this context, it could do more harm than good.

762.2 First, the construction management role of the prime contractor must be preserved even though the person or group assuming this role does not contract with the VA on the basis of a lump sum bid for the delivery of a completed building. He may be by profession a general construction contractor, and he would have a contractual arrangement with the VA for provision of management services on a fee basis, but he need not personally provide any portion of the actual construction work. He is simply a “construction manager.”

762.3 Second, the relation of the construction manager to the series of contractors introduced by phased bidding must be recognized as different in certain key respects from the traditional relation of a prime contractor with his sub-contractors. The construction manager would recommend to the VA the specific way in which work is to be subdivided into bid packages, and he would manage the phased bidding procedures in accordance with his knowledge of local conditions. All contracts are directly with the VA, but the construction manger would act as the VA’s agent in ensuring that each contract is properly executed, e.g., he may control progress payments.

762.4 Finally, the role of the construction manager must be expanded to include consulting services to the Office of Construction and the A/E Contractor. In fact, the O/C, the A/E and the construction manager should constitute a management and production team following the entire project through without any major shifts in burden of responsibility along the way. It is conceivable that A/E’s and construction managers may offer joint services so the O/C may deal directly with an “A/E/M Contractor.”

762.5 These procedures are possible because it is not necessary to wait for completion of conventional working drawings and specifications to bring the capabilities of a local general contractor to bear on the development of cost-effective design solutions; he may be retained as the construction manager at about the same time as the A/E contract award. If construction funds are not immediately available, he could be paid out of design funds.

763 PRODUCT EVALUATION

763.1 RESPONSIBILITY OF THE A/E CONTRACTOR

763.1.1 Select Generic Design

The Prototype Design provides a small number of generic design options for each integrated subsystem except plumbing and electrical distribution. If the VA has not specified which option is to be utilized in each case, the A/E must make a selection. This selection may be obvious under the circumstances of the particular project, or it may require cost-benefit analysis. Parallel selections of generic solutions for the non-integrated subsystems must proceed by conventional procedures, with particular emphasis on compatibility with the Prototype Design.

763.1.2 Develop Detailed Design

Detailed design of all subsystems proceeds in conjunction with product evaluation in a more or less conventional manner except that products under consideration for the integrated subsystems must be able to meet the design criteria. Similar criteria may be established by the VA for the non-integrated subsystems (see VA Construction Standard CD-31 re curtain walls).

763.1.3 Record and Submit Data

The results of all evaluations should be tabulated in terms of cost and performance in a manner allowing direct comparison and submitted to the VA for inclusion in a building product data base. This may be done on standard formats provided by the VA. The A/E's of successive projects can draw on this resource and contribute to it in turn. (See Section 635.5.)

763.1.4 Supervise Product Development

In the event that the VA wishes to proceed with any special product development programs, these may be organized and/or managed by the A/E. (See Section 764 below.) This could involve development of performance specifications such as those provided in this report for a platform-ceiling (Section 770 below).

763.2 RESPONSIBILITY OF THE CONSTRUCTION MANAGER

If the VA elects to attempt a highly accelerated design and construction schedule through use of phased bidding and a construction manager (See Sections 761 and 762 above), the manager could assist the A/E in product evaluation, including selection of generic subsystem designs. He would organize the sub-division of all work into appropriate contract packages, manage the bidding and supervise execution of the contracts. He would also assist the A/E in managing special product development programs, or he could manage them directly.

764 PRODUCT DEVELOPMENT

764.1 FROM PROTOTYPE TO PRODUCTION LINE

The Prototype Design provides an intermediate step toward the ultimate objective of an industrialized building system specifically organized for the construction of hospitals. It has been carried in this direction as far as possible within the scope of the systems integration program. Further development can take place at the level of specific components and subsystems through various kinds of manufacturer incentive programs. A number of these were described in the Phase 1 (feasibility) study. Since any of these methods could be applied to the Prototype Design, they are reprinted here in full (Section 764.2).

764.2 PAYING FOR RESEARCH AND DEVELOPMENT

“By identifying the product needs and committing a potential sales volume, it is possible to provide manufacturers with the incentive to undertake the sizeable financial risks attendant to product innovation.

“Four basic processes which have been used to provide the incentive for new product development are described below:

764.2.1 “The ‘Guaranteed Market’ Approach

“The potential consumer (in this case, the Veterans Administration) would guarantee a minimum volume of sales to the manufacturer who satisfies performance specifications and has the best price.

“As a prerequisite, the customer must guarantee the market in advance of research and development activity. Since research and development usually requires from two to four years, this means that the customer is guaranteeing a future building market some three to five years distant.

764.2.2 “Subsidized Research and Development

“A common practice for the Federal government is to contract for all or part of the research and development effort, due to Federal regulations which make it difficult to guarantee future markets. For example, in weapons systems development, a prime contractor is chosen on the basis of preliminary design/cost submissions.

He is then given a contract to develop and test prototypes, which, if successful, the government may then order in volume. In this way, the manufacturer is guaranteed the bulk of development costs, and no commitment on purchase of the final product is required. A major disadvantage to the building industry is that the resultant designs and processes are in the public domain. This denies the manufacturers the right to patent, which is an important competitive incentive. It becomes difficult to convince manufacturers to undertake such efforts if no competitive advantage results.

764.2.3 "Predesign and Competitive Bidding

"As a compromise between the above approaches, partial subsidy of innovation may be considered. One approach might be to contract for product design. For example, the Veterans Administration might contract with a professional organization or joint venture combining systems and medical architecture/engineering capability to complete design of a component system. Competitive bidding for production of components would then take place. Components, as produced by alternative manufacturers, might then be placed on a supply schedule similar to a GSA schedule, and could then be purchased as required. No guarantee market would be mandatory, though it would be preferable. Even though the manufacturer is spared design cost, he would still face plant, equipment, tooling and testing costs, and he may not be willing to bid unless he sees a market, or unless his designs require relatively little innovation, minimizing such costs.

"A potential disadvantage is that the design team may not posses the full technical expertise of a team of designers within the manufacturer's own operation.

764.2.4 "Sales Payback

"Another innovative approach was developed by the Federal government in cooperation with industry for the development of the supersonic transport aircraft. A prime contractor was selected on the basis of preliminary design and cost information. The government loaned him the money for research and development, on the stipulation that this loan would be paid back out of sales revenue. The rate of payback is geared to sales volume. Thus, if total sales are as the government predicts, they will recover the entire loan.

If sales are less than predicted, the manufacturer is protected against major losses, as he would not be required to make full payback. Such an approach guarantees the risk costs, while not specifically guaranteeing the market."

764.3 LIMITED PROGRAMS

764.3.1 If these kinds of programs are not feasible for the VA for the time being, the constraints to new product development are considerable. Research and development must occur within the scheduling as well as economic framework of a single building project or small group of projects in the design stage at any one time. Projects already in the construction phase could only benefit from development of products scheduled for installation near time of completion. On the other hand, work started during the design phase might suffer from uncertainty of construction funding. Such programs also imply proceeding with design, and probably construction, without complete knowledge of the detailed characteristics of certain subsystems and components. It is quite possible to do this, but it may require commitment of construction funds without completely detailed working drawings and specifications in the conventional sense.

764.3.2 The primary vehicle for defining the scope of manufacturer research and development work, whether based on one or many building projects, is the performance specification. To qualify as bidders, manufacturers must first submit their proposed designs in sufficient detail to allow reasonable judgment of their capability for satisfying the specifications. They may then bid on the basis of their own designs and some stated volume of work. Typically, designs of buildings in which the new products are to be used are not yet available. In fact, after a certain point, building design cannot proceed without knowledge of which product design is going to be developed. Thus, if performance bidding by manufacturers is to be utilized for a particular project, initiation must occur as early as possible to avoid conflict with the building design and construction schedule.

764.3.3 Performance specifications are normally neither feasible nor desirable as an integral part of a set of construction documents. This is not only because of the time and contingency factors discussed above, but also because such specifications are aimed primarily at manufacturers rather than construction contractors.

Modern conventional specifications are increasingly performance-oriented, and VA Master Construction Specifications are a case in point. Under most imaginable circumstances, the use of performance specifications in this context has no real advantage over direct subsystem design by the A/E, and it could have serious disadvantages, primarily large contingency factors in building contractor bidding and delays in the construction schedule.

764.3.4 The Prototype Design does, however, present one opportunity for some product development work, and that is in optimizing the detailed design of the ceiling system. If a carefully planned program could be started promptly after commitment of design funds, there is probably enough time available for a limited but useful manufacturer response to a request for performance design and bids, even within an accelerated design and construction schedule. Use of phased bidding and construction management would in fact improve feasibility. A format for a ceiling system performance specification is provided for this purpose (Section 770).

A discussion of how the specifications could be utilized within a single building project is presented in Section 764.4 below.

764.4 A DEVELOPMENT PROGRAM FOR A SPECIAL CEILING SYSTEM

764.4.1 Determine Feasibility

An initial study is made to determine if the scheduled time available before the ceiling system must be installed in a building for which design funds have been committed is adequate for a superimposed development program. Potential bidders are identified and interviewed to assess research and development capabilities. They are given all pertinent information such as the Prototype Design, performance requirements, preliminary cost targets, and delivery schedule. If these discussions indicate that there are capable manufacturers willing to invest development effort within the given constraints, and that this effort is more likely to lead to a cost-effective solution than direct design by the A/E utilizing products already available, the program is considered feasible.

764.4.2 Establish Scope

Preliminary analysis is conducted in cooperation with interested manufacturers to identify those components of the ceiling system most likely to benefit from research and development in terms of both cost and performance. The specifications in Section 770 have been prepared on the assumption that the hangers cannot be significantly affected and should therefore not be included in the scope. Work to be performed by bidders is delineated and includes installation as well as manufacture and delivery.

764.4.3 Encourage Alliances

There are few if any manufacturers presently prepared to accept single responsibility for all components or for installation as well as delivery. Alliances are therefore necessary among manufacturers and between manufacturers and installation sub-contractors. Partial bids are not acceptable, so each alliance presents itself as a single bidder called a “component contractor.” The VA and its consultants encourage and assist the formation of these groups. If viable groups cannot be quickly formed, project feasibility and scope are re-examined.

764.4.4 Publish Bid Documents

Using the format provided in Section 770, all performance parameters are quantified on the basis of appropriate standards, cost-benefit analyses, trade-offs, etc. The performance specifications and other required bidding documents, such as general and special conditions, are distributed to interested parties. This includes bid forms stating component quantities to be used as the basis for bidding. A conference is held shortly thereafter for verbal explanations and answering of questions. The A/E or other consultant is designated as the official interpreter of documents and arbiter of disputes.

764.4.5 Provide Design Assistance

Each bidder prepares his design in response to the performance specifications. The A/E provides design guidance to the bidders to a degree commensurate with their own internal capabilities and as required to assure responsive submissions. The A/E fee is adjusted accordingly by the VA.

Design proposal material is prepared in the form of shop drawings, material specifications, and any other sketches, models or text required to completely describe the design.

764.4.6 Evaluate Designs

At the termination of the design period established in the bid documents, all designs are submitted to the VA and its consultants for evaluation. Failure to submit a responsive design disqualifies a bidder. Designs judged probably capable of meeting all performance criteria if developed are officially accepted and considered equivalent for bidding purposes regardless of various features which may exceed minimum requirements. Bidders thus qualified are so notified and invited to submit sealed bids on the basis of their own designs. Until bid opening, all designs have their confidentiality guaranteed.

764.4.7 Evaluate Bids

Bid forms require application of certain weighting factors to the bidder's base cost calculations to reflect external cost implications of his design. The purpose is to approximate true owning cost in the adjusted total and thus render different designs more truly comparable. For example, a weighting factor of four cents per inch of thickness per square foot of ceiling is added to account for the cost effect on the total building of increased floor-to-floor height.

Bids are opened at the scheduled time and place and examined for responsiveness. If alternates have been requested, they are applied to the base bid in a predetermined manner. The overall low bidder is nominated Component Contractor and assigned a contract to develop, test, supply and install the required quantity of ceiling in accordance with his design. If all bids significantly exceed the target, the VA either rejects all bids or negotiates with the low bidder.

Unit prices are either required on the bid forms, or the contract requires their submission at some designated time during the development period.

If the VA has provided any direct financial aid to potential bidders to offset design costs, all designs are made public. Otherwise, only the designated Component Contractor's design is revealed; all others are kept confidential and design material returned to the unsuccessful bidders.

764.4.8 Provide Development Assistance

Development of the ceiling design into a manufactured product meeting all performance criteria is the responsibility of the Component Contractor. However, it is in the VA's own interest to provide the Contractor with technical, and perhaps financial, assistance to assure optimum cost-effectiveness.

Prototype components are subjected to a predetermined testing program and certification of test results submitted according to schedule. This work is performed either on the construction site with all components in their actual location or under suitable simulated conditions elsewhere. If possible, one service module is completed on a crash schedule to provide for mock-ups and testing while remaining construction proceeds at normal pace. Development and testing is supervised by the A/E, or by the construction manager if there is one.

The Component Contractor provides the VA and the A/E with unit prices (if not required in the bid) and an information manual completely describing the developed design.

764.4.9 Install the Developed Ceiling

Upon successful completion of all performance tests, the Component Contractor becomes a sub-contractor to the general construction contractor, or continues under direct contract with the VA if a construction manager is being used. The Component Contractor must install, and the VA buy, approximately the quantity of ceiling established as the basis of original bidding, at exactly the submitted unit prices, subject to appropriate escalation clauses. After completion of the contract, the Component Contractor is free to change his design and prices.

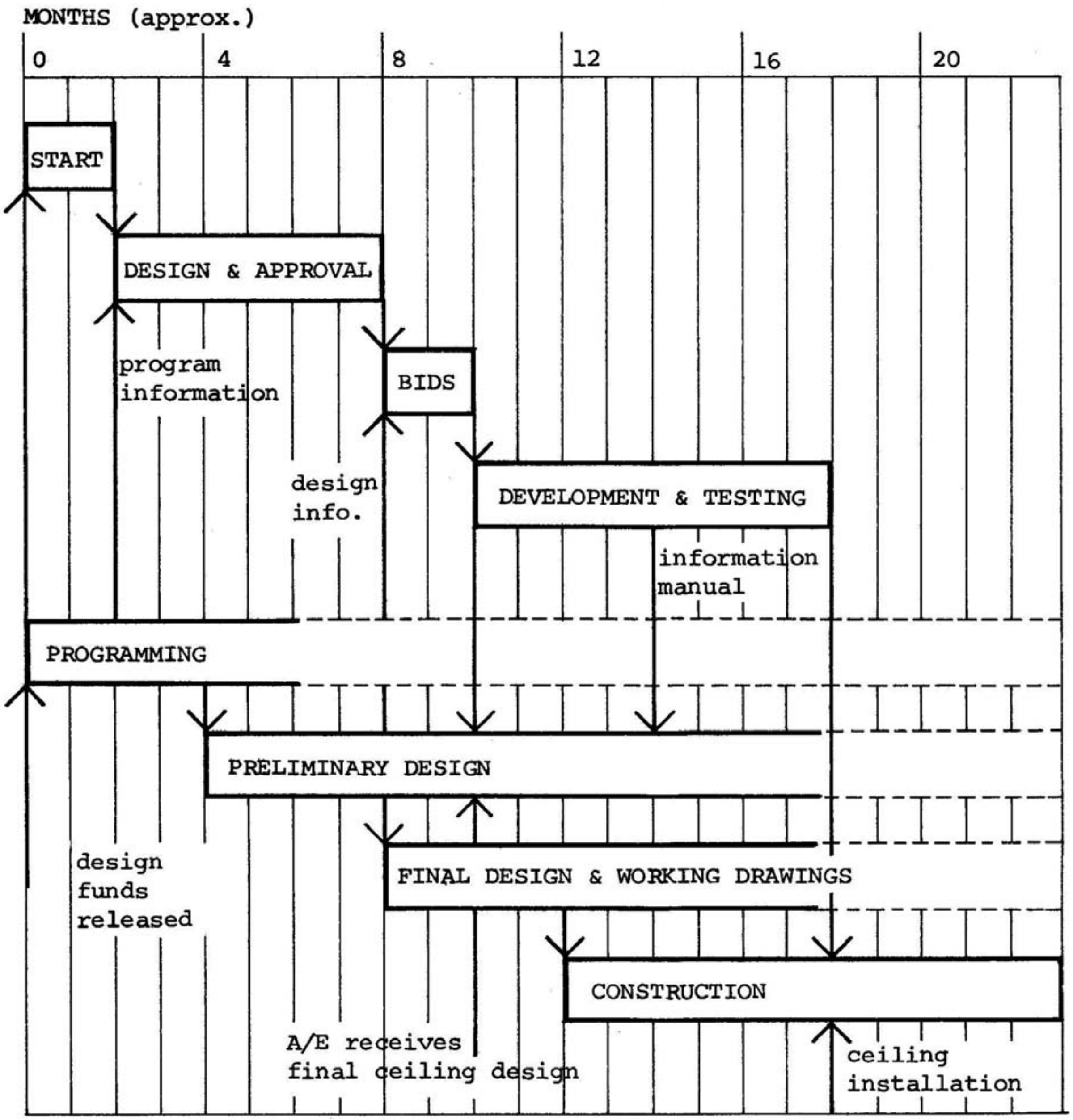
764.4.10 Expedite Decisions

The time available for the complete development program, assuming accelerated scheduling, is about eighteen months. The product development program is superimposed on the design and construction schedule as shown in Figure 760-2.

Bidders have about six months to qualify their designs, perhaps two months to prepare their bids, and some eight months to develop all components and pass performance tests.

This is rather tight considering the possibilities for unexpected delays in an innovative program, so every effort must be made by all parties to make necessary decisions promptly and submit fully responsive material at each deadline.

Figure 760-2. APPROXIMATE SCHEDULE FOR SPECIAL CEILING DEVELOPMENT PROGRAM



765 SYSTEM EVALUATION

765.1 MONITORING THE PROCESS

765.1.1 Objectives

The construction of a demonstration hospital utilizing the Prototype Design will constitute an example of the application of the principles of systems integration to the particular building problems of the VA.

765.1.2 Scope of Subject Material

The precise nature of the monitoring program will depend to a great extent on the degree to which the VA is involved in special funding, phased bidding, product development, subsystem innovation, construction management, etc., at the time. In any case, the scope of the program should cover the entire production process, from inception through occupancy, to provide full benefit. Limited monitoring should continue through the life of the building to determine long-range effects, particularly on adaptability.

765.1.3 Structuring the Experiment

From the point of view of overall building system research and development, the more innovations that can be tried out on a single project, the better, so long as their effects can be kept sufficiently separated to allow accurate assignment of each effect to a specific innovation. The general parameters are cost, time and performance, but appropriate specific parameters must be selected for each project, depending on what degree of emphasis has been placed on various subsystems and on particular aspects of design, construction, operations and alteration. Both innovations to be tried and parameters to be measured should be selected to maximize return of useful information within budget available for monitoring.

765.1.4 The Threat of Red Tape

Monitoring is a task requiring expenditure of considerable time and effort by all parties involved in administration, design and construction on a systems project. This effort is superimposed on all the usual as well as new tasks these parties will be responsible for just to build the building, and therefore can come into conflict with the demands of these tasks.

This problem is not untypical of scientific experiments in which the process of observation can have disturbing effects on the phenomena being observed. Thus, quality of information obtained depends not only on a level of cooperation and an appreciation of common objectives appropriate to a team effort, but also on highly efficient monitoring procedures which extract the desired data with minimum interruption of primary activity.

765.2 PROCESSING THE DATA

An effective monitoring program must be coupled to a broadly based data processing program if each successive systems project is to benefit fully from experience gained not only by the VA but by all agencies, public and private, engaged in parallel efforts. Eventual industrialization of general and special building systems will require ready access to all current information by owners, designers, manufacturers and construction contractors. Information presently available in a form directly applicable to systems design and development problems is fragmented and generally inadequate as the basis for commitments and decisions involving radical innovations. The data processing program should therefore accommodate pertinent material from external sources as well as from the monitoring process, and should organize information for the specialized demands of system development.

770 Ceiling Performance Specifications

771 INTRODUCTION

771.1 INTENT

771.1.1 These specifications provide the basis upon which the ceiling system to be incorporated in the Veterans Administration Hospital Facility to be built at (location) will be designed, evaluated, bid, developed, tested and installed.

771.1.2 Section 320 of the VA Design Manual, Hospital Building System, is an integral part of these specifications.

771.1.3 There is no intent to imply that any particular material or design is desired by the VA. Any detailed designs indicated in the Design Manual as possible approaches to meeting the requirements are for guidance only. Bidders are encouraged to apply their most advanced design concepts and materials to the problem described.

771.1.4 Specific minimum criteria are established in critical areas of performance where parameters can be quantified. Bidders are expected to exceed these if appropriate to the nature of their products, and to provide a performance level at least equal to normal industry standards in those areas not directly covered.

771.2 BASE OF CONTRACT AWARD

Priced proposals will be accepted only from qualified bidders on the basis of their approved designs. All such designs will be considered of equivalent value for purposes of bidding. The successful bidder will be selected on the basis of the lowest responsive lump sum bid submitted on the Bid Form provided by the Office of Construction. Approval of design, selection of the successful bidder, or award of a contract will not relieve the Component Contractor from meeting the performance requirements during the Development and Construction Phases.

771.3 GOVERNING REGULATIONS

All work and materials shall be in accordance with the following codes and standards unless specifically required or authorized to the contrary by the VA:

1. Federal Procurement Regulations

2. VA Construction Standards

3. VA Master Construction Specifications

4. NFPA Life Safety Code

5. National Building Code

6. Uniform Building Code

771.4 SCHEDULE

	Event	Date
771.4.1	Pre-design conference for interested bidders.	(2 months)
771.4.2	Letter of Intent due from interested bidders.	(4 months)
771.4.3	Design Proposal Due.	(7 months)
771.4.4	Design Evaluation returned to bidders, design approved or disapproved. Schematic design of hospital provided to qualified bidders.	(8 months)
771.4.5	Priced Proposal due.	(9 months)
771.4.6	Bid Evaluation complete, Component Contractor nominated, contract awarded.	(10 months)
771.4.7	Information Manual due. Unit Prices due (if not included in Priced Proposal).	(16 months)
771.4.8	Development complete. Test certifications due. Component Contractor signs sub-contract with General Construction Contractor. Commence production and installation.	(18 months)

772 SCOPE

772.1 INCLUDED

772.1.1 Development Phase

1. All necessary product research, development and testing.
2. Design coordination with the VA, A/E and General Construction Contractor (or Construction Manager if used).
3. Descriptive material and samples as required by VA, A/E and GCC (or CM).
4. Supply, installation and testing in mock-up and/or prototype as required.
5. Information Manual and unit prices.

772.1.2 Construction Phase

1. All equipment, materials, labor and supervision required for the manufacture, supply, storage, weather protection and installation of all ceilings in the hospital, except in service bays.
2. Construction coordination with VA, A/E and GCC (or CM).
3. Shop drawings.
4. Leveling devices.
5. Platform and walking surface.
6. Horizontal frame and bracing as required.
7. Ceiling base and finish.
8. Access doors through ceiling and platform.
9. All clips, anchors, spacers, edge trim and other attachments and accessories necessary for a complete finished installation.
10. Sealants, gaskets, etc., as required for sound and air tightness.

11. One year guarantee of materials, workmanship and performance.

772.2 NOT INCLUDED

1. Hangers and attachments to beams.

2. Lighting fixtures, HVC terminals, cubicle tracks, or any other ceiling-mounted equipment.

3. Attachments or support devices for service distribution elements.

4. Radiation or electrostatic shielding.

773 DESIGN PROPOSAL

773.1 GENERAL

Not later than the date specified in 771.4.3 above, each bidder shall submit a Design Proposal to the Office of Construction for evaluation and approval of his design solution. No additional material will be accepted after that date unless specifically requested by the O/C. Evaluations and notifications of approval or disapproval will be returned to all bidders by the date given in 771.4.4 above. Since disapproval shall constitute disqualification of the bidder, it is recommended that all bidders maintain liaison with the O/C and the A/E during the Design Phase to assure responsiveness of their submissions.

773.2 DESCRIPTION OF THE DESIGN

773.2.1 The Proposal shall be in the form of a written description of the bidder's design with appropriate visual material such as drawings, photographs or models. No verbal presentation will be permitted. The Proposal shall include specific statements describing how the design will meet each and every requirement established in these Specifications. Description must be in sufficient detail to permit an accurate assessment of the capabilities and limitations of the design. Include all available reports of tests by recognized testing agencies giving performance data for components already in production. Prices are not required. All submitted material will be kept confidential.

773.2.2 The Component Contractor shall be responsible for all work listed in 772.1. However, to ensure comparable bids with respect to services offered, bidders shall submit lists of the specific items they regard as being inclusive and exclusive of their designs. These lists will be used by the O/C to clarify this aspect of the program before priced proposals are submitted.

773.2.3 The description shall include all special requirements, such as clearances from other building, tolerances of other building, and items required to be supplied by others. The Proposal shall also describe the process of fabrication and installation of all ceiling components, including the relationship to other contractors and trades. Specific reference shall be made to:

1. Fabrication location and procedures.

2. Methods of achieving tolerance control in fabrication and installation.

3. Job site storage requirements.

4. Construction elevator and/or crane requirements.

5. Installation technique, including trades, equipment, etc.

6. Installation schedule, including time required for each step and average installation rates in square feet of platform and square feet of finished ceiling installed per week.

773.2.4 Extra features inherent in the design shall be described. Bidders wishing to offer components with characteristics not listed in the Specifications shall describe them so the O/C may provide guidance on their relative importance as an assistance to preparation of the Priced Proposal. Bidders intending to submit alternatives with their Priced Proposal shall submit complete descriptions of them for evaluation.

773.3 OTHER MATERIAL

773.3.1 The Proposal shall include suggestions for detailed test procedures during the Development Phase, stating which characteristics would be examined by testing laboratory, mock-up, field prototype, etc. Space will be provided by the O/C in the hospital under construction for final prototype testing. All other testing costs will be borne by the Component Contractor.

773.3.2 Bidders who wish to have criteria modified shall submit a description of any proposed changes not later than __(date)__. If in the opinion of the O/C the bidder can show that a change in criteria is justified, the change might be made. All bidders will be notified of all changes through addenda to the Specifications. Any modification of the Approved Design during the Development and Construction Phases will be allowed only by a written change order from the O/C.

773.3.3 The Proposal shall include a copy of the guarantee to be provided by the Component Contractor upon completion of his work.

774 PRICED PROPOSAL

774.1 GENERAL

Priced proposals shall be submitted in accordance with the Invitation for Bids. A certified copy of the bidder's Approved Design shall be included. Prices shall be based on quantities derived by the bidder from schematic drawings supplied by the O/C and any other information included with such drawings. The lump sum bid will be the total price quoted by the bidder for all required work, plus the weighting factors described in Section 774.2 below.

774.2 WEIGHTING FACTORS

774.2.1 A weighting factor of four cents ($0.04) per outside gross square foot of total hospital area will be added for each inch of thickness from the finished surface of the ceiling to the walking surface of the platform.

774.2.2 A weighting factor of one-fifth of a cent ($0.002) per pound of total ceiling weight will be added.

775 PERFORMANCE CRITERIA

775.1 ASSUMPTIONS

775.1.1 The basic structure of the hospital will be a steel or concrete frame with concrete floor slabs and shear walls. Girders will span columns in the short direction of the structural bays and beams will span girders in the long direction. The ceiling will be hung at a uniform height with its top (platform) surface about 6’6” below the underside of the floor slab and with its bottom finished surface 9’3” to 10’3” above the top of the structural floor slab.

775.1.2 Ceiling hangers, to be provided by others, will be ½” diameter steel rods with three inches of standard bolt thread at the lower end. Hangers will be attached by others along the center line of beams, 9’0” on center, minimum. In the direction of the girders, hangers will be spaced either 7’6” or 5’7-1/2” on center.

775.1.3 The Component Contractor will have access to each floor by stairway and construction elevator, and if required, by crane. The external wall will be in place at the time of ceiling installation, but sections may be temporarily omitted for delivery of large components. Interior two-hour partitions will be in place running from slab to slab and dividing each floor into areas of 5,000 to 20,000 square feet. The floor topping slab will not be in place and there will be no depressions in the structural slab. The floor structure will be designed for a 75 psf uniform live load.

775.1.4 Vertical shafts penetrating enclosed spaces will occur rarely, if at all. Interior columns will be spaced 22’6” in one direction and from 40’6” to 58’6” in the other direction. Trunk ducts and all main horizontal service lines will be in place, hung from the structural slab between ceiling hangers.

775.1.5 No other trades will be present in any space in which the ceiling is being installed.

775.1.6 Heavy ceiling-mounted equipment which would exceed design live load capability of 40 psf will be hung directly from the structure above, after completion of ceiling installation.

775.1.7 All partitions, except two-hour partitions, including door frames, will be installed after the ceiling is complete. No framing members of these partitions will penetrate the ceiling.

775.1.8 The ceiling, except for finishes, will be regarded as a more or less permanent part of the building shell, along with the structure, exterior walls and major service mains.

775.2 REQUIREMENTS

775.2.1 Vertical Loads

The ceiling shall provide a platform over its entire upper surface, capable of supporting some of the distribution components located in the service zone, HVC terminals, and workmen engaged in construction, maintenance, repairs and alterations. It must also provide support for ceiling-hung items such as cubicle tracks, TV consoles, etc. These shall be calculated as a uniform live load of 40 psf. The ceiling shall withstand upward point loads of at least 25 pounds over a six-inch square area without appreciable deformation. Deflection of ceiling base material shall be limited to 1/360 of the distance between supporting members under full live load.

775.2.2 Lateral Loads

The ceiling is not required to contribute to the lateral force resistance of the structure, but it shall transmit all lateral forces developed in partitions, as well as within the ceiling itself, to the structure.

775.2.3 Acoustics

1. The ceiling shall provide a sound barrier between the service zone and the functional zone of Sound Transmission Class (STC) 40.

2. Ceiling surface treatment shall have a minimum absorption capability of Noise Reduction Coefficient (NRC) 60.

775.2.4 Fire Safety

The ceiling shall be non-combustible and shall have a fire resistance rating of one hour. Maximum flame spread rating of surface materials is 25 and maximum smoke developed rating is 50. When burnt, surfaces shall not produce noxious or toxic fumes.

775.2.5 Surface Characteristics

The ceiling shall have a finished surface with the following characteristics:

1. A minimum reflectance of 80, and low gloss.
2. High resistance to abrasion, moisture, cleaning and disinfectant materials, staining, fading, and impact.
3. Easily repaired and patched.

The ceiling shall have the capability of supporting standard types of radiation and electrostatic shielding.

775.2.6 Framing and Leveling Devices

1. Ceiling framing, stiffening ribs and the like, if required by the design, shall not protrude above the walking surface of the platform more than one foot at any point. Such elements shall not place undue restrictions on the location of partitions; ideally, there would be no restrictions.
2. The ceiling shall be attached to the hangers by leveling devices capable of adjustment to provide a level lower surface during construction, and periodic readjustment throughout the life of the building.

775.2.7 Provision for Plenum

The ceiling shall be airtight under pressure differentials produced by utilizing the service zone as a return air plenum.

775.2.8 Adaptability

Adaptability of the ceiling is principally a question of access to, and variable support of, other building components.

1. Access to the service zone will be primarily horizontal and will be provided via building components other than the ceiling. Nevertheless, a reasonable degree of vertical access through the ceiling shall be provided for convenience of engineering personnel.

2. There will be no horizontal distribution of services within partitions; all such distribution will occur above the ceiling. Distribution to service containers within functional spaces will be routed vertically via ceiling penetrations. Ceiling materials shall allow rapid and convenient drilling, cutting and patching. Penetrations of distribution lines through the ceiling will be sealed (by others) to preserve acoustic qualities.

3. The ceiling shall provide support for a wide range of ceiling-mounted items such as cubicle tracks, I.V. hangers, TV consoles, etc., in a manner allowing simple cutting and drilling of holes as they are installed and patching when they are removed.

4. For purposes of relocating lighting fixtures, HVC terminals and the like, the ceiling shall provide for convenient introduction of new openings and closing off of unused openings.

5. Ceiling base and finish materials shall allow for simple partition head attachment, and for relocation of partitions without major damage of these materials.

6. The base ceiling surface shall provide substantial backing for commonly used ceiling finishes which can be applied, cleaned, repaired, removed or changed without significant damage to the base material.

775.2.9 Compatibility

1. The ceiling shall be fitted around and fastened to columns and shear walls in a manner allowing for construction tolerances of both ceiling and structure while transferring all lateral loads developed in the ceiling to the structure. Vertical loads will be transferred to the structure solely through the hangers provided.

2. The ceiling shall be fitted and fastened to the exterior wall and to the two-hour partitions in a manner allowing for construction tolerances of ceiling, walls and partitions. The joint at the exterior wall shall allow for reasonable deflection due to wind loads. All joints shall be sealed to prevent flanking paths for sound transmission.

3. To receive partitions within their vertical adjustment capability, the ceiling shall, under dead load conditions, be set at a uniform specified height above the finished floor within ¼" ± and shall not slope more than ¼" in 10'0".

780 Service Containers

781 INDENTIFICATION OF SUITABLE PRODUCTS

The extent to which services and partitions are able to be uncoupled on any particular project will be directly linked to the cost and availability of suitable products for containing the services.

Ideally, the service containers would comprise a whole system of easily movable appliances, ranging in complexity from the simplest electrical raceway or pole to the most complex, highly specialized medical equipment consoles. These would all be dimensionally and aesthetically coordinated, and several competing manufacturers would each fabricate the total range required for the whole hospital.

This ideal is far from the present state of fragmented, uncoordinated product development, however, and very few products can be described as “appliance-like”. Several manufacturers have indicated a willingness to modify their products or engage in new product development if a need could be demonstrated and/or specifications were made available. It also appears that more and more types of manufacturers are entering this field of development. These include manufacturers of hospital equipment such as monitors, nurse call systems, etc., who are beginning to realize the marketing possibilities of coordinating their own products into containers – or “consoles” – rather than leaving this function to others. The whole field of product development in the area of service containers appears to be very fluid at present, with a great deal of interest in the hospital market displayed by all types of manufacturers.

In order to identify the many manufacturers and products necessary to comprise a complete range of service containers for a total hospital, the word “container” was loosely defined as any product which would free the partitions of the function of containing services. Six broad categories emerged. A description of each category and a list of manufacturers is included below.

782 CATEGORIES AND MANUFACTURERS (Figures 780-1 and 780-2)

782.1 ELECTRICAL RACEWAYS AND DISTRIBUTION POLES

Surface-mounted electrical raceways are commonly used in conventional construction. In the majority of cases, they are mounted horizontally on walls, either at dado height or at the base. It is possible to mount them on the ceiling in appropriate situations (e.g. laboratories) or use them vertically as containers of telephone jacks, duplex outlets, switch boxes, thermostats and even small night lights.

To facilitate open planning in schools and offices, a comparatively new building component has appeared on the market which is designed to house telephone, power and other electrical outlets. It is essentially a floor-to-ceiling, free-standing pole, sometimes made up of standard back-to-back raceways (Wiremold) or of bent sheet metal (Luminous Ceilings, Inc.)

Manufacturers in this category include:

1. Electro-Link Systems Ltd., Ontario, Canada.

2. Luminous Ceilings, Inc., Chicago, Ill.

3. The Wiremold Company, Hartford, Conn.

782.2 LAVATORY CONSOLES

A number of manufacturers currently make a product which is essentially a cabinet containing a combination of various components such as a pre-plumbed lavatory, waste receptacle, mirror, overhead light, bed pan, etc., built into a unit and either recessed or surface-mounted on partitions. These consoles are already used in conventional hospital construction; typically they are recessed. Certain consoles would require modifications to conform with the system rules. For instance, the casing would have to extend to the finished ceiling to cover the service drops from the service zone above.

Manufacturers in this category include:

1. Accessory Specialties, Inc., New York, N.Y.

2. Anco Industries, Riverton, N.J.

3. Bobrick Dispensers Inc., Los Angeles, Ca.

4. Innerspacenetics, Inc., San Francisco, Ca.

5. Charles Parker Co., Meriden, Conn.

6. Watrous, Inc., Bensenville, Ill.

782.3 PREFABRICATED BATHROOM COMPONENTS

A number of large manufacturers of bathroom fixtures are making significant efforts in the direction of prefabricated bathroom components for various markets, including hospitals. Few of these new products are currently available, though plans exist for prefabricating plumbing walls and modular bathroom units.

Manufacturers interested in product development in this category include:

1. American Standard, New York, N.Y.

2. Eljer, Pittsburgh, Pa.

3. Kohler Co., Kohler, Wisc.

4. Meridian Modules Inc., St. Louis, Mo.

5. Moen, Division of Stanadyne, Elyria, Ohio.

6. Rohr Corp., Chula Vista, Ca.

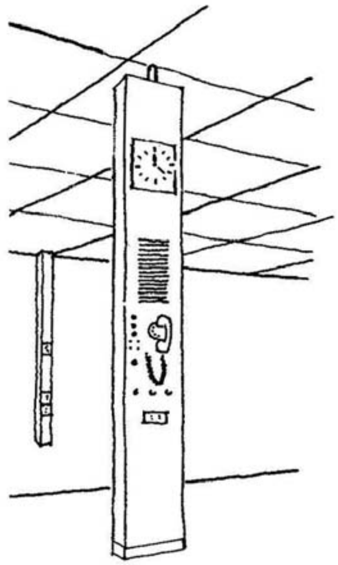
7. Stahl Industries, Inc., Youngstown, Ohio.

8. Symmons Engineering Co., Braintree, Mass.

782.4 WALL-HUNG INTEGRATED SERVICE CONTAINERS

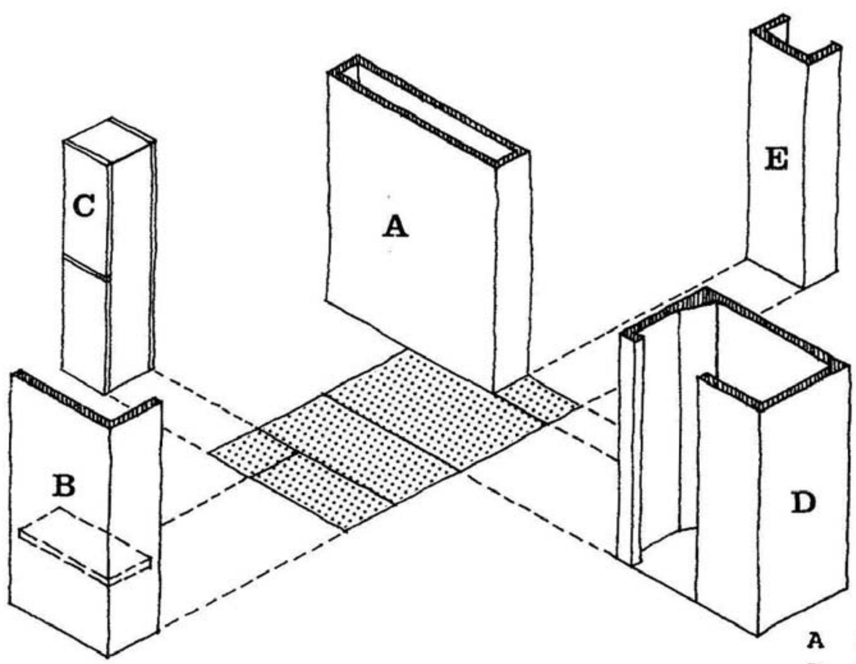
Several manufacturers are currently producing patient bedside units with multiple outlets for medical equipment and patient conveniences, including lighting, communications, terminals, medical gases, TV, etc. These service containers are currently designed for use in general patient rooms, intensive care units and recovery rooms. They range in complexity from a simple flush-mounted console containing a limited number of service outlets to large, modular, surface-mounted wall assemblies. Generally, the container manufacturer's task is primarily one of coordination; he usually fabricates only the container which houses the equipment supplied by a variety of other manufacturers.

Figure 780-1. SERVICE CONTAINER CATEGORIES 1 – 3



1. Electrical Raceways and Distribution Poles

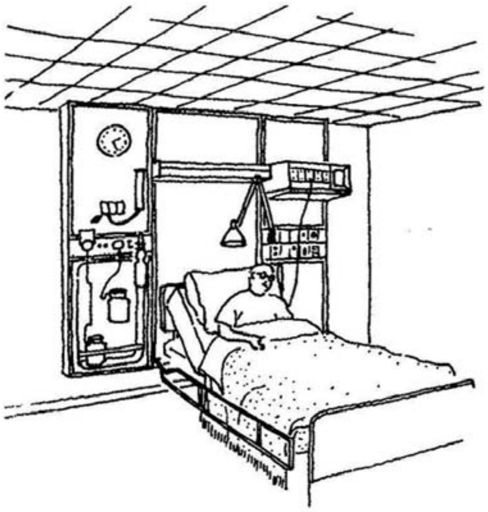
2. Lavatory Consoles



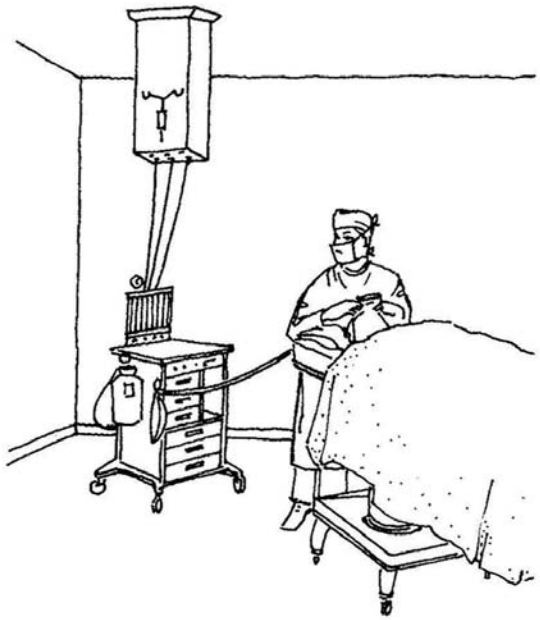
A Mechanical Chase
B Lavatory Center
C Nurserver
D Toilet-Shower
E Wardrobe Closet

3. Prefabricated Bathroom Components

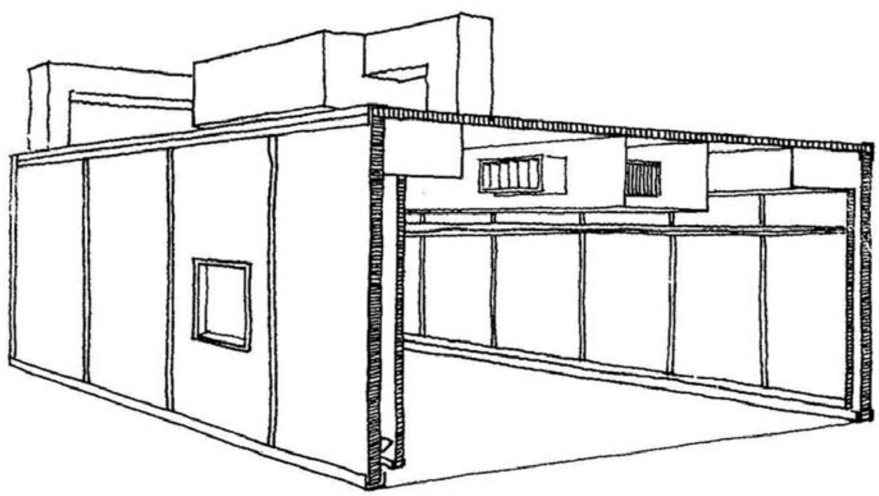
Figure 780-2. SERVICE CONTAINER CATEGORIES 4 – 6



4. Wall Hung Integrated Service Containers



5. Ceiling Hung Integrated Service Containers



6. Prefabricated Rooms for Specialized Environments

At least one manufacturer of bedside units (Post-Glover) also makes panels for more specialized areas such as surgeries. It seems quite likely that other manufacturers will extend their line of products as well.

Manufacturers in this category include:

1. Amsco, Patient/Power Products, Richmond, Ca.

2. Electro/Systems, Inc., Richmond, Ca.

3. Hill-Rom Co., Inc., Batesville, Indiana.

4. Hospital Systems Inc., Berkeley, Ca.

5. National Cylinder Gas (NCG) Division, Chemetron Corp., Chicago, Ill.

6. Pacific Associated Lighting Co., Inc., (Palco), San Francisco, Ca.

7. Post-Glover Division, ESB Inc., Erlanger, Kentucky.

8. Sunbeam Lighting Co., Los Angeles, Ca.

782.5 CEILING-HUNG INTEGRATED SERVICE CONTAINERS

Products in this category include retractable or rigid ceiling columns, overhead dispenser units, etc. Generally, the units are approximately 70-150 square inches in cross section and are hung from the ceiling so that they clear the floor by about 6'4". They typically provide medical gases in spaces such as surgery, emergency, recovery and intensive care areas, but the concept appears to be applicable in many other areas of the hospital for those units which can also furnish electrical and monitoring receptacles.

Manufacturers of products in this category include:

1. Logan Manufacturing Company, Manheim, Penn.

2. Ohio Medical Products, Madison, Wisc.

782.6 PREFABRICATED ROOMS FOR SPECIALIZED ENVIRONMENTS

If the term "container" is taken to describe those objects which enhance building adaptability by housing services more or less independently of the building elements, then prefabricated rooms for specialized purposes will fall into this category at one end of the scale, just as the electrical raceways fall in at the other end. An attempt was made to identify manufacturers not only of the more commonly used environmental, audiometric and clean rooms, but also of prefabricated surgeries and laboratories, etc. It appears that manufacturers of totally equipped prefabricated surgeries have not yet been able to market their product in the United States, though some progress has been made in Europe. Information was sought from the following manufacturers or their representatives:

1. American Air Filter (clean rooms) Berlin, Conn.

2. Bendix Corporation (laboratories) Dayton, Ohio.

3. Honeywell (surgeries) Minneapolis, Minn.

4. James Howarth & Co., Ltd., Bolton Lanes, England.

5. Industrial Acoustics Co., Inc., (audiometric and environmental rooms) Bronx, N.Y.

6. Liberty Industries, Inc. (clean rooms) Berlin, Conn.

7. Rayproof Corp. (shielded and audiometric rooms) Norwalk, Conn.

8. Thermatron (environmental rooms), Holland, Mich.

9. Tracor (audiometric rooms) Austin, Texas.

10. Veller (surgery) Gentilly, France.

11. Weber (clean rooms) Grand Rapids, Mich.

783 COST COMPARISON (EXAMPLE)

The cost of service containers in the same category will vary widely depending on the services contained, the materials and details of the container etc.

The comparison of these costs with costs of conventional methods of installing services in partitions, or enclosing them with furring, will also produce widely varying results depending on the location and quantity of services.

The following example is given to assist in estimating the range of costs involved in several alternatives.

783.1 BASIS OF COMPARISON

Figure 780-3 illustrates two back-to-back two-bed patient rooms, with clustered services in two locations in each room.

The costs include the labor, materials, overhead and profit for the service drops from the branches in the service zone to outlets in the functional zone, including connections to the branches and including the outlets.

The outlets to be provided are as follows:

1. The Bedside Location. Each bed will be provided with the following outlets:

   a. Three medical gas outlets,

   b. one nurse call outlet,

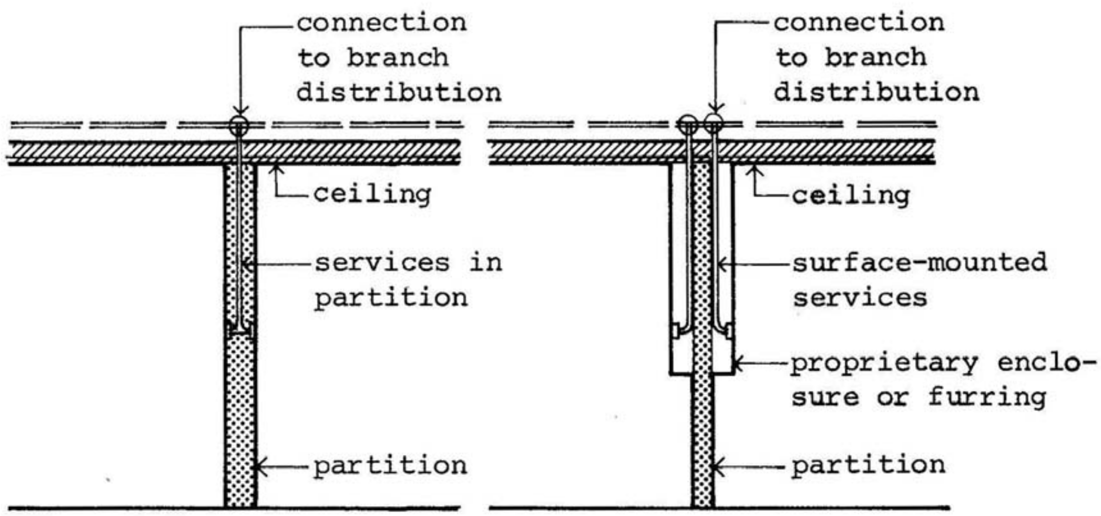
   c. one physiological monitoring outlet,

   d. one outlet for bed light,

   e. one telephone jack, and

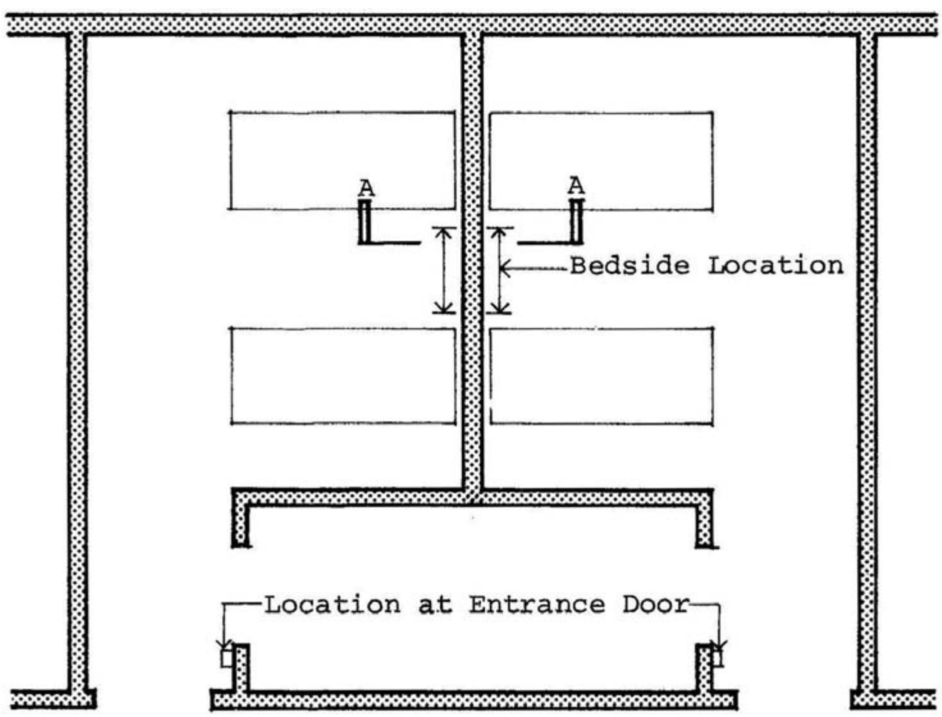
   f. three power outlets.

Figure 780-3. BASIS OF COST COMPARISON



SECTION A-A
(CONVENTIONAL)

SECTION A-A
(SURFACE-MOUNTED SERVICES)



PLAN SHOWING BACK-TO-BACK
PATIENT BEDROOMS

2. Location Near Entrance Door. At the entrance door to each room, the following outlets will be provided:

   a. One light switch,

   b. one thermostat (including the thermostat itself) and,

   c. one night light.

783.2 RESULTS OF COMPARISON

Provision of the outlets at the patient bedside as described above would cost an estimated $275 per patient using conventional construction, i.e. services within the partition.

Surface mounting services and enclosing them with furring would cost approximately 30% more, whereas the use of proprietary enclosures could cost 50-80% more.

If the comparison is made in a situation where patient beds are not back-to-back, the difference between the cost of conventional installation and the cost of furring out services will be no more than the cost of the furring. (This amounts to approximately $50 per unit, or $25 per patient.) In this case the proprietary enclosure would be only 30-50% more than the cost of conventional installation.

The difference in cost between conventional installation and surface mounting services is mostly due to the increased cost of outlets for medical gases and not to the electrical work. This is reflected in the cost comparison for electrical services near the entrance door.

At the location near the entrance door, the difference in cost between conventional construction and the use of a surface mounted raceway is approximately 20%. Conventional construction would cost approximately $80 and surface mounting would cost $100.

It must be emphasized that all percentages quoted will be greatly reduced when the cost comparisons are considered in relation to the total subsystem costs of the various subsystems involved.

The benefits of surface mounting services have been discussed in Section 723.

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