Health Facility Flexibility and Humanity

An Agenda for the 21st Century

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Worldwide, the way healthcare is delivered continues to change, and the rate of change continues to accelerate. Many forces bring about these changes and, having been widely discussed, need not be reiterated here. In most cases, the changes are not unidirectional (e.g., there are forces both reducing and increasing the demand for inpatient care). These changes are affecting healthcare in nearly all countries, but not necessarily in the same way at the same time.

Change	Causative force
Increasing outpatient care	Cost reduction, patient convenience technology/advance
Increasing acuity of inpatient care	Acute care becoming outpatient; increasing capabilities
Reengineered delivery organisations	Cost reduction, mobidity changes, healing design
Changing diagnostic treatment tools (largely activity)	Information technology, Midurization, genetic advances
Changing health problems	Diminishing of some conditions through more effective diagnosis, treatment and prevention, aging population, reemergence of infectious diseases

In other words most things are changing in healthcare. The rate of change is accelerating and the period of change is fractions of a building's life or even functions of the design and construct time frame.

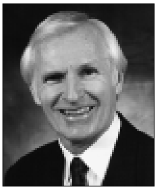
The resources available to provide healthcare continue to be stretched by an increasing demand for health services, particularly in developing countries, and by increasing cost in advanced countries due to expanding diagnostic and treatment capabilities.

The question is how to design healthcare facilities that can effectively support a changing care delivery system, and provide an environment that contributes to healing. Additional criteria is that the solution must be both affordable in first cost, and effective in long term cost.

Thus, the buildings must balance reasonable cost, great flexibility, functional effectiveness and a sense of humanity throughout many permutations of care giving. This is a tall order, but certain important strategies, when linked together, make success possible.

Flexibility strategies

The goal in creating balanced strategies is to bring the satisfaction of multiple objectives to the highest possible level, achieving the highest



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Managing Partner of NBBJ, he is an architect with a broad base of experience in health, laboratory, and technical facilities planning and design. For the last 34 years, he has participated in and led multidisciplinary teams on a wide range of planning and design projects within these fields. Mr. Jonassen is a health care futurist. His insights into the future of health care and new health care delivery systems have influenced his firm and his clients. His experience includes health facility research in the United States, Europe, and Asia. Mr. Jonassen was an early proponent of healing design, as demonstrated by the Children's Hospital in San Diego. He has presented numerous papers on the specifics of light, sound, color, control, views, and art in healing facilities.

rather than the lowest common denominator. Effective flexibility strategies, therefore, must also be good operating, environmental and cost strategies. For example, they should establish a long-term facility system that is reasonable in cost, responds to change over time and on many levels, maintains cost-effectiveness, and enables healing and green design.

While we have acknowledged that change affects most things in health facilities and the rate of change is accelerating, it is also true that some important things about facilities do not change.

These are:

- People arrival, movement, departure.
- Supply of materials, removal of waste.
- Distribution of energy, signals.
- Human needs for civility, clarity, light, and air.

This has lead us to a new way of thinking about zoning a building and separating the permanent from the changing (or temporal).

In practice, the following strategies form an interlocking set that, as a whole, can successfully reach these goals. This set of strategies establishes a long term facility system, which is capable of response to change at a number of levels from short term to long term in a very cost effective way, it is initially reasonable in cost. It enables healing and green design and provides an excellent exit strategy by providing a building suitable for non-health as well as health uses.

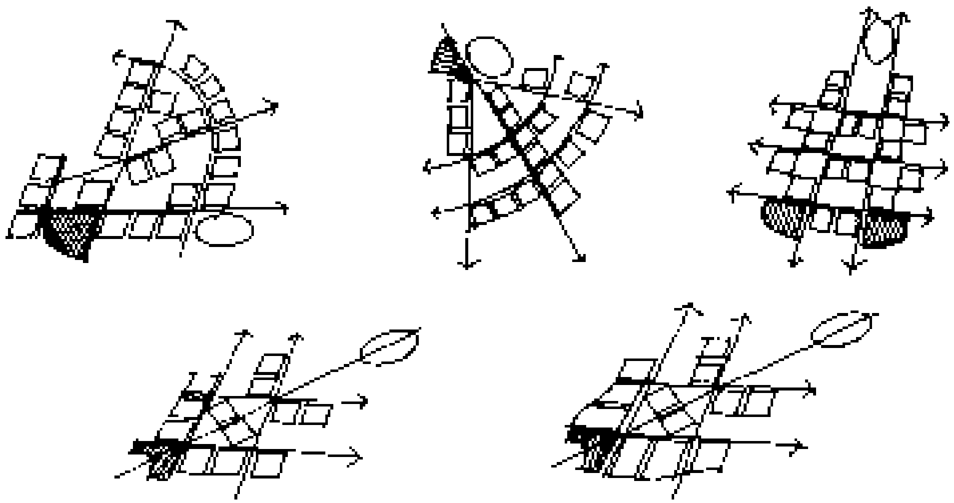
Components of the strategy include:

The Permanent Facility

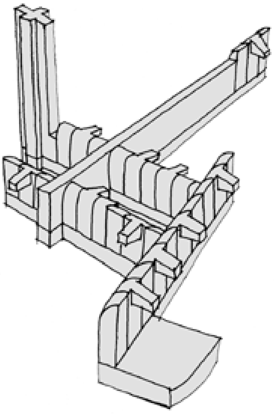
- An integrated three dimensional infrastructure distribution and major people circulation system (i.e., a multi level tube of space containing circulation and infrastructure).
  - A stand alone servant building.
  - An architecture of four dimensional movement.
  - An architecture of encounter and socialization.

The Changing (Temporal) Facility

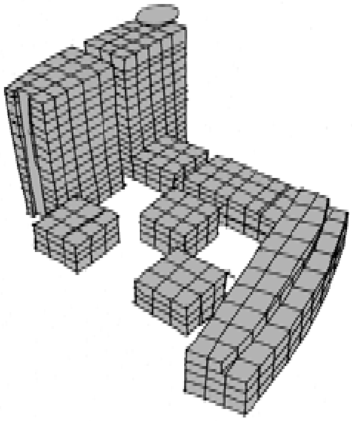
- Affordable architecture of change
- Space for concentration, privacy, serenity
- Integrating the following strategies:
  - A universal space field approach (i.e., uniform multi level blocks of functional space).
  - A universal space module (i.e., a uniform increment of space bounded by structural module including floors and columns).
  - Universal rooms (i.e., rooms configured to accommodate a range of uses without permanent change).
  - Modular movable and semi movable casework.



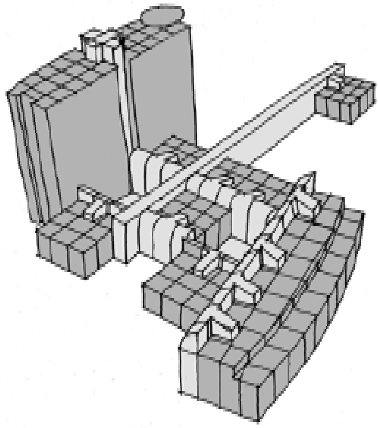
Many layouts are possible.



Integrated Infrastructure.



Universal Space Fields.



Total System.

The Permanent Integrated Circulation and Infrastructure

The key to making this set of strategies work in the long term and in enabling both healing and green environments, is the integration of the building service distribution systems with the permanent circulation systems.

This approach makes infrastructure distribution accessible without disturbing functional areas, and does it less expensively than with full interstitial space. It also reinforces the permanence of the people circulation system as an understandable means of way-finding, and as an armature for growth and change.

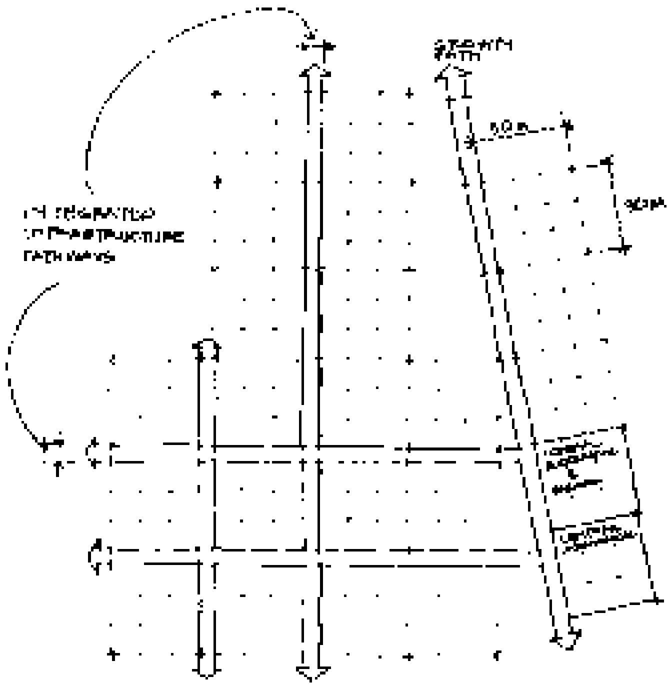
This infrastructure system is a three dimensional approach that links mechanical, electrical, signal and logistic systems with horizontal and vertical people circulation. Basically, it is a horizontal space tube with the same number of stories as its space fields. This system is organized so that logistics, piping, power and communication systems are horizontally distributed at the bottom; air systems are handled at the top; and vertical distribution for all of these along one side.

This system works at 6.0 to 6.5 meters wide divided into three vertical zones (1.0 to 1.5 meters for vertical distribution, 3.0 meters for horizontal people circulation and 2.0 meters for vertical people movement). The people circulation zone widths will vary with needs for larger public spaces at entries and other important nodes.

Typically, the space would open to a garden on one side for at least half its length. It is a good candidate for natural ventilation due to that exposure and to the decentralized fan system at the top of the space which can easily serve that purpose.

The *planning* for this permanent infrastructure pathway must allow locations for expansion of the universal space field system, and can also accommodate special functions that are exceptions to the rule. A loading dock approach (or mobile docking) may be reasonable for some of these needs.

The *design* of this infrastructure/circulation system is key to the success of the structure's environment. It becomes one of the major connections to light, air and nature. It provides a rich opportunity for sculpting the architecture into landmarks for way-finding. As indicated



System layout.

above, the space is a good candidate for natural ventilation, depending on climate, orientation and function.

Air Handling

While air handling may be accomplished in several ways, one strong approach uses a decentralized small fan system related to each space block for structures up to five stories (plus basement). The capability to add fan systems and ducts locally (vertically), allows for an initial tight fit of air capacity to function with ease of increasing future capacity and avoiding disruption to adjacent areas. These fan units are located on top of each space field adjacent to the infrastructure "tube," and are tied into it at the top. Both the supply air and the return air are ducted vertically to the floor served through the vertical distribution zone. These fan units also serve the infrastructure tube. Our analysis shows that by using the largest available American pre-assembled (weather tight) package fan system, one fan for every three modules will accommodate most uses, and one fan unit for each module will more than accommodate the most air change intensive uses we have ever seen.

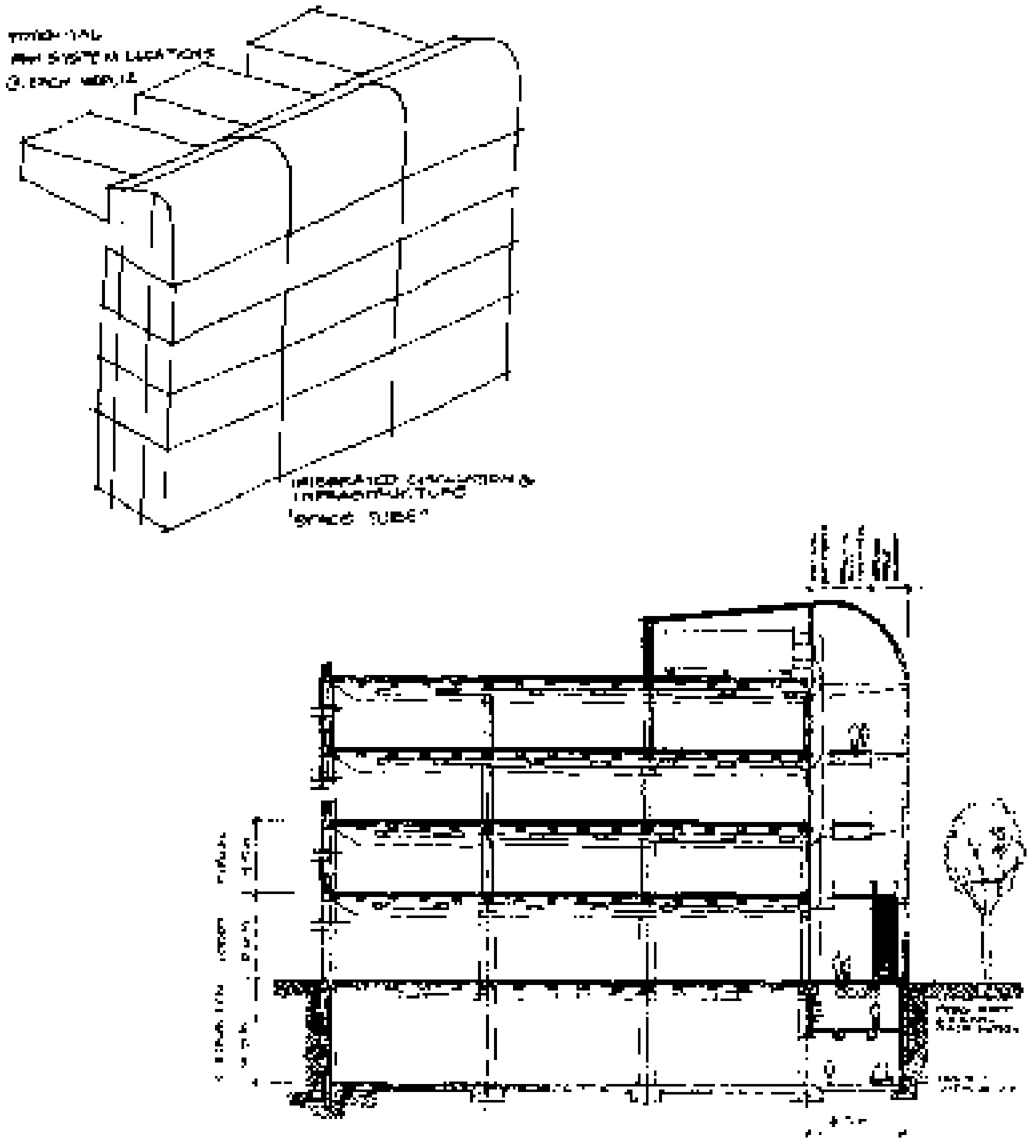
This system accommodates taller structures by aligning the fan level with interstitial spaces every six floors.

People Movement

For vertical movement within this system, we provide a zone for passenger elevators and escalators. These are typically located against the outside wall which reinforces way-finding. Patient and service elevators are typically accommodated in designated modules, located adjacent to the infrastructure tube.

Horizontal Piping, Power and Signal

Distribution for these services takes place at a mezzanine level sandwiched between the lowest (typically sub grade) level and the first or public entrance level. This is a dedicated level that allows



Example of section through integrated infrastructure and space block.

maintenance and alteration work to the distribution mains, to be done without interference to or from other operations.

Horizontal Logistic Movement

This is accommodated on the lowest level, typically a tall floor for warehousing and major mechanical facilities, with the least public circulation. Where parking is included, this volume will accommodate two levels.

The temporal

The changing part of the system is an integrated set of strategies that are designed to provide:

- change by designation
- change by furniture movement
- change by conversion
- change in whole area function
- time and cost saving in design and construction
- ability to replace without disruption.
- space that appeals for non-health as well as health uses.

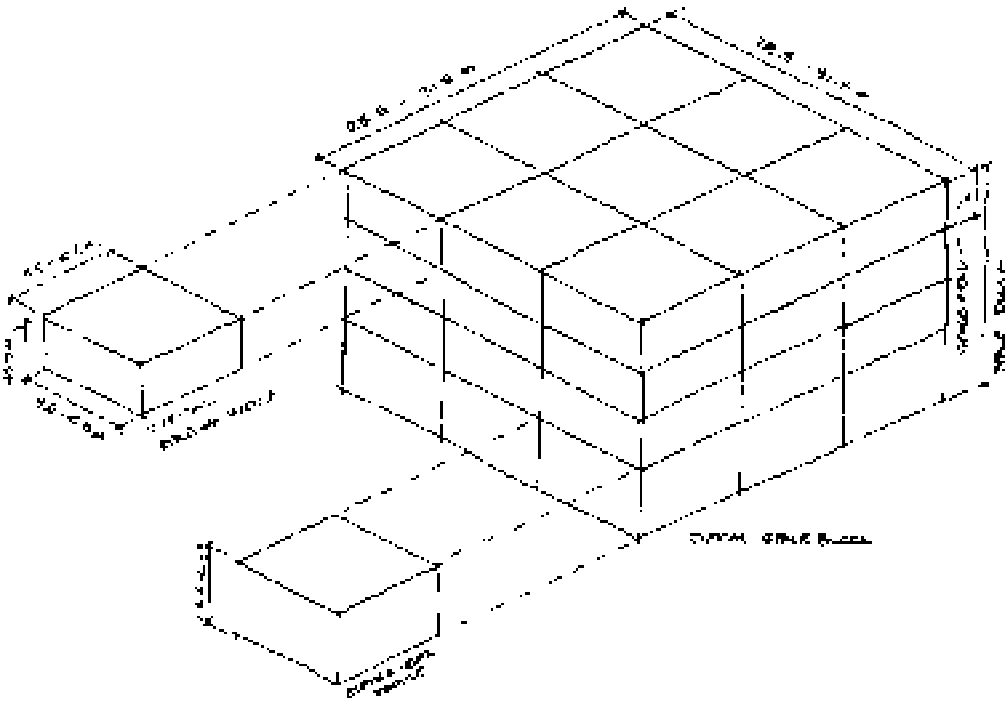
Universal Space Fields/Space Blocks

Space fields are assemblies of universal modules into areas or fields that integrate smoke compartmentation, as well as exiting and functional department requirements. The strategy of universal space fields allows for integrating the infrastructure strategy with the functional areas, and for setting the rules that assure both the functionality and the environmental quality of the space. Space blocks are created when space fields are stacked in multi-floor configuration.

The field rules take into account the relationship of fields to building service systems, the needs of all types of medical functions, and the relationship of occupiable space to daylight and natural ventilation.

Fields that are three modules (roughly 30m x 30m) work well for diagnostic and treatment functions, inpatient and outpatient functions, and service functions, and are reasonably compatible with situations that demand parking at the base.

Universal space blocks are created when space fields are stacked in multi-floor configurations, usually with a lower service level (with mezzanine), an entry level, and one to four additional functional fields.



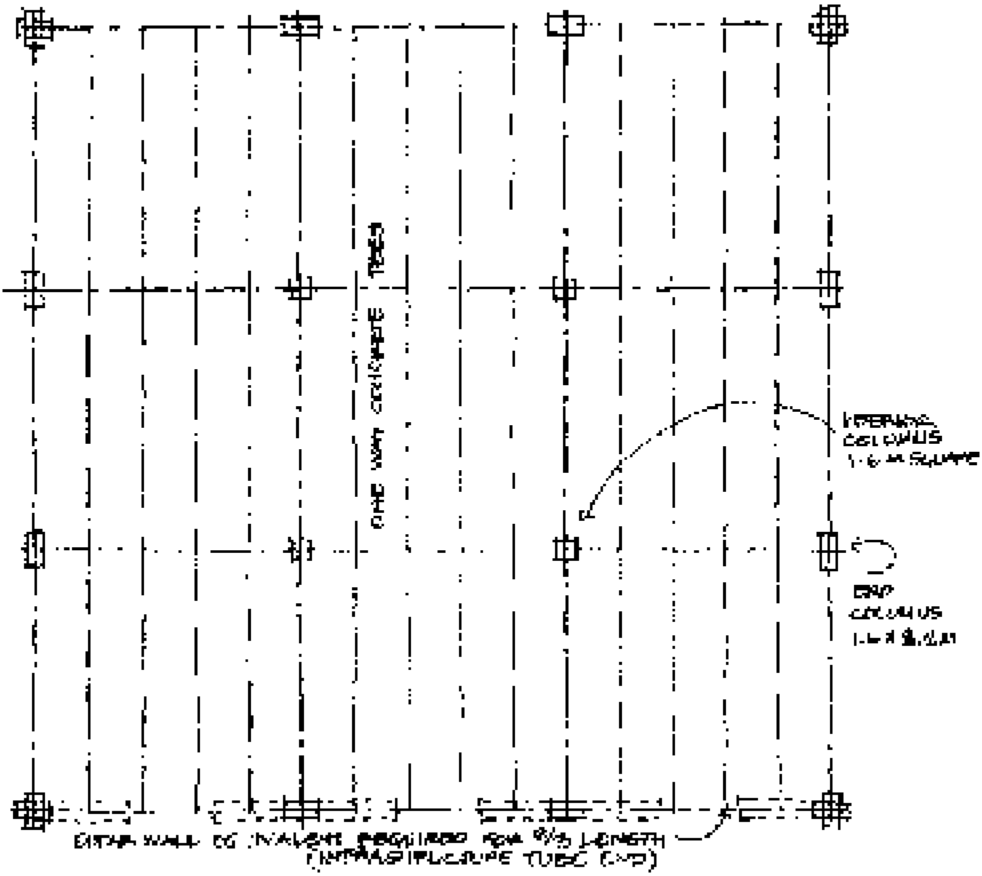
Mechanical Electrical Distribution

The field plan depth works for services feeding from one side (the infrastructure side), which reinforces an integrated infrastructure strategy. While the 3x3 module plan is too wide for natural ventilation, central ventilation shafts can be used in inpatient towers to allow a natural ventilation strategy. This is common in Japan. A two module wide by four module deep configuration is sometimes a viable and useful alternative for inpatient or clinic functions.

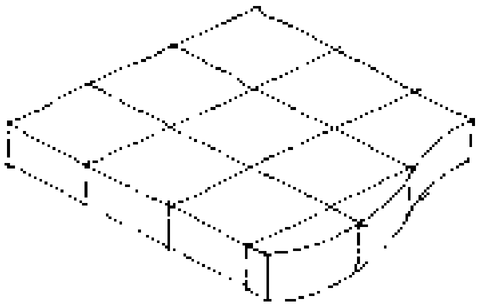
Structure

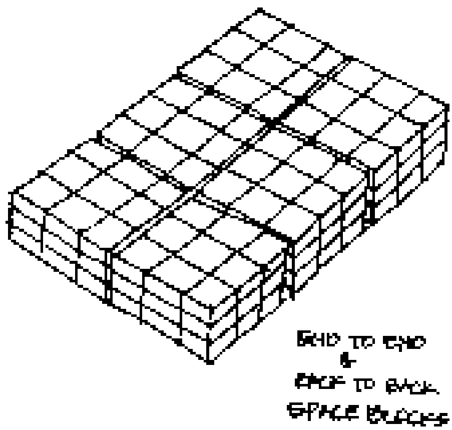
The structural strategy in this case is to gather all of the shear resistance to the perimeter, enabling a shallow floor system to run in one direction through three modules.

Exceptions to the system can occur at the permanent edges, allowing it to be sculpted to respond and relate to site and local conditions, breaking the visual tyranny of the system and creating meaningful architecture.



Typical space field structural plan.





Grouping

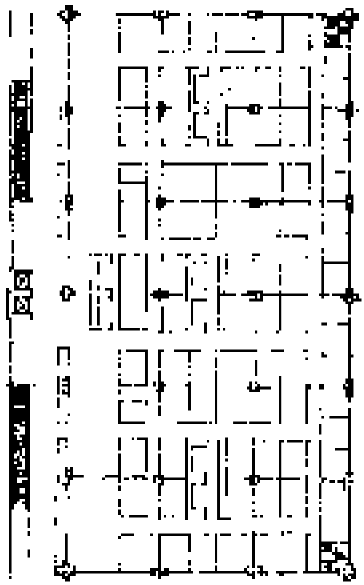
Space Blocks can be strung together along the infrastructure tube. Three in a row is typical, yielding a 90-meter by 30-meter space field. For massive areas, they can also be aligned back to back, yielding a 60-meter depth served by infrastructure from both sides.

The benefits of the Universal Space Field and Block strategy are particularly relevant in terms of changing the function of an area, such as converting clinics to treatment functions or from inpatient to outpatient services.

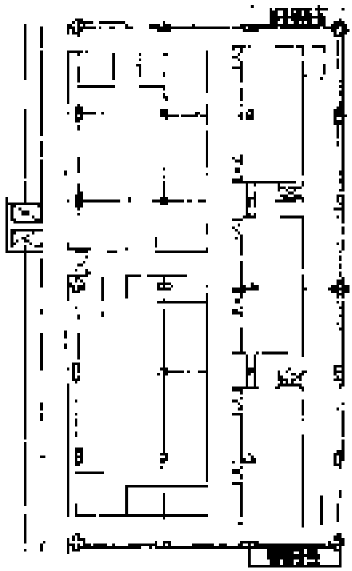
Universal Building Modules

This strategy is to develop a building module, including structure, floor to floor space and service system distribution, that can accommodate any aspect of care that is likely to be needed.

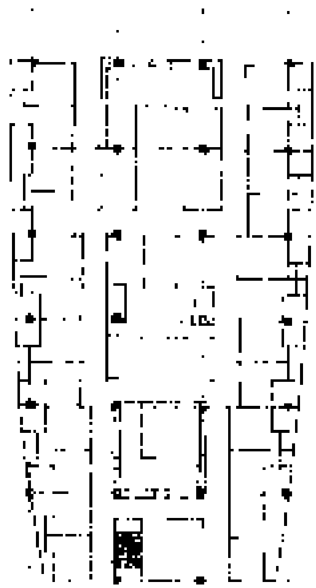
The type of module involved in this case is designed to meet the needs of inpatient, outpatient and diagnostic and treatment uses, but would also serve processing, warehousing, and office functions. We have tested the module for versatility in a number of design projects, which indicate that a module plan dimension of ap-



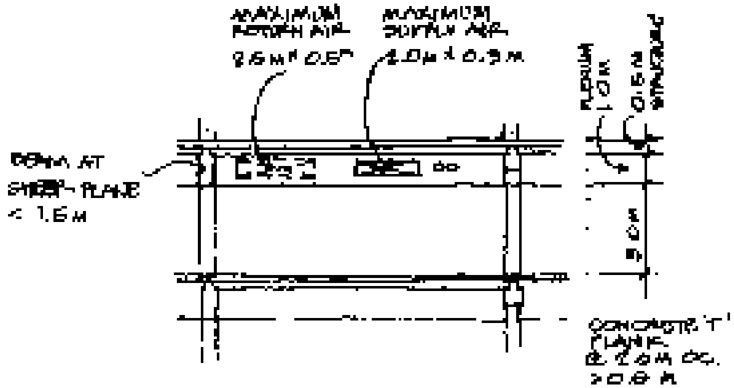
Clinic.



Operating Theatres.



Nursing Units.



Section through typical module.

proximately 10 meters square works best functionally. These dimensions vary slightly according to each country's legislated planning standards and customary architectural module with Japan at the smaller end of the spectrum, Korea and Norway in the middle, and the United States at the larger end. The range seems to be from 9.5 to 10.5 meters square.

When the harmonic resonance of a structural bay corresponds with frequencies that the human body is sensitive to, and can create discomfort. This phenomenon usually occurs in shorter spans under 9.15 meters square (30 feet) and diminishes as the span increases beyond that dimension. Therefore, when at all possible, the shorter spans that are most subject to harmonic resonance should be avoided.

Floor to floor heights from 4.5 to 5.0 meters work well for most functional floors. The utility distribution system in this concept typically runs through a maximum of three modules. A slightly taller entry level floor is often appropriate (4.5-5.5m) while a taller service level (6.0-6.5m) is preferred.

Given these parameters, the structural system, whether steel or concrete, can be a one way system with a maximum depth of 0.5 meters (except at the perimeter). This allows a space of 3.0 meters below the ceiling and 1.0 to 1.5 meters from ceiling to structure. Based on a maximum of three modules, along with the most intensive air change requirement anticipated, the likely maximum height of a duct is 0.5 meters. This can be accommodated with the required vertical bending radius and collocated lighting fixtures within the 1.0 meter space.

The Universal Building Module strategy is not necessarily a loose fit approach. Benefits from the flexibility it provides are realized when making any changes within a function that require altering services or moving walls. The use of a uniform module throughout a project provides economy of time in design and construction, and potential for material and labor cost savings in construction.

Universal Rooms

This strategy is based on designing rooms that can serve several related uses, either without making changes to built-in systems, or making relatively minor changes that accommodate an even wider range of uses. While this strategy is currently being developed by a number of architects, NBBJ's efforts began with the Genesys project, continued with the new research hospital for the National Institutes of Health (NIH) in the US, and is now a part of nearly every project the firm has underway.

It is definitely a loose fit strategy, but immediately beneficial in providing operating flexibility. There are a number of ways in which the system can be applied. At both Genesys and

NIH, the inpatient room was designed to accommodate acute, critical and day hospital patients. NIH has both single patient and two patient versions using the same structural module. The opportunity to unify room details may provide some design and construction economies to offset the loose fit aspect of this strategy.

Modular Movable and Semi-movable Casework

Movable casework, particularly such things as mobile charting desks, lockable medication carts, sleeper chairs, and clothing storage units are an integral part of a universal room strategy, but are also useful in changing care team staffing during different hours of the day.

Example: Design for a Norwegian Replacement Hospital

This series of diagrams shows how this set of strategies would apply to phased replacement of a major medical center. An additional feature of this application is the embedment of permanent construction crane locations in the infrastructure.

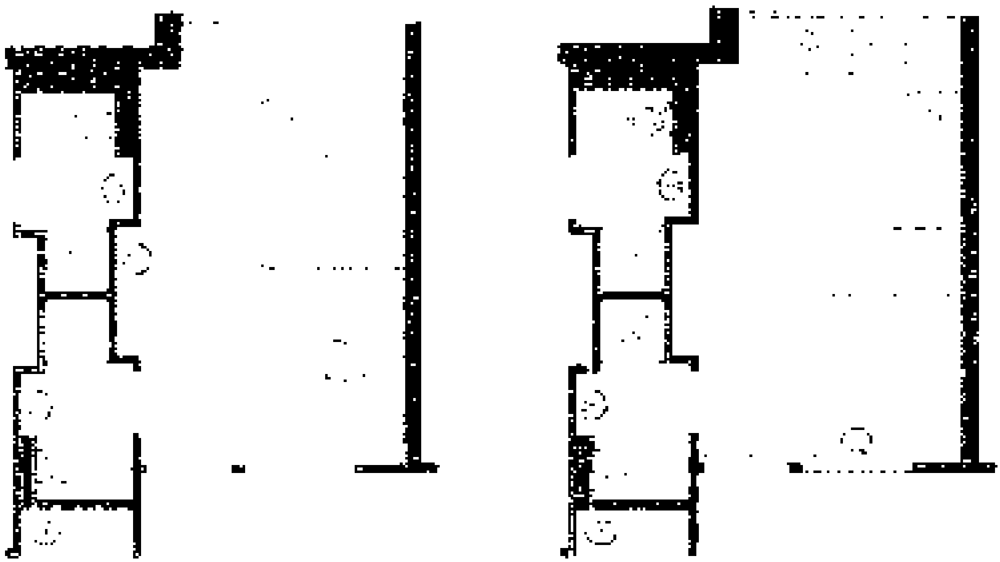
Humanism, civility, and healing design

The whole point of this approach is to achieve a balance in healing architecture that is flexible and cost effective, as well as nurturing and uplifting. As a result, the design ultimately must:

- Do no harm
- Facilitate medical service
- Contribute to healing

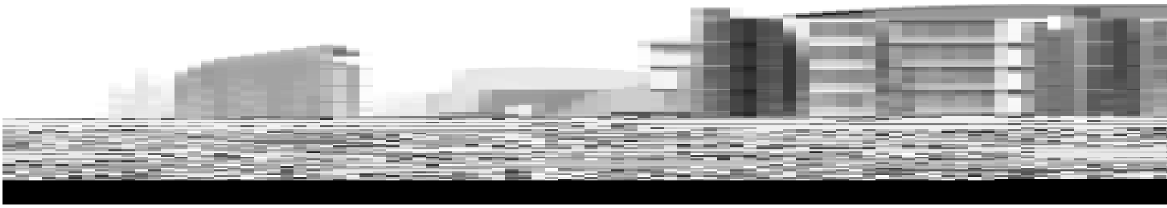
In order to meet its mission, therefore, healing architecture must address the positive use of sound, light, color, air quality, nature, art, materials and aesthetic form as tools for creating a spirit-reinforcing environment. It should also incorporate culturally appropriate responses and importantly it must reinforce civility in the environment.

The permanent infrastructure creates a lasting framework for this, so sensitive integration of all of these issues is critical. In the temporal space as well however these tools are essential to the success of the facility.



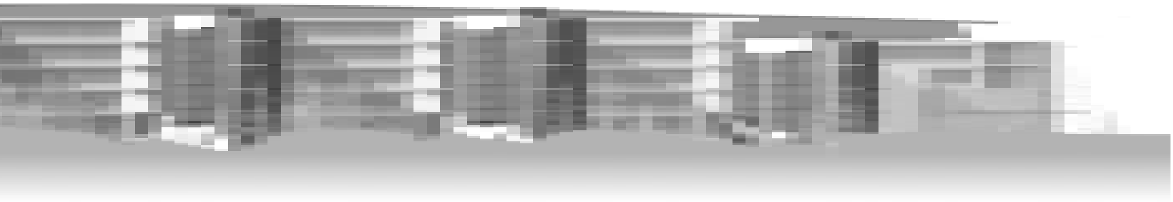
Universal rooms.

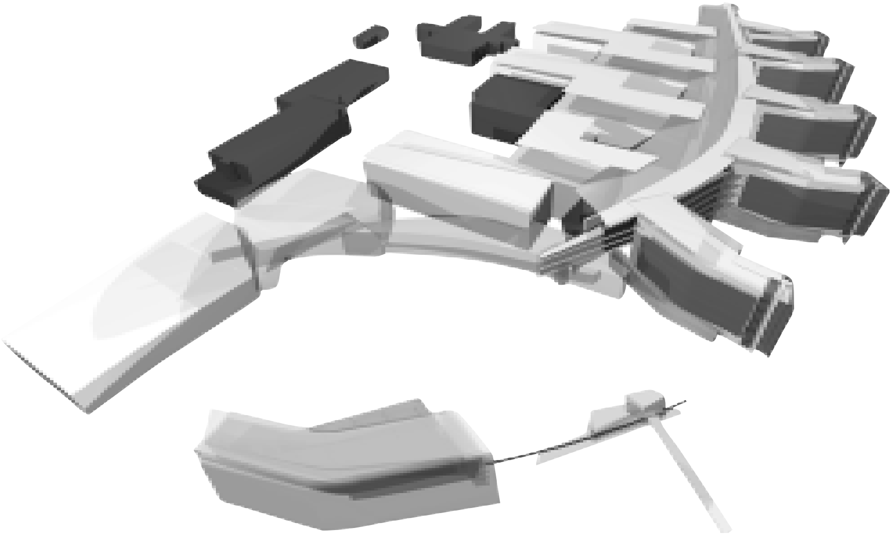
Site Plan.



West elevation.

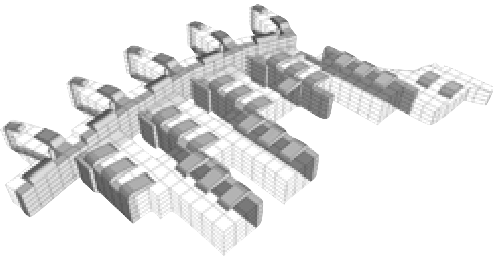
Model view from south.



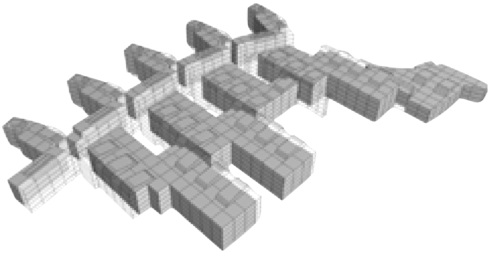


Computer model from north.

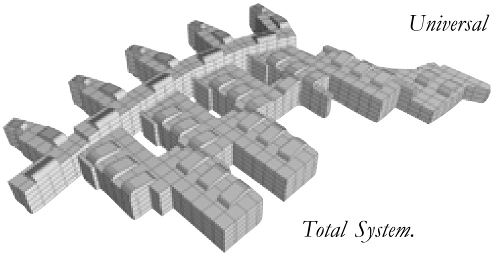
View at entry.



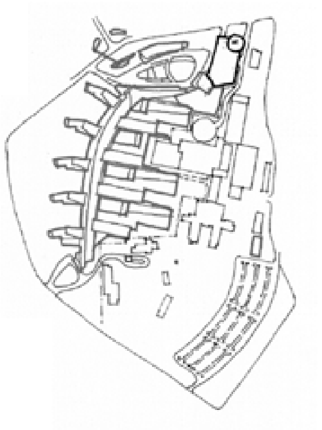
Integrated Infrastructure and Circulation – Permanent.



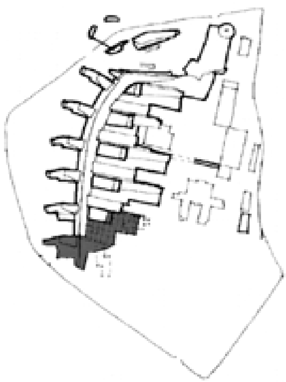
Universal Space Fields Flexible – Temporal.



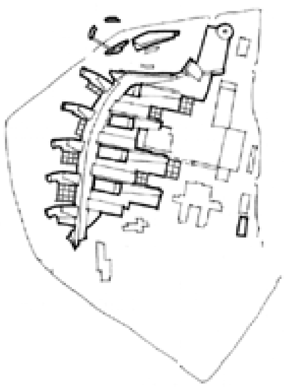
Total System.



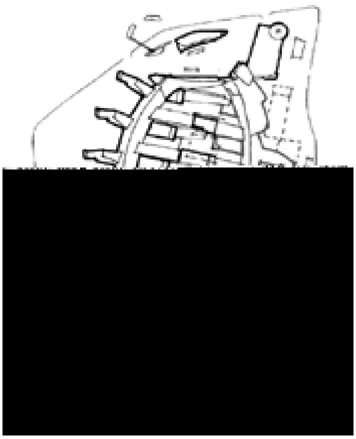
Site Plan, Phase I.



Site Plan with potential major addition.



Site Plan with potential small additions.



Site Plan showing crane locations.

Advantages and Disadvantages of these strategies

Advantages

The advantages of the combined strategies discussed here are that they provide a building system that can accommodate the prevalent needs in healthcare delivery characterized by continuous change. The development of standards early in the process can save time in design, and time and cost in construction. The ability to respond to change at many levels creates a powerful tool:

Change by Designation	õ	Universal rooms
Change by easy conversion	õ	Universal modules allow easy conversion of spaces
Change in whole area function	õ	Universal fields enable major changes in function (moving departments)
Clarity in pathways, accessible services	õ	Integrated infrastructures allow clear expansion pathways and strategies
Time saving in design and construction	õ	Modular repetitiv construcstruction and design standard
Exit Strategy	õ	A building that fits many commercial uses

Pomona Valley Hospital Medical Center, Pomona, California.

Swedish Medical Center, Seattle, Washington.

Swedish Medical Center Ambulatory Care, Seattle, Washington.

Swedish Medical Center Women & Infants' Center, Seattle, Washington.

Swedish Medical Center Chapel, Seattle, Washington.

Disadvantages

The disadvantage of this approach is it will not be as cheap initially as the tightest fit approach. It will not accommodate all potential needs such as super heavy, or exotically isolated functions within the universal spaces, although the infrastructure system would provide locations for these. Space configuration for some functions may be compromised in the name of universality, but it will likely be for smaller rather than larger spaces.

Summary

The lifecycle cost economics of this approach have not been rigorously tested and, to do so, may never be practical. More importantly, this set of strategies deals with a balance of issues that include cost, the healing and supportive environment, and accommodating non-disruptive change. In most situations, healthcare buildings will spend most of their useful lives undergoing continuous change. Having a system that minimizes the impact of change on operations, therefore, is invaluable